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COOLANT, CONVECTION, AND PARTS THAT FAIL

Most cylinder heads are aluminum nowadays, and they tend to warp, crack, and blow gaskets if the temperature needle drifts into the red and stays there for too long. In extreme cases of engines running too hot for too long, rings can lose their temper and engine blocks can be destroyed. Over time, hoses can split and plastic radiators can crack or clog with debris. Water pump bearings and seals can give out, ferrous water pump impellers can be consumed by rust, and plastic impellers with aluminum hubs sometimes get loose and spin on their shafts. Cavitation can damage timing covers or water pump surfaces opposite their impeller blades, and in some cases, an improperly installed serpentine belt can spin a water pump backwards. I once received some e-mails from a guy who said his van was running too cold. In the end, after he'd replaced several thermostats, he finally e-mailed to tell me that he had the belt routed wrong. I would have enjoyed doing a detailed analysis of that one!

All above said, a healthy emissions-friendly engine generally needs to run between 200 and 240 degrees F, and some electric cooling fans don't even kick in before the ECT sees nearly 230 degrees. That's a pretty tight temperature window, and little things can upset the balance. When thermostats fail nowadays, they usually break (allowing coolant to pass unchecked) or open too soon, and a cold running engine will run dirtier, both at the tailpipe and in the crankcase. And sometimes, I've had to order two or three thermostats to get one that worked right. The PCM will toss a P0128 if the 'stat isn't good. One way or another, airflow and coolant flow are of paramount importance, so every spinning blade that moves water or air needs to be operating at peak efficiency. But first let's talk about keeping the coolant where it belongs.

Containing the Coolant

One complication (albeit a profitable one) that we as technicians face is the obsolescence built into so many of today's vehicles. In the quest to reduce weight, just about every OEM has hot coolant flowing through plastic parts at 16 psi. It may be a good idea to sell your customer replacements for those aged components if their wheels have rolled more

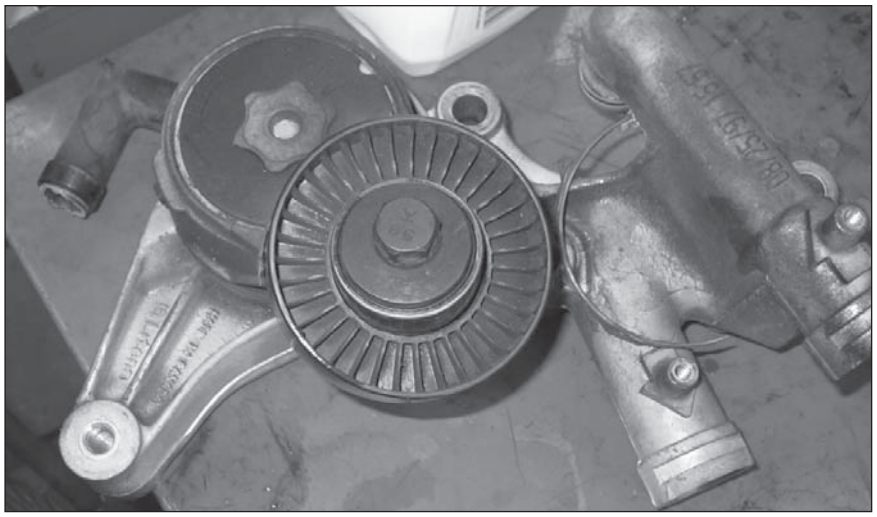

Figure 1: *This tensioner bearing failed, and a replacement costs nearly a hundred bucks.*

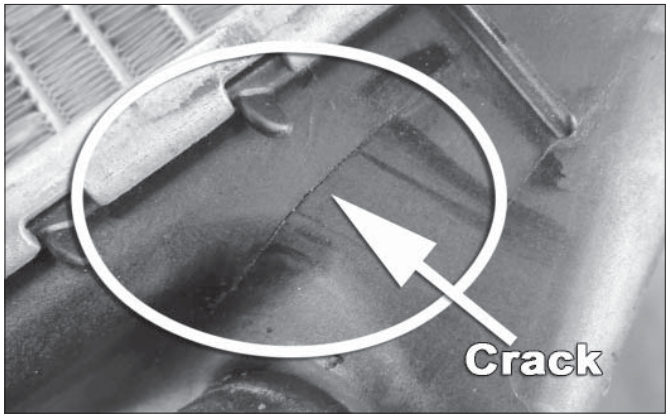

Figure 2: *This kind of radiator failure happens thousands of times a day, with practically no warning, on just about every make and model, and it can have devastating consequences. I've seen more than a few cars with cracked plastic radiators and fried engines. Replacing the radiator at 120k might seem like overkill, but if it saves an engine it might just be worth the cost.*

than 100k miles. Beyond the cooling system, cast aluminum spring-loaded belt tensioner arms can pop into two pieces without warning, or overheated tensioner bearings melt, causing the units to lose their plastic pulleys (Figure 1).

Just about everybody uses aluminum core radia-

Figure 3: *Coolant passes through the tensioner (as seen in Figure 1) by way of a couple of plastic elbows that routinely fail while the tensioner is still good.*

tors capped with plastic tanks and rubber joint seals nowadays. In addition to the potential cracks in the plastic (Figure 2), those rubber seals give away. I like to replace aluminum radiators at about 120,000 miles on my personal vehicles. They don't cost that much, and peace of mind is a wonderful thing to have. Then there are those OEM plastic heater hose tees and the o-ringed plastic elbows that can fail and jettison obscene amounts of coolant with almost no warning at all.

GM 3.8 liter engines have two plastic elbows (Figures 3, 4) that very oddly route coolant through the belt tensioner bracket (see Figure 1), and earlier 3.8L

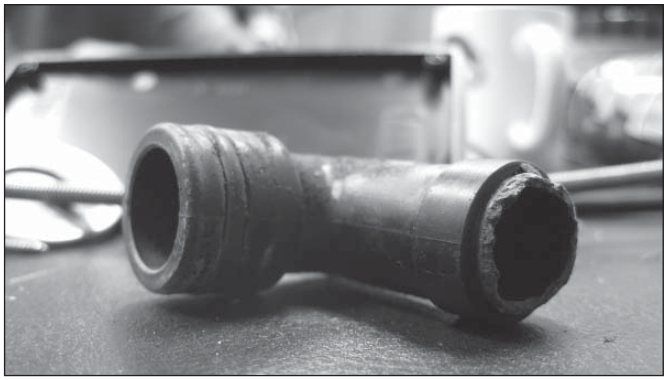

Figure 4: *The elbows' inner o-ring bosses generally crumble away, allowing their rubber ring to move, which results in leakage. If these are OEM and it's a high mileage ride, changing these elbows to protect a customer is a good idea and a legitimate upsell.*

models have a plastic bypass hose fitting screwed into the intake where it's neatly concealed behind the alternator. Some parts stores have a machined steel replacement part for that one, which is a badly needed upgrade. Imagine yourself doing a cooling system flush or a water pump replacement only to have one of these plastic parts dump the coolant a week later. It's a good idea to sell the customer on replacing the plastic fittings while you have an empty cooling system. Not only is it a legitimate upsell, but it's also a bit of insurance against later comebacks, and most customers will appreciate your going the extra mile, even if it adds time and

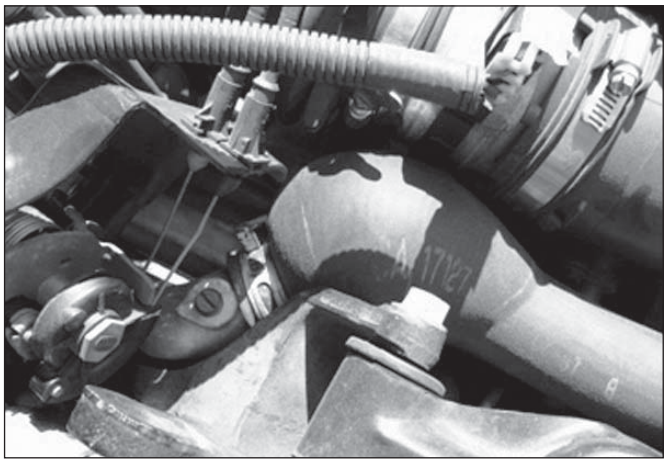

Figure 5: *It was pretty scary to notice this hose on a car that was running at 230 degrees F! A hot coolant bath can ruin your whole day.*

parts to their bill.

Sometimes those spring-loaded OEM hose clamps will break and a coolant leak is born, and there are other times when hoses get thin and swell.

I was under the hood of a very hot Pontiac Grand Prix one day with the engine idling when I noticed a huge bulge on the upper radiator hose (Figure 5). It only took me a moment to get the heck away from that and switch the engine off. If that hose had

burst I'd have had third degree burns.

I saw one Toyota Camry that had done a lot more than just 'bust' a hose. That upper radiator hose failed so violently that an eight inch section of the hose was totally missing.

Moving the Coolant

The water pump is the most active component of a vehicle's heat transfer system; it's forced to work harder and more consistently than any other cooling system part. The water pump impeller has to swish through coolant while spinning within about .040 inch of its reaction surface, and if cavitation or rust begins to attack that reaction surface, the coolant doesn't move aggressively enough. If the cooling system is full and the engine is overheating, cool heater hoses are a pretty good indicator that the water pump isn't doing its job. Most seasoned techs can tell some really good water pump stories. Keep reading and you'll hear about one or two of my own.

At this point I'll indulge in a mild digression: Let's consider for a moment the plight of a British national I'll call William who contacted me from South Africa via e-mail about the water pump on his Mercedes:

My car is a Mercedes 1979 450 SLC. The water pump is leaking from a small hole in the top of the pump. I am told, that as it is an aluminum pump, if I buy a service kit, at any time thereafter, the bearing can strip the inside lining of the casing in which it sits and rotate inside, causing damage. I am also told that this doesn't happen with a cast steel pump. So I must pay for a new pump. A new pump R 3000-00 and a repair kit is R 310.00 in local currency. R 3000-00 is half a month's take home salary. Your advice, please, what should I do? Can I temporarily epoxy up the hole? Help me please and thanks in advance for the service. William

What would you tell this guy? He was in a pinch, to be sure! With my engine oil-stained roots running deep into the concrete service bay of an ancient South Alabama gas station where I spent some of my teenage years (after working in my dad's VW bug shop where there were no liquid cooling systems), I let my British friend William in on a trick. It's one I was taught to apply whenever Farmer Joe was in a hurry to get his peanuts to market and couldn't take time out to let us replace the water pump on his pickup.

For a temporary repair, try this: Add a couple of tablespoons of brake fluid to the coolant. That may (and usually will) soften the seal enough to stop the leak. Don't epoxy the hole. After the leak stops (which it probably will), drain the cooling system, refill, and bleed it. The water pump will eventually need replacing, but this should buy you some time. Richard

This was kind of fun, especially when I saw his reply a couple of days later:

Well knock me down with a feather! I put in the brake fluid and it has stopped leaking. William

Country folk (like me) have learned and shared a lot of tricks like that over the years, but in most cases they simply postpone the inevitable. Black pepper or raw egg whites in the radiator might stop a pinhole leak too. But obviously, neither are the right fix. William's water pump will eventually need replacing, but maybe this gentleman can gather the "quid" to make it happen with the time he bought.

Then there are the strange ones. A 1997 F150 sprung a coolant leak right after a January cold snap. Figuring the repair would be quick and easy, the owner took it to a shop in the town where he lives and that shop quoted him a thousand dollar estimate, claiming that all the expansion plugs needed to be replaced. He thanked them for their time and paid their diagnostic fee, then brought the truck to my automotive department *(Editor's note: Correspondent McCuistian is an instructor at a technical college)*. What a grand adventure it turned out to be!

We found one expansion plug leaking (front of the right head) that had rusted through, but just barely. Could some or all of the other expansion plugs be suspect? Sure, but they weren't leaking now, and the owner completely understood the fact that others could follow. We replaced that one expansion plug and pressure tested the cooling system to find the intake gasket leaking like a sieve on both banks – it was pouring coolant topside and into the crankcase, with coolant running back and dripping from many places. Right after a bark-busting cold snap, it's no wonder the shop made a snap-click diagnosis and condemned all the expansion plugs.

Two of my students replaced the intake gasket, filled the cooling system, fired up the engine, and even after the air was burped out, it tended to slowly overheat in the service bay. But only with the coolant filler cap installed.

We used a pressure tester gauge as a tool to determine that there was no rapid pressure rise in the cooling system that would indicate head gasket failure, so the thermostat was replaced as an inexpensive first step, but to no avail. As before, with the cap removed it never heated above 220 – but if they installed the cap, it would slowly begin to climb beyond safe levels.

With the heater hoses getting hot right away, the water pump was ruled out (incorrectly). We removed the radiator and did a borescope inspection to find some pretty substantial clogging.

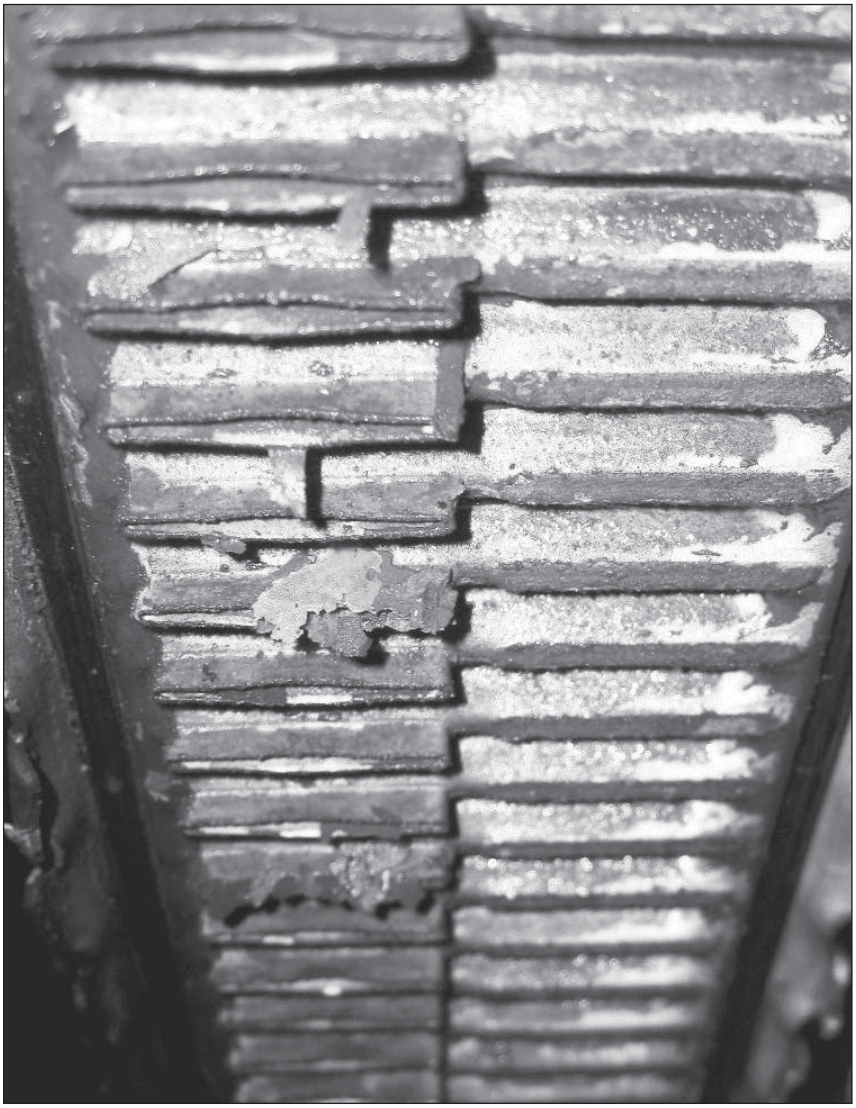

Figure 6: *These flakes of material had come from stamped steel (expansion plugs, water pump impeller, etc.). This dissection happened after we replaced the radiator, which cured part of the overheating problem on the F-150, but not all of it.*

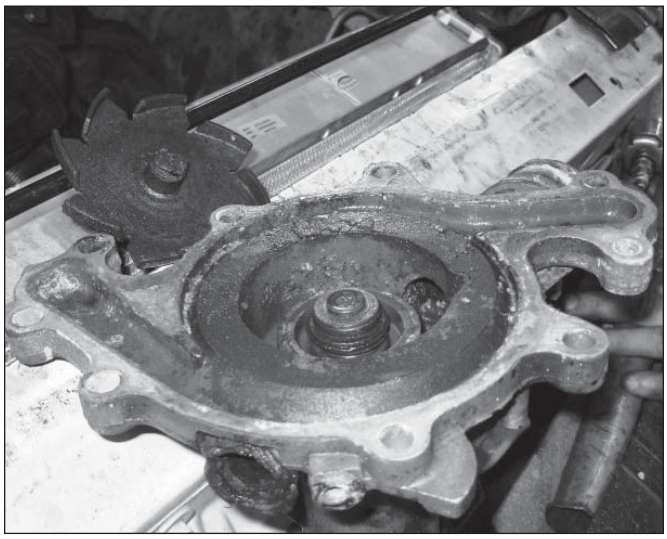

Figure 7: *It was downright weird that the F-150's 4.2L engine ever ran cool with the water pump in two pieces like this. But believe it or not, this is how we found it.*

A replacement radiator ($160) was in stock at the parts store, and early the next day with the radiator in place and the cooling system burped we had a cool running F150 in the service bay (210 degrees), even at high rpm and with the cap installed.

With the scan tool ECT readings and the instrument gauge in firm agreement, we thought we were done with the overheating problem – WRONG. Now comes the strange part: When we drove the truck on the road, the temp gauge would spike up into the red, and it only took about two hundred yards for it to heat up like that. Yet we could stop the truck and it would cool down immediately (I'm not making this up). This kind of cooling system performance is downright spooky, and just didn't make sense, especially since we had just installed a nice clean radiator. The students who did the work are real troopers – they never complained, nor did the owner, even though his repair bill was climbing as fast as his temperature gauge was.

We removed the tanks from the old radiator, and there were lots of big rust flakes floating around in them (Figure 6). The only component that could produce that many large rust flakes was the water pump impeller, which is stamped steel on this unit, and it was there that we found the answer (Figure 7).

The water pump impeller had separated from its shaft. Since the owner only drives the truck to work and back and it's less than two miles each way, there was no telling how long it had been since the failure occurred. But at least this truck's problems were now solved.

A failed radiator on a 2005 Dodge Caravan led to a pair of cracked heads, and my students did the work. A couple weeks later, the same van came in low on coolant, and we found a pinhole in a block expansion plug, which was pretty scary (Figure 8). These things can look just fine on the outside, whilst flaking away badly on the inside. Short of replacing all the expansion plugs in every rusty cooling system (which would practically require removing many engines) it would be hard to guard against potential failures like this one. Fortunately, the engine didn't get hot enough to repeat its earlier failure.

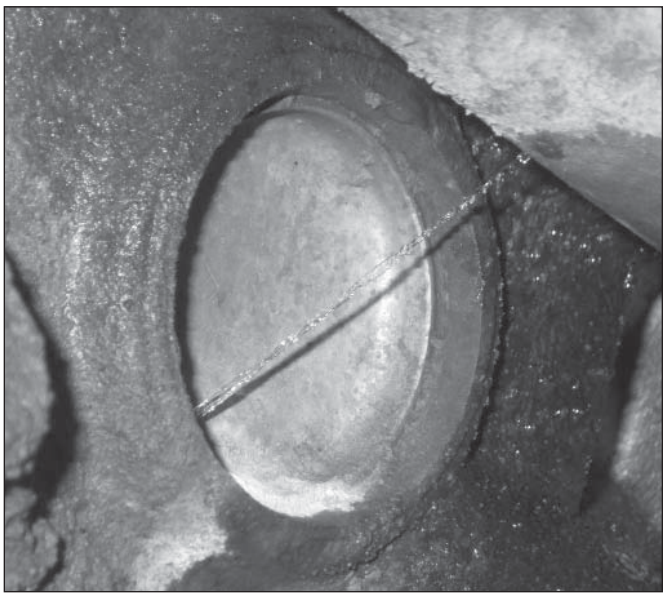

Figure 8: *This squirting expansion plug didn't look so bad on the outside, but then, they seldom do. It gave away not two weeks after we replaced the heads.*

Filling the System

When I'm filling a cooling system that has a regular radiator cap, I either use a vacuum tool (Figure 9) or I simply fill the cooling system as full as I can (opening bleeders and using hoses as necessary to cold-burp it). Then I install a radiator cap (Figure 10) from which I've removed the spring and lower seal (it still seals well around the top of the radiator neck, but lets coolant flow freely into and out of the surge bottle) and start the engine. I watch things carefully to keep 50/50 coolant/water mix in the overflow bottle. With this arrangement, the system pushes air into the bottle and draws in as much coolant as it needs to stay full. It doesn't build pressure, nor does it spew out coolant everywhere. And after everything is good and warm and the fan has cycled on and off a few times, I replace that "tool cap" with a new cap to finish the job. ■

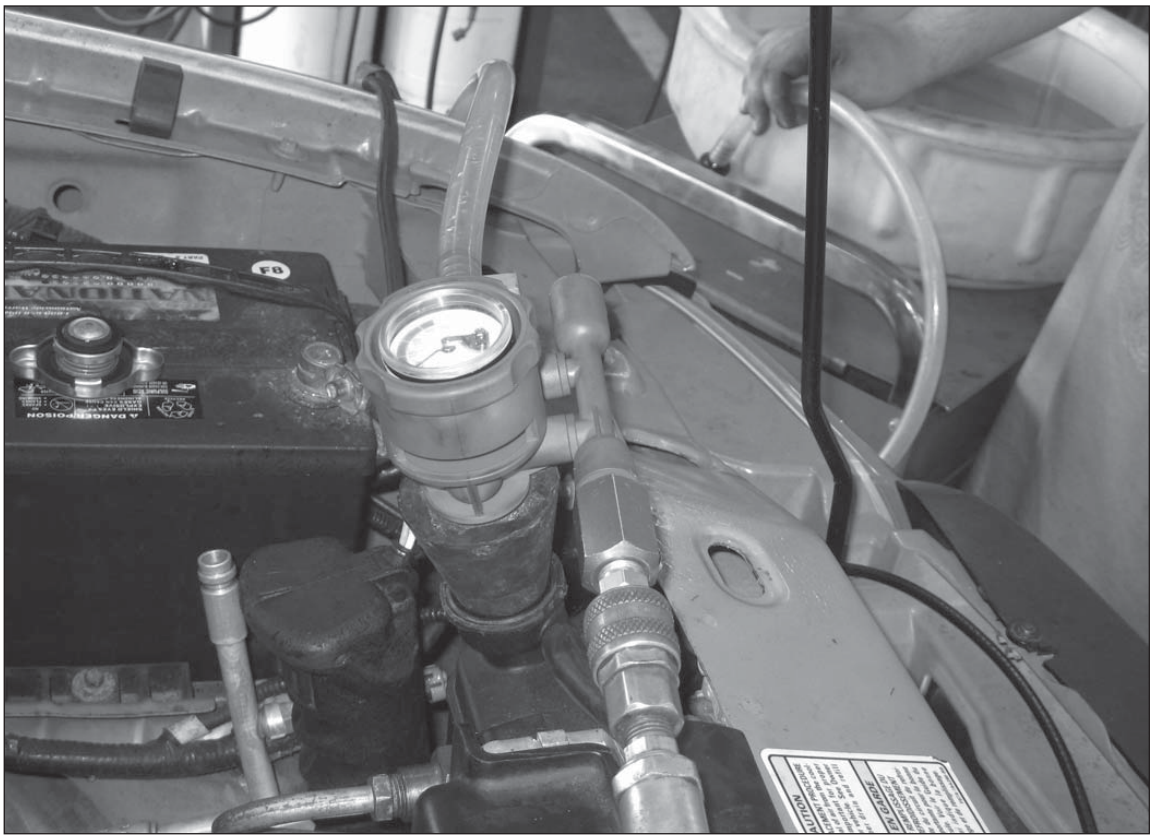

Figure 9: *This is a handy tool for filling cooling systems – universal in its design, so it works on just about any cooling system. I teach my students to use it, but I also teach them a method I came up with on my own (see Figure 10). I don't know of anybody who does it my way unless I taught them.*

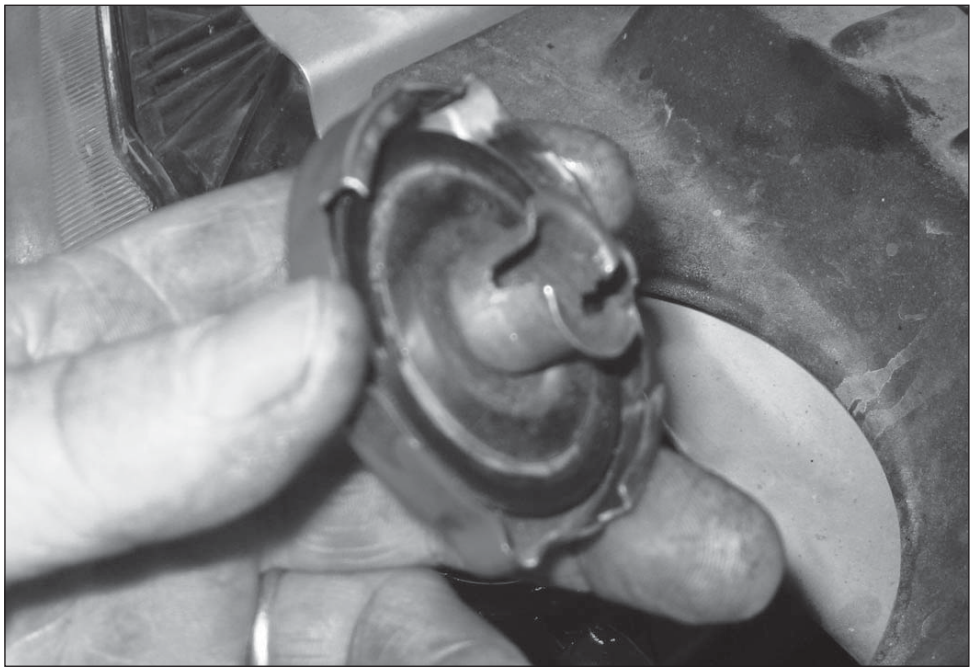

Figure 10: *This is a modified radiator cap I painted red (so I remember not to leave it on) with its lower seal removed. With this cap installed, fill the cooling system as full as you can, then start the engine. The cooling system can expel air and draw in coolant as needed from the overflow bottle (you just have to watch the level in the bottle). This method builds no pressure on the system and prevents coolant surges that tend to flood the service bay and wet the serpentine belt and pulleys. Remove this cap and replace it with a good or new cap when the coolant is warm and the system is full.*

FANS, FLOTSAM, AND ELECTRICAL STUFF

My computer support guy at the college brought his 1997 Camry to me with an odd dash panel vibration when the blower fan was running. We removed the blower, and in the cage, found what looked like the clean but stringy remains of a dishtowel that had been mostly dissolved by bleach. Try as he might, Alan couldn't fathom how that bunch of stringy cotton rag made its way in there. His wife drove the car sometimes, but he said she never put anything on the dash, let alone a dishtowel.

Those blower motors work hard, and sometimes connectors and conductors in their current paths can fail anywhere from the junction box all the way through the blower resistor to the motor itself. When I worked at a Ford dealership, we routinely had to retrofit the blower circuit on E150 vans with a sturdy 30 amp circuit breaker, because the fuse in the IP fuse panel would melt due to the oxidation/resistance/heat "snowball" (Figure 11).

Blower controllers and resistors generate heat by default when the fan switch is on any position except high.

One day I was on my way to Savannah Georgia on U.S. Highway 84 when I saw a Ford Explorer beside the road with the hood up. The woman who owned it was easy to spot – she was dressed in bright colors and the only female. There were four men poking around under the hood. I don't usually intrude on situations like this, especially when there are so many other "mechanics" on the scene. But in this case, I decided to stop and find out what was going on. The guys under the hood seemed to be having quite a powwow, so I steered clear of that area and asked the lady what happened.

"A bunch of smoke came out of my air conditioner vents," she told me, "so I pulled over and turned off the engine."

I opened the driver's door and smelled burning leaves. The fan switch was set to its lowest speed.

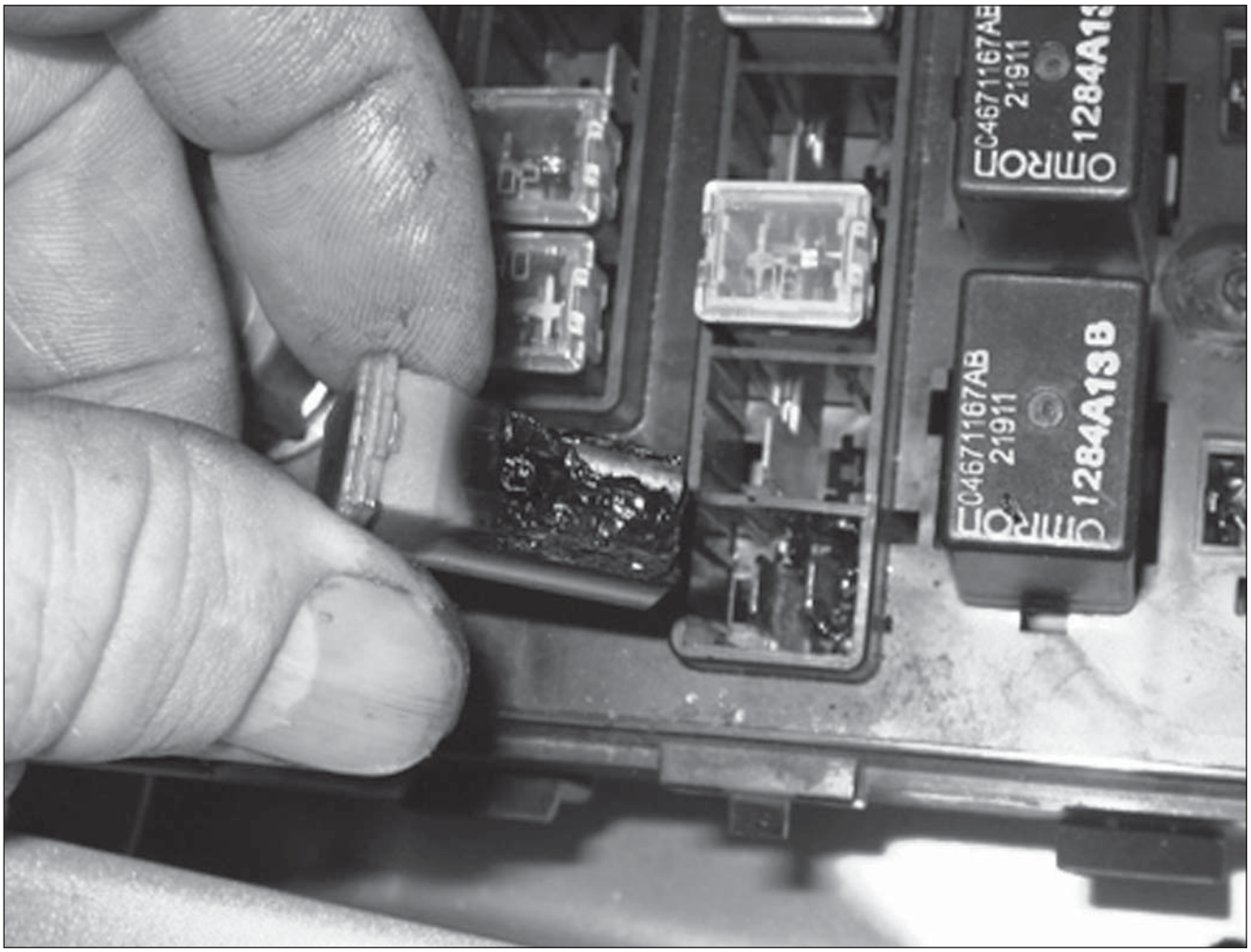

Figure 11: *This fuse melted on a 2004 Chrysler Sebring (it didn't blow, it just melted), taking the engine cooling fan offline. Fortunately, we were able to clean the connector in the junction box well enough that all we needed to do was replace the fuse. We coated the terminals with dielectric grease to prevent future oxidation.*

"You seem to have some tree leaves in your air conditioner plenum and they've migrated to rest on the blower resistor, which gets hot when your fan is on low speed. The leaves are blocking the air that cools it and are smoldering. Somebody needs to remove that resistor from the plenum and try to vacuum those leaves out of there. You can drive with the blower off and you shouldn't have any more smoke problems."

Cooling fans are in a more hostile environment, and the circuits that make them work are also subject to the "snowball effect" of current flow, oxidation, resistance, heat, and the melting of things that comes with that syndrome. And sometimes, those failures can spill over to cause problems in other systems.

Once I investigated a concern of noises coming from under the hood of a Crown Victoria and found the entire fuel system (including the PCM) cycling off and on as if it were connected to a turn signal flasher. All the activity was taking place on the driver side of the engine compartment, and after trying to determine which of the many clicking solenoids and relays was the source of this confusion, I decided to move to the passenger side and yank fuses from the PDC (Power Distribution Center) one at a time to get a handle on what to do next. Before I even yanked a fuse, I smelled something burning, and my focus shifted to the source of the stink and the heat. The source of this nonsense was the high current relay box.

The high current relay box is a small box that has the starter relay and engine cooling fan relay housed beneath a cover, which hid the fact that the

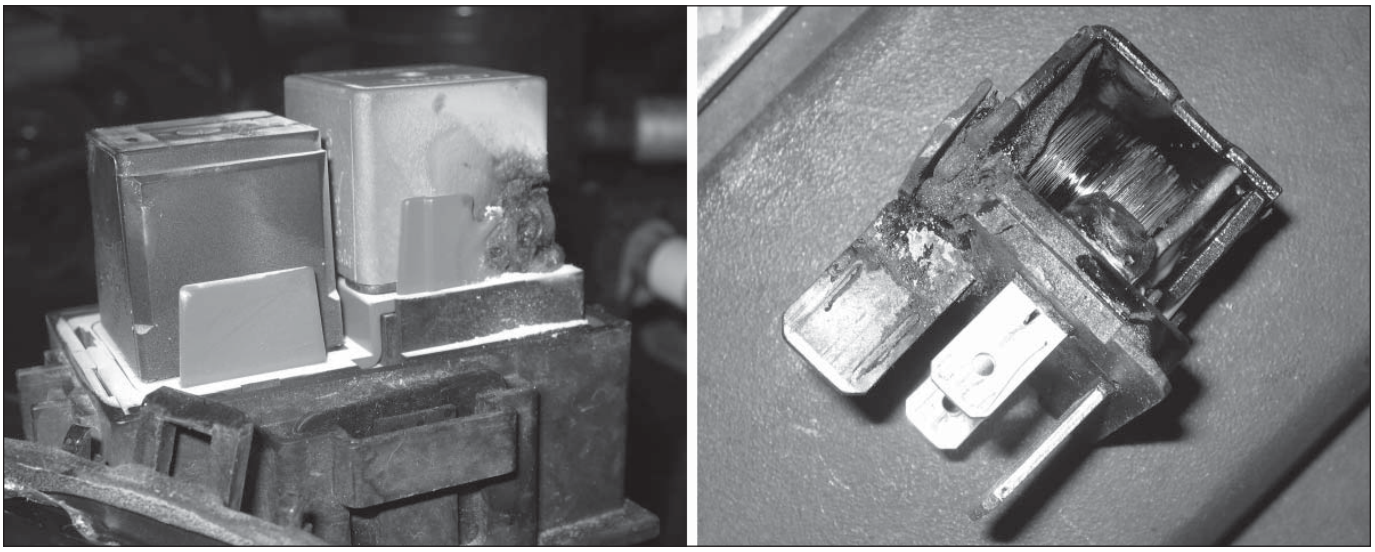

Figure 12: *This relay was the guilty party in the drama that caused the PCM to fire up and shut down every couple of seconds with the key switched off. The EEC Power Relay circuit was being fed by voltage that bled from the B+ circuit through distorted components inside the relay. There was enough voltage drop in the shorted relay connection that the fuel pump load was causing the voltage threshold to bounce above and below the PCM's baseline requirement. It created a 2 Hz cycle that was as regular as a metronome.*

large gray cooling fan relay had experienced that current flow/oxidation/resistance/heat progression (Figure 12). Since it's controlled by the PCM, the EEC Power Relay feed line powers up the coil, and the heat had distorted the relay to the point that current from the B+ feed wire was bleeding over onto the EEC Power Relay circuit, where it back fed all the way to the PCM (which is booted up by this same wire). When the PCM came to life, it wanted to operate the fuel pump relay for two seconds, but that fuel pump load pulled the marginally sufficient renegade voltage feed below the PCM's threshold, and the PCM would shut down and the fuel pump would stop. When the fuel pump shut down, the voltage would rise back to the PCM's acceptable parameter, and the cycle would repeat itself about twice per second.

A shop owner friend of mine got a call from a customer whose 2006 Malibu kept blowing the A/C clutch fuse. When the car arrived at the shop, there were other problems, because the owner had taken a short piece of 12 gauge Romex wire like electricians use to wire a house, stripped both ends of that wire, and shoved it down into the fuse terminals in the junction box. Then he and his wife drove the car (which probably had a partially shorted A/C clutch coil or a bad clamping diode) until it melted the wire from the junction box all the way to the A/C clutch, effectively wiring a lot of circuits together within that very expensive and no longer available wiring harness.

My shop owner friend told him that he could fix the car, but he couldn't quote a labor price, because he'd have to charge actual time to repair the wiring harness – that'd be the number of hours spent on the harness rather than a flat rate. In addition to that, the junction box would need replacing because it was ruined as well. The customer declined the work. ■

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