COOLING SYSTEM SERVICE UPDATE

By Paul Weissler

Engine overheating (or near overheating) can be caused by several subtle, small things (or a combination of them) rather than one very obvious big thing. It shouldn't take long to check each one off your diagnostic list.

An engine can run hot without overheating. A customer may ask you, then, "Why do I care, if there are no symptoms?" The answer is that there *are* symptoms; they just may not be as obvious as a column of steam billowing out from under the hood.

When the coolant temperature is too high, even if the engine isn't overheating, there will be problems beyond the cooling system. These include transmission and engine oils running too hot, which will certainly affect transmission life and increase engine wear. Of course, the issue the motorist is most likely to sense is intermittent loss of a/c cooling or poor a/c cooling performance in hot weather. That can get your customers hot under the collar, in more ways than one.

If the coolant temperature gets high enough in heavy traffic, the powertrain computer will shut down the a/c compressor. The trigger temperature can be as low as 220° to 225°F, a temperature at which the engine may be well below overheat in a pressurized system. With a 50% to 60% an-

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MOTOR

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If you hit the so-called sweet spot on the engine casting adjacent to the coolant temperature sensor from as close as possible, the infrared thermometer should read within 15°F of the scan tool. That would confirm the relative accuracy of the IR thermometer when used at other cooling system locations.

tifreeze concentration, the boiling point of the coolant is 265° to 273°F.

Even if the coolant doesn't hit the trigger temperature for a/c compressor cutout, it may be high enough to add mightily to the load on the front cooling module. With all the front module heat exchangers competing for the available airflow, anything extra from engine coolant can be enough to raise refrigerant pressures in the condenser. The a/c compressor may not shut off, but a/c system performance will definitely drop.

Furthermore, if the weather is hot and the motorist is using regular gas to save money (where premium is recommended), the high temperatures will often contribute to engine knock. On a modern computer-controlled engine, no one hears knocking and pinging anymore, because the knock sensor sends the word and the instant response—retarding ignition timing—keeps things quiet, but at a loss of performance.

If strips of cardboard were installed in front of the condenser to improve heater performance during the winter, they should have been taken out in the spring. If they were not removed, their presence could contribute to higher coolant temperatures and reduced a/c performance.

So if a sluggish engine is another complaint you've been hearing this summer, that's a second reason to look at coolant temperature. If the premium-gas vehicle previously ran acceptably on regular, the motorist is not going to switch to premium—not at today's prices.

In addition, if you're doing a coolant replacement, you want to make sure that the work you do is not going to be responsible for coolant temperatures going up.

First find out what the coolant temperature really is. If the dashboard gauge reads high, that's a hint, but not exactly a precision report. In fact, even if the gauge markings include numbers, that still may give you just a hint. Compare it with what your scan tool reads off the coolant temperature sensor. If both readings are within 10° of each other, that tells you enough to start a diagnosis.

If both readings seem high, confirm the condition by checking the coolant temperature at the engine sensor, using an infrared gun. The IR reading will be lower, by as much as 10° to 15°F, because of the heat loss through the engine casting. In checking with an IR thermometer, you have to hit the so-called sweet spot on the casting to get an optimum reading, which also helps confirm the accuracy of the thermometer. That's important if you're later using the IR thermometer to look for restrictions elsewhere in the cooling system.

If the readings between the scan tool and dash gauge differ more significantly than 10° to 15°F, one is surely wrong, because of a problem in the circuit (usually the dashboard gauge). On some older cars, there may be two sensors, and some difference may be based on location and sensor condition. So make sure you're aiming the infrared gun at the right sensor when you want to make a comparison.

If you've found that coolant temper-

ature is high, that would seem to indicate a reason why a/c operation and engine performance may not be normal.

Were There Winter 'Fixes'?

First, if the winter really was cold in your area, as part of a vehicle history report, find out if anything was done to improve heating performance that should have been undone at the end of the winter season. For example, a higher temperature thermostat might have been installed. We've never considered installing one a great idea, because if midwinter temperatures break, the engine will start to run too hot. On the flip side, it's also a bad idea to replace the thermostat in summer with one that's intended to maintain a lower coolant temperature, because that's likely to trigger a trouble code and Check Engine light for slow warm-up.

The only reasonable heater helper that should have been done in (a really cold) winter is partly blocking the front of the cooling module (on the condenser) with strips of cardboard across the condenser face. However, you can't see the strips on most cars because the front of the condenser is out of sight, unless the car is on a lift or a top radiator support or cover strip is removed for access.

A refractometer is the most accurate way to check antifreeze concentration, which should be about a 50/50 mix with water for best performance.

If the winter weather in your area included a lot of snow, also check the condenser and radiator for the possibility that salt-laden road film was packed in. We've seen cases where large sections of fins, which are what carry away the heat, were gone—eaten away.

And finally, make sure that any underbody airflow control strips or covers are intact and in place. They're what direct the airflow through the cooling module. Also, check the fan shroud for looseness and any missing foam stuffers or weatherstripping around the headlamps and front cooling module heat exchangers. Unless the stuffers and seals are all squarely in place, some of the airflow bypasses the heat exchangers, and that, of course, will cause the engine to overheat.

Is the Mixture Right?

Too much of a good thing isn't always so good. Although the turning point in the antifreeze curve is at about 70% concentration (the freeze point drops to about −90°F), the antifreeze part of the coolant mixture is not a great heat-transfer

Make sure you inspect the radiator cap pressure seals—not just the inner seal for the pressure valve, but the sealing gasket as well, which must help keep air from being drawn into the system during cooldown.

A coolant filling funnel is a simple way to add coolant while burping air from the system. Install the radiator cap adapters, then the funnel with its stopper. Fill the funnel half with water and half with antifreeze and stir. Then run the engine, pull out the stopper and let the coolant mixture flow in to top up the system while allowing any air to bubble out. When coolant stops flowing in, squeeze the upper hose to help expel any remaining air.

medium. Water is a lot better, so if the summer temperatures really climb in your area and winter rarely gets below −10° to −15°F or so, the system does better at 50/50—good corrosion protection, enough antifreeze performance (−34°F) and good heat transfer.

When was the last time you saw anyone top up a system with a jug containing a 50/50 mix? Standard operating procedure is to add pure antifreeze, so it isn't surprising when a system ends up overloaded with antifreeze after a few years of top-ups. The moral: Mix it yourself, so when you pick up a jug to do a top-up, you don't change the ratio. Also, check the antifreeze concentration as a routine diagnostic step if you have any question. And remember that you need to do this with every type of antifreeze—DexCool, G-05, conventional American green, Japanese conventional and Japanese long-life. Top-ups are no excuse for mixing antifreezes.

Coolant flow rate is another matter. The more flow the better, within reason. But more than you need will cost horsepower, so engineers don't go overboard. If the drive belt is slipping, that should be apparent, and so will be the fix. However, if the water pump is badly eroded by a worn out coolant mix, the flow rate drops, and the engine runs hot, particularly in low-speed driving.

Testers that measure coolant flow never were big sellers, and we haven't seen one on the market in years, so you probably don't have one. If the coolant composition appears bad, you can confirm your suspicions with a coolant test strip. But about the only way to check flow is to remove the radiator cap and look, with the engine warmed up and running. Or if there's no radiator fill neck through which to look, you might install a sight glass between the radiator and the upper hose. Other techniques include checking temperature with an infrared gun along the circuit, looking in particular for a normal temperature drop (10°F or so) across the radiator to indicate good flow. With water pumps tough to take out on so many engines, an R&R just for a look is not an appealing thought, so you want to try everything else first.

Is the System Really Full of Coolant?

The standard check for a full system these days is to glance at the reservoir and see if the level looks good. Of course (particularly with the atmospheric pressure type), that doesn't really tell you, so if there's a radiator cap, remove that and see if the level in the radiator itself is up. That's better information, and if the level is down, you can suspect that the air-sealing gasket may not be so good, even if it isn't noticeably deteriorated. The pressure test for the cap checks only the pressure valve and its

A drain & fill machine is still the best way to perform a coolant exchange. This new Yellow Jacket equipment has four containers—one 16-gal. container in the rear for used coolant, the other three in front, each with an 8-gal. capacity, for holding different antifreezes.

Although a vacuum drain is not as effective as a drain & fill machine, a vacuum refill kit works well on a system that has been manually drained. Here the adapter is pressed into the fill neck and a valve is turned to allow a venturi vacuum pump (which operates with shop air) to pull out air. When the adapter gauge reads about 24 to 26 in. of vacuum, close the valve. Then disconnect the venturi pump and attach the refill hose (with the other end submerged in a container of 50/50 mixture). Finally, open the valves on both the fill neck adapter and the refill hose, and the vacuum in the cooling system will draw in the fresh coolant mixture from the container.

seal, not the air sealing gasket. But if that gasket doesn't do the job, the system will inhale air as it goes into a partial vacuum on engine cooldown.

With a leaking air-seal, the coolant level in the radiator drops, and any excess coolant that collected in the reservoir is forced out of its overflow vent during the next engine operation. The reservoir level still may look fine, but there's a lot of air in the system, and air is nowhere near as good a heat transfer medium as a 50/50 coolant mixture.

To check the clutch fan with a photocell tachometer, apply a small strip of reflective tape to the outer edge of the fan blade before starting the engine. Aim the tachometer carefully, and the peak reading will be the speed of the fan. Clutch fan speeds at idle with the engine still cool are about 1250 to 1400 rpm, and peak at about 2350 rpm at operating temperature on most vehicles.

An anemometer (airflow meter) is often used by technicians to check airflow from the HVAC registers, but it also can be used to check airflow through the front cooling module heat exchangers by holding the sensor module (a fan spun by the airflow) against the condenser at several locations to get an average airflow reading in cfm. There are no factory specs, so you'll have to compare the reading with that on another vehicle to see if high coolant temperatures on the vehicle in your bay are caused by low airflow.

Or the pressure cap valve rubber seal deteriorates, usually swells, so it doesn't seal properly. The coolant is then partly depressurized, so it boils at a lower temperature, seeps past the defective seal and into the reservoir and (once again) when there's too much, the excess blows out the overflow vent. You basically have to find this one by looking carefully at the pressure valve seal, because the cap often will pass a pump tester pressure check.

Also look at the plastic tank's sealing surface in the radiator fill neck. It's supposed to be clean (no debris) and super-flat. If it isn't, the effect is the same as a bad rubber seal on the pressure valve. A super-fine sandpaper—400 grit—should remove any imperfections. Just don't go overboard.

Systems with thread-on pressurized reservoirs are usually immune to the air-sealing problem, but if the pressure valve seeps, the coolant could blow out the overflow vent.

Air Bleeding or a Drain & Fill?

It's tough to bleed air out of a cooling system, and if you're doing a drain & fill, it's also difficult to keep air pockets from forming. To top up a problem system and get the air out, you have to jack up the front of the vehicle—all the way up—and open all the air bleeds. After that, I like to use a funnel-filler, the tool that fits into the fill neck and lets the coolant dribble in as air bubbles out with the engine running at idle or fast idle. While waiting for the thermostat to open you may have to watch the coolant level in the funnel. If it's rising close to overflow, shut the engine briefly until it drops, then restart. Finally, if coolant remains in the funnel, shut the engine and give the upper radiator hose a few squeezes to see if any more air bubbles escape.

A full-bore drain & fill can be done any number of ways. Many technicians like a kit that does the vacuum drain (and with the system in a vacuum, refills it). The kit does enable a refill or even just a top-up that eliminates air

pockets. It also will empty an atmospheric coolant reservoir and even may get most of the coolant out of some radiators. But if you want to do a coolant exchange, it seems you usually just don't get enough of the old coolant out with any of those kits.

So if you think you've removed all the old coolant, add what would be 50% of the system capacity in the form of pure antifreeze and then top up with water. You're likely to end up with a mixture that's well over 50% antifreeze concentration.

This is why using a drain & fill machine is the best approach. The pump pushes new coolant into the system as old coolant flows out, and typically exchanges about 90% of the stuff. Some shops complain that they have to change the new coolant in the tank for different vehicles, unless they're lucky enough to get the same makes back-to-back.

However, machine manufacturers have been building equipment with easy-change tanks, so you can keep spares. And a new machine we just saw, the Yellow Jacket No. 37505 (which also does a backflush and vacuum drain & fill), comes with four separate tanks—one for old coolant and three for new coolant. That doesn't cover every possible vehicle recommendation, but most shops primarily use DexCool for GM and VW/Audi, G-05 for Ford, Chrysler, Mercedes and one more. That third coolant might be conventional American green or a Japanese conventional (deep green or Toyota red) antifreeze, depending on what a shop's customers drive. So any specific alternatives you have to use should be occasional.

If you don't have a drain & fill machine, a carefully done drain—by opening the radiator and engine drains, emptying the reservoir and, if possible, the heater core, then pulling the system into a vacuum with a vacuum refill kit to eliminate air pockets—generally delivers acceptable results. But you'll leave in some coolant, so top up with a 50/50 premix.

An alternative is to do three drain & refills with water, followed each time by thermocycling—a warm-up, followed by a cooldown. What's left in the system after the third warm-up and cooldown is close to 90% water, so if you drain enough water (including the reservoir) to fill with pure antifreeze equal to 50% of system capacity, the system should be 50/50. Too time-consuming? Yeah. Get a drain & fill machine.

Fan Operation

If the electric fan doesn't come on at all, that's the obvious reason for engine overheating. Also, it's not hard to understand if the clutch fan is just

loping along as you rev up the engine and the temperature gauge keeps climbing. But when the fan operation is just weak, that's harder to spot.

More likely to cause an engine to run hot is when only one of two electric fans is running, or if a single two-speed fan runs only on low speed. Also, many vehicles have an auxiliary fan on the front side of the cooling module—basically out of sight—that's easy to miss.

A second fan (or a second speed on a two-speed fan) may come on with high coolant temperature and almost invariably with a/c, so you should turn on the a/c, look and listen. If the circuit design and computer software mean the higher speed fan also should come on with high coolant temperature but that doesn't happen, you'll realize there's a coolant temperature sensor or computer problem. We've encountered cooling systems where the coolant temperature actually dropped under some operating conditions, when the a/c was turned on, because of the engagement of an additional fan.

You can determine that a clutch fan is weak in any of several ways. Most technicians watch the coolant temperature increase and listen for an increase in fan noise. If you want to get more precise, use a photocell tachometer (if you have one) to see if fan speed increases as coolant temperature goes up. As with an infrared thermometer, you have to aim the photocell unit carefully at the fan blade to get the correct (highest) reading. Or if there's enough room (again, if you have one), you can see an increase in airflow with an anemometer (airflow meter), a neat tester we've used to check blower fan airflow from the a/c registers. As with clutch fan speeds, there's no factory spec, but if the airflow number rises significantly from what it was after a cold start, that's a good sign. And finally, if you can slip a thermometer probe into the fan shroud, you should see fan speed rise to keep the air temperature at 190°F or lower.

If everything checks out and the coolant has been maintained but the engine still runs hot, you probably have to consider the operating conditions. Heavy traffic, hot weather, maybe a lot of heavy gear to carry around—all that raises the temperature of the coolant, particularly with normal cooling system deterioration as a vehicle ages. The customer may choose to wait for an overheat, but if a/c performance is down, and there's a willingness to spend for a cooling system upgrade, there are auxiliary electric fans and high-performance radiators available to make an improvement.

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