Hot Coolant To Cold Cash

Cooling system diagnosis seems like a simple task. Checking a thermostat or pressure testing for leaks is not all that difficult. Cooling system service should be an easy and profitable job. Right? Then one of those pesky over-heaters comes in your bay that doesn't seem to act like anything you've seen before. Anyone who has been around for a while has at least a few war stories to tell concerning this problem-prone system.

The key to diagnosing a cooling system problem is a good understanding of the basics. Knowing how coolant carries heat, how heat is produced and dissipated, as well as how pressure changes within the system affect overall performance, separates the top technicians from the wanna-be's.

Is There Really A Problem?

The first step in any diagnosis is making sure the service writer obtains the correct information. This becomes especially important when trying to solve a cooling system problem. Many times a customer will complain of an overheating problem, when everything is actually operating normally.

There is nothing more frustrating to a technician than spending time checking a system for a problem that doesn't exist. You must ask the customer several questions to determine why they think the vehicle is overheating:

- Is the temperature gauge reading high?
- Did the temperature light come on?
- Has the radiator boiled over?
- Did you hear the fan operating?
- What repairs or maintenance have already been done?
- When does the problem occur?
  - Highway speed or city driving?
  - Towing or cruising?
  - Was the A/C on?

Answers to these questions will simplify the diagnosis and help the technician pinpoint the cause of the problem more efficiently.

Preliminary Visual Inspection

After establishing that the problem is real, the cooling system testing procedure should begin with a thorough visual inspection. The fan and water pump belt condition and tension are important. Inspect fan blade and clutch for condition and leakage. The radiator and condenser should be free of obstructions. Grab the hoses and see if they are brittle or too soft.

Temperature Gauge Operation

It's not uncommon for an overheating complaint to be caused by a gauge reading that appears to be higher than normal. This may be due to the engine operating at cooling fan temperature, instead of thermostat temperature. Winter temperatures keep the car from reaching this point on the gauge. Once spring returns, warmer air causes the engine to operate at cooling fan temperature. This change in climate can mean a difference of 20 to 40 degrees Fahrenheit which shows significantly on some instrument gauges.

Air Dam

One thing that is commonly overlooked is the condition of factory air dams. These are usually plastic dams under the car near the radiator. You know, the ones that curbs love to knock off during parking maneuvers. When they are missing, some cars will overheat—usually at speeds above 45 MPH. I like to road test the car in a lower gear at a moderate speed to check for this problem.

Coolant

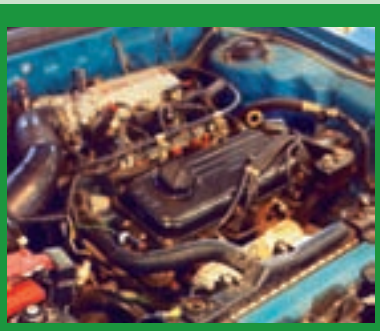
Next, check the level, condition, and protection of the coolant. This is best done before any other tests are performed and while the engine is still cool. Make sure the protection is adequate. Too much antifreeze in the system will not allow heat to be conducted away from the engine and carried into the radiator to be cooled. Too little antifreeze and the coolant can boil before the cooling fan even kicks in. Some cooling fan switches are set near 240 degrees Fahrenheit, which is above the boiling point of pressurized water.

Radiator Cap and Overflow Tank

Let's not forget to check the overflow tank to see whether it is over or under-filled. Either way is an indication of a problem. An overflow tank that is over-full can mean that the radiator has boiled over or that the radiator cap is defective or incorrect. A bad cap will cause the radiator to be under-filled due to the pressure cycles of the system. This may lead to air bubbles in the system and end up causing an engine to run intermittently hot.

We recently had a Toyota with a bad seal on the large portion of the cap. The complaint was that the vehicle overheated after a 75-mile trip. The radiator was low on coolant. After filling the radiator, everything checked out okay, except for an overfilled overflow reservoir. The radiator was more than a gallon low on coolant because the pressure had forced it out.

The seal on the large portion of the radiator cap was damaged and the coolant could not be drawn back into the radiator. Eventually the cooling system became low enough to cause the engine to run hot. Of course the cap passed a pressure test but failed the visual. After installing a new cap, the car was back on the road.



Preliminary Inspection

Temperature Gauge

A simple test for this condition is to drain the radiator without removing the radiator cap. As the coolant leaves the radiator, the radiator cap should allow the radiator to draw new coolant out of the overflow tank. If not, suspect a bad cap or broken overflow hose.

Pressure Test

If the overflow tank or radiator is low, a pressure test is the next step to determine the location of any leaks. I like to apply the pressure when the engine is cool. Putting pressure on a hot engine can give false readings. As the coolant temperature drops, the pressure will decrease. This can mislead technicians into thinking that pressure is escaping. Many times I have left pressure on for several hours on a system that was low. It can take this long before a slow leak will show itself.

Internal Leaks

If you have determined that there is a loss of coolant but nothing is leaking externally, it is time to check for an internal leak. The first thing to look for is coolant in the oil. If it has been there for any length of time the oil will be a chocolate brown color. If you have had pressure on the system, break the oil drain plug loose and see if antifreeze runs out

Coolant Protection Check

Gushing Radiator Overflow Tank

before the oil does. Oil floats on water so any new antifreeze will be on the bottom. Locating the source for this problem can be difficult. Experience is the best tool for the job. Knowing the specific engine and its failure tendencies help locate the problem.

Internal Problem Diagnosis

A damaged head gasket or cylinder head cracks are another common source of internal engine coolant loss. Several methods exist for checking this problem. I prefer to use a four-gas exhaust analyzer. Care must be taken to keep coolant away from the exhaust analyzer probe or damage to the analyzer bench will occur.

The first test point is the overflow reservoir. Remove the cap to see if hydrocarbons or carbon monoxide are present. These gasses will migrate to the overflow reservoir and become trapped if the reservoir cap is sealing properly. Next, remove the radiator cap, then start the engine and test the radiator for hydrocarbons or carbon monoxide. In my experience, cracks tend to show up when the engine is cold, while gasket failures more frequently reveal themselves when the engine is hot.

I always look closely for the presence of carbon monoxide in the system, as hydrocarbons in the radiator can be misleading. Several years ago I had a vehicle with hydrocarbons in the radiator. That particular car had cast iron heads and rarely had head gasket problems. Quizzing the customer revealed that he had used a plastic jug to fill the radiator. This was the same jug he used to fill the gas tank on his lawnmower.

The key was the very high hydrocarbon reading, with no carbon monoxide present. Hydrocarbons are common in many chemicals, but carbon monoxide is the result of combustion. If carbon monoxide is present, then combustion has taken place. The only way this could happen is in the combustion chamber, so carbon monoxide is the best confirmation of an internal leak.

On rare occasions, a minor leak may only show some hydrocarbons, with no carbon monoxide. While carbon monoxide is the preferred indicator, both gasses have value as internal leak detectors.

Radiator Pressure Test

Checking Thermostat Opening Temperature

Gushing Radiator

Test Drive

If no leaks are found, I test drive the car to simulate the condition the customer described. Whenever possible, I connect a voltmeter to the engine control coolant temperature sensor. This allows me a more exact measurement of the cooling system temperature, instead of relying on a dash gauge or light. Of course, scan tools help make this measurement easier on some models.

Thermostat Opening Temperature

After the test drive, it is time to test for thermostat opening temperature. This can be done in the stall using a temperature probe or scan tool. The step most technicians forget here is to make sure the fan is running. If the fan is off, the engine will heat up until it reaches cooling fan temperature. Thermostat temperature will vary from 180 degrees to 195 degrees Fahrenheit. Make sure you know which thermostat is right for the car you are working on.

Correct Thermostat

Make sure the proper thermostat is installed. Always check the temperature at the thermostat. Thermostats installed near the lower radiator hose will cause the upper portion of the engine to run hotter than its opening temperature. This condition is normal and reflects the importance of installing the proper thermostat.

Thermostats can be troublesome to diagnose. Remember to install a quality thermostat when replacing it so you can be sure it will operate correctly.

Aeration

During diagnosis, if you find the thermostat is opening at a higher temperature than it should, replace it and recheck. If the problem persists, you are likely dealing with an aeration problem. Air bubbles may be getting behind the thermostat and causing it to remain closed longer than it should. Remember that a thermostat is designed to detect liquid temperatures. When air is present next to it, it insulates the thermostat from the actual coolant temperature. The temperature must then rise high enough to overcome the insulating effect before it can open.

Once you have determined that air is the culprit, you must find the source. Water pumps can allow air to enter the system, while at the same time sealing perfectly against external leakage. It seems like I see this more often on Toyotas than other makes, but it could happen on any car. If the conditions are right, any external leak may allow air to enter when the system cools down.

Air bubbles can also be caused by hot spots in the engine. Boiling coolant, usually associated with improper coolant mix, will cause bubbles to form and migrate to the thermostat. Combustion leaks into the coolant are still another aeration source. Finally, always follow recommended procedures when refilling a system. Many times air bubbles are trapped in the engine when the system is drained and refilled. This complaint is often heard after a system has been flushed.

Fan Operation

After checking for proper thermostat operation, turn the fan off and let the engine heat up until the fan turns on again. Record this temperature and then make sure it cools the radiator enough to turn the fan

Damaged Water Pump

Measuring Coolant Flow

back off. If the car has air conditioning and the condenser is in front of the radiator, turn it on and see if the cooling system can handle the added load. If necessary, connect your air conditioning gauges and watch high side pressure. High side pressure should level off. If it continues to rise, it can be an indication of improper airflow across the condenser.

Checking Cooling System Airflow

Check the cooling fan and radiator for airflow restrictions. A/C gauges can be a good test tool here because they can differentiate between a radiator coolant flow problem and a radiator airflow problem. Of course the test is dependent on a properly functioning A/C system. Checking a radiator for proper coolant flow isn't always easy. Many times it is impossible to look into the radiator because the radiator cap is actually nowhere near the radiator.

Systems with remote filler necks can be difficult to check. An infrared temperature probe is nice for this test. Get the engine up to operating temperature and make the fan run all the time. After the system stabilizes, check several locations on the radiator. You should see a higher temperature on the inlet side. The temperature should gradually decrease on all tubes as you check toward the outlet side. The temperature drop varies depending on the airflow, humidity and the amount of heat produced by the engine. I use 30 degrees Fahrenheit as a general rule of thumb. The radiator must gradually cool from inlet side to outlet side. If the temperature is close to the same on both sides, recheck for proper airflow. If it is too cool on the outlet side or on one portion of the radiator, you know it has a coolant flow problem.

Checking Coolant Flow

Coolant flow problems can be tricky to find. The flow starts at the water pump and continues throughout the system. As long as you know there is adequate flow to the radiator, you can be sure the radiator is the source of the restriction.

If you are unsure about the flow to the radiator, check for proper water pump operation. Make sure the right pump is installed. A pump designed to turn in a clockwise direction will not work in a counterclockwise configuration. A sure giveaway to improper flow is shown in the photo on page 12. You can see the coolant gushing out of the fill neck when the engine overheats. This symptom is commonly misdiagnosed as a leaking head gasket. This is because the technician thinks excessive pressure can only come from the combustion chamber. Excessive pressure can also come from excessive heat. As the heat builds, so does pressure.

The cause of this condition was an impeller that came off the water pump shaft, as in photo to the left. Although this particular vehicle wasn't an import, the problem is not uncommon on import vehicles.

Checking for proper flow the old fashioned way can be messy. This involves removing the heater hose and seeing if the water pump is pushing coolant out the end. Another method is to use a flow measuring device as shown above. When installed in a heater hose, you can visually see whether coolant is moving through the system.

That's Cool

Understanding a cooling system is not difficult if you concentrate on the basics:

- Pressure is necessary to lower the boiling point.
- Proper coolant mixture is important to help transfer heat and maintain a proper boiling point, not to mention corrosion and freeze protection.
- Coolant flow must be sufficient to allow the heat to be transferred from the engine to the radiator.
- Airflow is critical to dissipate the heat from the radiator and, in some cases, the engine.
- Proper thermostat operation maintains correct engine temperature.
- And last but not least, make sure the engine is not producing excessive heat whether it is due to an engine problem (like a blown head gasket), or an overworked engine (during towing or a poorly tuned vehicle). ■

—By Randy Bernklau