

Overheating Causes and Cures



Internal combustion engines run on heat. Chemical energy in the fuel is transformed into thermal energy when the fuel burns, which produce mechanical energy to push the pistons, spin the crankshaft and drive the vehicle down the road.

As efficient as today's engines are, they still waste a lot of the heat energy they produce. The average gasoline engine is only about 22 to 28 percent efficient. That means over two-thirds of the heat produced by each gallon of fuel either goes out the tailpipe or is soaked up by the engine itself. Diesels squeeze a little more bang out of each buck's worth of fuel with efficiency ratings of 32 to 38 percent, but even that leaves a lot of waste heat that must be managed and carried away by the cooling system.

Ironically, the hotter an engine runs the more efficient it becomes. But there's a limit because aluminium pistons and heads can only get so hot before they start to soften and melt. The same goes for cast iron. Engineers have been tinkering with exotic ceramic materials and metallic-ceramic alloys in an attempt to build high-temperature, super-efficient engines. They've realized some significant gains but ceramics are still too expensive for everyday applications.

How Hot Is Too Hot?

Most engines today are designed to operate within a "normal" temperature range of about 195 to 220 degrees F. A relatively constant operating temperature is absolutely essential for proper emissions control, good fuel economy and performance.

A 50/50 mixture of water and ethylene glycol antifreeze in the cooling system will boil at 225 degrees if the cap is open. But as long as the system is sealed and holds pressure, a radiator cap rated at 15 psi will increase the boiling temperature of a 50/50 coolant blend up to 265 degrees. If the concentration of antifreeze to water is upped to 70/30 (the maximum recommended), the boiling temperature under 15 psi of pressure goes up to 276 degrees.

So does this mean a cooling system with a maximum concentration of antifreeze in the coolant (70 percent) can run as hot as 276 degrees without boiling over? Theoretically yes - but realistically no. The clearances in most of today's engines are much, much closer than those in engines built in the 1970s and early 1980s. Piston-to-cylinder clearances are much tighter to reduce blow by for lower emissions. Valve stem-to-guide clearances also are closer to reduce oil consumption and emissions, too. Plus, many engines today have aluminium heads with overhead cams. Such engines don't handle higher than normal temperatures well, and are very vulnerable to heat damage if the engine gets too hot.

Anytime temperatures climb beyond the normal range, the engine is running in the danger zone.

Consequences of Overheating

If the engine overheats the first thing that will happen are a gasoline engine will start to detonate. The engine will ping and start to lose power under load as the combination of heat and pressure exceed the octane rating of the fuel. If the detonation problem persists, the hammer-like blows may damage the rings, pistons or rod bearings.

Overheating can also cause pre ignition. Hot spots develop inside the combustion chamber that becomes a source of ignition for the fuel. The erratic combustion can cause detonation as well as engine run-on in older vehicles with carburetors. Hot spots can also be very damaging and burn holes right through the top of pistons.

Another consequence of overheating may be a blown head gasket. Heat makes aluminium swell almost three times faster than cast iron. The resulting stress can distort the head and make it swell in areas that are hottest, like those between exhaust valves in adjoining cylinders, and areas that have restricted coolant flow like the narrow area that separates the cylinders. The typical aluminium head swells most in the middle, which can crush the head gasket if the head gets hot enough. This will cause a loss of torque in the gasket allowing coolant and combustion leaks to occur when the head cools.

Overheating is also a common cause of OHC seizure and breakage.

Wait, there's more. If the coolant gets hot enough to boil, it may cause old hoses or an age-weakened radiator to burst under the increased pressure. Pistons may swell up and scuff or seize in their bores, causing serious engine damage. Exhaust valve stems may stick or scuff in their guides. This, in turn, may cause valves to hang open which can damage pistons, valves and other valve train components. And if coolant gets into the crankcase, you can kiss the bearings and bottom end of the engine goodbye.

A HOT warning lamp should never be ignored. Though a few high tech cars like Cadillac's with the Northstar engine can disable cylinders to "air-cool" the engine and keeps it running at reduced power in the event of coolant loss, most engines will suffer serious damage if they overheat. Turn the engine off, let it cool down and try to find and fix the cause before risking further travel.

Causes of Overheating

Overheating can be caused by anything that decreases the cooling system's ability to absorb, transport and dissipate heat, such as a low coolant level, loss of coolant (through internal or external leaks), poor heat conductivity inside the engine because of accumulated deposits in the water jackets, a defective thermostat that doesn't open, poor airflow through the radiator, a slipping fan clutch, an inoperative electric cooling fan, a collapsed lower radiator hose, an eroded or loose water pump impeller or even a defective radiator cap.

One of nature's basic laws says that heat always flows from an area of higher temperature to an area of lesser temperature, never the other way around. The only way to cool hot metal, therefore, is to keep it in constant contact with a cooler liquid. And the only way to do that is to keep the coolant in constant circulation. As soon as the circulation stops, either because of a problem with the water pump, thermostat or loss of coolant, temperatures begin to rise and the engine starts to overheat.

The coolant also has to get rid of the heat it soaks up while passing through the block and head(s). So the radiator must be capable of doing its job, which requires the help of an efficient cooling fan at slow speeds.

Finally, the thermostat must be doing its job to keep the engine's average temperature within the normal range. If the thermostat fails to open, it will effectively block the flow of coolant and the engine will overheat.

What To Check

- **Thermostat** - Severe overheating can often damage a good thermostat. If the engine has overheated because of another problem, the thermostat should be tested or replaced before the engine is returned to service.

One way to check the thermostat is to start the engine and feel the upper radiator hose (or use an infrared noncontact thermometer to read its temperature). The hose should not feel uncomfortably hot until the engine has warmed-up and the thermostat opens. If the hose does not get hot, it means the thermostat is not opening.

Another way to test the thermostat is to remove it and dip it into a pan of boiling water (it should open). The exact opening temperature can be checked by using a thermometer.

If the thermostat needs to be replaced, install one with the same temperature rating as the original. Most cars and light trucks since 1971 require thermostats with 192- or 195-degree ratings. Using a cooler thermostat (160 or 180) in an attempt to "cure" a tendency to overheat can increase fuel and oil consumption, ring wear and emissions. On newer vehicles with computerized engine controls, the wrong thermostat can prevent the computer system from going into closed loop resulting in major performance and emission problems if the engine fails to reach its normal operating temperature.

- **Cooling system leaks** - Loss of coolant because of a leak is probably the most common cause of overheating. Possible leak points include hoses, the radiator, heater core, water pump, thermostat housing, head gasket, freeze plugs, automatic transmission oil cooler, cylinder head(s) and block.

Make a careful visual inspection of the entire cooling system, and then pressure test the cooling system and radiator cap. A pressure test will reveal internal leaks such as seepage past the head gasket as well as cracks in the head or block. A leak-free system should hold pressure for at least a minute or more.

It's important to pressure test the radiator cap, too, because a weak cap (or one with too low a pressure rating for the application) will lower the coolant's boiling point and can allow coolant to escape from the radiator.

- **Fan** - With mechanical fans, most overheating problems are caused by a faulty fan clutch - though a missing fan shroud can reduce the fan's cooling effectiveness by as much as 50 percent (depending on the fan's distance from the radiator), which may be enough to cause the engine to overheat in hot weather or when working hard.

Defective fan clutches are a common and often overlooked cause of overheating. The shear characteristics of the clutch fluid gradually deteriorate over time, with an average loss in drive efficiency of about 200 rpm per year. Eventually slippage reaches the point where effective cooling is no longer possible and overheating results. (On average, the life of a fan clutch is about the same as a water pump. If one needs to be replaced, the other usually does too.)

If the fan clutch shows signs of fluid leakage (oily streaks radiating outward from the hub of the clutch), spins freely with little or no resistance when the engine is off or wobbles when the fan is pushed in or out, it needs to be replaced.

With an electric cooling fan, check to see that the fan cycles on when the engine gets hot and when the air conditioner is on. If the fan fails to come on, check the fan motor wiring connections, relay and temperature sensor. Try jumping the fan directly to the battery. If it runs, the problem is in the wiring, relay or sensor. If it fails to run, the fan motor is bad and needs replaced.

- **Water pump** - Any wobble in the pump shaft or seepage would call for replacement. In some instances, a pump can cause an engine to overheat if the impeller vanes are badly eroded due to corrosion or if the impeller has come loose from the shaft. The wrong pump may also cause an engine to overheat. Some engines with serpentine drive belts require a special water pump that turns in the opposite direction of those used on the same engine with ordinary V-belts.

- **Belts & hoses** - Check belt tension and condition. A loose belt that slips may prevent the water pump from circulating coolant fast enough and/or the fan from turning fast for proper cooling.

The condition of the hoses should also be checked and replaced if they are over 5 years old.

Sometimes a lower radiator hose will collapse under vacuum at high speed and restrict the flow of coolant from the radiator into the engine. This can happen if the reinforcing spring inside the hose is missing or damaged.

- **Radiator** - The most common problems radiators fall prey to are clogging (both internal and external) and leaks. Dirt, bugs and debris can block air flow through the core and reduce the radiator's ability to dissipate heat. Internal corrosion and an accumulation of deposits can likewise inhibit coolant circulation and reduce cooling. A good way to find clogs is to use an infrared thermometer to "scan" the surface of the radiator for cold spots. If clogged, the radiator should be removed for cleaning or be replaced.

Back flushing the cooling system and/or using chemical cleaners can remove rust and hard water scale, but may do little to open up a clogged radiator.

When refilling the cooling system, be sure you get it completely full. Air pockets in the head(s), heater core and below the thermostat can interfere with proper coolant circulation and cooling. If the cooling system has no bleeder valves to vent air, you may have to temporarily loosen a heater hose to get all the air out of the system.

- Excessive exhaust backpressure - A clogged catalytic converter is usually the culprit here, but don't overlook the possibility of a crushed pipe or a collapsed double wall pipe. Check intake vacuum at idle. If it reads low and continues to drop, inspect the exhaust system.

- Retarded or over advanced ignition timing (may also contribute to detonation and preignition).

- Overheated incoming air - On older vehicles with a carburettor or throttle body injection, check the operation of the heated air intake system on the air cleaner. If the temperature control valve is stuck so only heated air from around the exhaust manifold is drawn into the air cleaner,

it may contribute to detonation and/or overheating. Also check the heat riser valve for manifold heat on older V6 and V8 engines. If stuck shut, it may be overheating the intake manifold.

- Dragging brakes - A calliper that's sticking or a parking brake that isn't releasing may be making the engine work too hard.
- Overworking the engine. The cooling systems in many passenger cars today are marginal and have little excess capacity to handle extra heat generated by towing or high speed mountain driving in hot weather.

Common Overheating Problems

1. Radiators - Older copper and aluminium radiators tend to get clogged, restricting the flow of coolant.
2. Thermostats - Either installed improperly or sticking closed.
3. Water pumps - Failure to replace older or failing pumps or install a new pump properly.
4. Heater core leaking - A common problem.
5. Coolant leaks from either hose connections or from the cylinder head due to overheating.
6. Bad radiator hoses or belts.

Cooling systems are often neglected. If coolant isn't changed, the coolant passages can experience build-up of scale and sludge and coolant won't flow rapidly enough to cool the engine.

Coolant should be changed at least every two years or 30,000 miles or it will lose its effectiveness, and the mixture of antifreeze and water should always be 50/50. A mixture with more than 50 percent antifreeze will cause the coolant to not perform properly, and with less than 50 percent, the engine can freeze and crack. Also, the system needs to be flushed when the coolant is changed.

Oil must also be changed regularly too. Old, dirty oil won't flow as quickly and will hamper cooling.

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The Overheating "Hot" List

Some engines do tend to overheat more than others, but this is not necessarily because these engines have flaws in their designs.

The problem is that some engines are designed in such a way that they have less tolerance for overheating conditions. This means that once a situation that could cause overheating occurs, these engines have less margin for error, and are more likely to overheat quickly and suffer damage.

One classic example is the 4.1L Cadillac engine. It has an all-

aluminium block with a cast iron cylinder head. So when the engine is shut off, the block dissipates its heat and cools rapidly, while the head stays hot. This places enormous pressure on the head gasket to maintain the seal. A little bit too much heat and you've got a problem.

Similarly, the original 2.9L Ford engine featured a cylinder head design which was unusually thin. As soon as the engine began to overheat, the heads would crack, starting at the top of the head and working down the sides. A redesign of the head about 1989 helped solve the problem, but there are still lots of potential 2.9L overheating problems out there. Again, this was not a basic design flaw, because the heads would not crack unless the engine first began to overheat.

Other engines which commonly suffer from overheating problems:

- GM Quad 4 - especially the SOHC version, the heads crack when overheating takes place.
- 2.2L Chrysler - Overheating frequently cracks the heads.
- Straight 6 and slant 6 engines - such as the AMC 150 c.i. unit, the AMC 258 c.i. and the Jeep 4.0L engine, frequently tend to show up with heat cracks.
- 151 c.i. Pontiac four-cylinder engines - Leaks and cracking heads on the power plant and were caused by stretching head bolts when the engine overheated, a silent recall was undertaken to help solve the problem.
- Suzuki 1.6L - This engine is subject to cracking in both heads and blocks when overheating. Frequent oil changes are essential to keep this engine from getting too hot.
- Toyota 3.0L V6 used in 4Runner - Overheating in these engines caused the head to lift away from the head gasket. A recall and a new head gasket design helped the problem after about 1992.
- Nissan Sentra 1600 Engine, mid-1980s - This engine had a tendency to blow head gaskets as soon as it got hot. A new gasket design helped solve the problem.

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