

Engine Cooling - System Operation and Component Description

System Operation

Engine coolant flows primarily from the engine to the radiator circuit and back to the coolant pump. Coolant is sent from the coolant pump through the engine block and cylinder heads. A separate circuit from the engine also feeds the heater core and turbocharger with coolant. The coolant pump, operated by engine rotation through the accessory drive belt, circulates the coolant. The coolant thermostat is a control valve actuated by coolant temperature. When the thermostat is closed, coolant flow bypasses the radiator circuit and returns to the coolant pump. When the thermostat is opened, coolant flows through the radiator circuit to transfer engine-generated heat to the outside air.

The engine uses a cold side thermostat. This means the thermostat is located at the lower radiator hose connection to the engine, where coolant enters the engine after being cooled by the radiator. During initial warm-up, the cooler coolant from the radiator quickly closes the thermostat after the warm coolant in the engine opens the thermostat slightly. The thermostat opens and closes several times before the coolant coming from the radiator is warm enough to allow the thermostat to remain open. The engine must run much longer than a vehicle with a hot side thermostat before the thermostat remains fully opened.

The degas bottle holds surplus coolant and removes air from the cooling system. It also allows for coolant expansion and system pressurization, replenishes coolant to the cooling system and serves as the location for service fill.

The thermostat monitor is a function of the PCM and is designed to verify correct thermostat operation. The monitor executes once per drive cycle and has a monitor run duration of 300-800 seconds. If a malfunction occurs, DTC P0125 or P0128 sets, and the MIL illuminates.

Fail Safe Cooling

A strategy called Fail Safe Cooling is built into the PCM that will control the engine if it starts to overheat.

Fail Safe Cooling has two modes: A "Closed Loop"™ mode that relies on CHT sensor and an "Open Loop"™ mode that relies on ECT sensor. When the engine starts to overheat, the decision to go into closed loop or open loop mode is made based on sensor availability and sensor failures. Closed loop mode takes priority over open loop. The reason is that a good CHT sensor is able to reliably track engine block temperature at all times, while the ECT sensor will fail to do so when the engine coolant is dumped.

Closed Loop Mode

Stage 1 of the strategy commences if the engine starts to overheat. The CHT sensor transmits a signal to the PCM, which moves the temperature gauge pointer into the red zone.

If the engine is not switched off and the temperature continues to rise, the Powertrain Check Lamp is illuminated. This indicates to the driver that the engine is approaching critical limits and should be stopped. At this point DTC P1285 is set in the PCM which can be retrieved using a scan tool.

Stage 2 of the strategy commences if the lamp and temperature gauge are ignored by the driver. The PCM will start to control the engine by cutting out 2 cylinders and restricting load. The RPM will be limited below 3,000 RPM initially then will slowly be ramped down with time to as low as 800 RPM. Simultaneously the MIL illuminates. This indicates that long term engine damage can occur and vehicle emissions will be affected. At this point DTC P1299 is set in the PCM which can be retrieved using a scan tool.

Air is drawn into the deactivated cylinders. This helps to control the temperature of the engine internal components. The deactivated cylinders are alternated to allow even cooling of all the cylinders.

NOTE: If the driver is using a high percentage of throttle travel (for example, an overtaking maneuver) when the PCM starts engine deactivation (Stage 2), the deactivation will be delayed for 10 seconds.

NOTE: After 2-cylinder operation has begun, the engine will not revert to 4-cylinder operation, even if the temperature should fall, until the ignition is switched off and then on again.

NOTE: The MIL can only be extinguished by using a scan tool after the fault has been rectified and the DTC cleared.

Stage 3 of the strategy will commence if the engine temperature continues to rise. This results in the engine being totally disabled before major engine damage or seizure occurs. The Powertrain Check Lamp will begin to flash, indicating to the driver that the engine will be switched off after 30 seconds. This allows the driver time to choose a suitable parking place.

Open Loop Mode

This mode is entered when the ECT sensor indicates a high engine temperature that is rising at a dangerously high rate, much faster than expected based on current engine running conditions. This mode can also be entered when all sensors used in Fail Safe Cooling determination are failed.

When this mode is activated, the PCM will restrict load, and restrict engine speed to below 3000 RPM, then start ramping engine speed down slowly to as low as 800 RPM and hold the speed there.

At the same time, the PCM will also move the temperature gauge pointer into the red zone and the P1285 code is set.

If the engine is not switched off after a short period of time, the engine will be totally disabled before major engine damage or seizure occurs, The Powertrain Check Lamp will begin the flash, indicating to the driver that the engine will be switched off. The P1299 Code is set.

If the driver decides to restart the vehicle, it will be restarted but with the P1299 still set the engine speed is limited to 800 RPM. This mode can only be reset by clearing the DTC using a diagnostic scan tool.

Component Description

Engine Cooling Fan

The engine cooling fan is an electric design. The engine cooling fan clutch is electronically controlled by the PCM, based on input information received from various engine sensors. The PCM provides a PWM signal to the fan to control fan speed.

Cabin Coolant Heater Pump

The cabin heater coolant pump is available on vehicles equipped with Auto Start-Stop feature to assist in flowing coolant through the heater core. When the engine is OFF and ON at low and idle speeds,

Refer to: Climate Control System (412-00 Climate Control System - General Information, Diagnosis and Testing).

Transmission Fluid Heater Coolant Control Valve

The transmission fluid heater coolant control valve is an electrically controlled solenoid to allow or bypass the flow of engine coolant through the transmission fluid cooler. This electrically controllable valve is normally open when not energized. The valve receives a fused 12V B+ supply when the ignition is in the run or start position and is grounded by the PCM via a low side driver. The PCM monitors the solenoid and circuits for electrical faults and sets an appropriate DTC.
