Cooling System Description and Operation

Cooling System

The cooling system's function is to maintain an efficient engine operating temperature during all engine speeds and operating conditions. The cooling system is designed to remove approximately one-third of the heat produced by the burning of the air-fuel mixture. When the engine is cold, the system cools slowly or not at all. This allows the engine to warm quickly.

Cooling Cycle

Coolant is drawn from the radiator outlet and into the water pump inlet by the water pump.

Coolant is also pumped through the water pump outlet and into the engine block. In the engine block, the coolant circulates through the water jackets surrounding the cylinders where it absorbs heat.

The coolant is then forced through the cylinder head gasket openings and into the cylinder heads. In the cylinder heads, the coolant flows through the water jackets surrounding the combustion chambers and valve seats, where it absorbs additional heat.

Operation of the cooling system requires correct functioning of all cooling system components. The cooling system consists of the following components:

Coolant

The engine coolant is a solution made up of a 50-50 mixture of DEX-COOL and clean drinkable water. The coolant solution carries excess heat away from the engine to the radiator, where the heat is dissipated to the atmosphere.

Radiator

The radiator is a heat exchanger. It consists of a core and 2 tanks. The aluminium core is a downflow tube and fin design. This is a series of tubes that extend vertically down from the inlet tank to the outlet tank. Fins are placed around the outside of the tubes to increase heat transfer from the coolant to the atmosphere. The inlet and outlet tanks are moulded with a high temperature, nylon reinforced plastic. A high temperature rubber gasket seals the tank flange edge. The tanks are clamped to the core with clinch tabs. The tabs are part of the aluminium header at each end of the core.

The radiator removes heat from the coolant passing through it. The fins on the core absorb heat from the coolant passing through the tubes. As air passes between the fins, it absorbs heat and cools the coolant.

During vehicle use, the coolant heats and expands. The coolant that is displaced by this expansion flows into the coolant recovery. As the coolant circulates, air is allowed to exit. This is an advantage to the cooling system. Coolant without bubbles absorbs heat much better than coolant with bubbles.

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Screw On Pressure Cap

The pressure cap is a cap that seals and pressurizes the cooling system. It contains a blow off or pressure valve and a vacuum or atmospheric valve. The pressure valve is held against its seat by a spring of predetermined strength, which protects the radiator by relieving pressure if it exceeds 15 psi.

The pressure cap allows pressure in the cooling system to build up. As the pressure builds, the boiling point of the coolant goes up as well. Therefore, the coolant can be safely run at a temperature much higher than the boiling point of the coolant at atmospheric pressure. The hotter the coolant is, the faster the heat moves from the radiator to the cooler, passing air. The pressure in the cooling system can get too high. However, when the pressure exceeds the strength of the spring, it raises the pressure valve so that the excess pressure can escape. As the engine cools down, the temperature of the coolant drops and a vacuum is created in the cooling system. This vacuum causes the vacuum valve to open, allowing coolant from the recovery bottle to be sucked back into the cooling system. This equalizes the pressure in the cooling system with atmospheric pressure, preventing the radiator from collapsing.

Coolant Recovery System

The coolant recovery system consists of a plastic coolant recovery reservoir and overflow hose. The recovery reservoir provides an air space in the cooling system that allows the coolant to expand and contract. The coolant recovery system provides a coolant fill point and a central air bleed location. It is partially filled with coolant and is connected to the radiator fill neck with the overflow tube. Coolant can flow back and forth between the radiator and the reservoir.

In effect, a cooling system with a coolant recovery reservoir is a closed system. When the pressure in the cooling system gets too high, it will open the pressure valve in the pressure cap. This allows the coolant, which has expanded due to being heated, to flow through the overflow hose and into the recovery reservoir. As the engine cools down, the temperature of the coolant drops and a vacuum is created in the cooling system. This vacuum opens the vacuum valve in the pressure cap, allowing some of the coolant in the reservoir to be siphoned back into the radiator. Under normal operating conditions, no coolant is lost. Although the coolant level in the recovery reservoir goes up and down, the radiator and cooling system are kept full.

During vehicle use, the coolant heats and expands. The increased coolant volume flows into the recovery reservoir. As the coolant circulates, any air that is present in the cooling system will accumulate at the pressure cap as this is the highest point. When the pressure cap releases it is the air which is expelled first. When the systems goes into vacuum it will suck coolant back in.

Water Pump

The water pump is a centrifugal vane impeller type pump. The pump consists of a housing with coolant inlet and outlet passages and an impeller. The impeller is a flat plate mounted on the pump shaft with a series of flat or curved blades or vanes. When the impeller rotates, the coolant between the vanes is thrown outward by centrifugal force. The impeller shaft is supported by one or more sealed bearings. These sealed bearings never need to be lubricated. With a sealed bearing, grease cannot leak out, and dirt and water cannot get in.

The purpose of the water pump is to circulate coolant throughout the cooling system. The water pump is driven by the crankshaft via the drive belt.

Thermostat

The thermostat is a coolant flow control component. It's purpose is to regulate the operating temperature of the engine. It utilizes a temperature sensitive wax-pellet element. The element connects to a valve through a piston. When the element is heated, it expands and exerts pressure against a rubber diaphragm. This pressure forces the valve to open. As the element is cooled, it contracts. This contraction allows a spring to push the valve closed.

When the coolant temperature is below 86°C (186°F) for V8 and 82°C (180°F) for V6 the thermostat valve remains closed. This prevents circulation of the coolant to the radiator and allows the engine to warm up quickly. After the coolant temperature reaches 86°C (186°F) or 82°C (180°F) the thermostat valve will begin to open. The coolant is then allowed to circulate through the radiator where the engine heat is dissipated to the atmosphere. The thermostat also provides a restriction in the cooling system, even after it has opened. This restriction creates a pressure difference which prevents cavitation at the water pump and forces coolant to circulate through the engine block.

Transmission Oil Cooler

The transmission oil cooler is a heat exchanger. It is located inside the bottom of the radiator. The transmission fluid temperature is regulated by the temperature of the engine coolant that surrounds the oil cooler as the transmission fluid passes down through the cooler.

The transmission oil pump pumps the fluid through the transmission oil cooler feed line to the oil cooler. The fluid enters the oil cooler on the RHS, and then flows left through the cooler while the engine coolant absorbs heat from the fluid. The fluid is then pumped through the transmission oil cooler return line to the transmission.

Cooling Fan Operation

The cooling fans operate in two stages for V8 and three stages for V6; in both low and high stages both fans run. In stage 1 (low) the two fan motors are connected in series so both fans run at low speed. In stage 2 (high) each fan motor is connected to battery voltage so both fans run at high speed, (cooling fan operation is controlled by the engine control module (ECM) based on inputs from the following: V6 has a mid speed stage which has one fan at high speed and the other fan is off).

- The A/C request signal
- The A/C refrigerant pressure sensor
- The engine coolant temperature (ECT) sensor

Low Speed - Both Fans Operate at Low Speed

When the conditions for low speed operation are met the ECM provides a ground to the coil of engine cooling fan relay 1, causing it to operate (turn ON). The fan current path is then from the battery via the left radiator fan fuse, through the left fan motor, cooling fan relay 2, the right fan motor and cooling fan relay 1 to ground.

The conditions for low speed operation are:

- There is an A/C request and:
- A/C refrigerant pressure is greater than 1517 kPa (220 psi).
- ECT is greater than 109°C (228°F) for V6 or 104°C (219°F) V8.

- ECT is greater than 121°C (250°F) for V6 or 113°C (235°F) for V8 when the engine is switched off (in this case stage 1 will operate for approximately four minutes - this is referred to as low fan run-on).

Low speed operation will cease when:

- There is no A/C request and the ECT is less than 105°C (221°F) for V6 or 100°C (212°F) for V8.
- There is an A/C request and the A/C pressure is less than 1000 kPa (145 psi) and the ECT is less than 105°C (220°F) for V6 or 100°C (212°F) for V8.

Mid Speed - Left Fan Operates at High Speed (V6 Only)

When the conditions for mid speed operation are met the left fan gets battery voltage and operates at high speed. The right fan does not operate.

The conditions for Mid Speed operation are:

- The A/C has been requested and the A/C pressuer is greater than 1700 kPa (247psi).
- The ECT is greater than 112°C (234°F) for V6 .

  Mid speed operation will cease and revert to low speed operation when:
- ECT is less than 108°C (226°F) and there is no A/C request.
- There is an A/C request and the A/C pressure is less than 1200 kPa (174psi) and the ect is less than 108°C (226°F).

High Speed - Both Fans Operate at High Speed

When the conditions for high speed operation are met the ECM provides - in addition to that already provided for the coil of engine cooling fan relay 1 - a ground to the coils of engine cooling fan relays 2 and 3, causing them to operate (turn ON). For the left fan, the current path is then from the battery via the left radiator fan fuse, through the left fan motor and engine cooling fan relay 2 to ground. For the right fan, the current path is from the battery via the right radiator fan fuse, through engine cooling fan relay 3, through the right fan motor and engine cooling fan relay 1 to ground. The conditions for high speed operation are:

- The A/C has been requested and the A/C refrigerant pressure is greater than 2000 kPa (290 psi).
- The ECT is greater than 117.5°C (243°F) for V6 or 109°C (228°F) for V8.
- An ECT sensor fault is detected and a DTC is set.
- There is a body control module (BCM) message response fault, which will cause a powertrain interface module (PIM) DTC to set.

If low speed operation is off when the conditions for high speed operation are met, high speed operation will be initiated five seconds after initiation of low speed operation.

High speed operation will cease and revert to low or medium speed operation when:

- The ECT is less than 112°C (235°F) for V6 or 103°C (217°F) for V8 and there is no A/C request.

- There is an A/C request and the A/C refrigerant pressure is less than 1400 kPa (203 psi) and ect is less than 112°C (235°F) for V6 or 103°C (217°F) for V8.