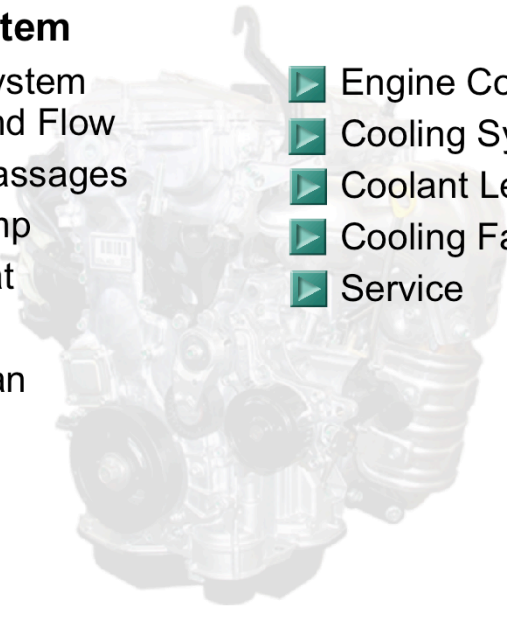
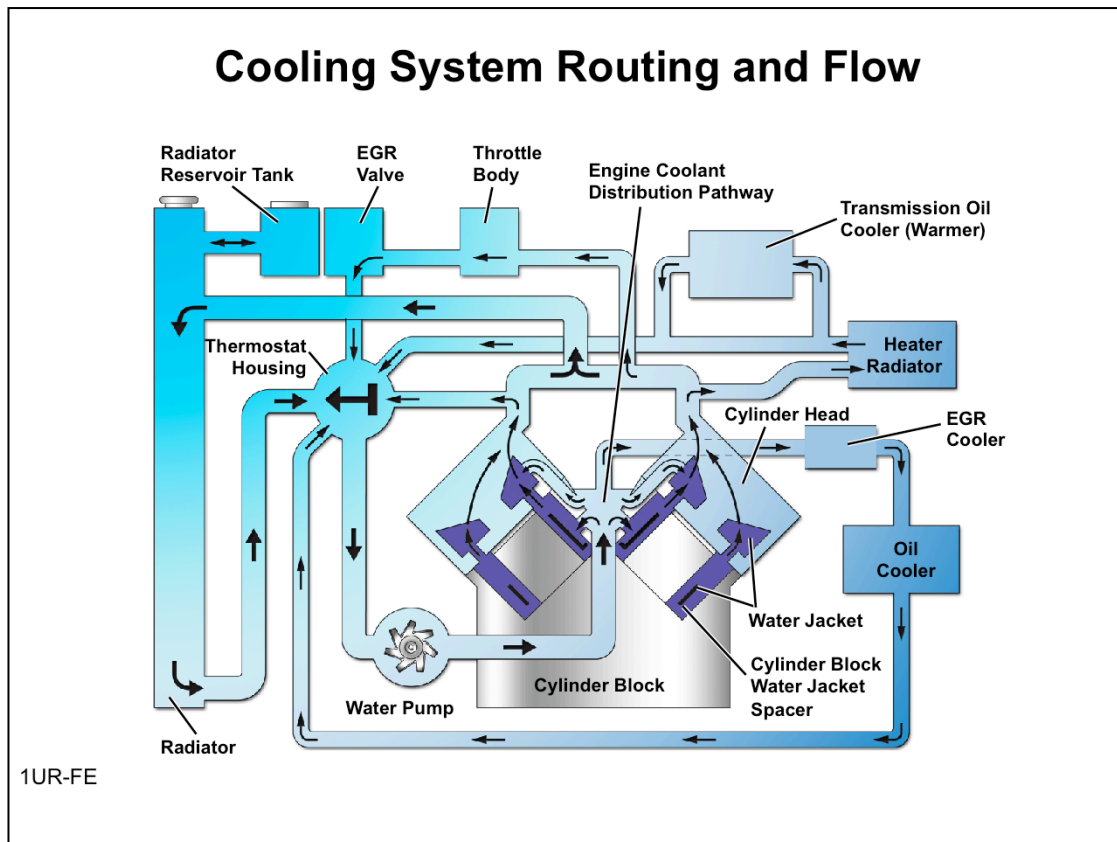


## Section 8 Topics

### Cooling System

- 
- ▶ Cooling System Routing and Flow
  - ▶ Coolant Passages
  - ▶ Water Pump
  - ▶ Thermostat
  - ▶ Radiator
  - ▶ Cooling Fan
  - ▶ Engine Coolant
  - ▶ Cooling System Problems
  - ▶ Coolant Leak Test
  - ▶ Cooling Fan Inspection
  - ▶ Service



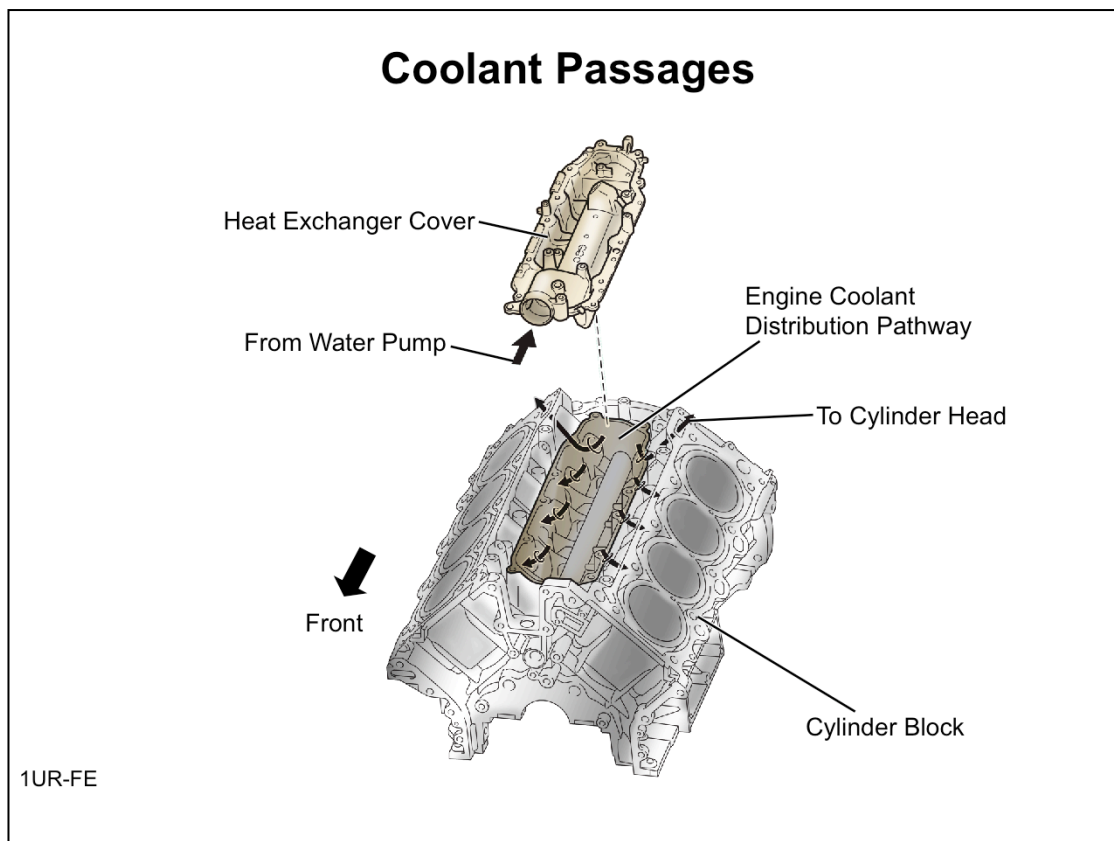
## Cooling System Routing and Flow

Engine coolant serves two main purposes:

- Exchange the byproduct of combustion (heat) with the atmosphere to maintain a constant operating temperature
- Provide heat to the occupants inside the cabin.

Engineers have found that an engine regulated at a constant temperature produces the maximum efficiency and power, and the least emissions.

As seen in the illustration above, the cooling system routes coolant throughout the vehicle for use in a variety of different systems.

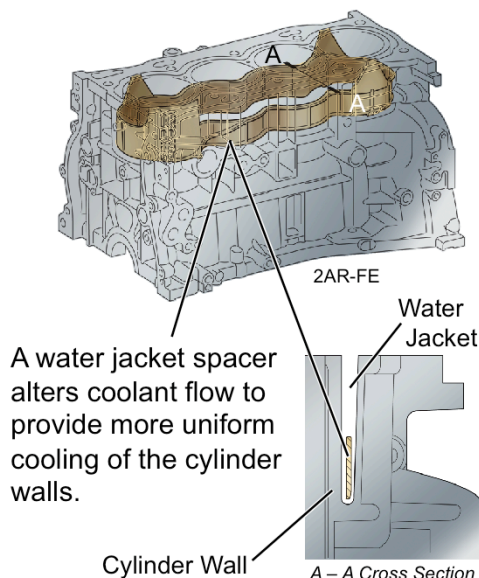
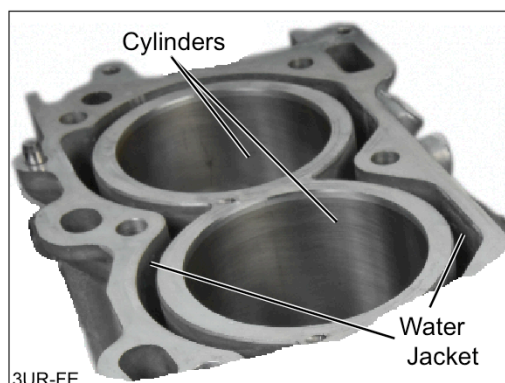


#### Coolant Passages

In the UR engine family, the water pump circulates the engine coolant and directs it to the engine coolant distribution pathway located between the left and right banks. From there, the engine coolant is uniformly distributed to each cylinder of the cylinder block, and is also directly discharged to the cylinder heads. As a result, the cooling performance of the cylinder heads is assured and reliability is improved.

## Water Jacket

The water jacket is a space surrounding the combustion chambers where coolant can circulate to remove heat.



### Water Jacket

Heat is produced inside the combustion chamber where temperatures can exceed 1800°F. Therefore, cooling the engine requires cooling the combustion chambers.

To achieve cooling, the upper half of the cylinders are surrounded by a cavity called a water jacket, where coolant can circulate to absorb heat from the cylinders.

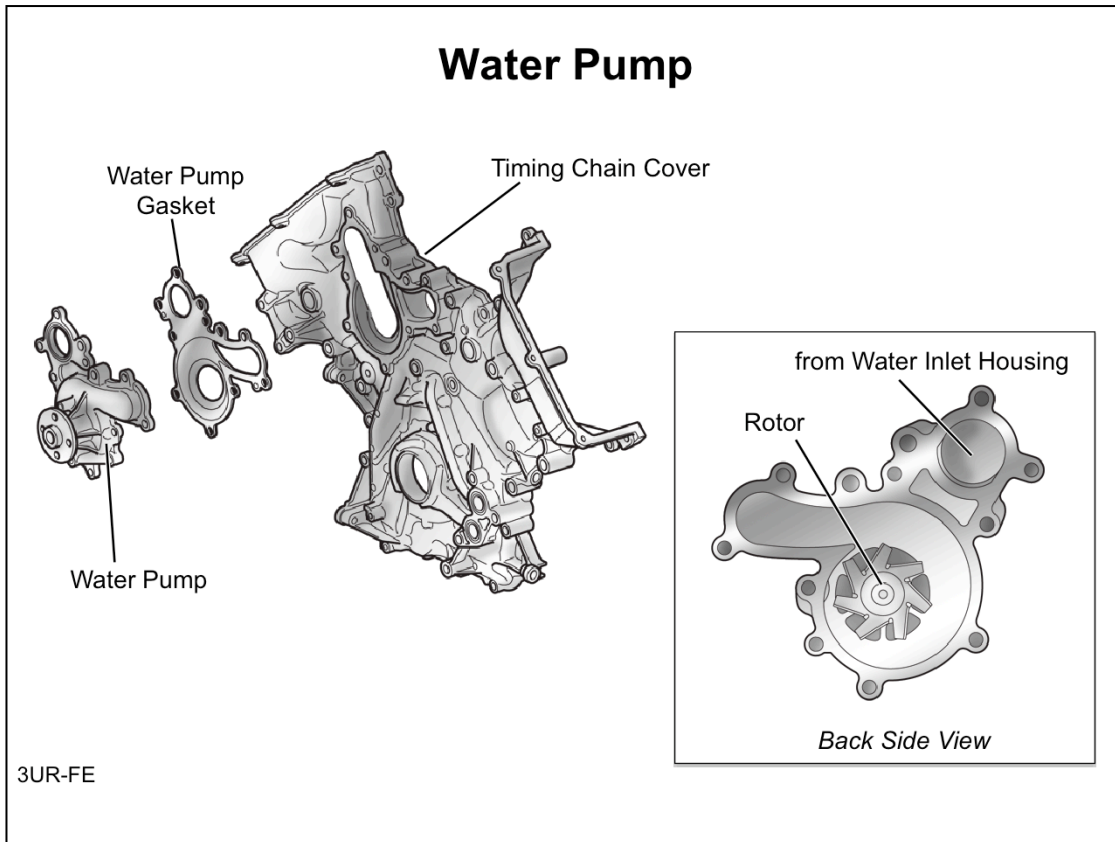
### Water Jacket Spacer

A plastic insert called a water jacket spacer is sometimes placed in the water jacket. The spacer alters coolant flow to provide more uniform cooling of the cylinder walls to avoid "cool" spots.

### NOTE

If the engine is subjected to severe overheating, the water jacket spacer may melt. Be sure to inspect the water jacket spacer if cooling problems persist after the engine has overheated.

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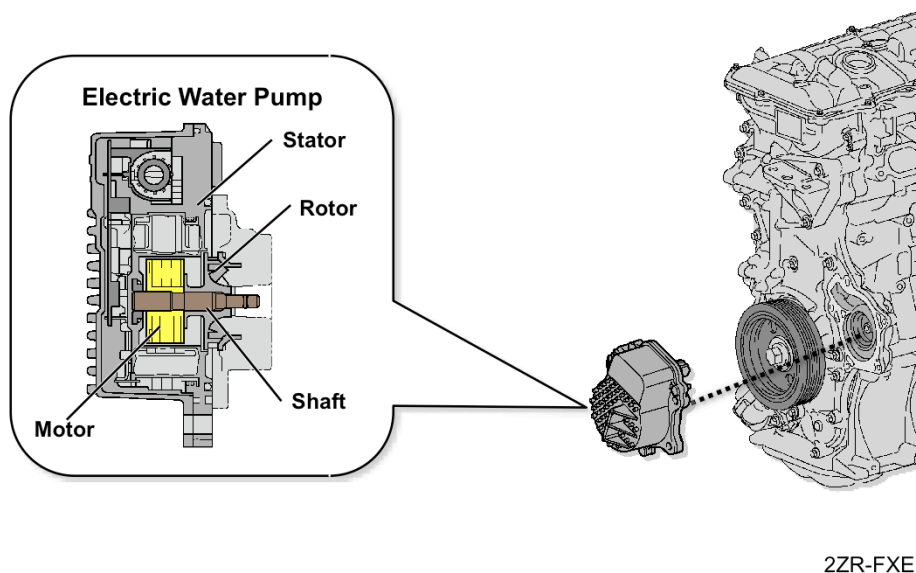
### Water Pump

The water pump in modern Toyota engines is mounted to the timing cover. The timing cover is equipped with inlet and outlet passages and sealed by a water pump gasket.

The water pump is belt-driven by the crankshaft. The water pump rotor that forces the coolant through the engine is mounted on a shaft, that is mounted to the housing on a sealed bearing. On the exterior of the water pump, the shaft is attached to the water pump pulley which is driven by the crankshaft. When the bearing begins to fail coolant will slowly begin to leak through the housing. This leak will be noticed coming through the “weep hole.” If and when this condition happens, the water pump must be replaced.

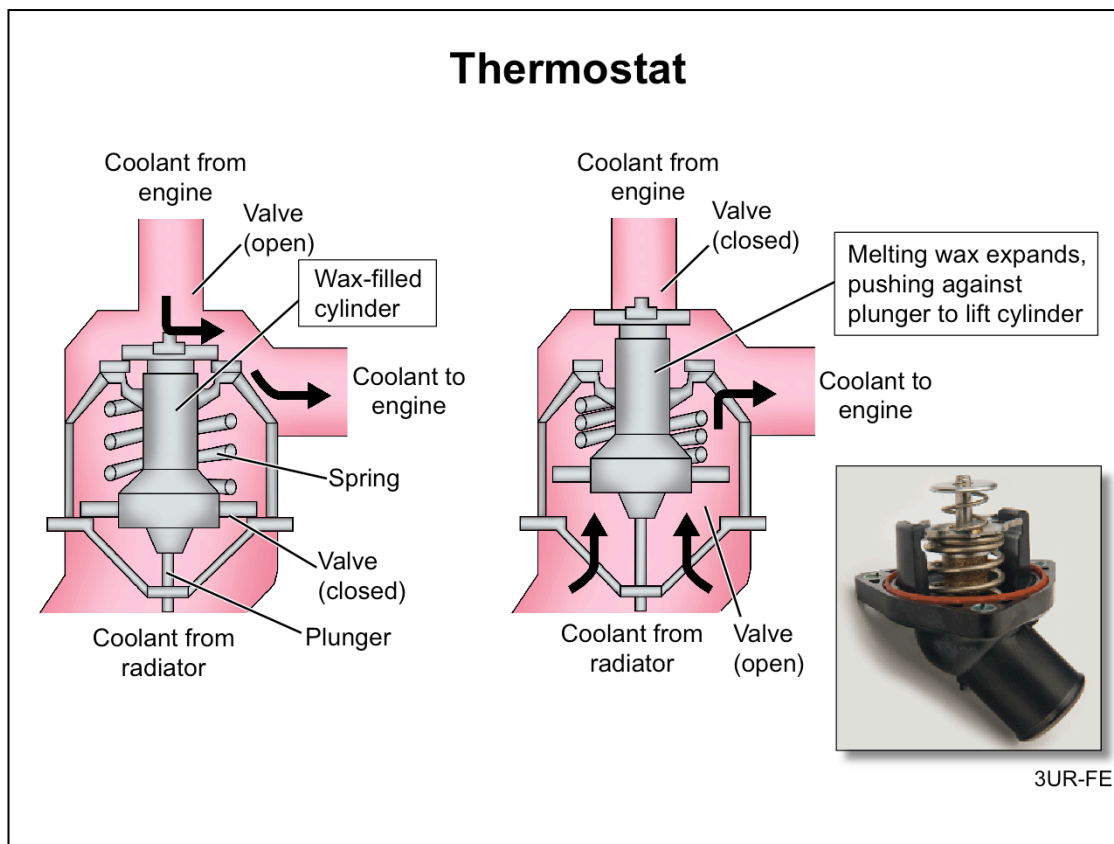
## Electric Water Pump

The 2ZR-FXE engine (2010 Prius) uses an electric water pump.

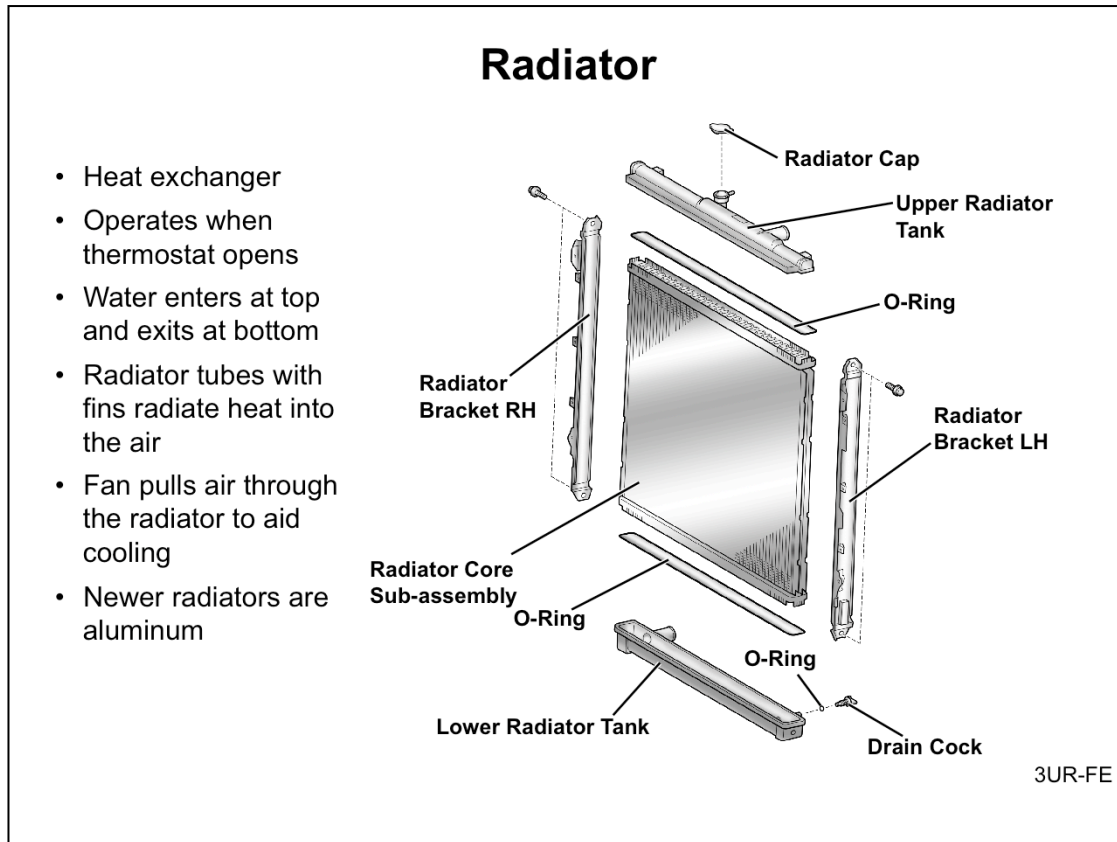


### Electric Water Pump

The 2ZR-FXE engine (2010 Prius) has one electric water pump. Other hybrid models have both a belt-driven main water pump and a smaller electric water pump. The electric water pump allows coolant to be circulated through the heater core when the engine is off.



**Thermostat** A thermostat with a bypass valve is located on the water inlet housing. Based on the coolant temperature, the thermostat opens and closes to control coolant flow to the radiator. Its purpose is to regulate coolant temperature for optimum engine operation.

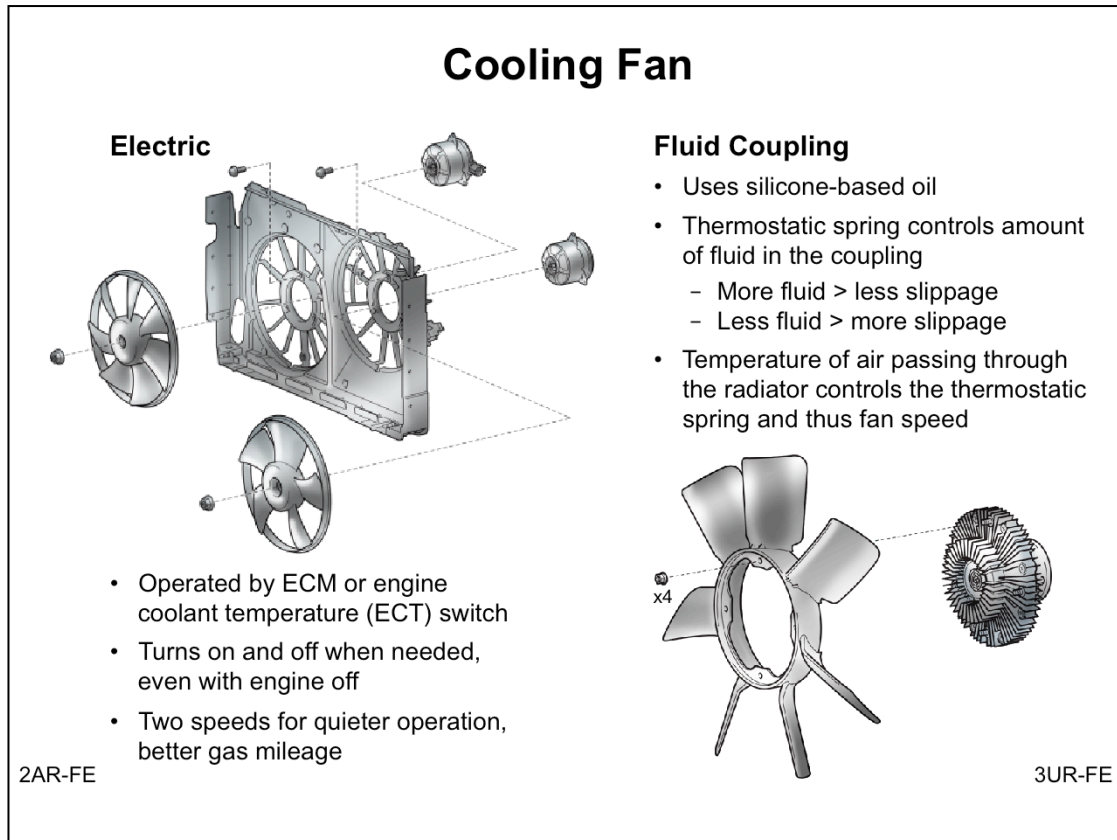


**Radiator** The radiator is the heat exchanger for the cooling system. The radiator is made up of an upper and lower radiator tank with hundreds of small pipes connecting them. Between these pipes are thin metal fins.

Coolant flowing through the engine absorbs heat. As hot coolant flows through the radiator, air passes over the fins removing heat. After the heat is absorbed by the atmosphere, the coolant is then routed back to the engine to begin the process again.

For the radiator to operate efficiently, air must be able to pass through the fins and coolant needs to be able to pass through the tubes. Debris on the fins or bent cooling fins will lower the radiator's ability to exchange heat. Internal scaling or impurities will also restrict coolant flow lowering the radiator's performance.





### Cooling Fan

Cooling fans operate when coolant temperature reaches a predetermined threshold or when the A/C is on. Fans mounted on back of the radiator (engine side) are designed to pull air through the radiator. Fans mounted in front of the radiator push air through it.

Toyota typically uses two types of cooling fans; electric or fluid coupling. Electric fans are ECM controlled and can have multiple speeds. Fluid coupling fans use a thermostatic spring to control the amount of fluid in the coupling, and thus control the fan speed.

## Engine Coolant

### Toyota Super Long Life Coolant (SLLC)

- Provides extended maintenance interval
  - First time maintenance: 100,000 miles
  - Next Maintenance: Every 50,000 miles
- SLLC is pre-mixed:
  - P/N 08889-80070
  - 50% coolant and 50% water
  - Does not need dilution
- If LLC is mixed with SLLC, use the maintenance interval for LLC
  - Every 30,000 miles or 24 months, whichever comes first

**Note:** Coolant provides lubrication for the water pump.

Toyota Genuine LLC  
(red color)



Toyota Genuine Super LLC  
Pre-Mixed @ 50% (pink color)

### Engine Coolant

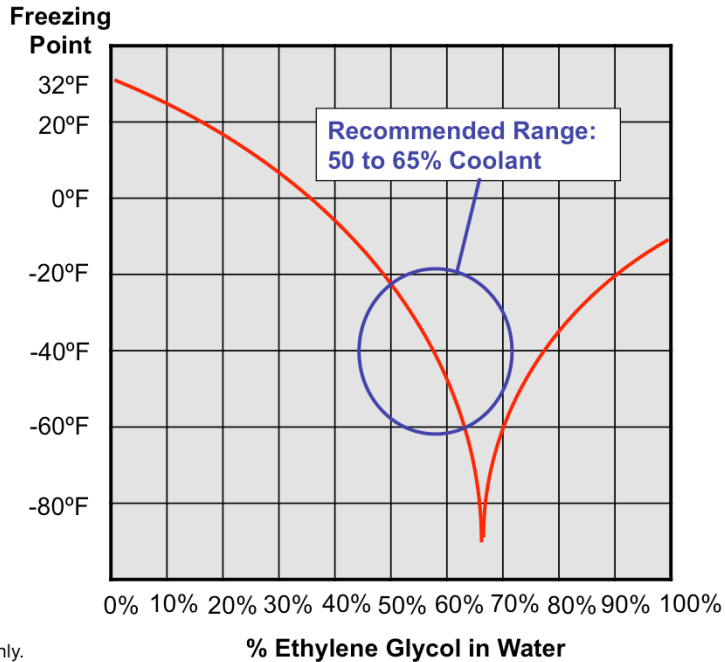
TOYOTA Genuine Super Long Life Coolant (SLLC) is a high quality ethylene-glycol-based, non-silicate, non-amine, non-nitrite and non-borate coolant with long-life hybrid organic acid technology. Coolant with long-life hybrid organic acid technology uses a combination of low phosphates and organic acids.

Pre-mixing the coolant with pure water is what gives SLLC its long life. Do not dilute with water.

## Freezing Point of Coolant/Water Mixture

Maximum freeze protection occurs with a mixture of about 68% coolant.

As the percentage of coolant increases beyond 68%, the freezing point of the coolant mixture rises.



**Note:** This chart is for ethylene glycol only.

### Coolant Dilution

Adding coolant to water lowers the water's freezing point. This protects the engine from the damaging effects that can occur from the expansion of water when it turns to ice. Maximum freeze protection occurs with a mixture of about 68% coolant. As the percentage of coolant increases beyond 68%, the freezing point of the coolant mixture actually rises. The recommended range for diluting coolant is to a mixture of 50% to 65% coolant.

Another reason for diluting coolant is that water is much more efficient at removing heat from the engine than coolant. Therefore, including the right percentage of water in the coolant mixture is necessary for optimum cooling system performance.

### Effect of Pressure on Boiling Point

When under pressure, the boiling point of water increases. In fact, the boiling point increases 3° F for each 1 psi of added pressure. Therefore a radiator cap capable of holding 13 psi will increase the water's boiling point to 251° F.

### Cooling System Safety

Pressurization of the cooling system is why it is dangerous to loosen the radiator cap when the engine is warmed up. When the pressure is released, the boiling point drops suddenly and the water turns instantly to steam. Because of the amount of calories of heat water must absorb to turn into steam, steam burns are much worse than burns from boiling water.

### CAUTION

Before loosening the radiator cap, carefully test the radiator hose to see if it is hot. If it is not too hot to touch, squeeze it with your hand to determine if the radiator system is pressurized. Do not loosen the radiator cap until you are sure the radiator system has cooled.

## Cooling System Problems



### Overheating

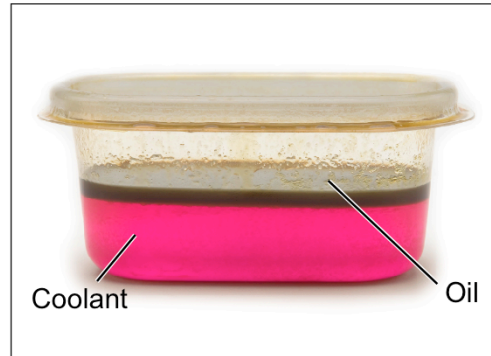
- Coolant low or diluted
- Faulty thermostat
- Faulty fan or fan circuit (electric fan)
- Leaking fluid coupling or bad belt (fluid coupling fan)
- Air in the engine coolant passages

### Coolant Condition

- Signs of corrosion or scaling may indicate the coolant's corrosion inhibitors are depleted due to age or improper maintenance.

### Coolant Loss

- If there is no sign of external coolant leaks, check for internal leaks:
  - Into the crankcase (oil/coolant contamination)
  - Into the combustion chamber (white smoky exhaust)



### Cooling System Problems

Heat is very detrimental to the internal combustion engine. If the cooling system does not do its job and the engine is allowed to operate at temperatures higher than normal, then components and fluids such as oil will start to break down and eventually fail. A properly operating cooling system is very important for the long life of an engine, and it's your job to ensure the cooling system is operating properly.

## Coolant Leak Test

After filling the radiator and reservoir with coolant, attach a radiator pressure tester.

Pump the radiator pressure tester to 17.1 psi, and check that the pressure does not drop.



1UR-FE

- If the pressure drops, check the hoses, radiator and water pump for leakage.
- If there are no signs of external coolant leaks, check the heater core, cylinder block and head.

### Coolant Leak Test

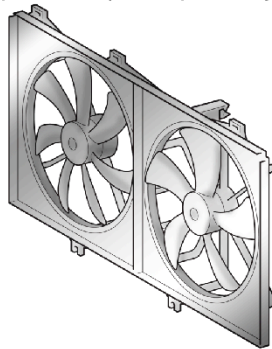
The cooling system is designed to operate under pressure. This pressure is regulated by the radiator cap. Water normally boils at 212 degrees F, but increasing the pressure in the cooling system raises the boiling point and allows the cooling system to operate above 212 degrees F.

When testing cooling systems for leaks, it is important to simulate the same operating conditions. To do this a cooling system tester pressurizes the system to enable technicians to check for leaks and verify the system can hold pressure.

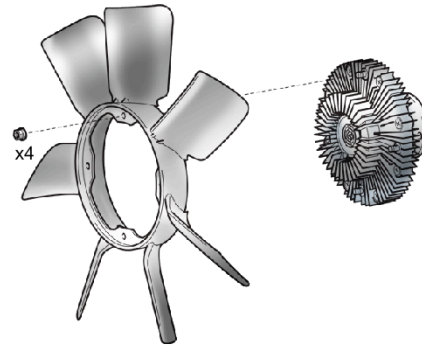
## Cooling Fan Inspection

### Electric Fan Inspection

- Visual inspection
- Techstream active test
- Observe operation:
  - When temp sensor is disconnected
  - When engine is warm
- Observe speed difference when A/C is operated (two-speed system)



2AR-FE



### Fan Fluid Coupling Inspection

- Check the fluid coupling for damage or silicon oil leaks.

3UR-FE

### Cooling Fan Inspection

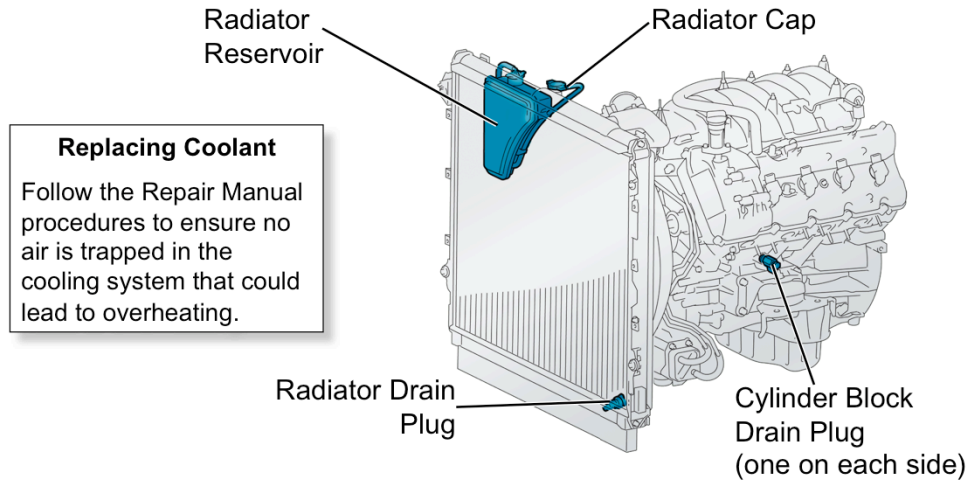
To inspect the cooling fan, allow the engine to reach operating temperature and verify the cooling fan is activated when the cooling system temperatures start to rise above normal. You may need to hold the engine RPM above idle to raise cooling system temperatures above normal.

Depending on vehicle model and year, electric fans may be activated through Techstream. This will ensure the fan functions and can be operated by the ECM. However, this does not confirm the ECM will trigger the fans under the proper operating conditions. Always allow the cooling system to reach normal operating conditions and verify the fans are activated.

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## Cooling System Service

- Inspect coolant and cooling system every 6 months or 15,000 miles.
- Replace coolant at 100,000 miles and every 50,000 miles thereafter
- If coolant appears rusty or contaminated, flush the cooling system and refill.



### Cooling System Service

When servicing the cooling system; drain and refill the radiator with the proper Toyota genuine coolant. SLLC comes premixed with water; do not dilute.

To ensure proper cooling system operation, all air must be purged from the system:

- Squeeze both inlet and outlet radiator hoses and recheck the level in the radiator. If low, add coolant to the reservoir and replace the radiator cap.
- Start the engine and allow the engine to reach operating temperature. If coolant temperature exceeds normal operating temperatures, stop the engine and wait for it to cool down. Check coolant level, refill reservoir and restart.

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