Section 3

Fuel and EVAP System

Overview

The EVAP system is designed to store and dispose of fuel vapors normally created in the fuel system and to help prevent their escape into the atmosphere.

The returnless fuel system helps reduce these evaporative emissions. Integrating the pressure regulator and the fuel filter with the fuel pump assembly has made it possible to discontinue the return of fuel from the engine area and prevent temperature rise inside the fuel tank.

Regulations require that the EVAP system be monitored for system performance and leak detection. Measuring the pressure of the EVAP system at various stages checks leaks, restrictions and components.

Bladder Fuel Tank

A bladder fuel tank is used to reduce fuel vapors generated when the vehicle is parked, during refueling or while driving. This system includes a resin vapor reducing fuel storage tank within a sealed metal outer tank. The resin tank expands and contracts with the volume of the fuel. By reducing the space in which fuel can evaporate, fuel vapors are minimized.

NOTE

At low ambient temperatures the capacity of the vapor reducing fuel tank is reduced due to the resin material from which it is made. If the outside temperature is at 14°F (-10°C) the size of the tank is reduced by approximately five liters.

Fuel Bladder

The resin bladder in the Prius fuel tank expands and contracts with the changing quantity of fuel.

Figure 3.1 T072f301c

Fuel Gauge

The direct acting fuel gauge is located in the sub tank. This gauge consists of a pipe surrounded by a coil. A float in the pipe moves up and down with changes in the fuel level. A magnet is attached to the float. The up and down movement of the float causes a change in the magnetic field. The flow of current through the coil creates a potential difference and the resultant voltage is transmitted to the meter ECU.

NOTE

The fuel pump module assembly is integral with the fuel tank and is not serviced separately.

Inclination Sensors

There are two inclination sensors located in the meter ECU to detect vehicle longitudinal and latitudinal inclinations and to correct the fuel level calculation. Corrections are made by the signals from the inclination sensors and the ambient temperature sensor located in the fuel tank.

The inclinometer must be reset if the customer complains that they can only pump a few gallons of gas into their tank or that they run out of gas with three or four bars left on the fuel meter. The inclinometer must also be reset if the Prius is refilled on an excessive slope or if the fuel gauge becomes inaccurate. Please refer to the Prius Repair Manual for the inclinometer calibration procedure.

Fuel Gauge Inclination Sensors

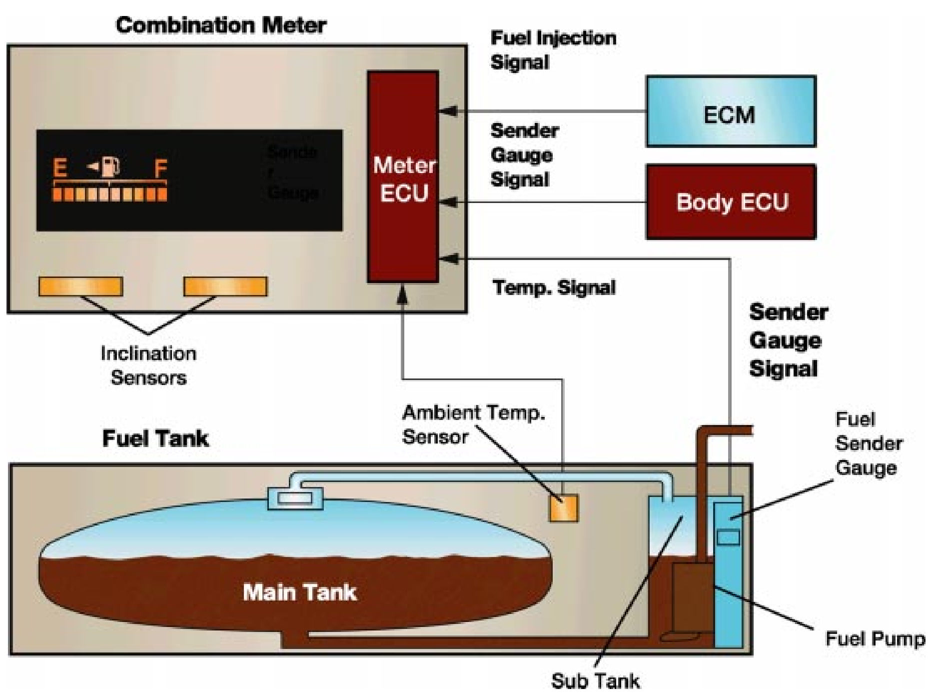

Figure 3.2 T072f302c

Fuel Capacity

Variations in the size and shape of the bladder fuel tank change the overall capacity of the tank. As fuel is added during refueling the bladder expands. Actual fuel capacity varies for several reasons.

- Temperature of the bladder - A cold bladder is stiff and will not expand to maximum capacity.
- Temperature of the fuel - Cold fuel will expand the bladder less, hot fuel more.
- Nozzle fit in the Prius filler neck - The Prius fuel filler neck is equipped with a rubber seal to improve bladder expansion with gas pump pressure. Some gas pump nozzles may be dented, scratched or gouged. Poor fit of the pump nozzle in the filler neck reduces fuel tank capacity.
- Overfilling - Trying to force additional fuel into the tank pushes excess fuel into the EVAP system. This may cause an EVAP DTC and may even require the replacement of some EVAP system components.

Energy Monitor

The Energy Monitor which includes a historical bar graph and total trip fuel economy (MPG) is very accurate. Multiple, comparative calculations are performed by several computers.

Fuel usage and fuel economy are calculated by monitoring fuel injector duration and operating frequency. The ECU compares these values with miles traveled to calculate miles per gallon.

The battery ECU closely monitors energy consumption in Watts. By calculating the amount of energy spent, recovered and stored, the computer can calculate the required fuel burn. Fuel required to create this amount of energy is compared against the engine ECU fuel injection calculation to insure accuracy.

Driving pattern, speed and load characteristics are stored in the HV ECU as “Historical Data”. Historical Data is used to further refine the MPG calculation. This data takes from three to six weeks to accumulate after “battery disconnect” or computer replacement.

Fuel Type

Use only UNLEADED gasoline in the Prius. The Prius has a smaller fuel tank opening to help prevent nozzle mix-ups. The special nozzle on pumps with unleaded fuel will fit, but the larger standard nozzle on pumps with leaded gas will not.

Octane Rating

At a minimum, the gasoline used should meet the specifications of ASTM D4814 in the United States. For the Prius, use only UNLEADED gasoline with an Octane Rating 87.

NOTE

Do not use premium gasoline. It may cause starting problems with the Prius. There is no gas mileage benefit when using premium gas!

NOTE

Starting may occur many times in a single drive cycle unlike conventional vehicles compounding potential “hot soak” issues.

Evaporative System Control

A vacuum test method has been adopted to detect leaks in the EVAP system. This method detects leaks by introducing the purge vacuum into the entire system and monitoring changes in pressure.

In order to detect EVAP leaks from the vapor reducing fuel tank, a density method has been adopted. This system uses an O2 sensor to measure HC density in the exhaust gases in order to detect leaks. Added HC from a leak will cause a reduction in exhaust oxygen content.

EVAP Parts Location

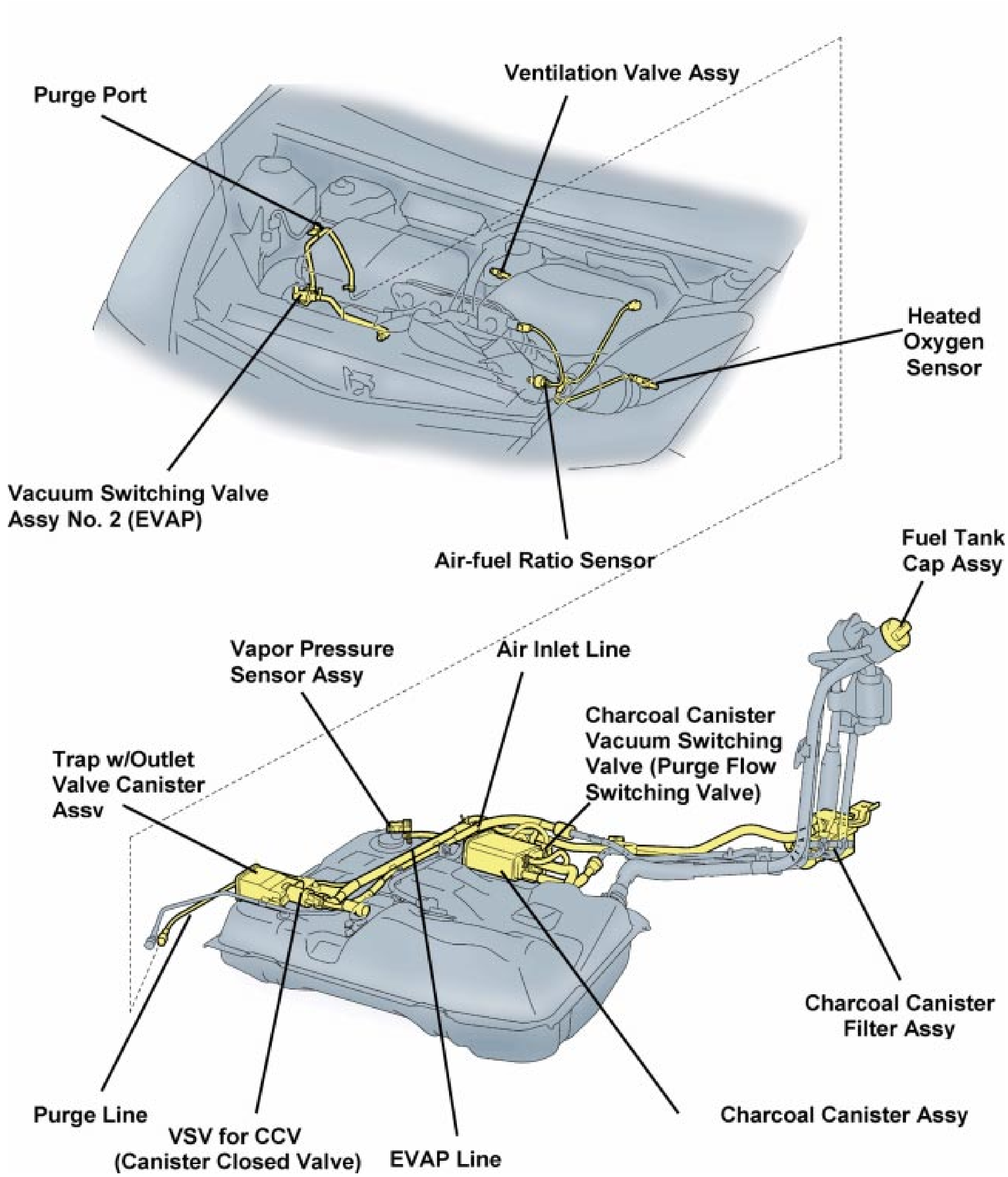

Figure 3.3 T072f303c

EVAP Components

The EVAP system consists of the following main components:

Canister Closed Valve

Canister Closed Valve VSV - This **normally open** valve is located between the fresh air line and the fuel tank. This VSV stops airflow into the EVAP system to seal the system and enable leak detection. It is also known as the CAN CTRL VSV or the CCV VSV.

Canister Closed Valve Location

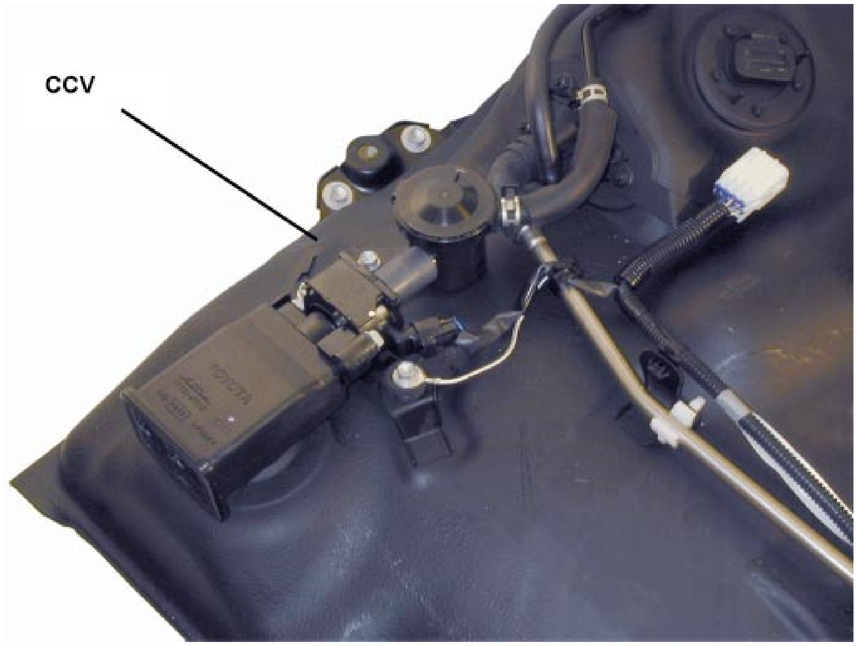

Figure 3.4 T072f304c

Fresh Air Valve Allows air to exhaust from the system during ORVR refueling. The valve is located near the Canister Closed Valve.

Fresh Air Valve Location

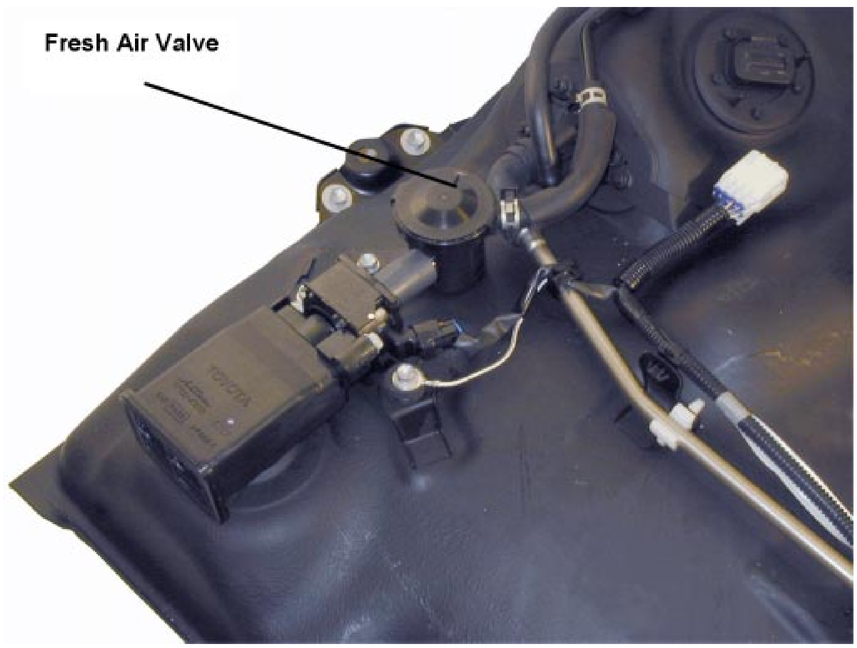

Figure 3.5 T072f305c

The Purge Flow Switching Valve

The Purge Flow Switching Valve VSV - This **normally open** VSV is located on the charcoal canister. It allows vacuum from the EVAP VSV (or Purge VSV) to flow through the canister. When activated by the ECM during internal fuel bladder leak detection, it switches airflow from the canister to the outer tank bladder only. This VSV is also known as the Tank Bypass VSV when using the Diagnostic Tester.

Purge Flow Switching Valve Location

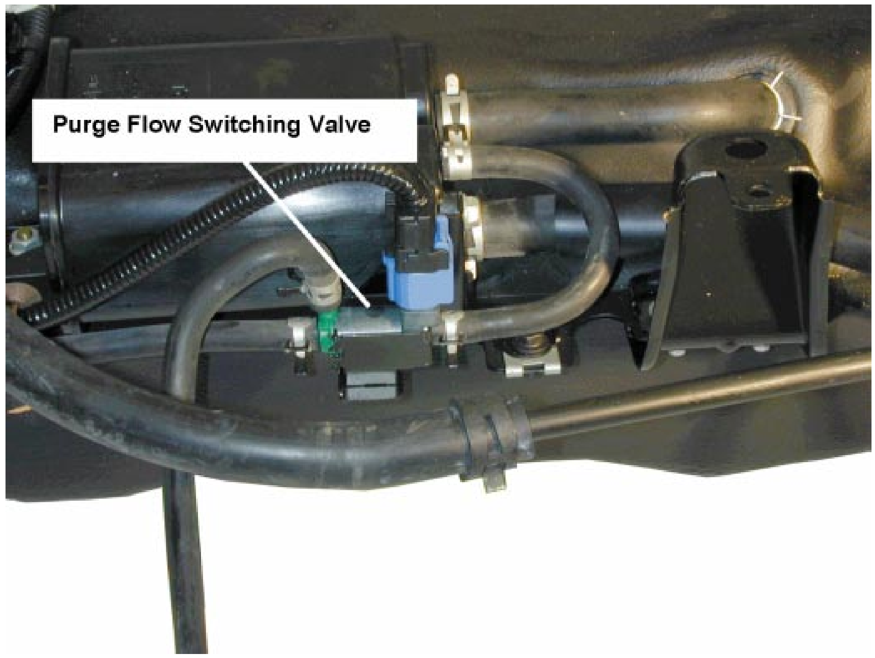

Figure 3.6 T072f306c

EVAP (Alone)

EVAP (Alone) VSV - This **normally closed** VSV is duty-cycle controlled by the ECM. It is used to control engine vacuum to the EVAP system in order to remove stored hydrocarbons from the charcoal canister. It’s also used for system leak detection and may be referred to as the Purge VSV.

EVAP VSV Location

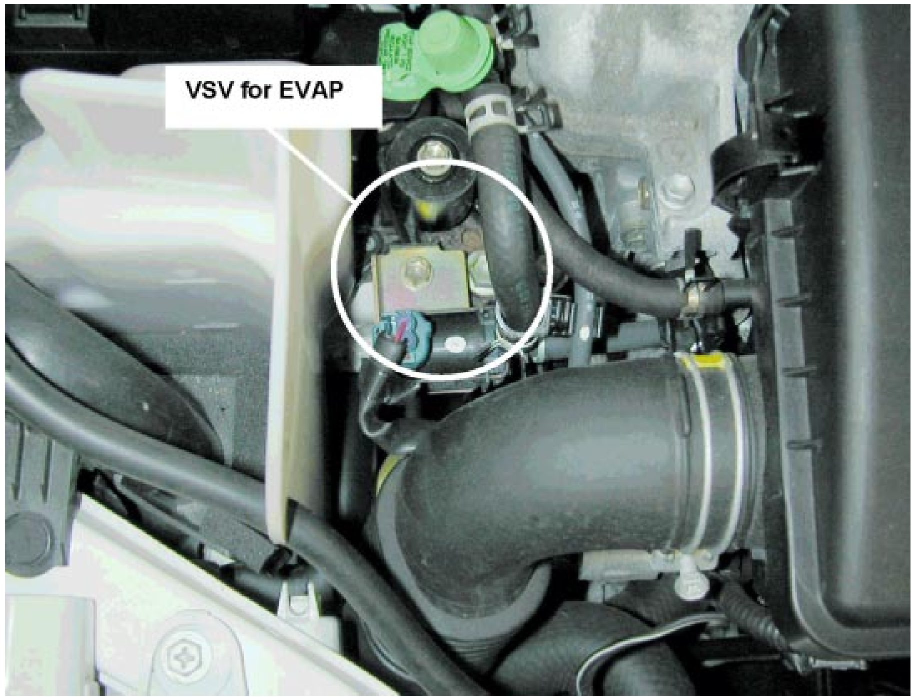

Figure 3.7 T072f307c

Vapor Pressure Sensor

Vapor Pressure Sensor (VPS) - The VPS is located on the fuel tank to precisely measure the vapor pressure in the EVAP system. The ECU provides a 5V signal and ground to the Vapor Pressure Sensor. The VPS sends a voltage signal back to the ECU, which varies between 0.1V - 4.9V in response to tank pressure.

NOTE

Check all hoses for proper connection, restrictions and leaks. Apply the specified pressure and check voltage output. The VPS is calibrated for the pressure found in the EVAP system. Apply the specified amount to prevent damaging the sensor.

Vapor Pressure Sensor Location

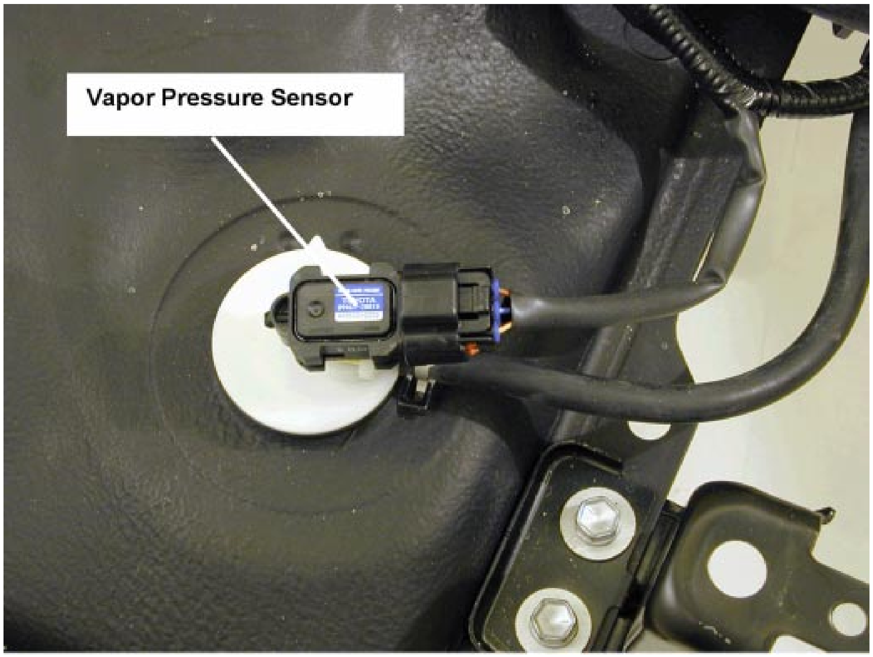

Figure 3.8 T072f308c

Fuel Cutoff Valve Fuel Cutoff Valve - Located on the upper end of the fuel filler pipe. Causes the filler nozzle to shut off when the fuel tank is full to prevent overfilling.

Fuel Cutoff Valve Location

Figure 3.9 T072f309c

Fuel Check Valve

Refuel Check Valve - Located on the upper end of the fuel filler pipe. An anti-siphon valve which prevents fuel from entering EVAP system lines.

Refuel Check Valve Location

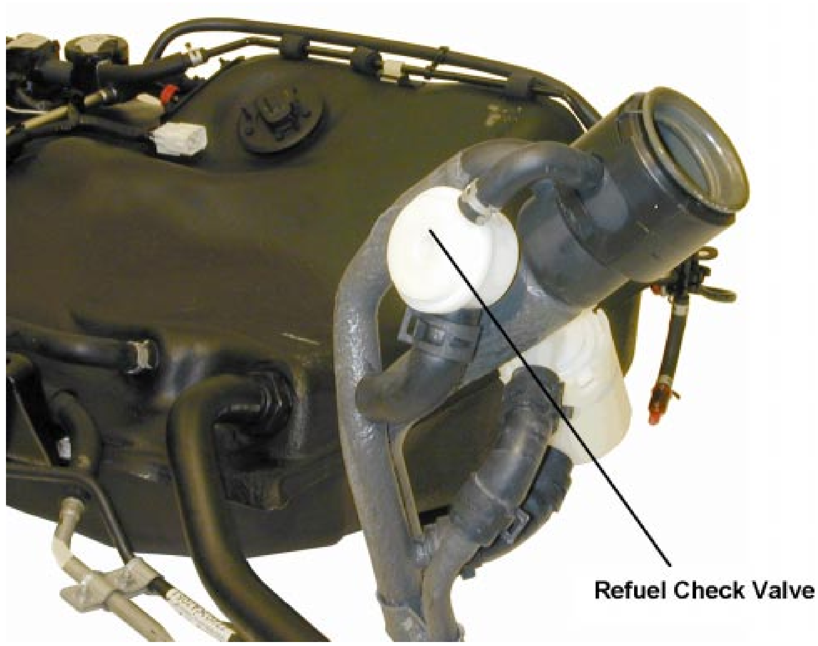

Figure 3.10 T072f310c

NOTE

The following VSVs are referred to by several different names in some Toyota repair information:

- CAN CTRL VSV - Canister Closed Valve or CCV VSV
- Tank Bypass VSV - Purge Flow Switching Valve
- EVAP VSV (Alone) - Purge VSV

EVAP Control Components

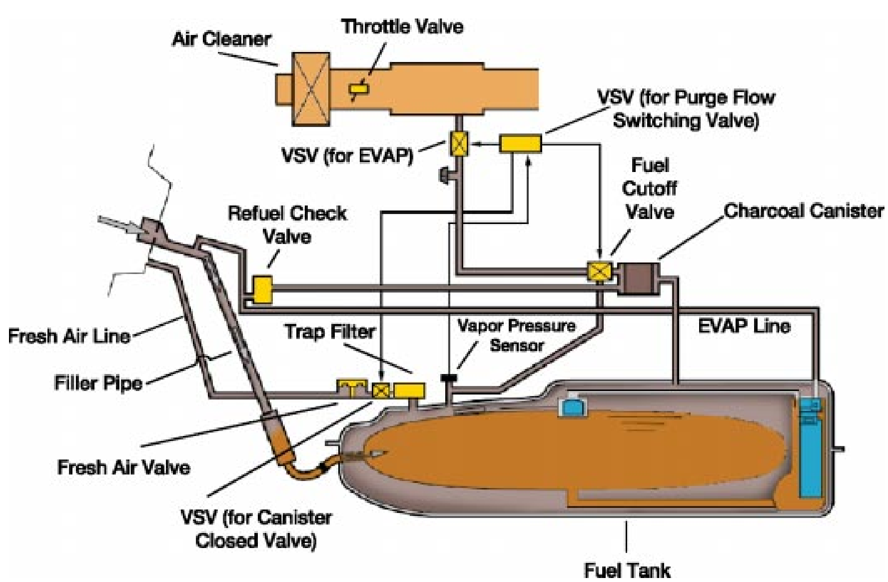

Figure 3.11 T072f311c

Operation - ORVR Refueling

When refueling, the engine is OFF and the EVAP VSV is CLOSED (OFF). The resin bladder expands as fuel enters, so there is virtually no vapor space above the fuel. Hydrocarbon (HC) vapor flows from the secondary tank and fuel pump through the EVAP line to the charcoal canister. The HC is absorbed by and stored in the charcoal canister.

Air flows from the charcoal canister to the airspace between the metal outer tank and bladder and to the Canister Closed Valve. The Canister Closed Valve (CCV) is OPEN, allowing air to exit from the Fresh Air Valve. The Refuel Check Valve and Fuel Cutoff Valve work together to prevent overfilling and liquid fuel from entering the charcoal canister.

ORVR Refueling

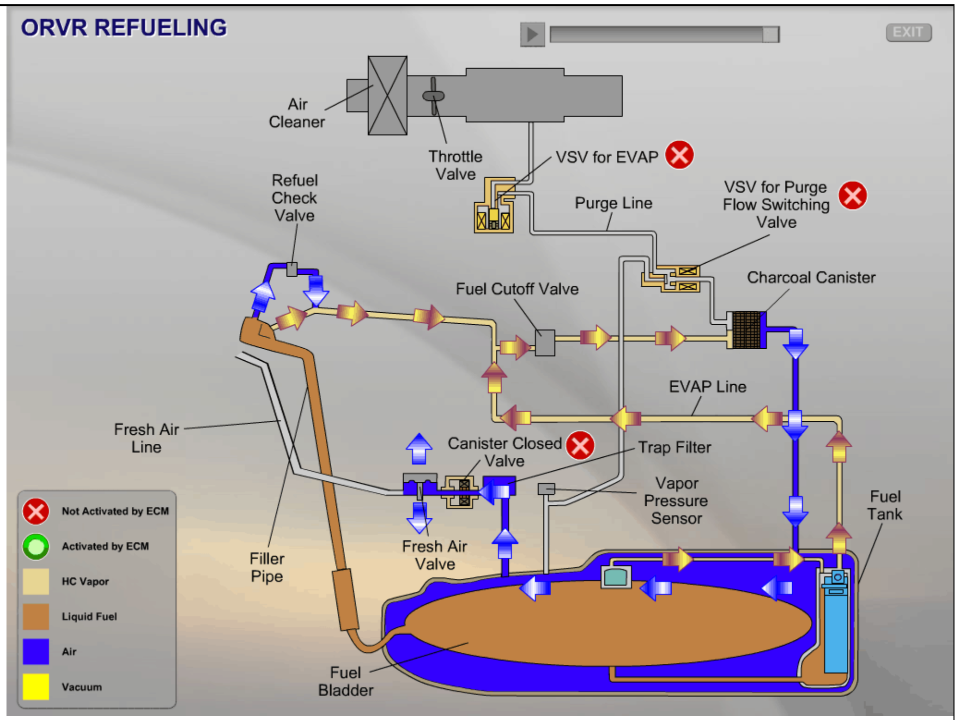

Figure 3.12 T072f312c

Purging

During normal purge operation the engine is running and the ECM duty cycles the EVAP VSV ON and OFF, allowing vacuum from the intake manifold to pull air through the EVAP system. The Purge Flow Switching Valve is OFF, opening the connection between the charcoal canister and the EVAP VSV. HC vapor flows from the charcoal canister to the EVAP VSV and into the intake manifold.

The Canister Closed Valve (CCV) is OPEN, allowing fresh air to enter from the air cleaner and flow through the airspace between the metal outer tank and bladder and up to the charcoal canister. As this air passes through the canister, it purges the HC.

Purging

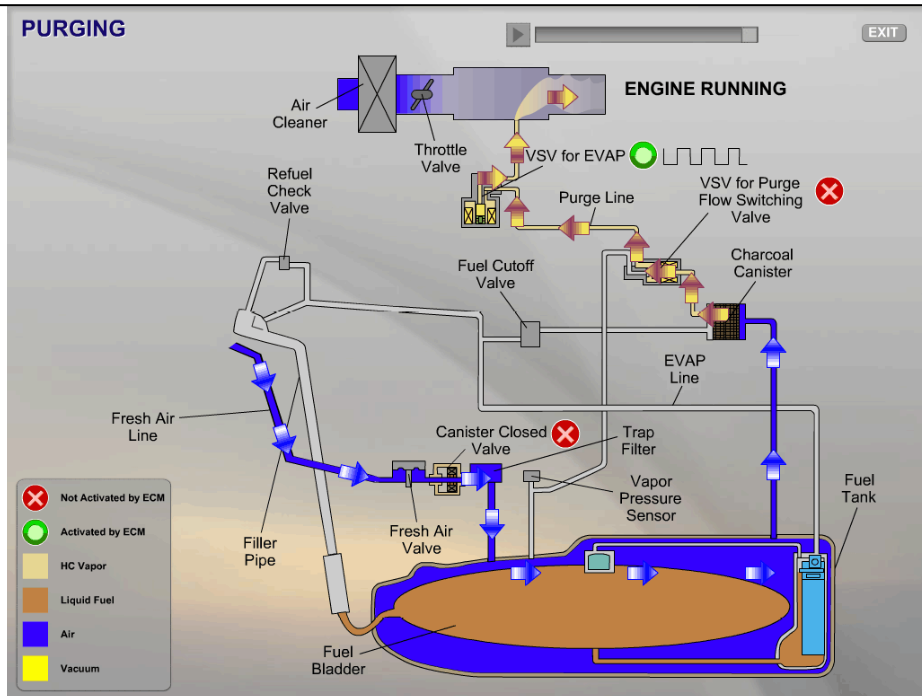

Figure 3.13 T072f313c

Tank Bladder Leak Check

To monitor the tank bladder for internal leaks the ECM controls the VSVs similar to purging except that the Purge Flow Switching VSV is activated (ON). The airflow then switches from flowing through the canister to flowing only to the outer bladder of the tank. If there is a leak in the inner tank the fuel vapor will create a rich engine condition. The O2 sensor measures the presence of HC in the exhaust gases. If the O2 sensor indicates a rich condition, a leak is assumed and the MIL will illuminate.

During the tank bladder leak check the engine is running. The EVAP VSV is turned ON and OFF on a duty cycle. The Canister Closed Valve (CCV) is OPEN, allowing fresh air to flow from the air cleaner through the airspace between the metal outer tank and bladder and to the Vapor Pressure Sensor, the EVAP VSV and intake manifold.

Tank Bladder Leak Check

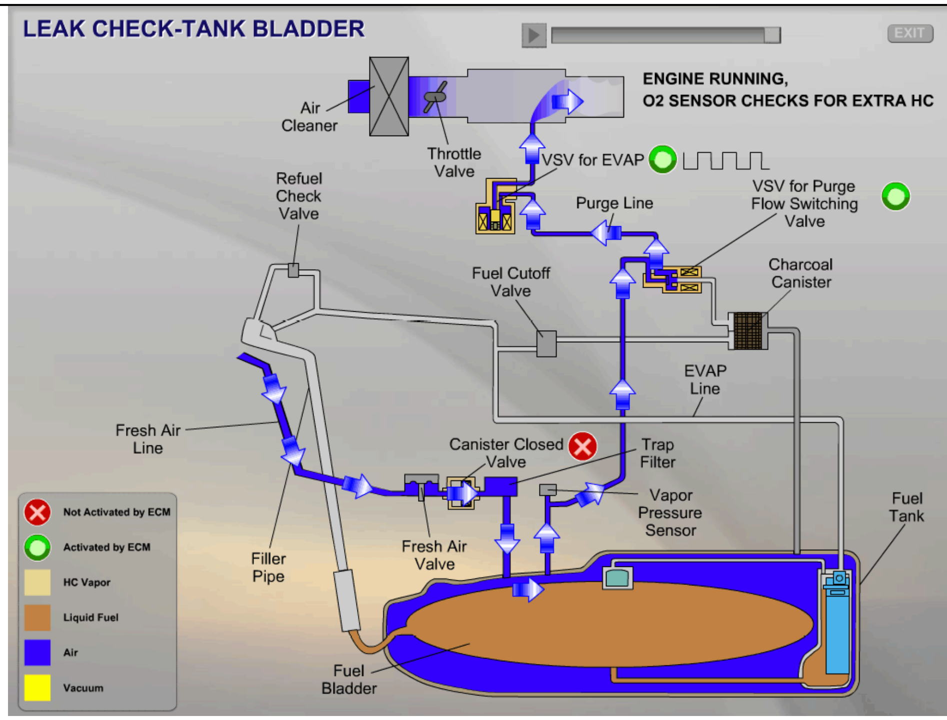

Figure 3.14 T072f314c

Leak Check Complete System

A leak check of the complete EVAP system is performed with the engine running. The Canister Closed Valve is CLOSED and the Purge Flow Switching Valve is OFF, opening the connection between the charcoal canister and the EVAP VSV.

The EVAP VSV is OPEN (ON) until EVAP system pressure drops at least 20mmHg. This should take no more than 10 seconds. The EVAP VSV then CLOSES to seal the system and the Vapor Pressure Sensor monitors system pressure. If pressure rises too rapidly, a leak is assumed. A DTC is set if the leak exceeds a hole diameter of 1mm (0.040 in.).

Leak Check Complete System

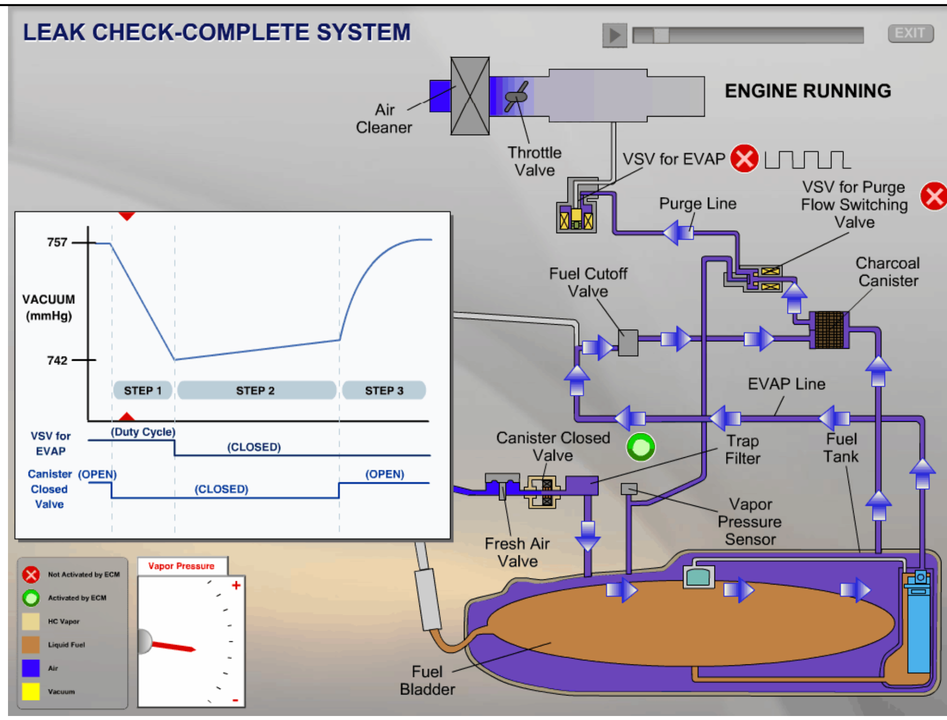

Figure 3.15 T072f315c

DTC P0440 Evaporative Emission Control System Malfunction

The ECM records DTC P0440 when an EVAP system leak is detected or when the Vapor Pressure Sensor malfunctions. The Vapor Pressure Sensor VSV for Canister Closed Valve (CCV) and VSV for Purge Flow Switching Valve are used to detect abnormalities in the EVAP system. The ECM decides whether there is an abnormality based on the Vapor Pressure Sensor signal.

The ECM turns the CCV ON, closing the EVAP system to fresh air. The ECM turns the EVAP VSV ON allowing manifold vacuum to drop EVAP system pressure. When pressure drops 20mmHg the Purge VSV is shut OFF, sealing the entire system in a vacuum.

The ECM monitors the level of vacuum in the sealed system to check for leaks. If pressure rises faster than the specification the system is judged to be leaking.

DTC P0441 Evaporative Emission Control System Incorrect Purge Flow

The ECM monitors the Vapor Pressure Sensor signal to check for abnormalities in the evaporative emissions control system. DTCs P0441 and P0446 are recorded by the ECM when evaporative emissions components do not perform as expected.

The ECM turns the EVAP (Purge) VSV ON with the CCV ON and closed. The ECM checks the Purge VSV performance:

- If pressure does not drop at least 20mmHg, the EVAP VSV is judged to be stuck closed.

When pressure drops, the ECM shuts off the EVAP VSV at 20mmHg. If pressure continues to drop more than 20mmHg, the EVAP VSV is judged to be stuck open.

DTC P0446 Evaporative Emission Control System Vent Control Malfunction

For P0446, the ECM cycles the EVAP VSV and CCV ON and OFF. The ECM checks CCV performance:

Purge is momentarily turned ON and OFF to raise and lower the tank pressure slightly (approx 10mmHg). Pressure in the tank should go up and down.

When the CCV is activated the pressure should drop rapidly. If pressure continues to go up and down the CCV is judged to be stuck open.

When the EVAP VSV ON/OFF cycle is started, if pressure immediately drops to minimum, the CCV is judged to be stuck closed.

DTC P1455 Vapor Reducing Fuel Tank System Leak Detected (Small Leak)

Based on the signals sent from the O2 sensor (Bank 1 Sensor 1) while the VSV for Purge Flow Switching Valve is ON, the ECM determines if fuel has leaked from the bladder tank or during purge operation. This condition is detected when the VSV for Purge Flow Switching Valve is ON and the vapor density of air which flows from the VSV for EVAP into the intake manifold is high.

DTC P1455 can occur from overfilling the vehicle which can cause raw fuel to collect in the lines. In extreme cases the fuel may run back down the vapor pressure port and contaminate the outer tank. The most common cause for this code is “topping off” the fuel tank or not fully inserting the nozzle into the filler neck during refueling.

In either case, excess pressure during refueling can force fuel through the vents at the top of the filler neck or the Fuel Cut-Off Valve, and can get into the Charcoal Canister or outer area of the Bladder Tank. If you get this code remove the Vapor Pressure Sensor and sample the tank with an emissions or 134a sniffer.

If HCs are detected, replace the fuel tank, canister and lines. It is important to educate the customer about proper refueling to eliminate this problem.

EVAP Component Test Tips

The tests below will help to identify potential problems while components are still installed on the vehicle. If you suspect a failure in an EVAP component from these tests, remove the component and follow the Repair Manual for complete diagnosis.

Canister Closed Valve Inspection:

1. Connect the EVAP Pressure Tester to the EVAP service port.
2. Set the pump hold switch to OPEN and the vent switch to CLOSE.
3. Turn the EVAP Pressure Tester pump ON. At this time, the pressure should not rise.
4. Using the Diagnostic Tester, **Active Test**, activate the Canister Closed Valve (ON). Pressure should begin to rise on the EVAP Pressure Tester.
5. When the Canister Closed Valve is turned OFF, the pressure in the system should drop.

Fresh Air Valve Inspection:

1. Remove the Air Inlet Hose from the side of the air cleaner.
2. Using the Diagnostic Tester, **Active Test**, turn the Canister Closed Valve (ON).
3. Attach a hand vacuum pump to the Air Inlet Hose and GENTLY apply light vacuum (less than 5in.hg). The Air Valve should hold a vacuum. **(Applying vacuum too quickly can “unstick” a stuck diaphragm and falsify the test.)**
4. Remove the hand pump and GENTLY blow into the Air Inlet Hose. You should hear the pressure escape from under the valve.

Purge Flow Switching Valve (Tank Bypass VSV) Inspection:

1. Remove the hose coming from the EVAP Purge VSV and attach a hand vacuum pump to the Purge Flow Switching Valve.
2. Using the Diagnostic Tester, Active Test, turn the Purge Flow Switching Valve (ON).
3. Clamp the hose going from the Purge Flow Switching Valve to the Vapor Pressure Sensor and begin to apply vacuum with the hand pump. The Purge Flow Switching Valve should hold vacuum.
4. Turn the Purge Flow Switching Valve Active Test OFF.
5. The pressure should now release into the hose going to the Charcoal Canister.

Fuel Cutoff Valve Inspection:

The Fuel Cutoff Valve helps prevent fuel from contacting the end of the nozzle. If the vehicle has been overfilled or refueled with the nozzle insufficiently inserted into the filler neck, fuel may flow past this valve and into the Charcoal Canister. To check for this condition and confirm proper operation do the following:

1. Carefully remove the valve from the filler neck. Try not to tip it so you can inspect it for liquid fuel.
2. If fuel is present the tank could have been overfilled or the fuel pump nozzle was not inserted properly during refueling.
3. Drain the fuel from the valve and inspect the Charcoal Canister for excessive fuel.
4. The valve should pass air through both ports easily when held upright (as installed on the vehicle). If the valve is turned upside down, it should prevent airflow through the ports. Replace the valve if it does not.

Refuel Check Valve Inspection:

When refueling, fuel traveling down the filler pipe can create a siphoning effect through the EVAP line connected to the inner bladder of the fuel tank. This siphoning effect can cause liquid fuel to be drawn up through the EVAP line and possibly into the Charcoal Canister. The refuel check valve is designed to vent air from the top of the filler neck above the lip seal into the EVAP line preventing this siphoning effect and preventing liquid fuel from splashing.

1. To test the Refuel Check Valve, blow low-pressure air into the larger of the two ports. Air should not flow freely through this port and you will hear the valve release as pressure increases. Air should flow easily from the small port through the large port. Replace the valve if it does not pass either of these tests.

Refuel Check Valve Inspection

The refuel check valve is designed to vent air from the top of the filler neck, above the lip seal into the EVAP line, preventing a siphoning effect.

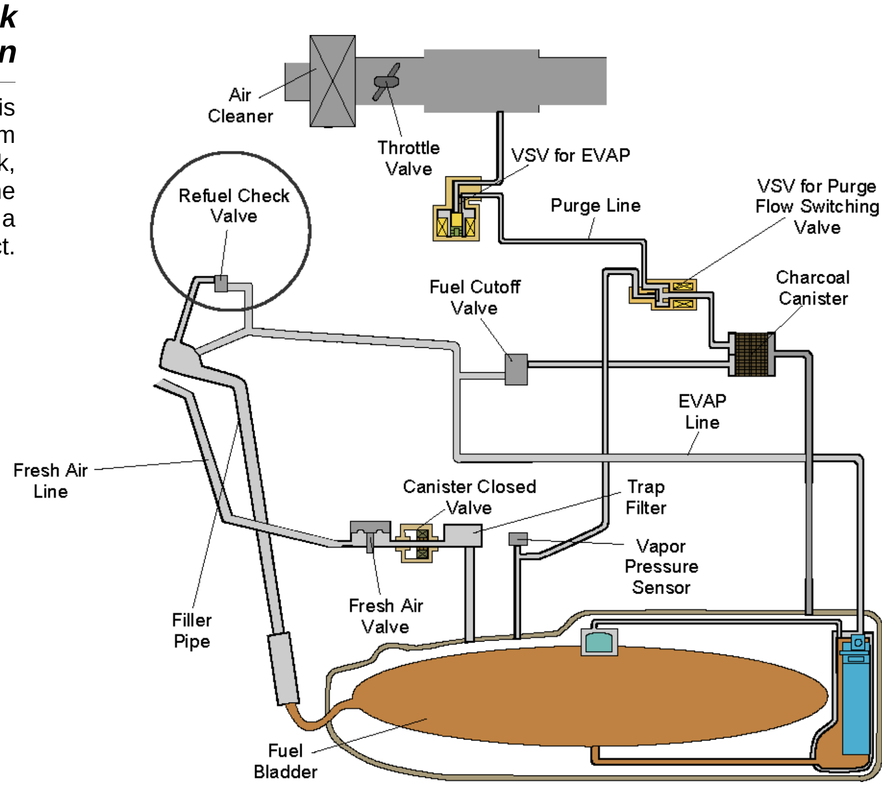

Figure 3.16 T072f316c