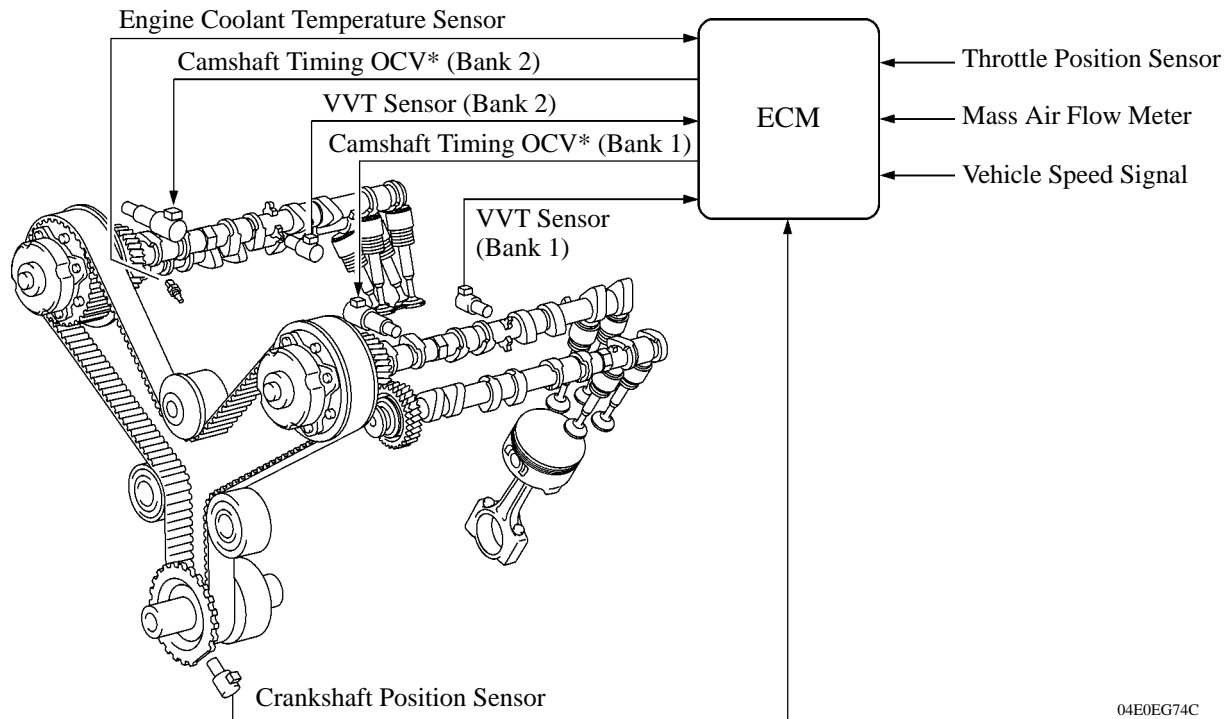


## 7. VVT-i (Variable Valve Timing-intelligent) System

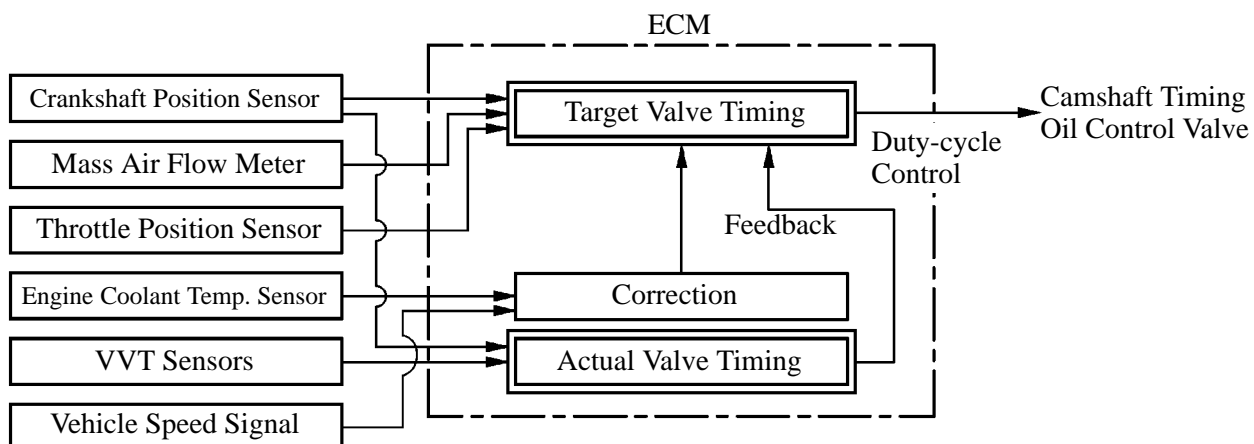
### General

- The VVT-i system is designed to control the intake camshaft within a range of  $40^\circ$  (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

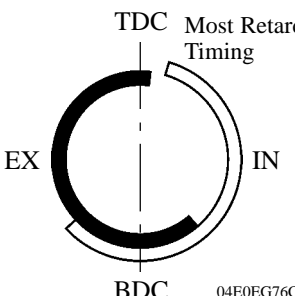
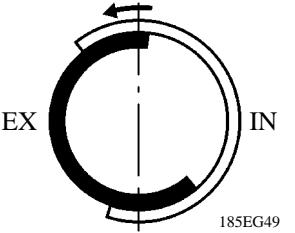
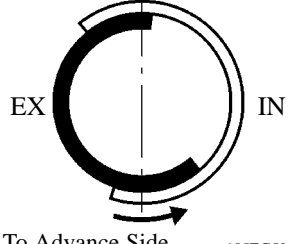
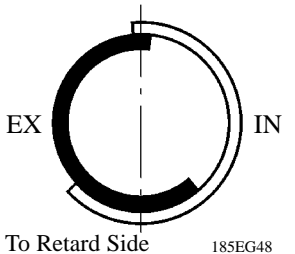
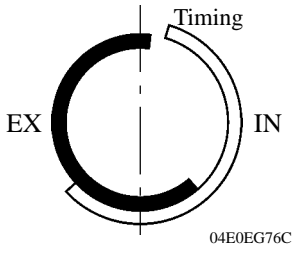
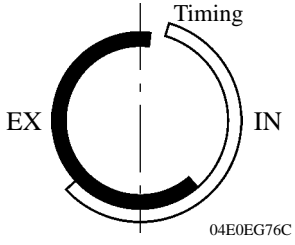


\*: Oil Control Valve

- By using the engine speed, intake air mass, throttle position, engine coolant temperature and vehicle speed, the ECM can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM uses signals from the VVT sensor and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



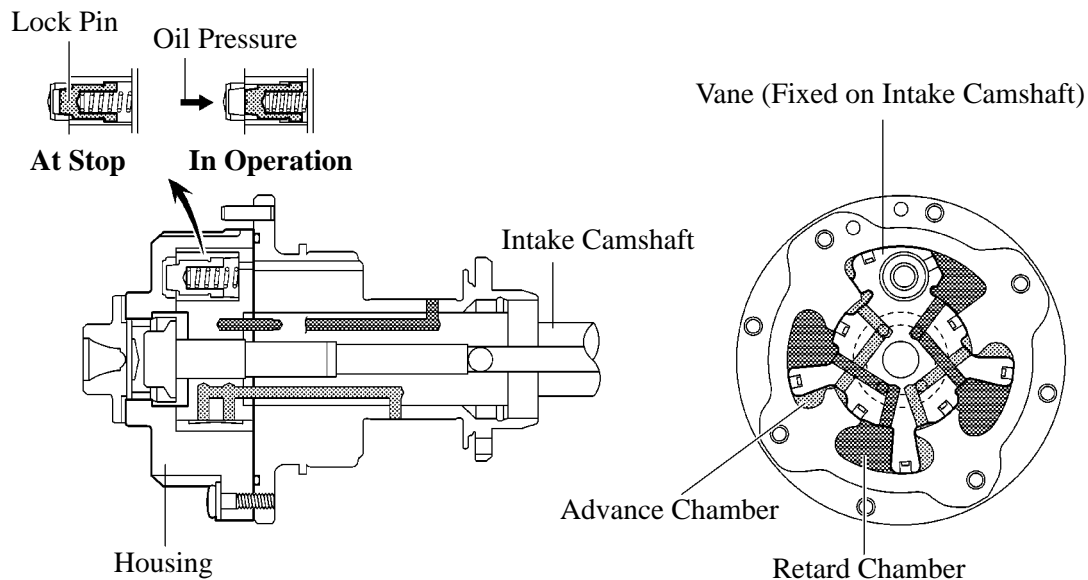
**Effectiveness of VVT-i System**

Operation State	Objective	Effect
<ul style="list-style-type: none"> <li>• During Idling</li> <li>• At Light Load</li> </ul>	<p>TDC Most Retarded Timing</p>  <p>EX IN</p> <p>BDC 04E0EG76C</p> <p>Eliminating overlap to reduce blow back to the intake side</p>	<ul style="list-style-type: none"> <li>• Stabilized idle speed</li> <li>• Better fuel economy</li> </ul>
At Medium Load	<p>To Advance Side</p>  <p>EX IN</p> <p>185EG49</p> <p>Increasing overlap to increase internal EGR to reduce pumping loss</p>	<ul style="list-style-type: none"> <li>• Better fuel economy</li> <li>• Improved emission control</li> </ul>
In Low to Medium Speed Range with Heavy Load	 <p>EX IN</p> <p>To Advance Side 185EG50</p> <p>Advancing the intake valve close timing for volumetric efficiency improvement</p>	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	 <p>EX IN</p> <p>To Retard Side 185EG48</p> <p>Retarding the intake valve close timing for volumetric efficiency improvement</p>	Improved output
At Low Temperatures	<p>Most Retarded Timing</p>  <p>EX IN</p> <p>04E0EG76C</p> <p>Eliminating overlap to prevent blow back to the intake side and stabilizes the idling speed at fast idle.</p>	<ul style="list-style-type: none"> <li>• Stabilized fast idle speed</li> <li>• Better fuel economy</li> </ul>
<ul style="list-style-type: none"> <li>• Upon Starting</li> <li>• Stopping the Engine</li> </ul>	<p>Most Retarded Timing</p>  <p>EX IN</p> <p>04E0EG76C</p> <p>Eliminating overlap to reduce blow back to the intake side</p>	Improved startability

## Construction

### 1) VVT-i Controller

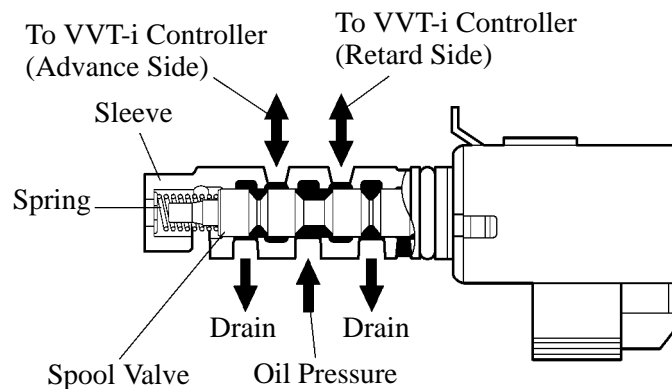
VVT-i controller consists of the housing, four vanes, and a lock pin. The oil pressure sent from the advance or retard side path of the intake camshaft causes rotation of the VVT-i controller vane in the circumferential direction to vary the intake valve timing continuously. When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability. When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise. Thereafter, when hydraulic pressure is applied to the VVT-i controller, the lock pin is released.



273GX18

### 2) Camshaft Timing Oil Control Valve

This camshaft timing oil control valve controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded position.

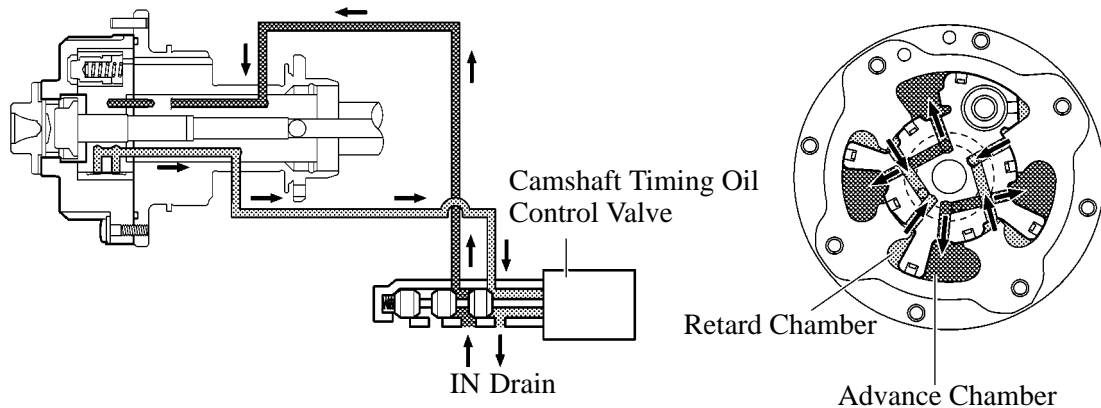


081EG94TE

## Operation

### 1) Advance

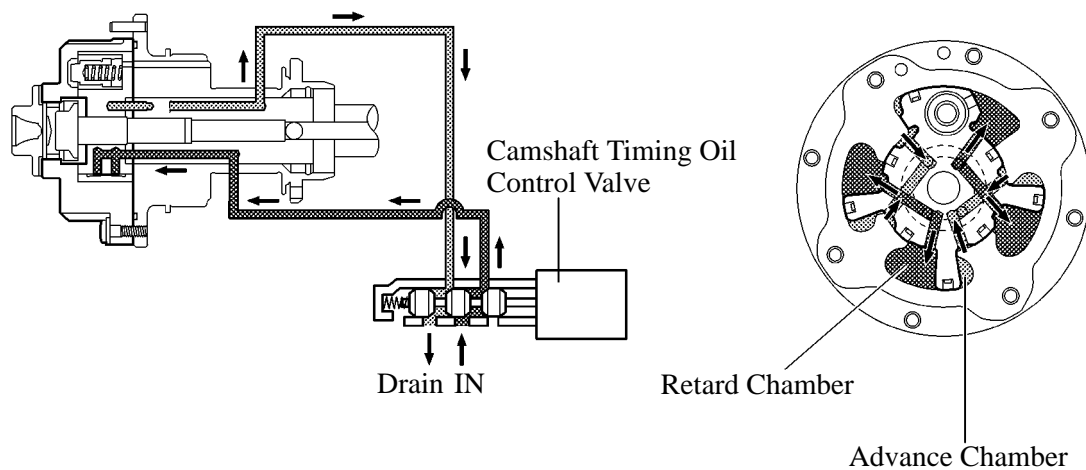
When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the ECM, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.



081EG112S

### 2) Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals from the ECM, the resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.



081EG111S

### 3) Hold

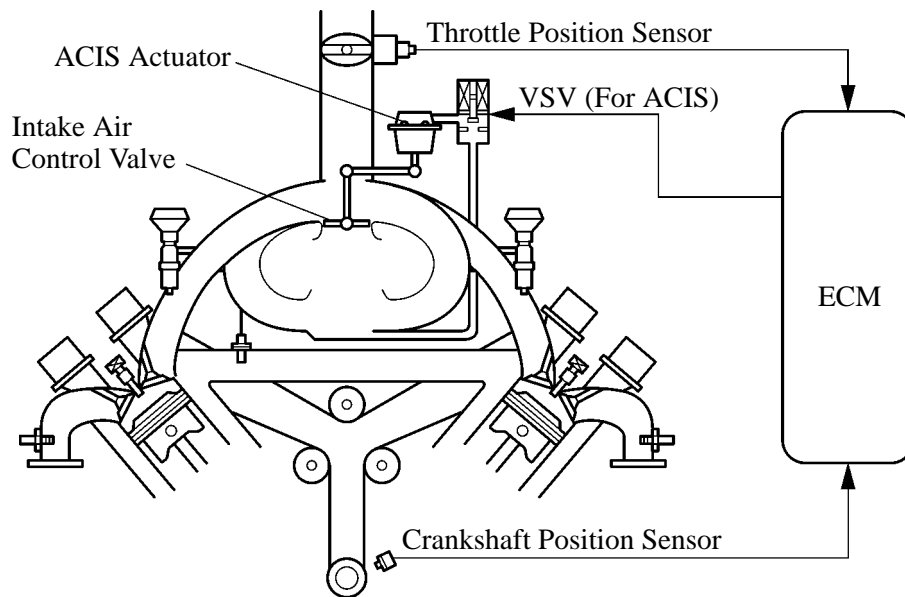
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.

This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

## 8. ACIS (Acoustic Control Induction System)

### General

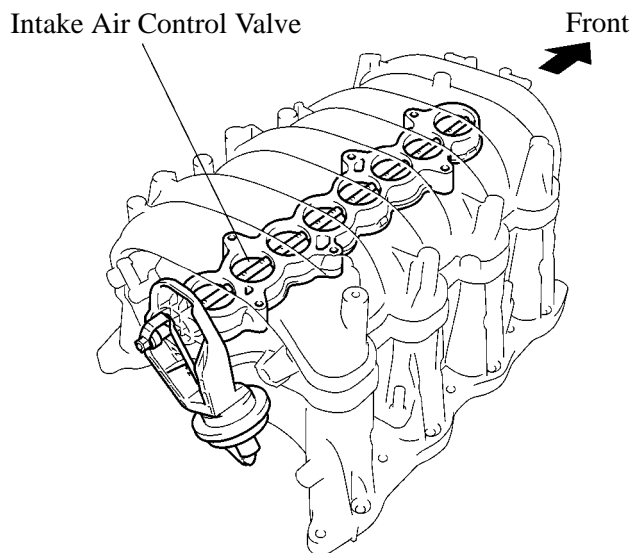
The ACIS uses the intake air control valve as a bulkhead to divide the intake manifold into 2 stages. The intake air control valve is opened and closed to vary the effective length of the intake manifold in accordance with engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high engine speeds.



04E1EG70C

### Intake Air Control Valve and Actuator

- The intake air control valve and actuator are integrated with the intake manifold.
- The intake air control valve opens and closes to make two effective lengths of the intake manifold possible.



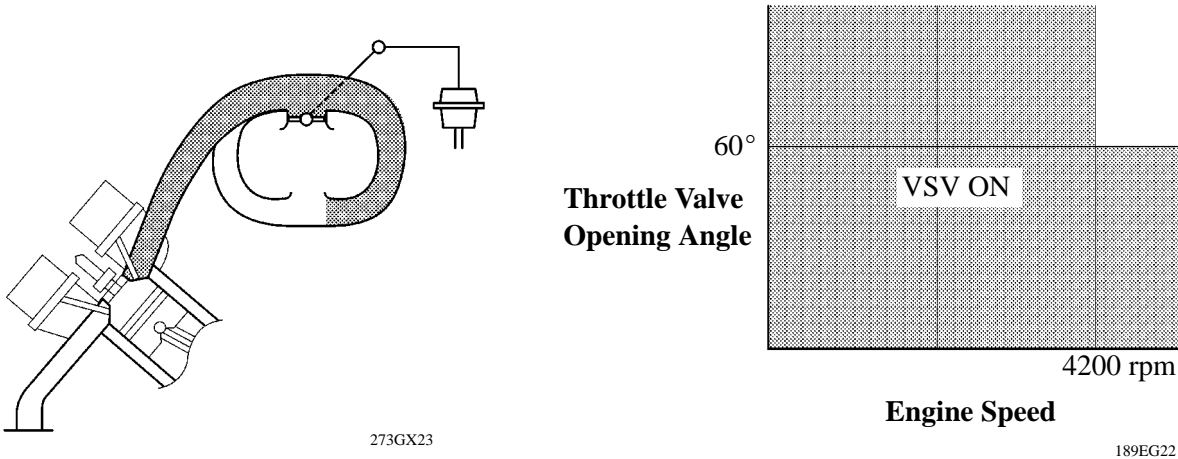
273GX22

Operation

1) Intake Air Control Valve Close (VSV ON)

The ECM activates the VSV so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve to match the longer pulsation cycle. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium engine speed range is improved due to the dynamic effect of the intake air, thereby increasing the power output.

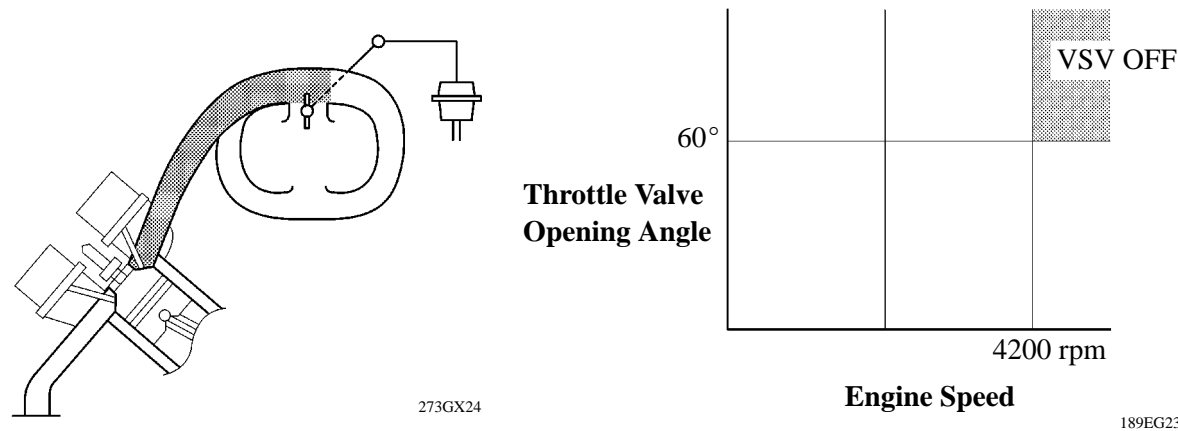
 : Effective Intake Manifold Length



2) Intake Air Control Valve Open (VSV OFF)

The ECM deactivates the VSV so that atmospheric air is led into the diaphragm chamber of the actuator. This opens the control valve to match the shorter pulsation cycle. When the control valve is open, the effective length of the intake air chamber is shortened and peak intake efficiency is shifted to the high engine speed range, thus providing greater output at high engine speeds

 : Effective Intake Manifold Length



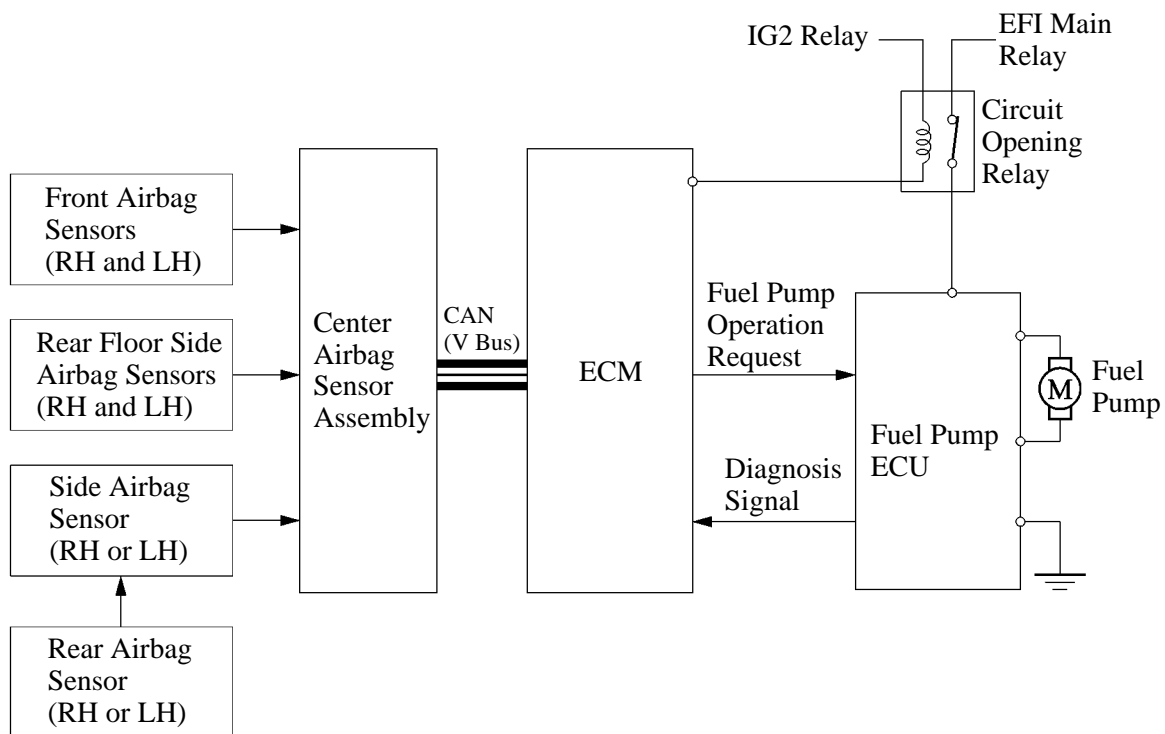
## 9. Fuel Pump Control

### General

In this vehicle, there are 2 types of fuel pump controls. The fuel pump is controlled to an optimum speed to match the engine operating conditions, and the fuel pump operation is stopped when the SRS airbags deploy.

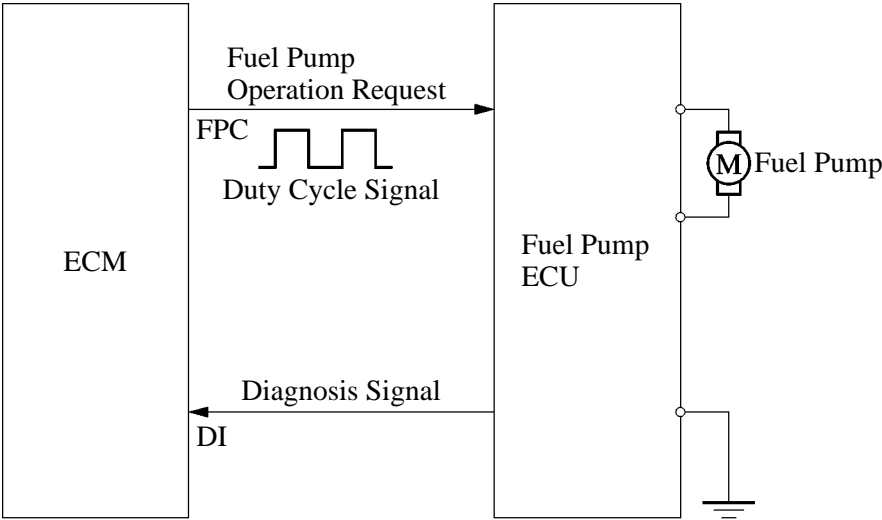
- The ECM transmits a fuel pump operation request signal to the fuel pump ECU that corresponds to the engine operating conditions. The fuel pump ECU receives this request signal and controls the speed of the fuel pump in 3 stages. As a result, under light engine loads, fuel pump speed is kept low to reduce electric power loss.
- A fuel cut control is used to stop the fuel pump when any of the SRS airbags deploys. In this control, if an airbag deployment signal from the center airbag sensor assembly is detected by the ECM, the ECM will turn OFF the circuit opening relay. As a result, the power supply to fuel pump ECU is stopped, causing the fuel pump to stop operating. After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, and the engine can be restarted.

### ► System Diagram ◀



Fuel Pump ECU

- The fuel pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, and control is performed in three stages.
- The fuel pump ECU also detects failures in the input and output circuits at the fuel pump ECU and transmits the failure status to the ECM.



04E0EG24C

► FPC Terminal Input ◀

FPC Input Signal (Duty Cycle Signal)	Fuel Pump Speed
<div><div>+B</div><div>GND</div><div><div></div><div></div></div><div>04E0EG25C</div></div>	High
<div><div>+B</div><div>GND</div><div><div>12.3 ms</div><div>8.2 ms</div><div></div><div></div></div><div>04E0EG26C</div></div>	Middle
<div><div>+B</div><div>GND</div><div><div>4.1 ms</div><div></div><div></div><div></div></div><div>04E0EG27C</div></div>	Low
<div><div>GND</div><div></div><div>04E0EG28C</div></div>	Stop



## 10. Air Injection System

### General

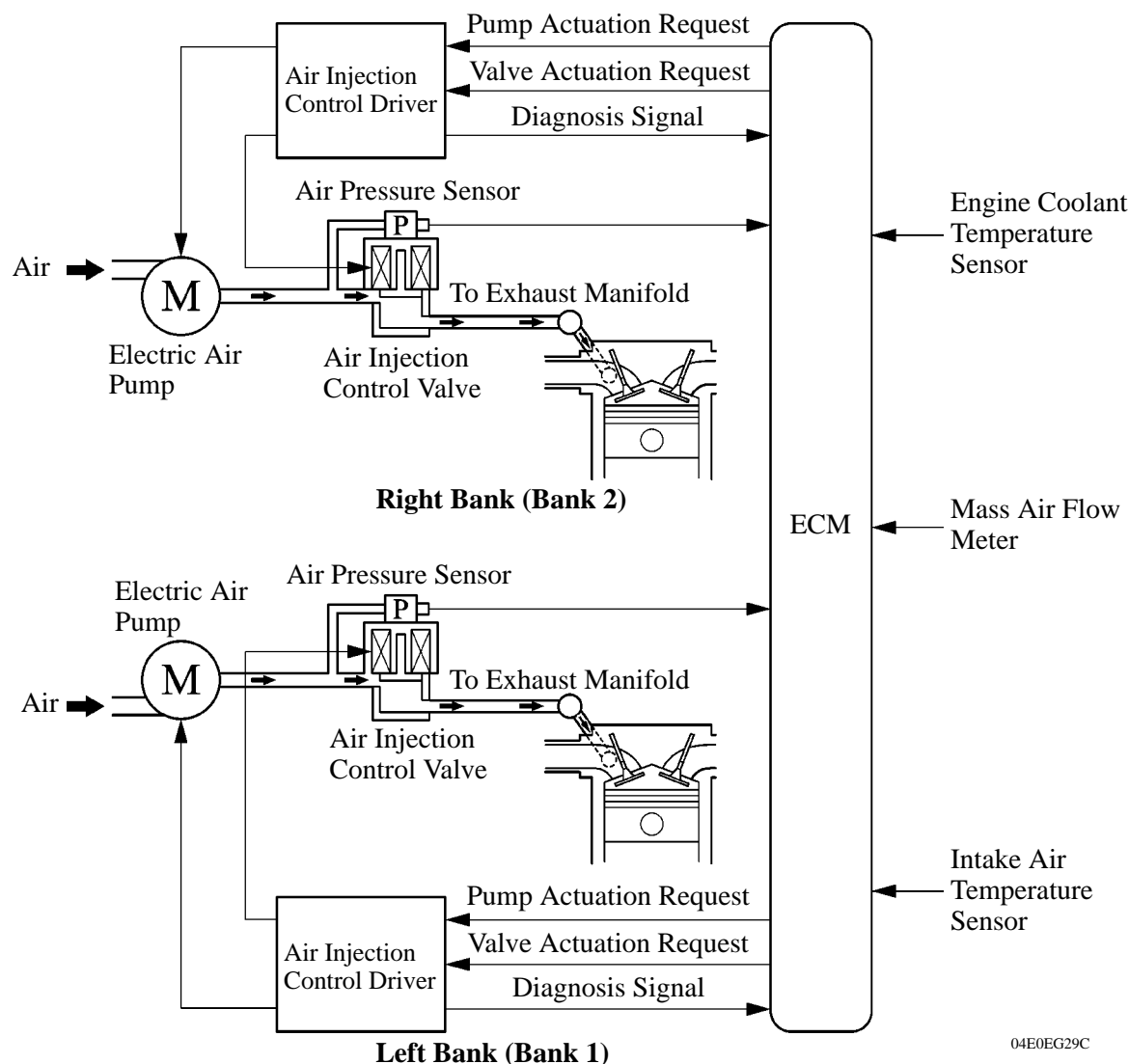
To ensure the proper warm-up performance of the TWCs (Three-Way Catalytic converters) after starting a cold engine, an air injection system is used.

- For this system, each of the right bank (bank 2) and left bank (bank 1) has an electric air pump, air injection control driver, air injection control valve, and air pressure sensor. Control of the right bank and left bank is performed independently. Two pumps are used to increase the amount of air supplied, shortening the catalyst warm-up time.
- The ECM estimates the amount of air injected to the TWCs based on signals from the mass air flow meter in order to regulate the air injection time.
- Air is injected under the following conditions.

### ► Operation Conditions ◀

Engine Coolant Temperature	5 – 45°C (41 – 113°F)
Intake Air Temperature	5°C (41°F) or more

### ► System Diagram ◀

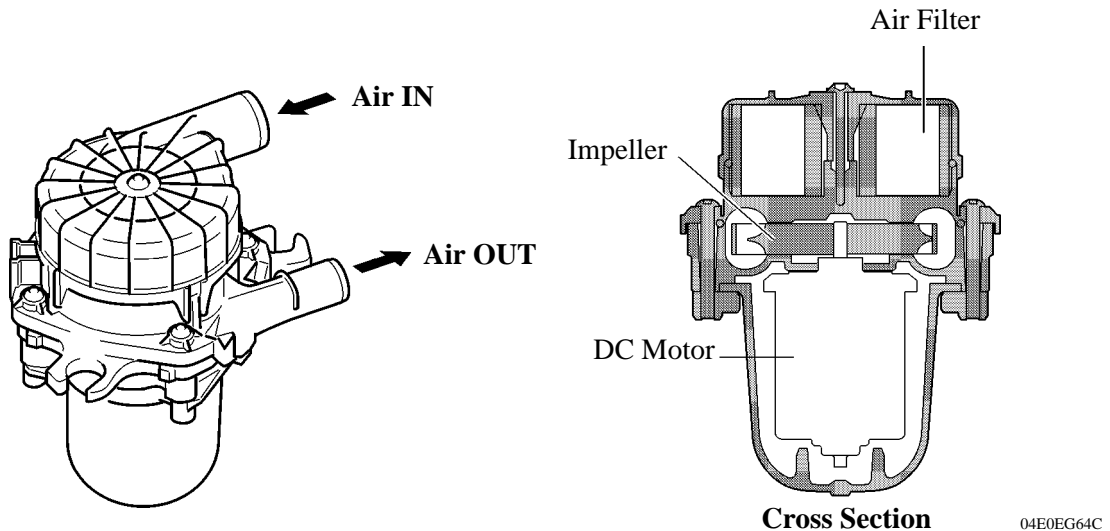


## Construction and Function of Main Components

### 1) Electric Air Pump

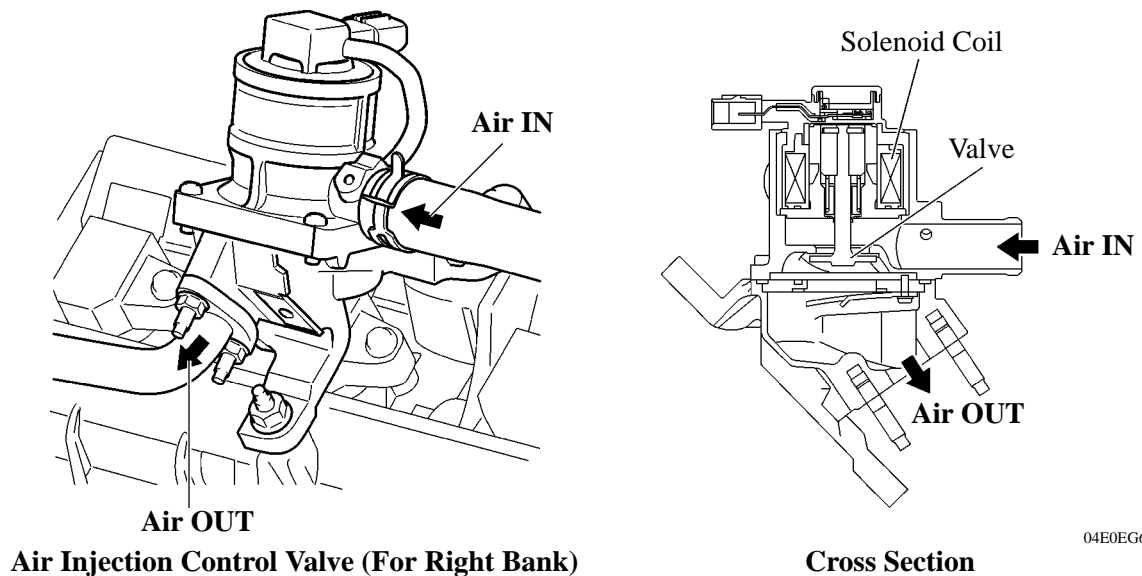
Each electric air pump consists of a DC motor, an impeller and an air filter.

- The electric air pump supplies air into an air injection control valve using its impeller.
- The air filter is maintenance-free.
- The structure and function of the electric air pumps for the right bank and left bank are basically the same.



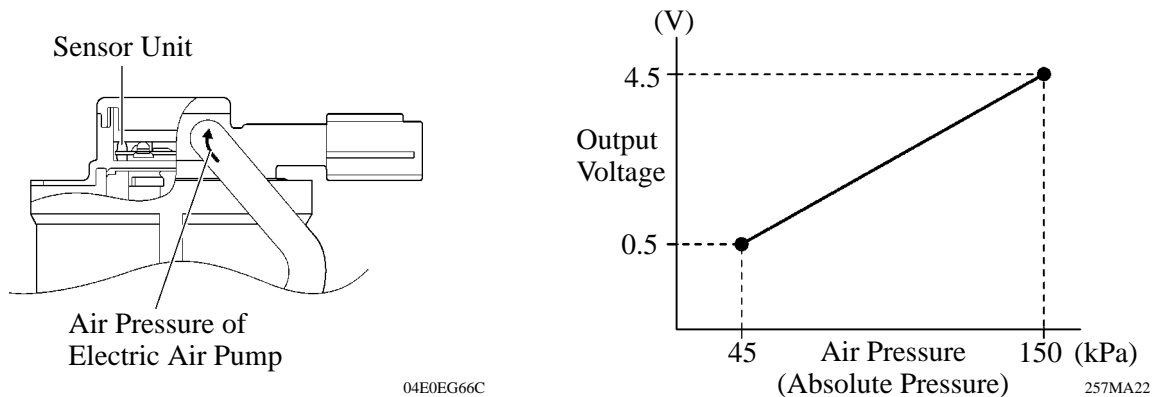
### 2) Air Injection Control Valve

- The air injection control valve is operated by a solenoid coil to control air injection and prevent back-flow of exhaust gas. Opening timing of the valve is synchronized with the operation timing of the electric air pump.
- Each air pressure sensor is built into the corresponding air injection control valve.
- The structure and function of the air injection control valves for the right bank and left bank are basically the same.



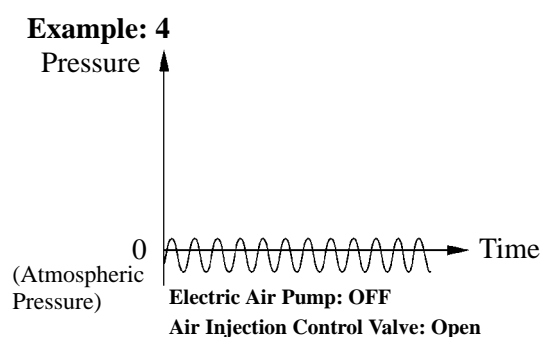
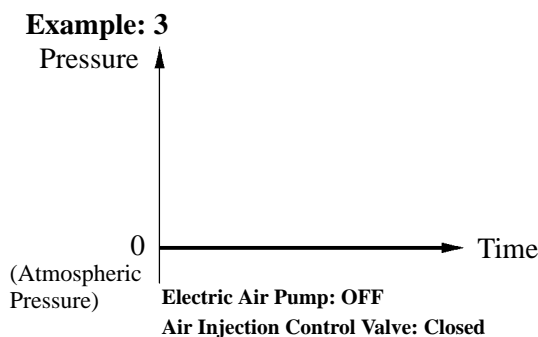
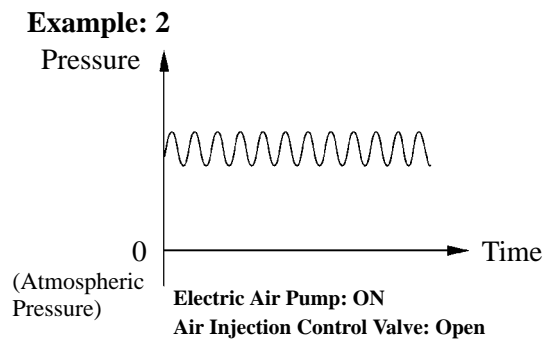
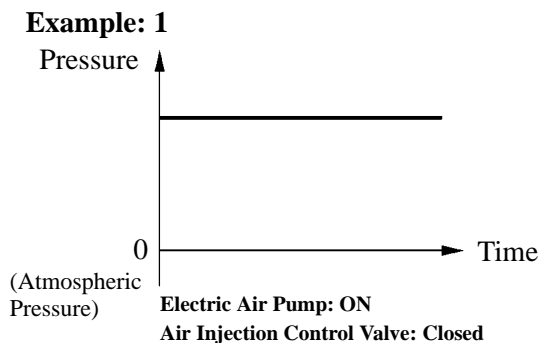
### 3) Air Pressure Sensor

- The air pressure sensor consists of a semiconductor, which has a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.
- The structure and function of the air pressure sensors for the right bank and left bank are basically the same.



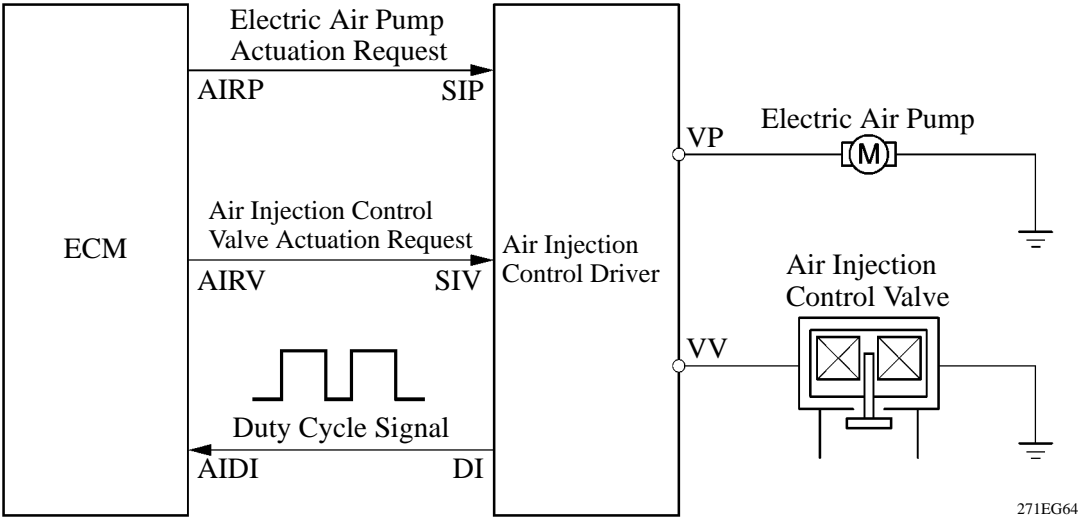
The ECM detects operation of the air injection system based on signals from the air pressure sensor as follows:

- 1) When the electric air pump is ON and the air injection control valve is closed, the pressure is stable.
- 2) When the electric air pump is ON and the air injection control valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
- 3) When the electric air pump is OFF and the air injection control valve is closed, the pressure remains at atmospheric pressure.
- 4) When the electric air pump is OFF and air injection control valve is open, the pressure drops below atmospheric pressure and becomes unstable because of exhaust pulses.

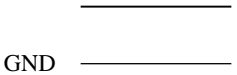
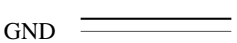
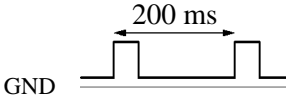
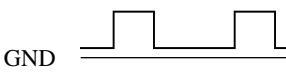
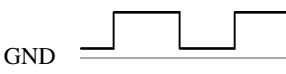
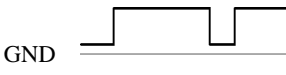
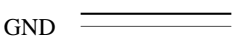


4) Air Injection Control Driver

- A semiconductor type air injection control driver is used. Activated by the ECM, this driver actuates the electric air pump and the air injection control valve.
- The air injection control driver also detects failures in the input and output circuits of the air injection control driver and transmits the failure status to the ECM via duty cycle signals.
- The basic functions of the air injection control drivers for the right bank and left bank are the same. The following system chart shows the left bank (bank 1).



► DI Terminal Output ◀

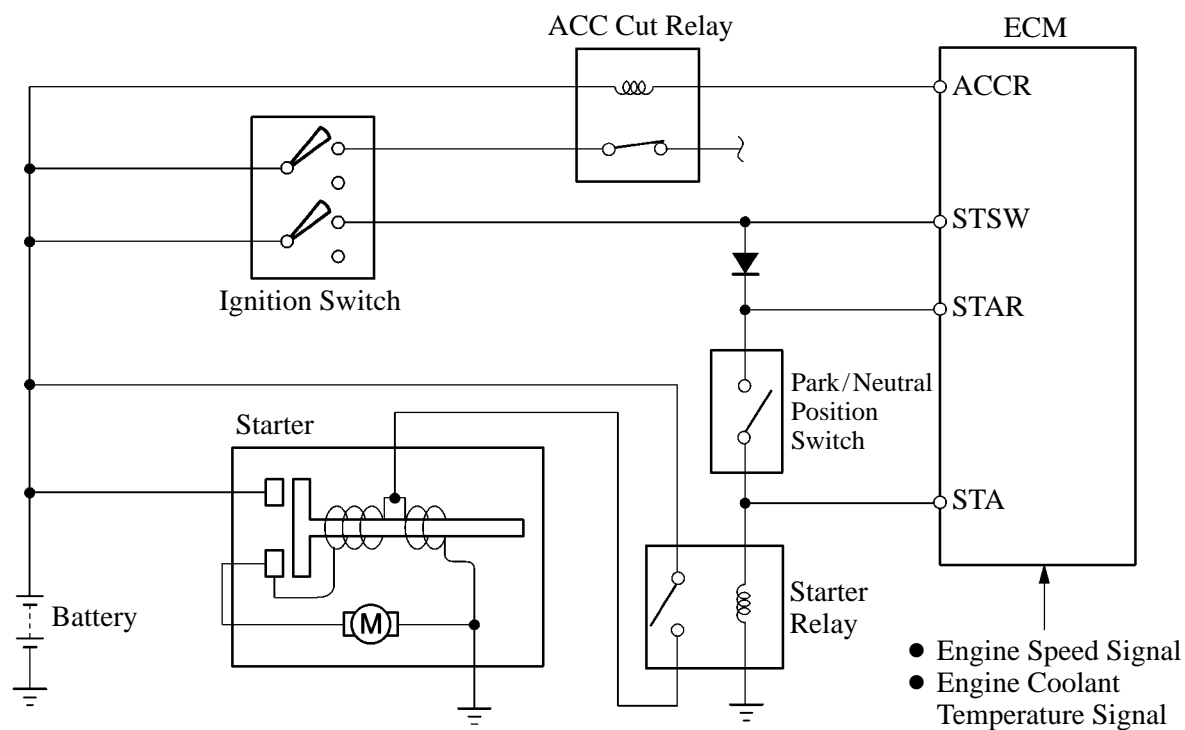
Condition	AIRP	AIRV	Output (Duty Cycle Signal)
Open circuit in line between AIDI and DI terminals.	—	—	 GND 273GX28
Failure in line between ECM terminals and air injection control driver.	—	—	 GND 273GX29
Output failure at air injection control driver. (Failure in electric air pump actuation circuit)	—	—	 GND 273GX30
Output failure at air injection control driver. (Failure in air switching valve actuation circuit)	—	—	 GND 273GX31
Overheat failure of air injection control driver.	—	—	 GND 273GX32
Normal	ON	ON	 GND 273GX33
	OFF	OFF	 GND 273GX29
	ON	OFF	
	OFF	ON	

## 11. Starter Control (Cranking Hold Function)

### General

- Once the ignition switch is turned to the START position, this control continues to operate the starter until the engine starts, without having to hold the ignition switch in the START position. This prevents starting failures.
- When the ECM detects a start signal from the ignition switch, this system monitors the engine speed (NE) signal and continues to operate the starter until it determines that the engine has started.

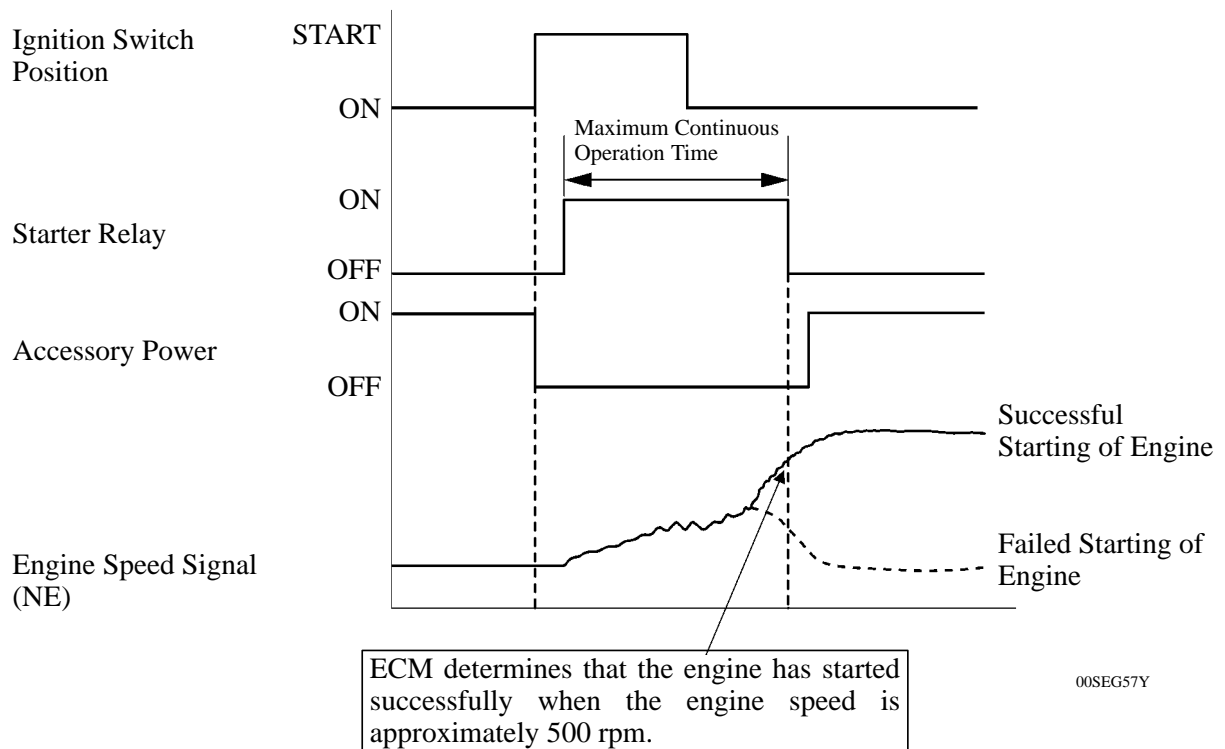
### ► System Diagram ◀



## Operation

- As indicated in the following timing chart, when the ECM detects a start signal from the ignition switch, it energizes the starter relay to operate the starter. If the engine is already running, the ECM will not energize the starter relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the ECM determines that the engine has started and stops the operation of the starter.
- If the engine has any failure and does not work, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time varies depending on the engine coolant temperature condition.
- This system cuts off the current that powers the accessories while the engine is cranking to prevent the accessory illumination from operating intermittently due to the unstable voltage that is associated with the cranking of the engine.
- This system has the following protections.
  - In case that the starter begins to operate, but cannot detect the engine speed signal, the ECM will stop the starter operation immediately. However, if the ignition switch is held in the START position, the starter continues to operate.

### ► Timing Chart ◀



## 12. Evaporative Emission Control System

### General

The evaporative emission control system prevents the fuel vapors that are created in the fuel tank from being released directly into the atmosphere.

The canister stores the fuel vapors that have been created in the fuel tank.

- The ECM controls the purge VSV in accordance with the driving conditions in order to direct the fuel vapors into the engine, where they are burned.
- In this system, the ECM checks for evaporative emission leaks and outputs DTC (Diagnostic Trouble Code) in the event of a malfunction. An evaporative emission leak check consists of an application of vacuum to the evaporative emissions system and monitoring the system for changes in pressure in order to detect a leakage.
- This system consists of the purge VSV, canister, refueling valve, canister pump module, and ECM.
- An ORVR (On-board Refueling Vapor Recovery) function is provided in the refueling valve.
- The canister pressure sensor has been included to the canister pump module.
- A canister filter has been provided on the fresh air line. This canister filter is maintenance-free.
- The followings are the typical conditions necessary to enable an evaporative emission leak check:

Typical Enabling Condition	<ul style="list-style-type: none"> <li>● Five hours have elapsed after the engine has been turned OFF*</li> <li>● Altitude: Below 2400 m (8000 feet)</li> <li>● Battery Voltage: 10.5 V or more</li> <li>● Power Source: OFF</li> <li>● Engine Coolant Temperature: 4.4 to 35°C (40 to 95°F)</li> <li>● Intake Air Temperature: 4.4 to 35°C (40 to 95°F)</li> </ul>
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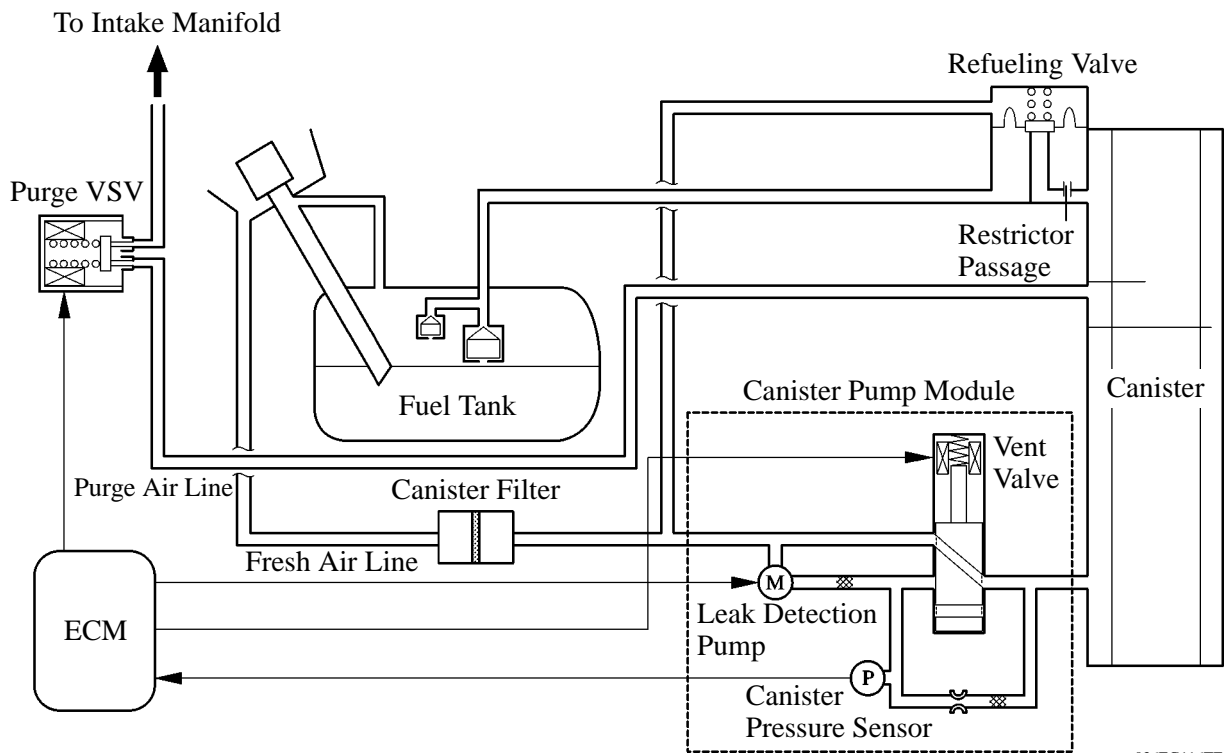
\*: If engine coolant temperature does not drop below 35°C (95°F), this time should be extended to 7 hours. Even after that, if the temperature is not less than 35°C (95°F), the time should be extended to 9.5 hours.

### Service Tip

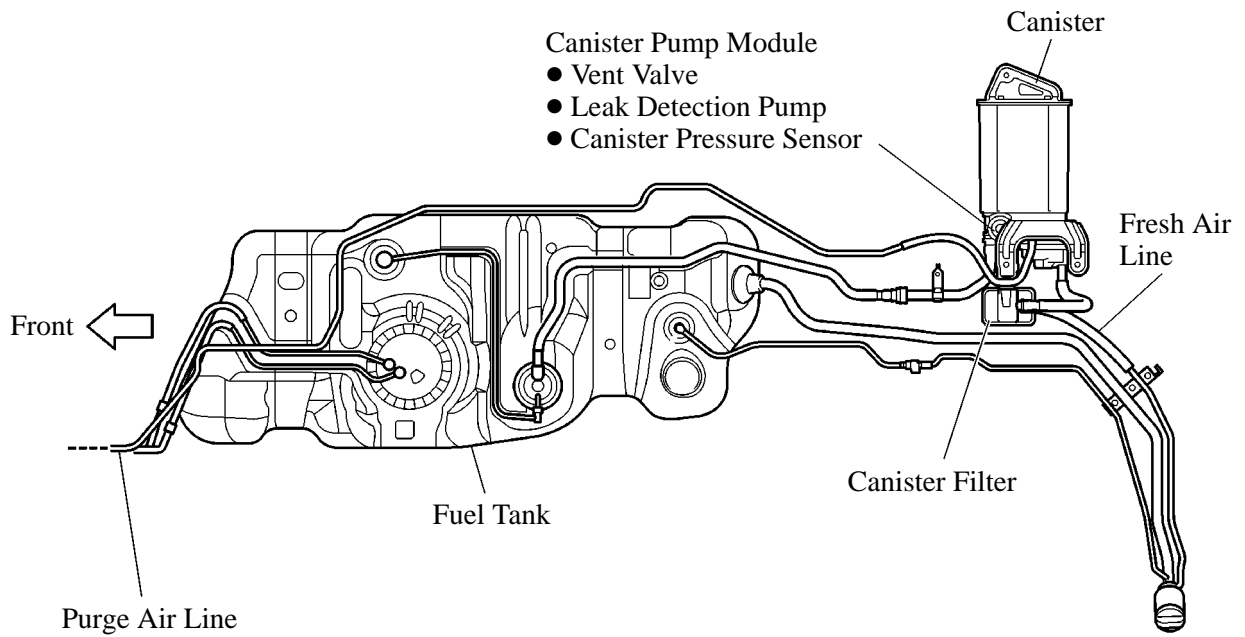
The canister pump module performs a fuel evaporative emission leakage check. This check is done approximately five hours after the engine is turned off. Sound may be heard coming from underneath the luggage compartment for several minutes. This does not indicate a malfunction.

- Pinpoint pressure test procedure is used by pressurizing the fresh air line that runs from the canister pump module to the air filler neck. For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

## System Diagram



## Layout of Main Components



08LEG21Y



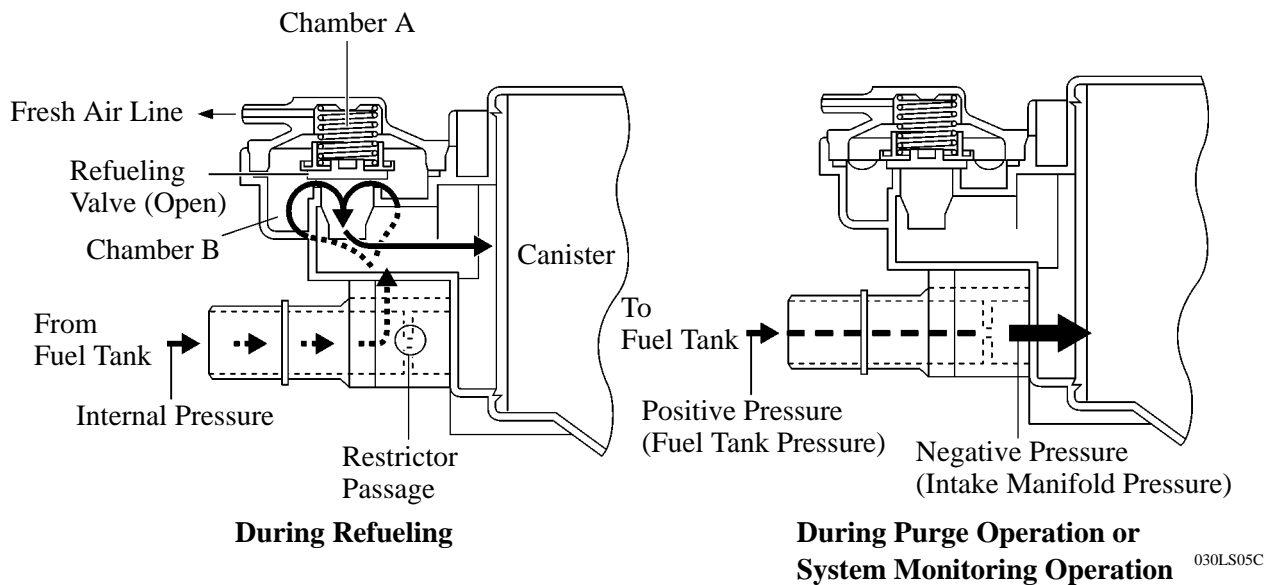
### Function of Main Components

Component		Function
Canister		Contains activated charcoal to absorb the fuel vapors that are created in the fuel tank.
Refueling Valve		Controls the flow rate of the fuel vapors from the fuel tank to the canister when the system is purging or during refueling.
	Restrictor Passage	Prevents a large amount of vacuum during purge operation or system monitoring operation from affecting the pressure in the fuel tank.
Fresh Air Line		Fresh air goes into the canister and the cleaned drain air goes out into the atmosphere.
Canister Pump Module	Vent Valve	Opens and closes the fresh air line in accordance with the signals from the ECM.
	Leak Detection Pump	Applies vacuum pressure to the evaporative emission system in accordance with the signals from the ECM.
	Canister Pressure Sensor	Detects the pressure in the evaporative emission system and sends the signals to the ECM.
Purge VSV		Opens in accordance with the signals from the ECM when the system is purging, in order to send the fuel vapors that were absorbed by the canister into the intake manifold. In system monitoring mode, this valve controls the introduction of the vacuum into the fuel tank.
Canister Filter		Prevents dust and debris in the fresh air from entering the system.
ECM		Controls the canister pump module and the purge VSV in accordance with the signals from various sensors, in order to achieve a purge volume that suits the driving conditions. In addition, the ECM monitors the system for any leakage and outputs a DTC if a malfunction is found.

## Construction and Operation

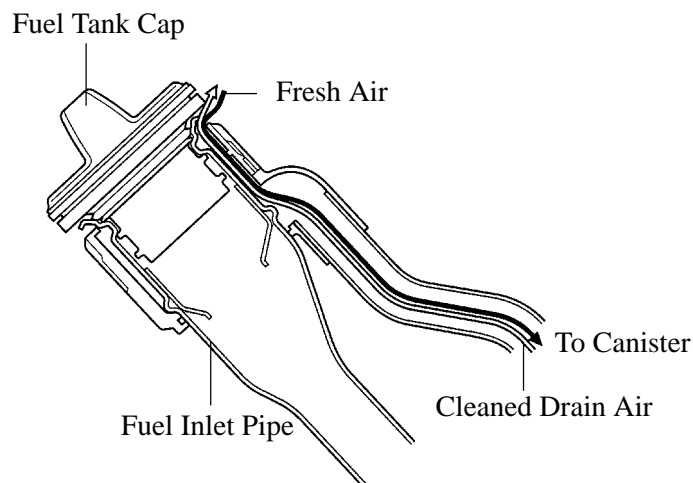
### 1) Refueling Valve

- The refueling valve consists of chamber A, chamber B, and the restrictor passage. A constant atmospheric pressure is applied to chamber A.
- During refueling, the internal pressure of the fuel tank increases. This pressure causes the refueling valve to lift up, allowing the fuel vapors to enter the canister.
- The restrictor passage prevents the large amount of vacuum that is created during purge operation or system monitoring operation from entering the fuel tank, and limits the flow of the fuel vapors from the fuel tank to the canister. If a large volume of fuel vapors enters the intake manifold, it will affect the air-fuel ratio control of the engine. Therefore, the role of the restrictor passage is to help prevent this from occurring.



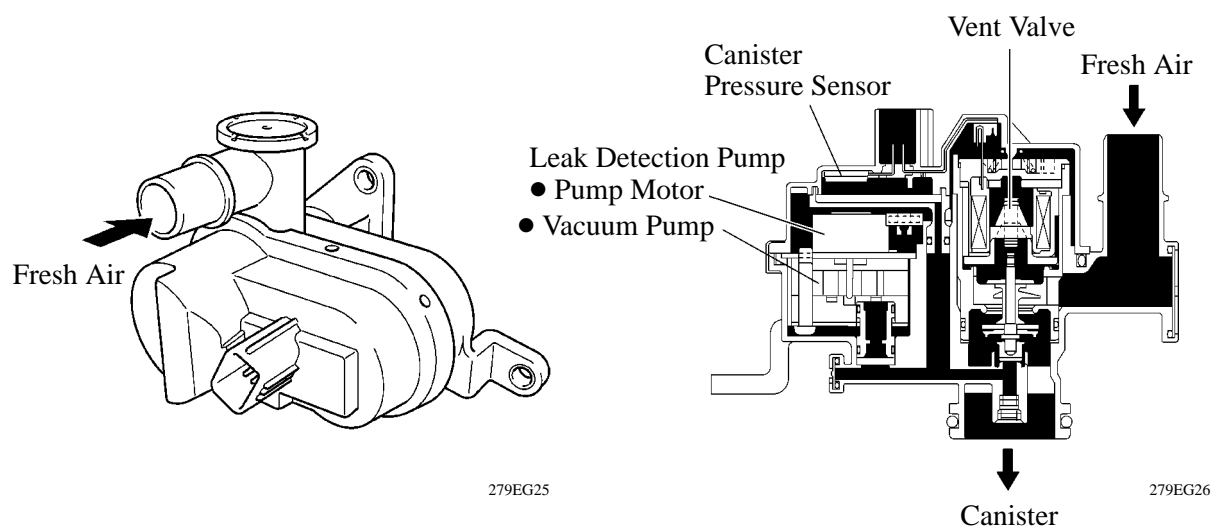
### 2) Fuel Inlet (Fresh Air Inlet)

In accordance with the change of structure of the evaporative emission control system, the location of the fresh air line inlet has been changed from the air cleaner to the near the fuel inlet. The fresh air from the atmosphere and drain air cleaned by the canister will go in or out of the system through the passages shown below.

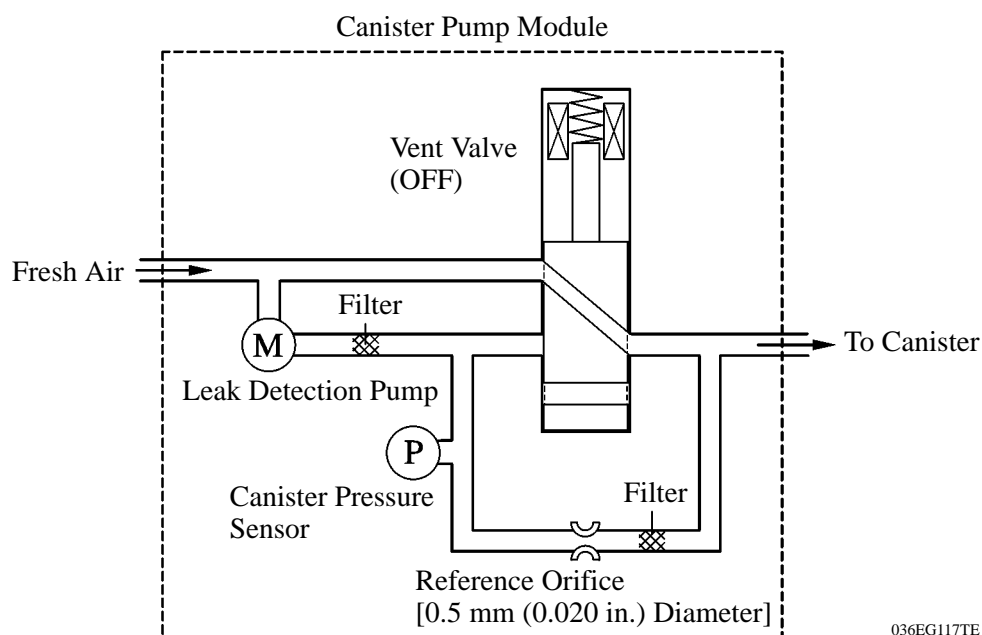


### 3) Canister Pump Module

- The canister pump module consists of the vent valve, canister pressure sensor, and leak detection pump (vacuum pump and pump motor).
- The vent valve switches the passages in accordance with the signals received from the ECM.
- A brushless type DC motor is used for the pump motor.
- A vane type vacuum pump is used.



#### ► Simple Diagram ◀

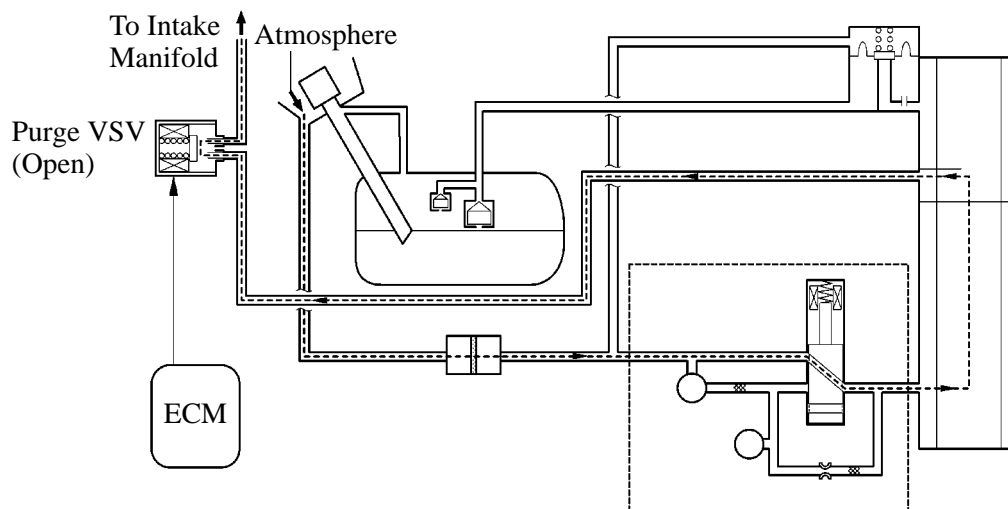


## System Operation

### 4) Purge Flow Control

When the engine has reached predetermined parameters (closed loop, engine coolant temp. above 80°C (176°F), etc.), stored fuel vapors are purged from the canister whenever the purge VSV is opened by the ECM.

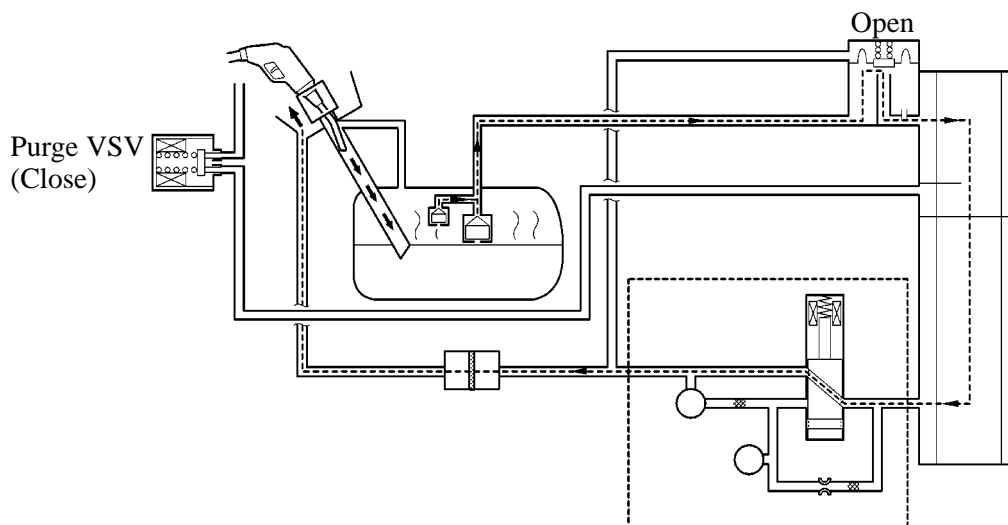
The ECM will change the duty ratio cycle of the purge VSV, thus controlling purge flow volume. Purge flow volume is determined by intake manifold pressure and the duty ratio cycle of the purge VSV. Atmospheric pressure is allowed into the canister to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the canister.



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### 5) ORVR (On-board Refueling Vapor Recovery)

When the internal pressure of the fuel tank increases during refueling, this pressure causes the diaphragm in the refueling valve to lift up, allowing the fuel vapors to enter the canister. The air that has had the fuel vapors removed from it will be discharged through the fresh air line. The vent valve is used to open and close the fresh air line, and it is always open (even when the engine is stopped) except when the vehicle is in monitoring mode (the valve will be open as long as the vehicle is not in monitoring mode). If the vehicle is refueled in system monitoring mode, the ECM will recognize the refueling by way of the canister pressure sensor, which detects the sudden pressure increase in the fuel tank, and the ECM will open the vent valve.



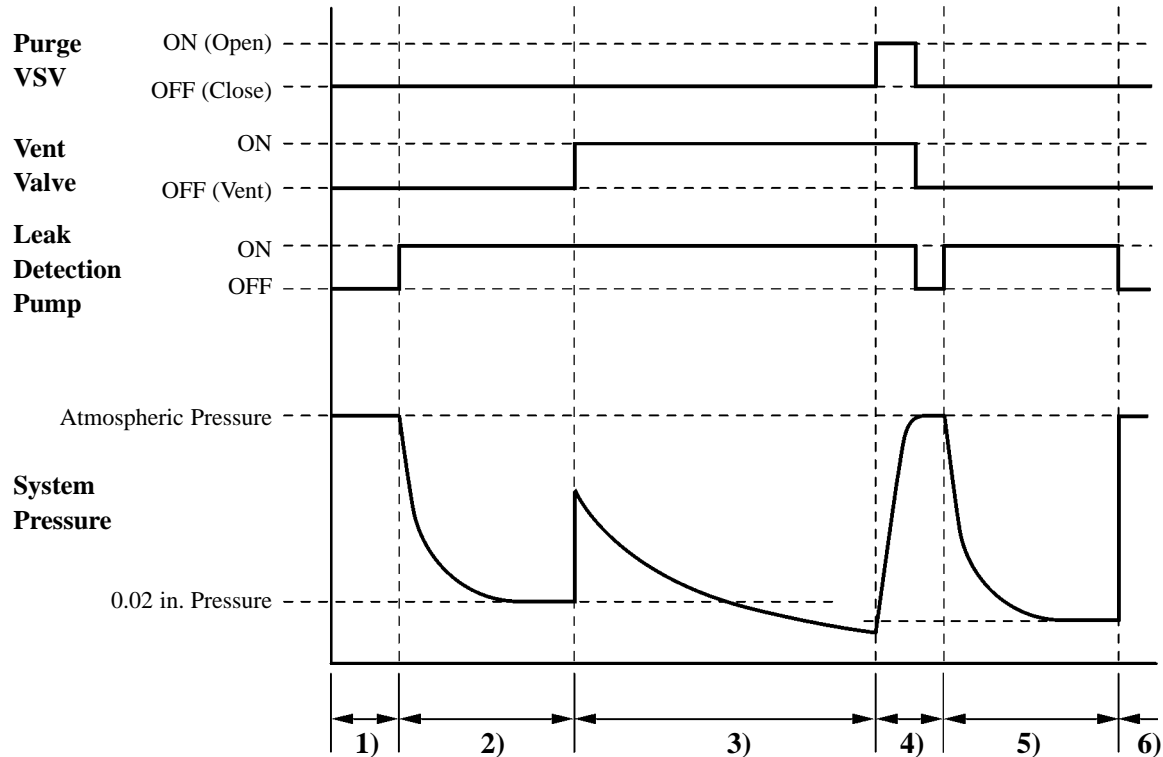
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## 6) EVAP Leak Check

### a. General

The EVAP leak check operates in accordance with the following timing chart:

#### ► Timing Chart ◀

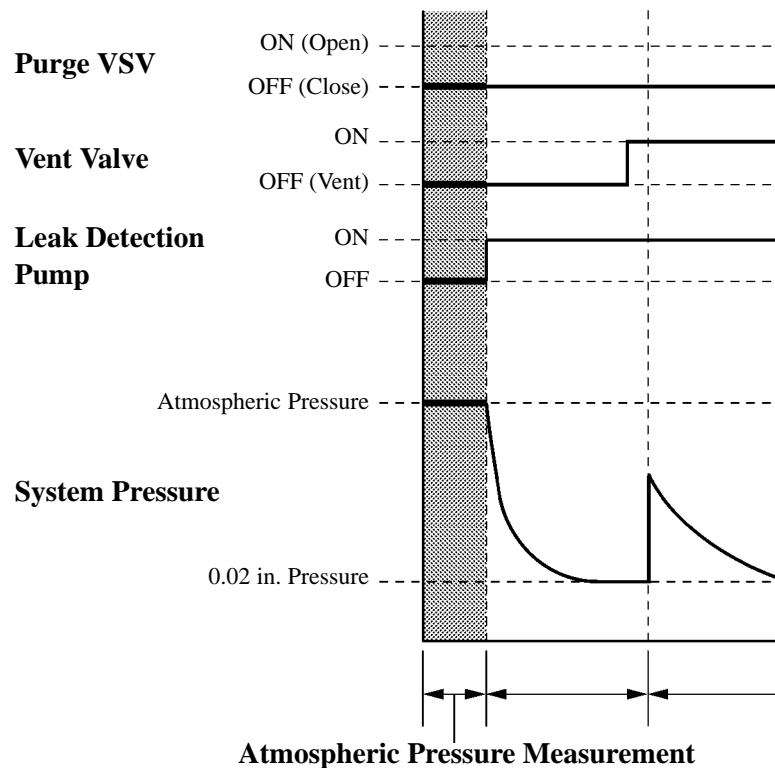
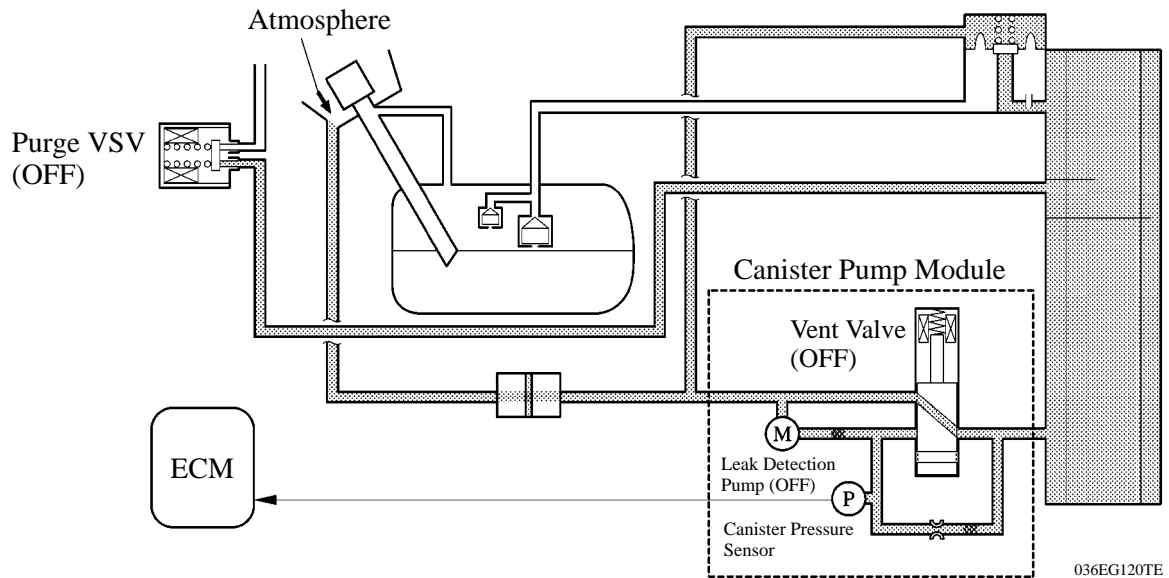


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Order	Operation	Description	Time
1)	Atmospheric Pressure Measurement	The ECM turns the vent valve OFF (vent) and measures EVAP system pressure to memorize the atmospheric pressure.	—
2)	0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through a 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	20 sec.
3)	EVAP Leak Check	The leak detection pump creates negative pressure (vacuum) in the EVAP system and the EVAP system pressure is measured. If the stabilized pressure is larger than the 0.02 in. leak pressure, ECM determines that the EVAP system has a leak. If the EVAP pressure does not stabilize within 15 minutes, the ECM cancels EVAP monitor.	Within 15 min.
4)	Purge VSV Monitor	The ECM opens the purge VSV and measures the EVAP pressure increase. If the increase is large, the ECM interprets this as normal.	10 sec.
5)	Repeat 0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through the 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	20 sec.
6)	Final Check	The ECM measures the atmospheric pressure and records the monitor result.	—

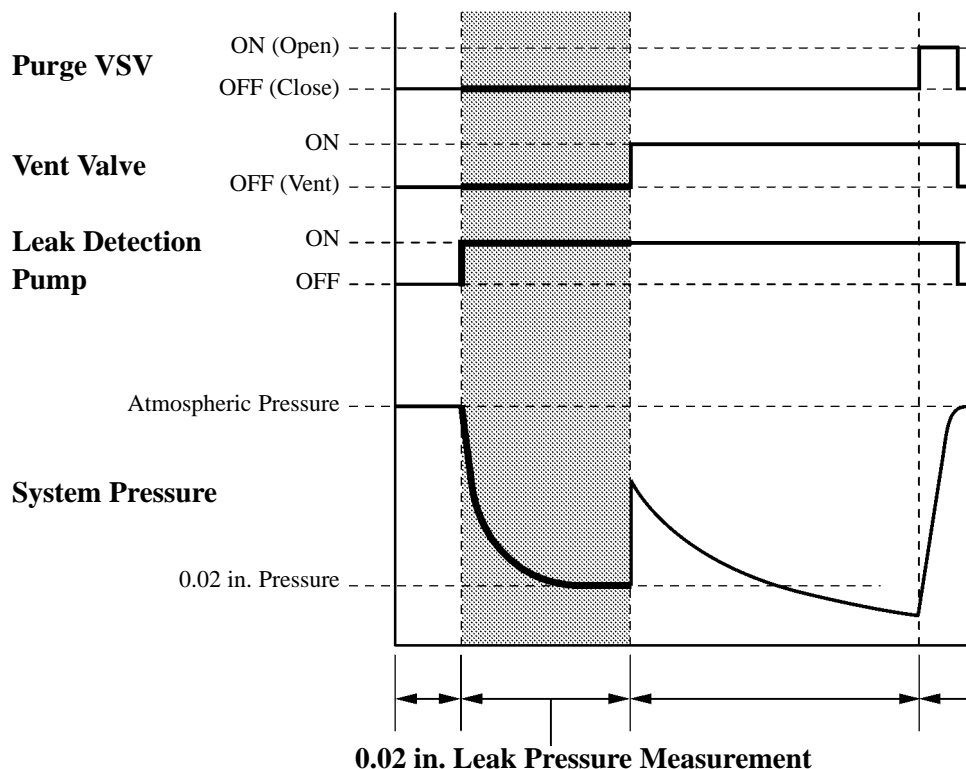
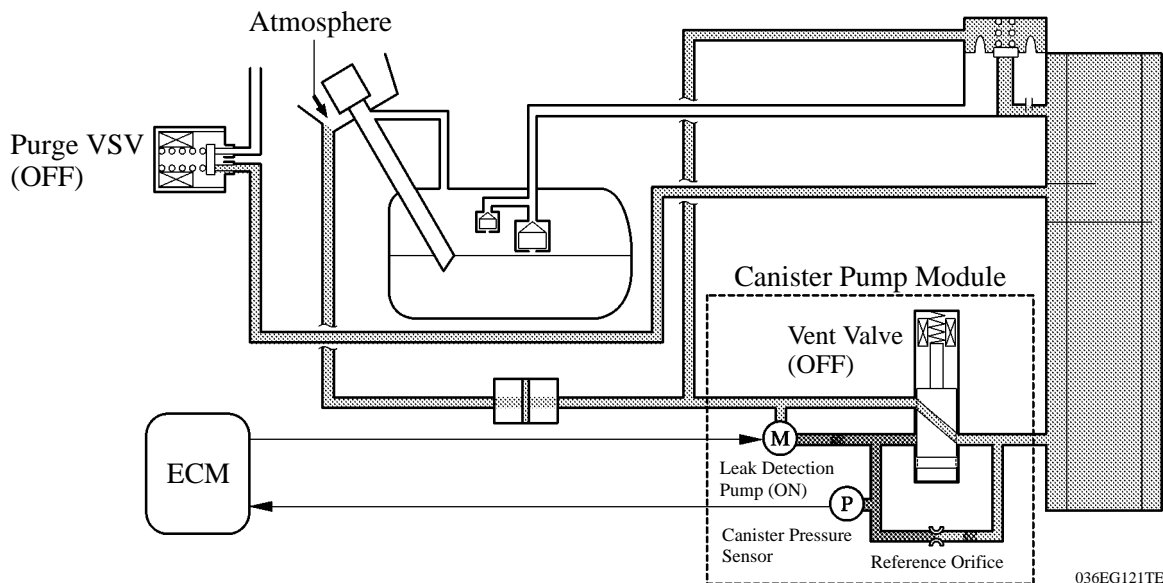
### b. Atmospheric Pressure Measurement

- 1) When the ignition switch is turned OFF, the purge VSV and the vent valve are turned OFF. Therefore, atmospheric pressure is introduced into the canister.
- 2) The ECM measures the atmospheric pressure based on the signals provided by the canister pressure sensor.
- 3) If the measurement value is out of standards, the ECM actuates the leak detection pump in order to monitor the changes in the pressure.



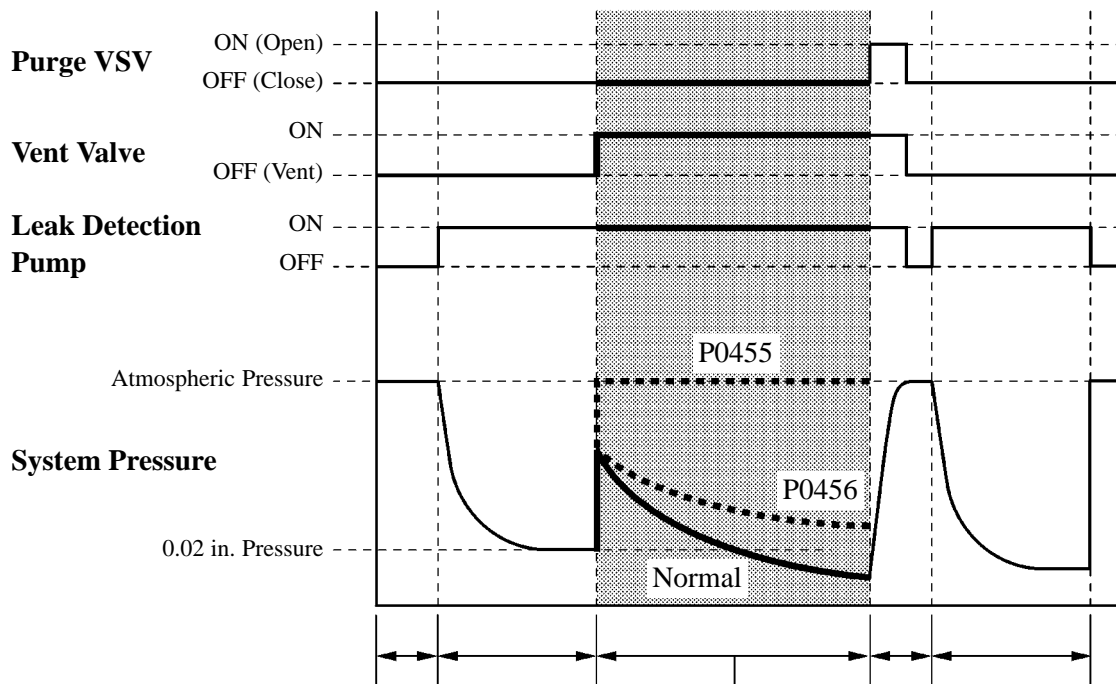
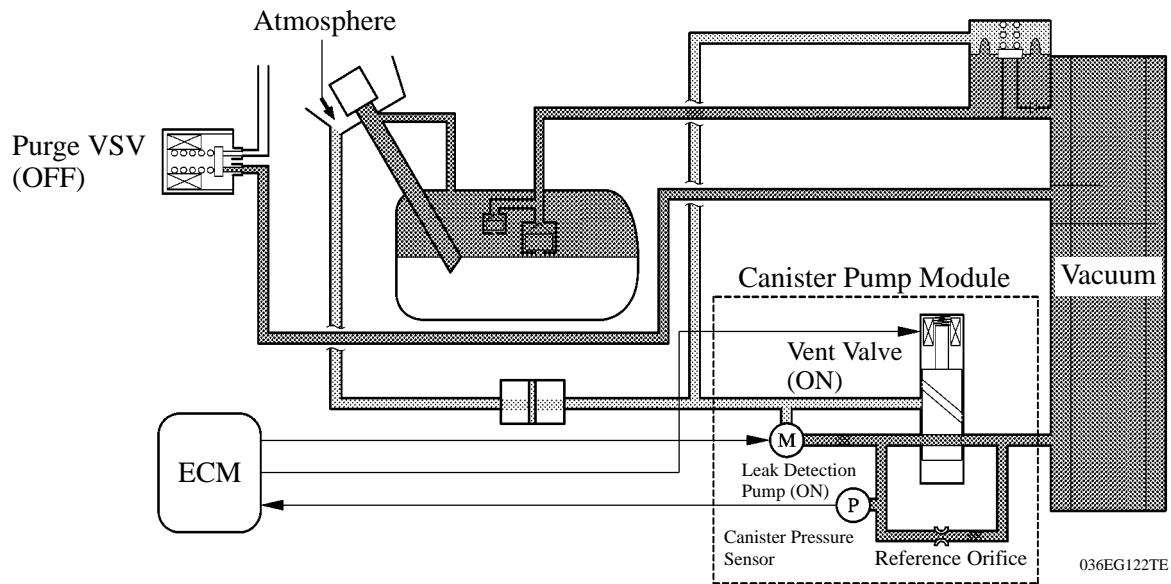
### c. 0.02 in. Leak Pressure Measurement

- 1) The vent valve remains OFF, and the ECM introduces atmospheric pressure into the canister and actuates the leak detection pump in order to create a negative pressure.
- 2) At this time, the pressure will not decrease beyond a 0.02 in. pressure due to the atmospheric pressure that enters through a 0.02 in. diameter reference orifice.
- 3) The ECM compares the logic value and this pressure, and stores it as a 0.02 in. leak pressure in its memory.
- 4) If the measurement value is below the standard, the ECM will determine that the reference orifice is clogged and store DTC P043E in its memory.
- 5) If the measurement value is above the standard, the ECM will determine that a high flow rate pressure is passing through the reference orifice and store DTC P043F, P2401 and P2402 in its memory.



**d. EVAP Leak Check**

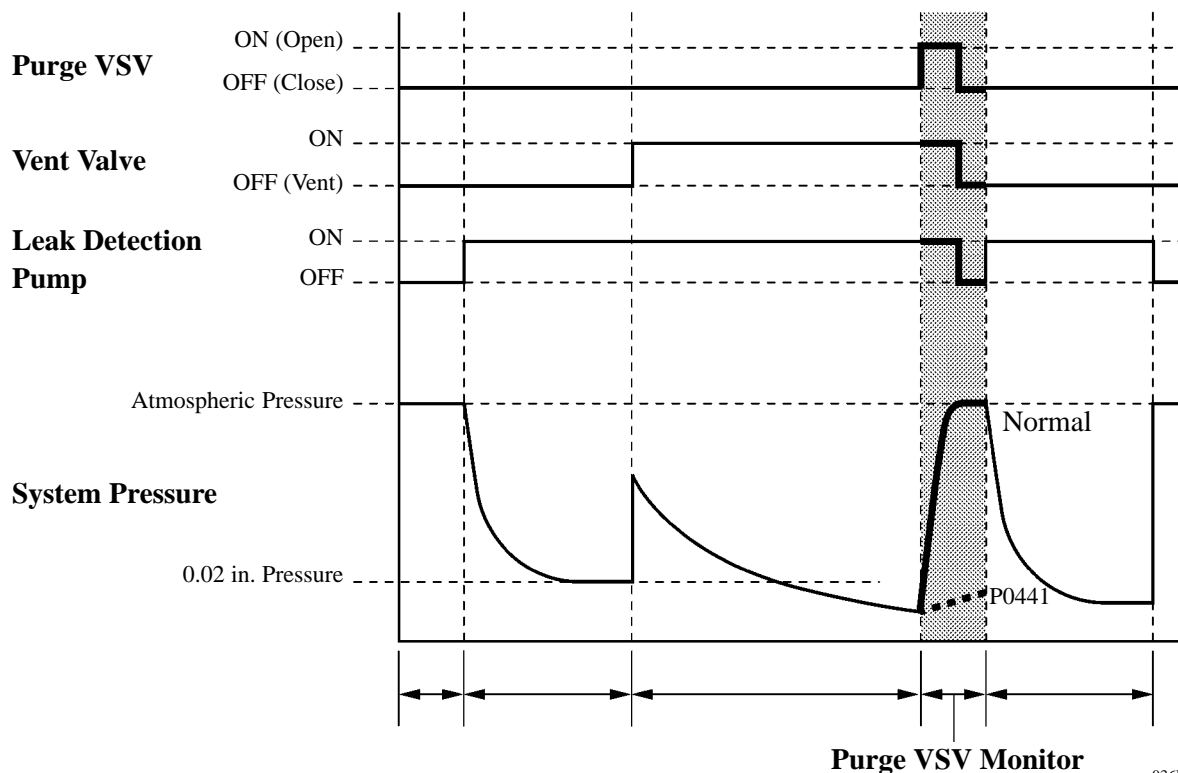
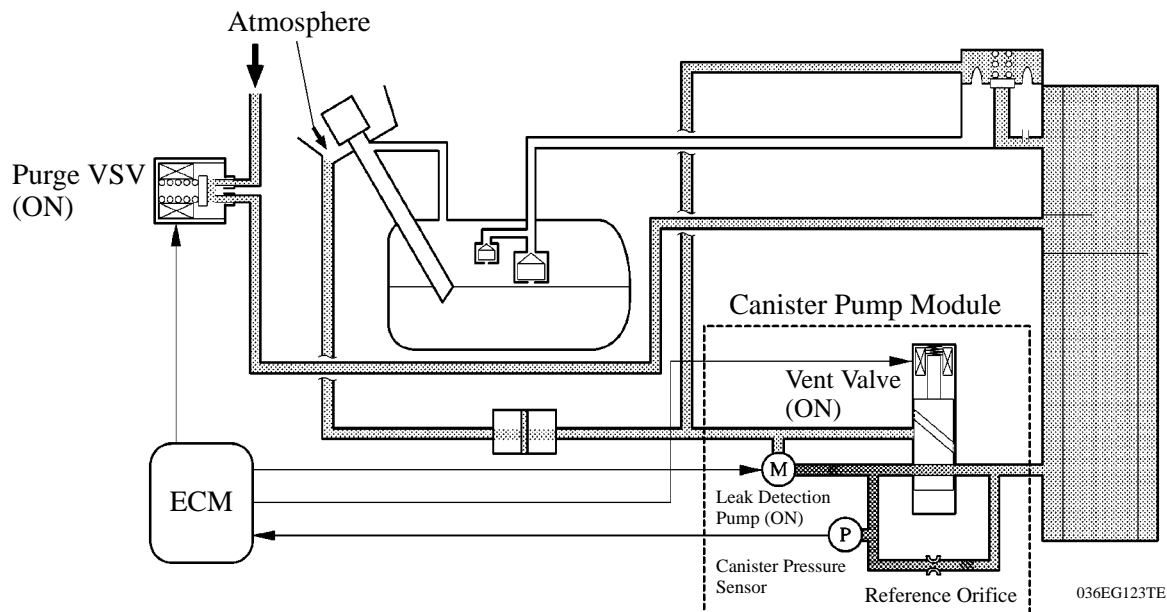
- 1) While actuating the leak detection pump, the ECM turns ON the vent valve in order to introduce a vacuum into the canister.
- 2) When the pressure in the system stabilizes, the ECM compares this pressure and the 0.02 in. pressure in order to check for a leakage.
- 3) If the detection value is below the 0.02 in. pressure, the ECM determines that there is no leakage.
- 4) If the detection value is above the 0.02 in. pressure and near atmospheric pressure, the ECM determines that there is a gross leakage (large hole) and stores DTC P0455 in its memory.
- 5) If the detection value is above the 0.02 in. pressure, the ECM determines that there is a small leakage and stores DTC P0456 in its memory.





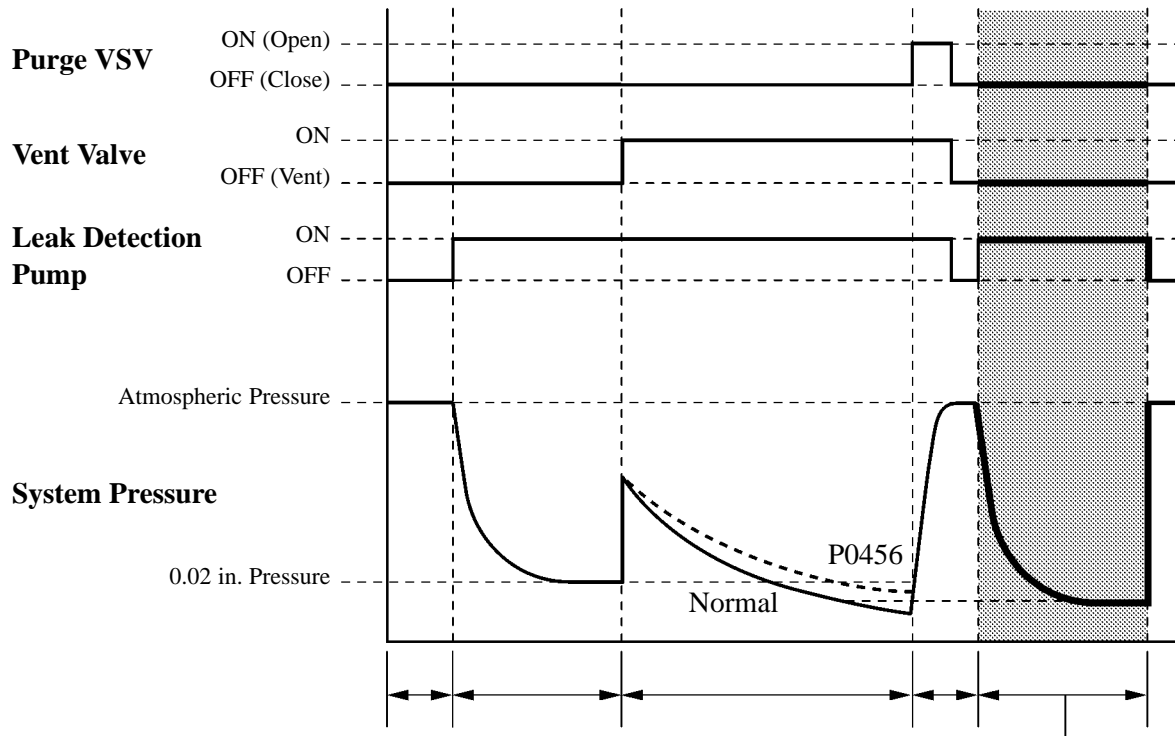
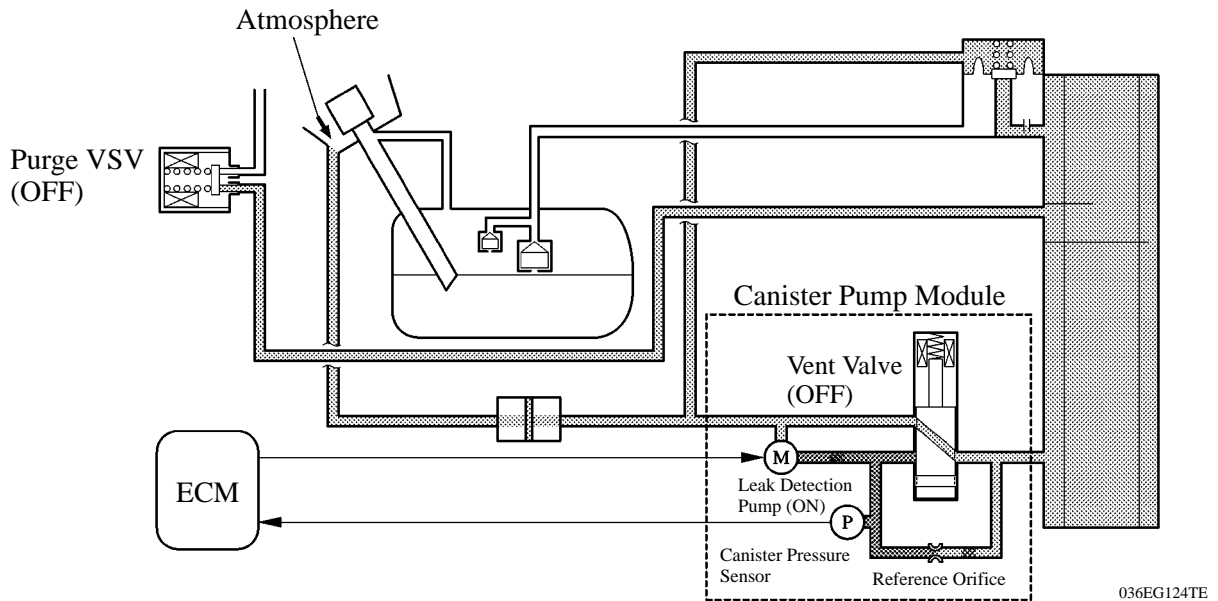
**e. Purge VSV Monitor**

- 1) After completing an EVAP leak check, the ECM turns ON the purge VSV with the leak detection pump actuated, and introduces the atmospheric pressure from the intake manifold to the canister.
- 2) If the pressure change at this time is within the normal range, the ECM determines the condition to be normal.
- 3) If the pressure is out of the normal range, the ECM will stop the purge VSV monitor and store DTC P0441 in its memory.



**f. Repeat 0.02 in. Leak Pressure Measurement**

- 1) While the ECM operates the leak detection pump, the purge VSV and vent valve turn OFF and a repeat 0.02 in. leak pressure measurement is performed.
- 2) The ECM compares the measured pressure with the pressure during EVAP leak check.
- 3) If the pressure during the EVAP leak check is below the measured value, the ECM determines that there is no leakage.
- 4) If the pressure during the EVAP leak check is above the measured value, the ECM determines that there is a small leak and stores DTC P0456 in its memory.

**Repeat 0.02 in. Leak Pressure Measurement**

### 13. Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the MIL (Malfunction Indicator Lamp) in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the Techstream.
- For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

#### **Service Tip**

To clear the DTC that is stored in the ECM, use the Techstream, disconnect the battery terminal or remove the EFI MAIN fuse and ETCS fuse for 1 minute or longer.

### 14. Fail-safe

#### **General**

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECM either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).