



In the March *Import Service*, we began a discussion of OBD-II evaporative emissions systems. We explained system operation and the problems engineers face when designing the monitoring devices for these systems. We also looked at the early Toyota evaporative emissions system and explained how the charcoal canister functions. This month we will continue with Toyota evaporative systems, examining the Toyota on-board fuel vapor recovery system, as well as Toyota's newest leak detection methods.

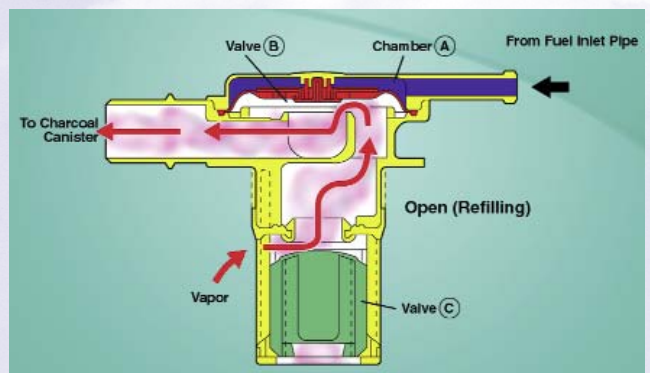
The designs of OBD-II systems are determined by EPA and CARB regulations, and these regulations are more restrictive each successive year. In response to recent changes, Toyota has introduced two new evaporative system variations. An on-board vapor recovery system was added to the Celica for the 1998 model year, and a new leak detection system was implemented for all Toyota models with the 2000 model year.

Right: Figure 1 — ORVR Valve
The ORVR valve relies on pressure differential to operate.

On-Board Refueling Vapor Recovery

Toyota's On-Board Refueling Vapor Recovery (ORVR) relies on a recovery valve at the top of the fuel tank, connected to the filler pipe and charcoal canister. As fuel is dispensed into the tank, a pressure differential builds between the fill pipe and fuel tank, across the vapor recovery valve. This opens the recovery valve and vents vapors from the fuel tank into the charcoal canister. The canister then adsorbs the hydrocarbons before they can enter the atmosphere. At rest, the recovery valve seals these vapors so they can't exit, except through the normal vent via the tank air valve on the canister.

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Illustrations courtesy University of Toyota

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As you can see, this system is very simple and does not require OBD-II monitors. The PCM is not involved, and there aren't any electrical components. This system should be very robust, and the only problem I can imagine would be a restriction in the ORVR that might hamper fuel filling. According to Toyota, another scenario occurs when the consumer fills the tank while the engine is running. This can cause an excessively rich condition, and the fuel trim will adjust to compensate. After refueling is complete, the fuel trim may be skewed to the lean side, which may cause a hesitation.

Evaporative System Leak Monitoring

Toyota's next generation evaporative leak monitoring system was introduced for the 2000 model year. It is designed to meet the stringent CARB and EPA-mandated 0.20-inch orifice leak detection standard. Accurate detection of leaks from such a small aperture is much more difficult than the older standard (0.40-inch orifice), so the system has changed somewhat. The most important change is the use of vacuum instead of pressure to run the leak monitor.

As we discussed in Part One, the early Toyota system pressurized the tank to check for leaks. This system didn't meet the newer standards, so Toyota adopted a system in use for some time by several other manufacturers. The "late system," as Toyota refers to it, is able to meet the tighter standards with only minor hardware changes.

Changes introduced with the late system include:

- The pressure sensor has been moved from the charcoal canister to the fuel tank.
- A closed canister valve (CCV) vacuum switch valve (VSV) has been added to the filtered air line on the canister.
- A bypass VSV was installed in the vacuum line where the VP (vapor pressure) VSV used to be.
- The canister is basically the same for early and late evaporative systems, including the air valves mounted to the top of the canister. The only exception is on the Echo, which uses one air valve.

Figure 2 — Echo Pressure Valve

The new Toyota Echo has the pressure sensor mounted directly on the fuel tank.



Figure 3 — Echo Canister

Caption: The Toyota Echo also uses a slightly different canister with only one air valve.

The basic concept of the late system is to close off the fuel tank and charcoal canister and use engine vacuum to pull fuel tank pressure low. The PCM then monitors for a pressure rise to determine whether there is a leak.

The CCV was added to the vent portion of the canister to close off fresh air and to seal the tank and canister while monitoring for a leak. Simply stated, the purge VSV opens, and the canister vent VSV closes. This applies vacuum to the fuel tank. When a predetermined vacuum threshold is reached, the purge VSV closes — trapping the vacuum in the tank. The system is held in this mode for a predetermined time, and the PCM tracks the rate of pressure change to detect a leak.

The bypass VSV was added to permit engine vacuum to reach the fuel tank, bypassing the tank valve assembly. This is a PCM-controlled device, and it is used only for leak detection. Leak detection is run only once per drive cycle, and a drive cycle is defined as follows:

- Coolant and air temperature must be within 12 degrees F of each other at startup. The ambient temperature must be between 40 and 100 degrees F and ideally should be below 95 degrees F.
- If these conditions are met, the vehicle must then be driven according to the Los Angeles Number 4 Drive Cycle (LA 4). Only then will the monitor run. The graph in **Figure 4** (page 30) illustrates the LA 4 Drive Cycle.
- The monitor will run in under 20 minutes and may actually complete in 12–15 minutes if no problems are detected during the test. If a problem is detected, it may take longer for the monitor to complete.

- Although a fuel level input is not used on Toyota models, there is software in place to estimate fuel sloshing, and this condition may suspend the monitor.
- Another point to take into consideration is that the vehicle can't be shut off during this test or the monitor will abort until the next cooldown cycle.
- If the monitor passes the first trip test, it will set the readiness flag to COMPLETE. A second trip failure test is necessary to set the MIL status to ON and store a code.

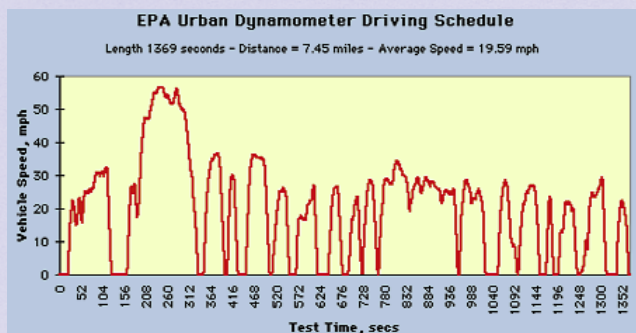


Figure 4 Los Angeles Number 4 Drive Cycle

The EPA Urban Dynamometer Driving Schedule (UDDS) is commonly called the "LA 4" or "the city test" and represents city driving conditions. It is used for light duty vehicle testing.

These steps should look familiar to you, as they are the same as for the early evap-monitoring system. The only difference is the method of detection. Leak detection follows a very specific sequence, and a failure in any part will set a DTC relating to that fault. **Figure 5** illustrates the sequence that occurs during the drive cycle.

Figure 5 — Test Procedure Chart

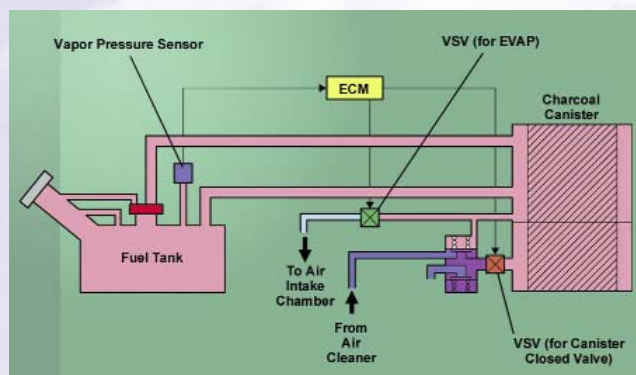
This chart illustrates the procedure used by the PCM during monitor operation.

1. The PCM monitors the tank pressure as it rises during normal operating conditions.
2. The PCM opens the purge VSV to purge vapors from the charcoal canister, and tank pressure continues to rise.
3. If the PCM determines conditions are within parameters to check for a leak, it closes the CCV and opens the bypass VSV.
4. The PCM continues to operate the purge VSV, which causes pressure to drop in the fuel tank.
5. When pressure reaches a specific point, the PCM turns the purge VSV off and monitors for a change in pressure.
6. Some pressure increase is normal, and when it reaches a specific value the PCM opens the CCV, causing a sharp rise.
7. The PCM then closes the bypass VSV, and the pressure rise is not as sharp.

Each step is critical to the system-check, and a failure in any step will abort the test or set a DTC. The evaporative monitor uses a two-trip detection logic. That is, the first time the monitor sees a fault, it will set a pending code and store the freeze frame data. If the system fails on a second complete drive cycle, the MIL turns on.

Figure 6 — Echo Evap Diagram

The new Echo uses a slightly different evap system. This canister has only one air valve, and only two VSV's are needed.



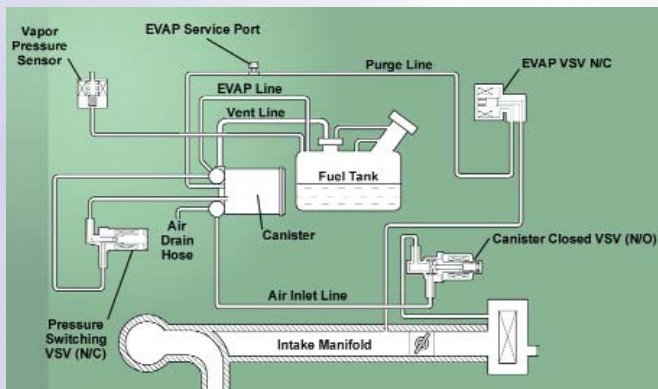


Figure 7 — Avalon Evap Diagram

The Avalon is typical of most Toyota late evap systems using ORVR — three VSV's and two air valves on the canister. N/C = normally closed.

During Step 4, the PCM monitors the tank for pressure drop. This is the Toyota method to determine purge flow. If you remember from Part One, the early system used a unique method to determine purge flow. In the late system, flow exists if a pressure drop occurs in the fuel tank when the vent valve closes and the purge valve opens. A lack of pressure drop here generally sets code P0441.

At least one new code has been added to the late evaporative system, depending on the model. Code P0440 is carried over from the early systems. It still indicates a leak, but now refers to a *large* leak. Code P0442 was added to 2000 models to indicate a *small* leak. These codes are set depending on how quickly the pressure rises during Step 5.

Practice Now, Profit Later

Many technicians refer to OBD-II evap DTC's as "gas cap codes," perhaps because a DTC can be set if the gas cap is not properly reinstalled after refueling. This can be misleading due to the OBD-II two-trip detection logic. Many newer gas caps are designed to be either completely ON or completely OFF. It seems unlikely that the cap could be left off long enough to run the monitor twice and turn on the MIL. This is especially true when you consider the difficulty in getting the monitor to run under ordinary circumstances. So before clearing the code and

chalking it up to another loose gas cap, check the system for leaks.

Many import and domestic cars built since 1996 include a pressure port on the evaporative line, which can be used to check for leaks. Toyota recently added this port to many of its cars as well. While this is not the only way to find a leak, it can be helpful for finding those pesky small leaks. I suggest you start practicing to find small 0.40-inch leaks on the earlier systems — before we start chasing the tiny 0.20-inch leaks.

Thanks

In closing, I'd like to give special thanks to the University of Toyota for their help with this pair of articles. They are committed to providing information to their dealership technicians, as well as to aftermarket technicians. This commitment builds a positive reputation among those who service and repair Toyotas. Technicians need the same level of cooperation from all manufacturers. Unfortunately, a few manufacturers have chosen to withhold necessary descriptions of their systems. Maybe some day more auto manufacturers will realize that independent shops make vehicle purchase recommendations to their customers on a daily basis. The cars they recommend are generally cars they are confident they will be able to repair in the future. ■

— By Randy Bernklau