E - THEORY/OPERATION - 2.4L

1995 Toyota 4Runner

1995 ENGINE PERFORMANCE
Toyota - Theory & Operation

4Runner - 2.4L

* PLEASE READ THIS FIRST *

NOTE: California and Federal applies to installed emission equipment, which may be verified by underhood emission decal. California emissions may be available in other states. References to California models applies to California emission vehicles.

INTRODUCTION

This article covers basic description and operation of engine performance-related systems and components. Read this article before diagnosing vehicles or systems with which you are not completely familiar.

COMPUTERIZED ENGINE CONTROLS

TOYOTA COMPUTER CONTROL SYSTEM (TCCS)

The TCCS is a computerized emission, ignition and fuel injection control system. The TCCS lowers exhaust emissions while maintaining good fuel economy and driveability. System consists of various sensors, switches and control units. See Fig. 1.

An Engine Control Module (ECM) controls the TCCS based on input signals received from various input devices. The ECM contains preprogrammed data to maintain optimum engine performance under all operating conditions.

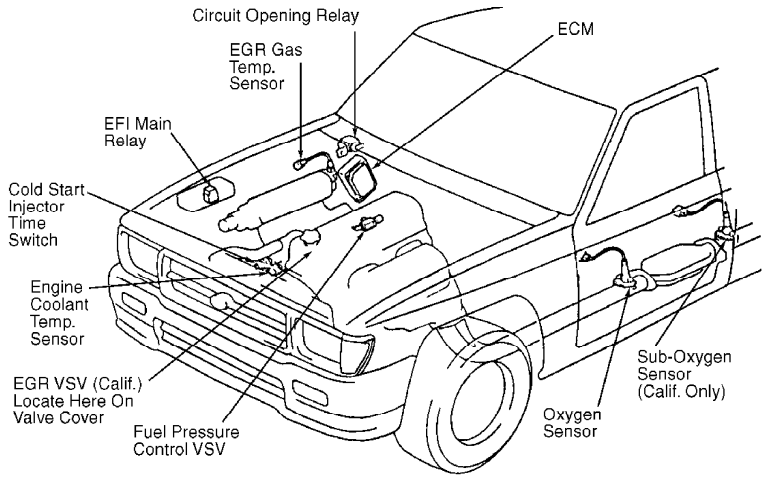

Fig. 1: Locating TCCS Components
Courtesy of Toyota Motor Sales, U.S.A., Inc.

ENGINE CONTROL MODULE

The Engine Control Module (ECM) microcomputer receives input signals from various sensors, switches, and ignition and starting system components. The ECM uses this information for controlling various functions. See OUTPUT SIGNALS under COMPUTERIZED ENGINE CONTROLS.

The ECM has constant battery voltage at BATT terminal. The ECM contains a fail-safe function, used in case of sensor or switch failure. Fail-safe function uses preprogrammed values to provide a limp-in mode for minimal driveability. If a failure exists, ECM will inform the driver by turning on Malfunction Indicator Light (MIL) on the instrument panel.

NOTE: The MIL may also be referred to as the CHECK ENGINE light.

The ECM is equipped with a self-diagnostic function. Diagnostic trouble codes may be set by the malfunction of various engine sensors, switches or circuits, and stored in the ECM memory. When certain diagnostic trouble code is stored, Malfunction Indicator Light (MIL) on instrument panel may come on.

ECM LOCATION TABLE

Model	Location
4Runner	Behind Passenger's Side Kick Panel

NOTE: Components are grouped into 2 categories. First category is INPUT DEVICES, which covers components that control or produce voltage signals monitored by the Engine Control Module (ECM). Second category is OUTPUT SIGNALS, which are components controlled by the ECM.

INPUT DEVICES

Vehicles are equipped with different combinations of input devices. Not all devices are used on all models. To determine input device usage on a specific model, see appropriate wiring diagram in the L - WIRING DIAGRAMS - 2.4L article. Available input signals include the following:

A/C Switch

When A/C is turned on, input signal is delivered to Engine Control Module (ECM). The ECM uses input signal to control engine idle speed during A/C operation.

NOTE: Airflow meter may be referred to as Volume Airflow (VAF) meter or Mass Airflow (MAF) meter.

Airflow Meter

Airflow meter measures intake airflow volume. Airflow meter delivers intake air input signal by means of a variable resistor (potentiometer).

Input signal is sent to Engine Control Module (ECM) for controlling fuel injection system operation and ignition timing (spark advance). Airflow meter also contains a switch which is used for controlling fuel pump operation.

Battery Signal

Battery voltage is always present at BATT terminal of Engine Control Module (ECM). When ignition is turned on, voltage for ECM operation is applied through EFI main relay to terminal +B.

Brakelight Signal

Brakelight switch delivers an input signal to STP terminal of Engine Control Module (ECM) to indicate when brakes are applied.

Cold Start Injector Time Switch

Cold start injector time switch delivers input signal to STJ terminal of Engine Control Module (ECM) to indicate when cold start injector is operating.

Engine Coolant Temperature (ECT) Sensor

The ECT contains a built-in thermistor in which resistance varies according to engine coolant temperature. The ECT delivers an input signal to THW terminal of Engine Control Module (ECM). The ECM uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, overdrive operation on electronically controlled transaxles/transmissions, ignition timing (spark advance), idle speed control system, fuel pressure control system (if equipped), heated oxygen sensor system (if equipped) and EGR system.

Engine Cranking Signal

While engine is cranking and voltage is applied to the starter an input signal is also delivered to STA terminal of Engine Control Module (ECM). The ECM uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, fuel pressure control system (if equipped), heated oxygen sensor system (if equipped), ignition timing (spark advance) and idle speed control system.

EGR Gas Temperature Sensor

EGR gas temperature sensor monitors EGR gas temperature and delivers an input signal to Engine Control Module (ECM).

Intake Air Temperature (IAT) Sensor

Intake air temperature sensor is mounted in either airflow meter or air filter housing. Intake air temperature sensor measures incoming intake air temperature and delivers an input signal to THA terminal of Engine Control Module (ECM) for controlling fuel injection system, fuel pressure control (if equipped) and heated oxygen sensor systems (if equipped).

Oxygen (O2) Sensor

Oxygen sensor monitors exhaust gas oxygen content and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal to determine fuel injection system operation. Some models may be equipped with more than one oxygen sensor and a sub-oxygen sensor. Some models may contain a heater to warm the oxygen sensor.

Park/Neutral Position (PNP) Switch (A/T Models)

On some models, park/neutral switch delivers an input signal to NSW terminal of Engine Control Module (ECM), indicating gear position. The ECM uses information to control engine idle and fuel injection system.

RPM Signal

Crankshaft position and engine RPM are detected by pick-up coil(s) in the distributor. Pick-up coils deliver input signal to the Engine Control Module (ECM) for controlling Pulsed Secondary Air Injection (PAIR) system, fuel injection system, ignition timing (spark advance), heated oxygen sensor system and fuel pressure control system.

Crankshaft position and engine RPM input signals are delivered by a single pick-up coil to ECM terminal NE.

Sub-Oxygen Sensor

Sub-oxygen sensor is used in conjunction with the oxygen sensor. Sub-oxygen sensor monitors exhaust gas oxygen content and delivers an input signal to Engine Control Module (ECM). The ECM uses input signal to determine fuel injection system operation.

Throttle Position Sensor (TPS)

The TPS, mounted on throttle body, delivers an input signal indicating throttle position to the Engine Control Module (ECM). The ECM uses input signal for controlling Pulsed Secondary Air Injection (PAIR) system (if equipped), fuel injection system, ignition timing (spark advance), idle speed control system, fuel pressure control system (if equipped), A/C-cut control system (if equipped), EGR system (if equipped), intake air control valve system or variable induction system (if equipped) and automatic transmissions/transaxles (some models).

Vehicle Speed Sensor

Vehicle speed sensor, mounted in transmission, delivers an input signal to instrument cluster and then input signal is sent to the Engine Control Module (ECM). The ECM uses input signal for controlling fuel injection system and ignition timing (spark advance).

4WD Switch

The 4WD switch delivers an input signal to 4WD terminal of Engine Control Module (ECM) to indicate 4WD operation.

OUTPUT SIGNALS

NOTE: Vehicles are equipped with different combinations of computer-controlled components. Not all components listed are used on every vehicle. For theory and operation on each output component, refer to system indicated after component.

The Engine Control Module (ECM) receives input from data sensors and switches, depending on model application, to control following components and sub-systems:

A/C-Cut Control System

See IDLE SPEED under FUEL SYSTEM.

A/C Idle-Up System

See IDLE SPEED under FUEL SYSTEM.

Circuit Opening Relay

See FUEL DELIVERY under FUEL SYSTEM.

Electronic Spark Advance System

See DISTRIBUTOR TYPE IGNITION SYSTEM under IGNITION SYSTEM.

EGR System Vacuum Switching Valve (VSV)

See EXHAUST GAS RECIRCULATION (EGR) SYSTEM under EMISSION SYSTEMS.

Electronically Controlled Transmission/Transaxle (ECT)

See TRANSMISSION/TRANSAXLE CONTROLS under MISCELLANEOUS CONTROLS.

EVAP Vacuum Switching Valve (VSV)

See EVAPORATIVE EMISSION (EVAP) SYSTEM under EMISSION SYSTEMS.

Fuel Pressure Control System Vacuum Switching Valve (VSV)
See FUEL DELIVERY under FUEL SYSTEM.

Fuel Pump
See FUEL DELIVERY under FUEL SYSTEM.

Idle Speed Control System
See IDLE SPEED under FUEL SYSTEM.

Pulsed Secondary Air Injection (PAIR) System Vacuum Switching Valve (VSV)
See PULSED SECONDARY AIR INJECTION (PAIR) SYSTEM under EMISSION SYSTEMS.

Self-Diagnostic System
See SELF-DIAGNOSTIC SYSTEM.

Throttle Opener Vacuum Switching Valve (VSV)
See IDLE SPEED under FUEL SYSTEM.

FUEL SYSTEM

FUEL DELIVERY

Vehicles are equipped with different combinations of fuel system electrical components. For complete wiring circuit of electrical components on a specific model, see appropriate wiring diagram in L - WIRING DIAGRAMS - 2.4L article.

EFI Main Relay
The EFI fuse supplies constant battery voltage to EFI main relay. When EFI main relay is energized by ignition switch, EFI main relay provides battery voltage to circuit opening relay (some models), data link connector No. 1 and various other electrical components. The EFI main relay may also provide battery voltage to +B terminal of ECM when ignition is turned on. The EFI main relay is located in engine compartment relay box. See Fig. 1.

Circuit Opening Relay
Circuit opening relay controls fuel pump circuit. When EFI main relay is energized, EFI main relay provides battery voltage to circuit opening relay. When engine is cranking, circuit opening relay receives a start signal which energizes circuit opening relay. Circuit opening relay then provides voltage to fuel pump. When start signal is released from circuit opening relay, relay ground circuit is controlled by fuel pump switch in airflow meter. Circuit opening relay is located in various locations. See CIRCUIT OPENING RELAY LOCATIONS table. See Fig. 1.

CIRCUIT OPENING RELAY LOCATIONS TABLE

Application	Relay Location
4Runner ..	Below Passenger's Side Of Dash, Near Kick Panel

Fuel Pump
Fuel pump is mounted in the fuel tank and contains an internal check valve.

Fuel Pressure Regulator
Mounted on fuel rail, vacuum-operated fuel pressure regulator

maintains constant fuel pressure to fuel injectors. As throttle is depressed and manifold vacuum decreases, fuel pressure regulator increases fuel pressure to maintain a constant fuel flow to fuel injectors.

NOTE: Fuel pressure control system may also be referred to as fuel pressure-up system.

Fuel Pressure Control System

Fuel pressure control system increases fuel pressure slightly on hot restarts for improved starting and idle stability. Fuel pressure increase is obtained by shutting off vacuum supply to fuel pressure regulator.

The Engine Control Module (ECM) controls vacuum supply to fuel pressure regulator by operating fuel pressure control Vacuum Switching Valve (VSV). Increased fuel pressure will exist for approximately 90-180 seconds after hot restart. Fuel pressure control VSV is located in engine compartment. See Fig. 1.

Fuel Pulsation Damper

Fuel pulsation damper is mounted on fuel delivery pipe to eliminate fuel line pressure surges caused by fuel injector operation.

FUEL CONTROL

Cold Start Injector

Cold start injector delivers additional fuel during cold engine starts. Cold start injector receives voltage from ignition switch during engine cranking. Ground circuit for cold start injector is controlled by cold start injector time switch.

Cold Start Injector Time Switch

Cold start injector time switch determines cold start injector on time for cold engine starting. Cold start injector ground circuit is controlled by cold start injector time switch, located in an engine coolant passage. See Fig. 1.

Fuel-Cut System

Controlled through input signals from throttle position sensor, the Engine Control Module (ECM) will shut off fuel delivery during closed throttle deceleration.

Fuel Injectors

Fuel injectors are ECM-actuated electric solenoids which deliver fuel to individual cylinders. ECM controls fuel injector duration based on various input signals to determine air/fuel mixture.

Oxygen Sensor Heater

Oxygen sensor is equipped with a heating element. The Engine Control Module (ECM) activates oxygen sensor heater when intake air volume and engine coolant temperature are low, warming the oxygen sensor for improved performance.

IDLE SPEED

A/C Idle-Up System

The A/C idle-up system provides a stable idle speed when A/C is operating. Engine Control Module (ECM) controls A/C idle-up valve which allows extra intake air to by-pass throttle valve for increased idle speed. The A/C idle-up valve is located in different locations. See A/C IDLE-UP VALVE LOCATIONS table. See Fig. 1.

A/C IDLE-UP VALVE LOCATIONS TABLE

Application	Valve Location
4-Cyl. 2.4L	Center Of Valve Cover & Contains 2-Pin Gray Connector

Auxiliary Air Valve

Auxiliary air valve provides additional air to intake manifold when engine is cold for increased idle speed. Auxiliary air valve is mounted on throttle body and determines engine temperature by engine coolant being routed around auxiliary air valve.

NOTE: Idle speed control system may also be referred to as idle air control system.

Throttle Opener (A/T)

Throttle opener, mounted on throttle body, is vacuum controlled and allows engine to return to specified RPM after throttle is released.

IGNITION SYSTEM

DISTRIBUTOR TYPE IGNITION SYSTEM

NOTE: The distributor type ignition system may be referred to as Electronic Spark Advance (ESA) system.

The ignition system uses the Engine Control Module (ECM) for determining ignition timing (spark advance). The ECM determines ignition timing (spark advance) based on various input signals. Following input signals may be used: engine coolant temperature, throttle position, oxygen sensor, engine RPM, vehicle speed sensor, A/C switch, brakelight signal, airflow meter, knock sensor, electrical load, MAP sensor and cranking (starter) signal. Input signals may vary on model application. Integrated (ignition coil on distributor) and remote ignition coil designs are used depending on model.

Crankshaft position and engine RPM input signals are delivered to the ECM by pick-up coil(s) in the distributor.

NOTE: Pick-up coils in distributor may be referred to as camshaft position sensor on some models.

ECM uses pick-up coil input signals to switch primary ignition circuit on and off. Primary circuit is turned off when ECM delivers a signal to ignitor on the IGT wire, causing ignition coil to fire the spark plug. After delivering a command to turn off primary circuit on the IGT wire, the ECM monitors IGF circuit to ignitor to ensure primary switching occurred. See appropriate wiring diagram in the L - WIRING DIAGRAMS - 2.4L article for wire color and application.

EMISSION SYSTEMS

PULSED SECONDARY AIR INJECTION (PAIR) SYSTEM

NOTE: PAIR system may be referred to as Air Suction (AS) system.

The PAIR system uses exhaust gas pulses to draw air into exhaust port to reduce hydrocarbon (HC) and carbon monoxide (CO) emissions when engine is cold and during deceleration. The PAIR system draws air through resonator and PAIR reed valve and into exhaust port.

See Fig. 2.

The Engine Control Module (ECM), based on various inputs, controls PAIR Vacuum Switching Valve (VSV). Controlling of PAIR VSV determines when vacuum is applied to actuator on the PAIR reed valve. Various input signals such as engine coolant temperature, engine RPM, throttle position, vehicle speed sensor, airflow meter, A/C switch and cranking (starter) signal may be used, depending on vehicle application.

For specific system operating parameters and system/component testing, see PULSED SECONDARY AIR INJECTION SYSTEM under EMISSION SYSTEMS & SUB-SYSTEMS in the I - SYSTEM/COMPONENT TESTS - 2.4L article.

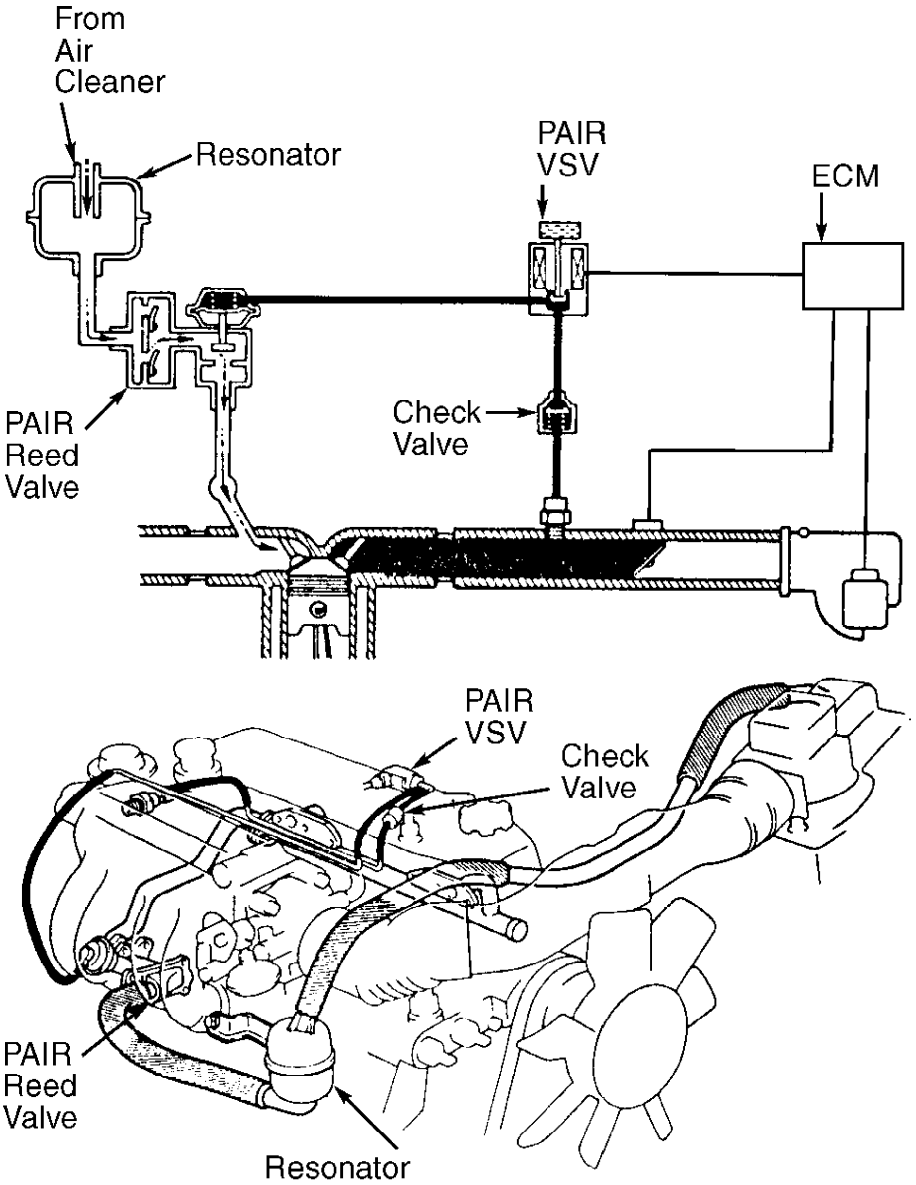

Fig. 2: Pulsed Secondary Air Injection (PAIR) System Components
Courtesy of Toyota Motor Sales, U.S.A., Inc.

POSITIVE CRANKCASE VENTILATION

The Positive Crankcase Ventilation (PCV) system prevents crankcase hydrocarbon (HC) vapors from escaping into the atmosphere. Crankcase vapors are routed from crankcase through a vacuum-controlled PCV valve, into the intake manifold. In the intake manifold, crankcase vapors are mixed with air/fuel mixture and delivered into the cylinders. See Fig. 3.

The PCV system provides primary control of crankcase blow-by vapors, according to manifold vacuum. When manifold vacuum is high (at idle), PCV restricts vapor flow to maintain a smooth idle condition.

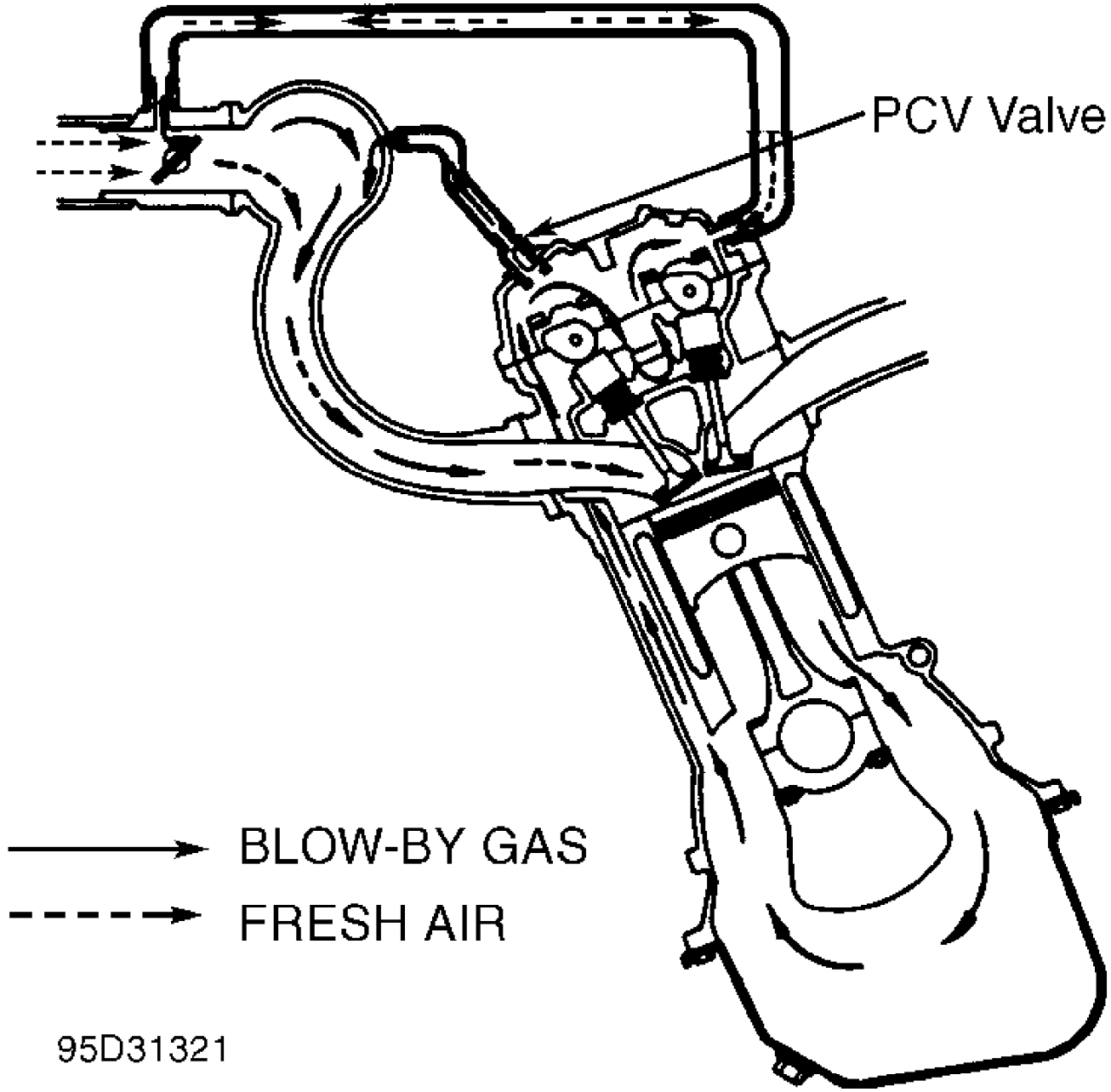

Fig. 3: Identifying Typical PCV System
Courtesy of Toyota Motor Sales, U.S.A., Inc.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The EGR system reduces oxides of nitrogen (NOx) emissions by lowering combustion temperatures. Combustion temperatures are lowered by recycling metered amount of exhaust gases back into the intake system.

The EGR system contains a vacuum-operated EGR valve and EGR vacuum modulator. See Fig. 4 or 5. Vacuum modulator regulates exhaust backpressure and balances atmospheric pressure and vacuum to allow EGR operation at heavy throttle. A check valve, EGR cooler, EGR Vacuum Switching Valve (VSV) and EGR gas temperature sensor may also be used depending on vehicle application.

The EGR cooler used on some models, assists in reducing exhaust gas temperature before entering combustion chamber. On some models, EGR operation is controlled by a EGR Thermal Vacuum Valve (TVV). The EGR TVV, mounted in engine coolant passage, opens at specified temperature, allowing EGR operation.

On some models, EGR operation is controlled by a EGR Vacuum Switching Valve (VSV). The Engine Control Module (ECM) controls EGR VSV for EGR operation. This system is referred to as EGR-cut control system. The ECM uses various input signals such as engine coolant temperature, engine RPM, throttle position, brakelight signal, airflow meter and vehicle speed for controlling the EGR VSV. Various model and engine types have different EGR system components. For EGR system and component testing, see EXHAUST GAS RECIRCULATION (EGR) under EMISSION SYSTEMS & SUB-SYSTEMS in the I - SYSTEM/COMPONENT TESTS - 2.4L article.

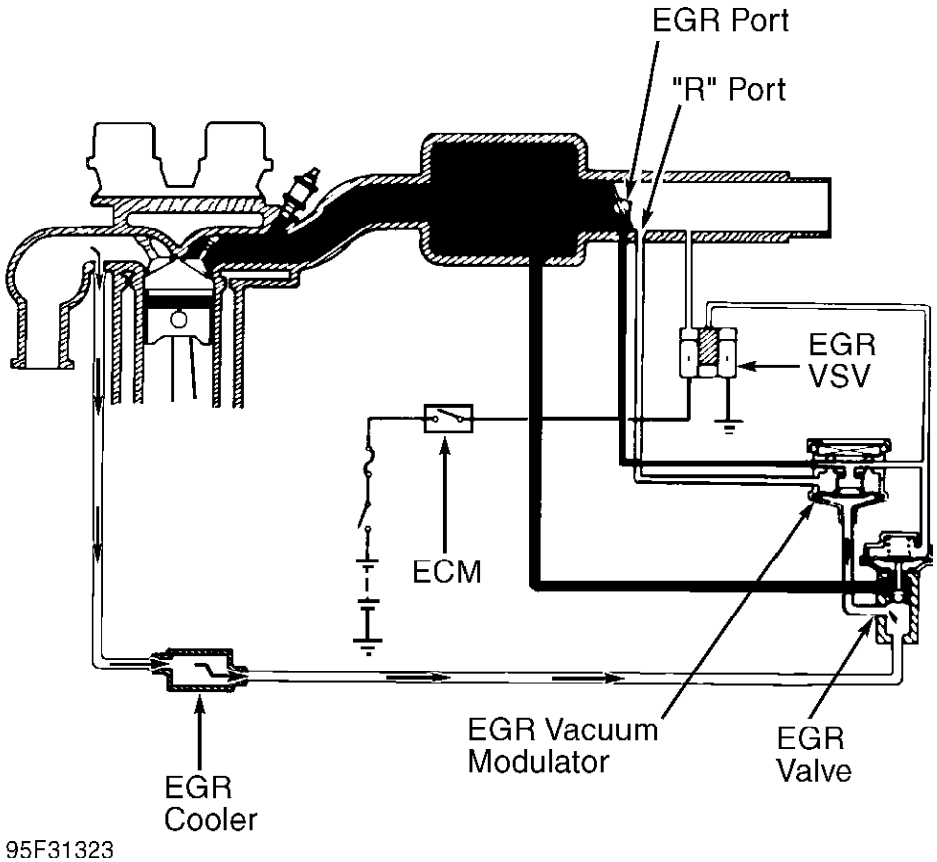

Fig. 4: Typical EGR System Components Typical System With EGR VSV
Courtesy of Toyota Motor Sales, U.S.A., Inc.

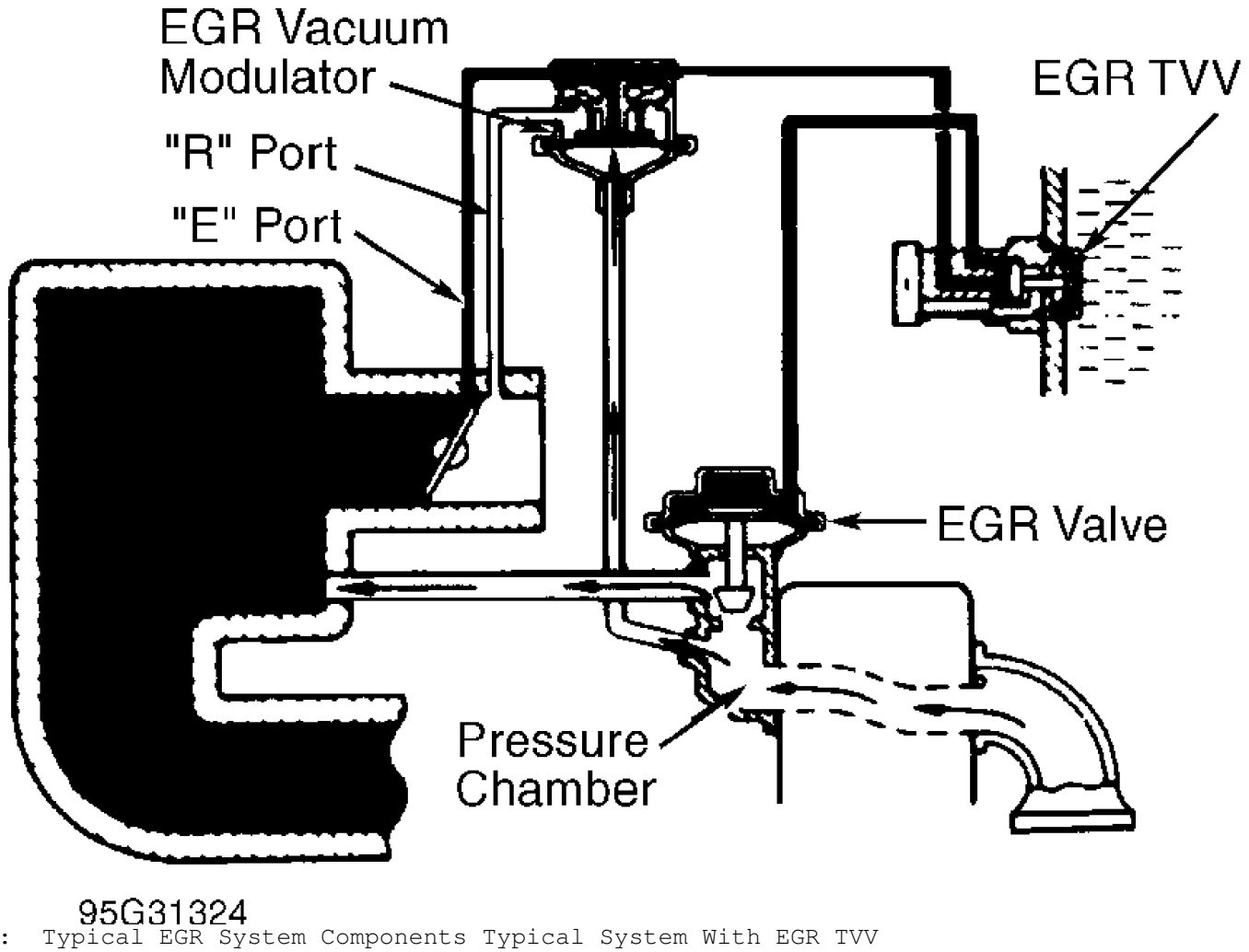

Fig. 5: Typical EGR System Components Typical System With EGR TVV
Courtesy of Toyota Motor Sales, U.S.A., Inc.

EVAPORATIVE EMISSION (EVAP) SYSTEM

NOTE: The EVAP may also be referred to as fuel evaporation.

The EVAP system prevents fuel tank gasoline vapors from escaping into the atmosphere. Fuel tank gasoline vapors are routed through charcoal canister into intake manifold for combustion in the cylinders. See Fig. 6.

On some models, an EVAP Thermal Vacuum Valve (TVV), mounted in the engine coolant passage, is used to control EVAP system in relation to engine coolant temperature.

On some models, an EVAP Vacuum Switching Valve (VSV) is used to control EVAP system. The Engine Control Module (ECM) controls EVAP VSV which controls the vacuum flow for EVAP operation.

Various model and engine types will have different EVAP system components. For EVAP system and component testing, see FUEL EVAPORATION under EMISSION SYSTEMS & SUB-SYSTEMS in the I - SYSTEM/COMPONENT TESTS - 2.4L article.

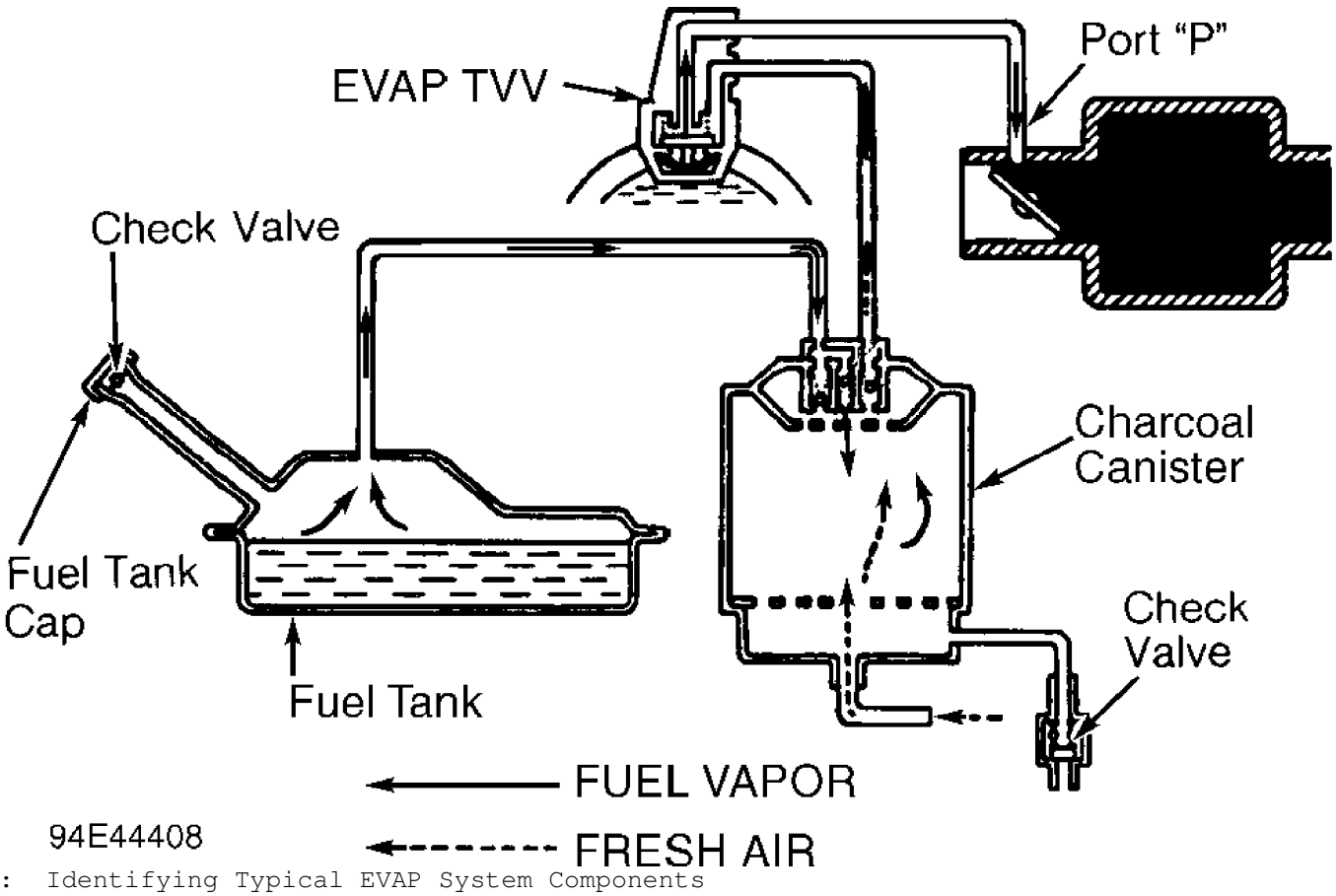

Fig. 6: Identifying Typical EVAP System Components
Courtesy of Toyota Motor Sales, U.S.A., Inc.

SELF-DIAGNOSTIC SYSTEM

The Engine Control Module (ECM) is equipped with self-diagnostic system. By analyzing various input signals, ECM detects system malfunctions related to various operating parameters. When malfunction occurs, ECM will inform the driver by turning on Malfunction Indicator Light (MIL) on the instrument panel.

NOTE: The MIL may be referred to as the CHECK ENGINE light.

Diagnostic Trouble Codes (DTC) may be set by malfunction of various engine sensors, switches or circuits. DTC is stored in ECM memory. When diagnostic trouble code is stored, MIL on instrument panel will come on. Diagnostic trouble code can be retrieved for system diagnosis. For additional information on self-diagnostic system, see the G - TESTS W/CODES - 2.4L article.

MISCELLANEOUS CONTROLS

TRANSMISSION/TRANSAXLE CONTROLS

NOTE: Only electronically controlled transmissions/transaxles are covered. Some models have transmissions and transaxles that are not electronically controlled.

Electronically Controlled Transmission/Transaxle (ECT)

The Engine Control Module (ECM) uses input signals for controlling transmission/transaxle operation.