JAGUAR ENGINE MANAGEMENT SYSTEMS: AJ16 OBD II; AJ6 OBD I; V12 OBD I/II

JAGUAR
EMS
SELF STUDY

SELF-STUDY TRAINING COURSE 801S

This publication is intended for instructional purposes only. Always refer to the appropriate Jaguar Service publication for specific details and procedures.

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INTRODUCTION

Welcome to the Jaguar Engine Management Systems Self-Study Course. This course is intended to provide an overview of Jaguar Engine Management Systems prior to your attending the instructor-led Jaguar Service Training Course: V6/V8 Engine Management. The contents of this self-study book also serve as your archival information for earlier Jaguar engine management systems.

This course and the accompanying test must be completed prior to attending the Jaguar Service Training Course: V6/V8 Engine Management unless you have already completed the instructor-led Service Training Course 801.

To complete this course:

- Thoroughly review the material in this manual, which is categorized by system version.
- Once you have invested adequate study time, review the Student Proficiency Test at the end of this manual.
- Fill out the answer sheet, making sure you include your name, your Social Security number and your Dealer Name.
- When complete, fax or mail your answer sheet to:

  Jaguar Cars Service Training Department
  ATTN: Service Training Administrator
  555 MacArthur Boulevard
  Mahwah, New Jersey 07430

  FAX: (201) 818-9074

Thank you for your participation.

JAGUAR ENGINE MANAGEMENT SYSTEMS: CONTROL FUNDAMENTALS

EMS

CONTROL FUNDAMENTALS

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ENGINE MANAGEMENT SYSTEM (EMS) CONTROL OVERVIEW

The primary purpose of engine management is to provide comprehensive engine control, which will produce a low level of vehicle powertrain emissions that meets clean air quality standards.

Powertrain emission sources:

- Engine exhaust emission
- Evaporative emissions from the fuel system and engine crankcase

In addition to emission control, the EMS must deliver:

- High quality engine operation
- Powertrain performance
- Vehicle drive quality

Clean air quality standards are interpreted into motor vehicle emission legislation that is known as On Board Diagnostics (OBD).

The first level OBD applied through vehicle model year 1994 and is known as OBD I.

The second level OBD applied to vehicle model year 1995 and remains in effect today. This standard is known as OBD II.

OBD standards are constantly evolving to produce a continuing reduction in vehicle powertrain emissions. As these standards evolve, engine management systems must become more comprehensive and more capable in order to meet the ever more stringent standards.

NOTES

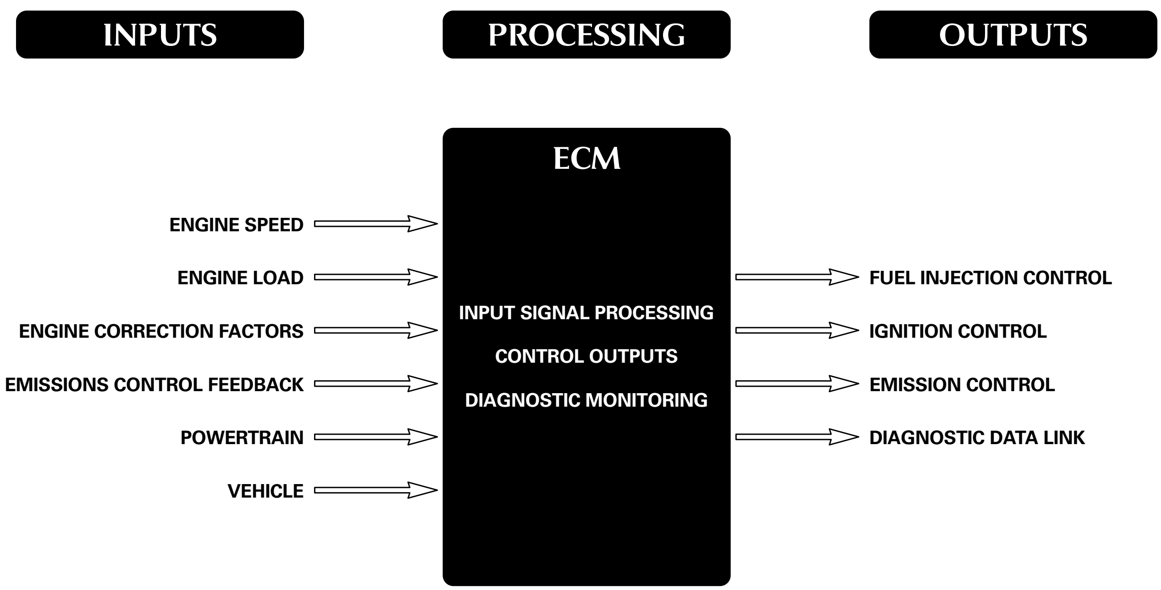
Engine Control Module (ECM)

The engine management system is centered around a digital engine control module (ECM). The ECM receives input signals from engine sensors to evaluate engine operating conditions. In addition, the ECM communicates with other powertrain systems and vehicle systems. The ECM then processes the sensor information and the information received from other systems using programmed software strategies and issues control output signals to the engine and emission control functional systems.

At its very basic level of control the ECM:
- takes engine speed and load input signals
- applies correction factor inputs and emissions control feedback signals
- processes the signals to access pre-programmed software strategies
- outputs control signals to the various engine and emission components.

During this process, the ECM employs diagnostic tests to monitor and report engine management system faults. Faults are stored in ECM memory as codes. Technician access to the fault codes and data is gained through a diagnostic data link.

BASIC ENGINE MANAGEMENT CONTROL



TPTEC.115

NOTES

JAGUAR ENGINE MANAGEMENT SYSTEMS: CONTROL FUNDAMENTALS

EMS

CONTROL FUNDAMENTALS

Important note regarding the information contained in this section:

The systems and components described herein are intended only to give the reader a foundation on which to build a complete understanding of current Jaguar engine management systems. Therefore, the information is based on out of production systems, which have less comprehensive control functions.

Certain sub systems, components, and functions may not apply directly to a specific engine management system, or may be added or deleted for the sake of clarity.

For a complete understanding of a specific Jaguar engine management system, refer to the publication(s) describing that system.

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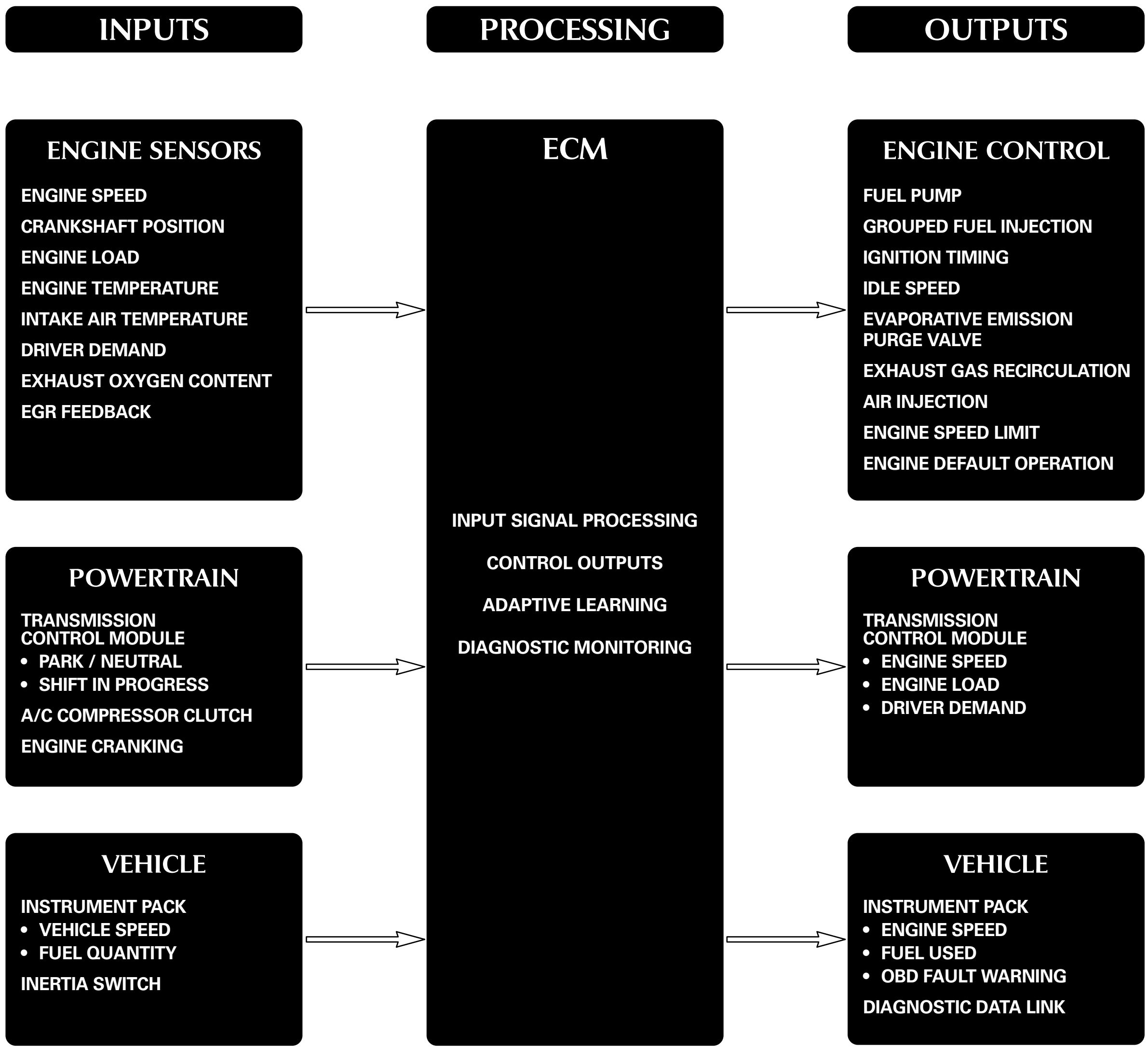
JAGUAR ENGINE MANAGEMENT SYSTEMS

Jaguar engine management systems achieve reduced powertrain emissions by combining ECM control with other mechanical and vacuum operated systems. These systems can generally be recognized by a mechanical throttle system. The combined systems include the following:

- Fuel injection control – grouped fuel injection
- Ignition control – timing
- Idle intake air control
- Control of emission related systems and components such as:
  - Evaporative emissions canister purge valve
  - Exhaust gas recirculation
  - Air injection
- Interface (hard wire) with other powertrain components such as:
  - Engine cranking
  - Transmission control module (TCM)
  - A/C compressor clutch
  - Instrument pack
- Interface (hard wire) with other vehicle systems such as:
  - Instrument pack
- Engine related mechanical and vacuum operated systems considered part of engine management:
  - Throttle body and air intake system
  - Ignition distributor
  - Exhaust system / catalytic converter(s)
  - Fuel tank, piping and evaporative emission equipment
  - Fuel pressure regulator and fuel rail
- Adaptive learning:
  - Idle fuel metering
- On-board diagnostic monitoring and reporting:
  - Diagnostic monitoring
  - Engine default operation
  - Diagnostic data link

NOTES

JAGUAR ENGINE MANAGEMENT SYSTEM



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JAGUAR ENGINE MANAGEMENT SYSTEMS

Engine Control Module Inputs

ECM INPUTS

Engine speed / crankshaft position

The crankshaft position sensor (CKP Sensor) is an inductive pulse generator that supplies the ECM with both an engine speed and crankshaft position alternating voltage signal. The sensor is located either on the timing cover or at the rear of the engine.

The reluctor, mounted on the crankshaft, has a number of "teeth" with one or two removed to form a gap, which creates a missing pulse. The missing pulse allows the ECM to determine the crankshaft position for fuel injector pulse synchronization.

Engine speed is one of the two main factors in determining fuel injector pulse duration (fuel metering) and ignition timing.

Engine load

Engine load is the other main factor in determining fuel injector pulse duration (fuel metering) and ignition timing.

Single throttle engines use a mass air flow sensor (MAF Sensor), located in the air intake before the throttle body to measure the volume of air entering the engine. The MAF sensor is a "hot wire" type sensor, which produces a voltage input signal to the ECM. The voltage input signal allows the ECM to determine intake air volume, which it interprets as engine load.

Two throttle engines (V12) use one or two manifold absolute pressure sensors (MAP Sensor), which sense engine intake manifold absolute pressure. The sensors connect to the intake manifolds downstream from the throttle valves so that manifold absolute pressure changes (opening / closing throttle valve) act on the MAP sensor element. The MAP sensors produce a voltage input signal to the ECM. The voltage input signal allows the ECM to determine engine load.

Engine temperature

Engine temperature is determined from the coolant temperature. The engine coolant temperature sensor (ECT Sensor) is a negative temperature coefficient (NTC) thermistor, located in the engine coolant system. Its resistance decreases with an increase in coolant temperature. The varying resistance creates a voltage drop that is sensed by the ECM.

Driver demand

Driver demand is determined from throttle valve position and the rate of change in throttle valve position (open / close). The throttle position sensor (TP Sensor) is a rotary potentiometer connected to the throttle valve shaft that supplies the ECM with a throttle position voltage signal.

Exhaust oxygen content

The exhaust system utilizes a three-way catalytic converter to significantly reduce exhaust emission. Catalytic converters require optimum combustion to operate efficiently. Optimum combustion is defined as "stoichiometric", a air : fuel ratio that is neither "lean" or "rich" for the prevailing engine operating condition. In order to maintain the air : fuel ratio as close to stoichiometric as possible, an exhaust gas oxygen content sensor (O2 Sensor) is used to provide the ECM with a feedback signal in the form of an air : fuel ratio lean / rich "voltage swing". The ECM uses the feedback signal to shift the injector pulse duration toward rich or lean as required to achieve stoichiometric. Two different types of sensors are used to produce a voltage swing: zirconium dioxide sensors and titanium dioxide sensors.

ECM

ECM INPUTS

Intake air temperature

The intake air temperature sensor (IAT Sensor) is a a negative temperature coefficient (NTC) thermistor located in the engine air intake system. Its resistance decreases with an increase in intake air temperature. The varying resistance creates a voltage drop that is sensed by the ECM.

Exhaust gas recirculation feedback

A feedback signal from the EGR system enables the ECM to monitor the flow of exhaust gas into the engine intake manifold.

Transmission

The ECM receives a transmission Park / Neutral signal (ground / open). The transmission control module signals the ECM before shifting so that the ECM can momentarily reduce engine torque.

A/C compressor clutch

The ECM receives a compressor clutch engaged signal (B+ / ground) that is used for idle speed compensation.

Engine cranking

When the engine is cranked (starter engaged), the ECM receives a cranking signal from the starter relay.

Instrument pack

The instrument pack provides the ECM with vehicle speed and fuel quantity signals.

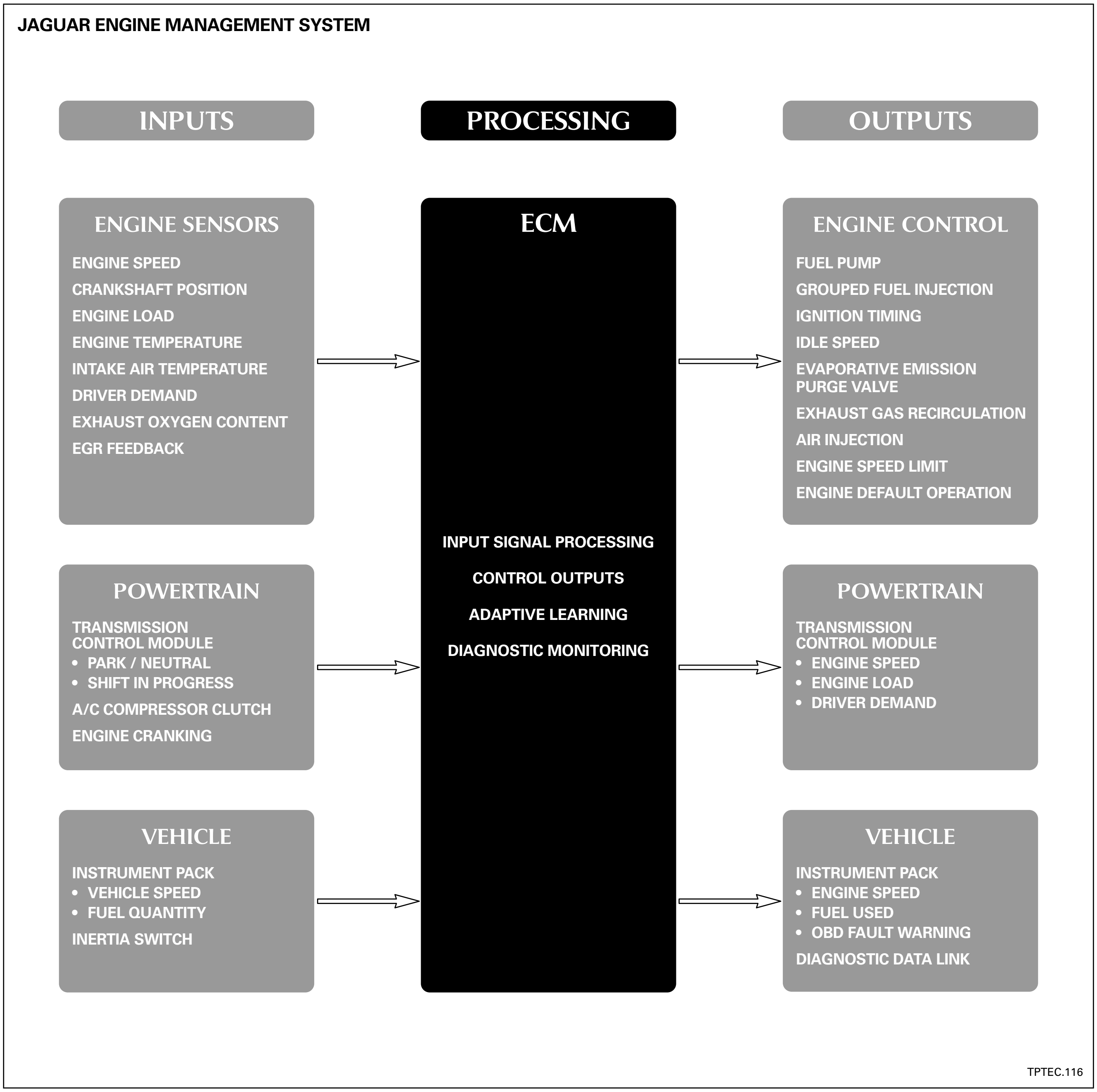
Inertia switch

If the vehicle is impacted from the front or rear, an inertia switch switches off all ignition switched power supply, thus de-energizing the fuel pump relay and de-activating the fuel pump.

ECM

JAGUAR ENGINE MANAGEMENT SYSTEMS

Engine Control Module Input Processing



ECM PROCESSING

Using programmed strategies, the ECM processes the input signals to determine the engine management control outputs necessary to achieve the specified emission level and engine performance during all phases of engine operation including:

- Start and warm-up
- Normal operation
- Idle
- Acceleration / deceleration
- Diagnostic monitoring / default operation

The inputs are used for the following purposes:

- **Engine speed and load** Fuel injector pulse duration; ignition timing; engine speed limiting.
- **Crankshaft position** Fuel injector pulse timing.
- **Engine coolant temperature** Fuel injector pulse duration; ignition timing correction; idle speed stabilization; air injection activation.
- **Intake air temperature** Ignition timing correction.
- **Driver demand** Fuel injector pulse duration; ignition timing correction; fuel cut-off (throttle over-run, wide open throttle before engine start).
- **Exhaust oxygen content** "Closed loop" fuel metering (injector pulse duration) control.
- **Exhaust gas recirculation feedback** EGR diagnostic monitoring.
- **Transmission Park / Neutral** Idle speed stabilization.
- **Transmission shift** Engine torque reduction (momentarily retarding ignition timing).
- **A/C compressor clutch** Idle speed stabilization.
- **Engine cranking** Start-up injector pulse duration; start-up ignition timing; start-up idle air flow.
- **Vehicle speed** Idle speed control functions.
- **Fuel quantity** Fuel metering diagnostics canceled when the fuel level falls below a specified level.

Adaptive learning

The ECM "adapts" the "base line" idle fuel metering strategy as the engine "ages".

Diagnostic monitoring

Sensor inputs and feedbacks are processed and used for diagnostic monitoring. Detected faults are logged in memory as diagnostic trouble codes (DTCs); engine default strategies are implemented as dictated by the fault(s).

NOTES

JAGUAR ENGINE MANAGEMENT SYSTEMS

Engine Control Module Outputs

ECM OUTPUTS

ECM

Fuel pump / fuel pressure

When the ignition is switched ON and the engine cranks, the ECM operates the fuel pump via the fuel pump relay. Fuel pressure in the engine fuel rail is maintained within a specified pressure range by a fuel pressure regulator that senses intake manifold vacuum.

Fuel injection

The fuel injectors are solenoid operated precision valves, which when activated, atomize gasoline. The ECM achieves the required air : fuel ratio by varying the fuel injector pulse duration (length of time the injectors are activated). All fuel injectors are pulsed simultaneously, normally once per engine revolution (twice per engine cycle).

Ignition

The ignition system employs a conventional distributor drive, rotor and cap for spark distribution. Spark timing is output from the ECM to an ignition module, which in turn switches the ignition coil primary circuit and controls ignition dwell. Momentary timing retard provides engine torque reduction for transmission shift quality enhancement.

Idle speed

The mechanical throttle body incorporates a motorized idle speed control valve and bypass air circuit. The ECM drives the idle speed motor open or closed to achieve the target idle speed. In certain systems a supplementary air valve, driven by the ECM, is used to augment idle air flow at low engine temperature.

Evaporative emission purge valve

The evaporative emission control system incorporates a charcoal canister, which absorbs fuel vapors from the fuel delivery system while the engine is running. A solenoid operated purge valve is driven by the ECM to open and allow the canister to be purged of vapor build-up by venting to the engine air intake system. Canister purge is controlled by the ECM from a programmed strategy.

Exhaust gas recirculation

Exhaust gas recirculation (EGR) is used to lower combustion temperature during peak periods thereby reducing the level of “oxides of nitrogen” (NOx) in the exhaust gas. Exhaust gas is allowed to flow into the intake manifold by a solenoid operated vacuum solenoid valve driven by the ECM. The ECM controls EGR from a programmed strategy.

ECM OUTPUTS

ECM

Air injection

Air injection into the exhaust manifold is used to reduce the time necessary for the catalytic converter to reach its operating temperature. When activated by the ECM, the engine driven air pump clutch engages the pump and air flow commences. Simultaneously, the ECM opens a solenoid operated vacuum valve, which opens an air injection cut-off valve allowing air flow to the exhaust manifold. The ECM controls air injection from a programmed strategy.

Certain engine management systems have air injection systems with electrically driven and controlled air pumps replacing the engine driven pumps.

Engine speed limit

The ECM limits the maximum engine speed by fuel injection cut-off.

Engine default operation

Engine sensor input defaults are substituted by the ECM in the case of sensor signals faults. These defaults allow the vehicle to be operated until the fault(s) can be repaired.

Transmission

The transmission control module receives engine speed, load and driver demand signals for use in calculating transmission shift quality values.

Instrument pack

The instrument pack receives an engine speed and fuel used signals for tachometer and trip computer operation. In the case of an OBD detected fault, the ECM provides the instrument pack with a signal to illuminate the CHECK ENGINE malfunction indicator lamp (MIL).

Diagnostic data link

A serial data link and data link connector (DLC) allow technician interface with the ECM and the transmission control module.

JAGUAR ENGINE MANAGEMENT SYSTEMS

Vehicle Range	Model Year	Engine Family	ECM Version Identification	OBD		Emission Compliance						
				I	II	Tier 0	Tier 1	TLEV	LEV	ULEV	Enh. EVAP	ORVR
XJ6	1990 - 94	AJ6 4.0	Lucas 15 CU	X		X						
	1995 - 97	AJ16 4.0	Sagem/Lucas GEMS 6		X	X					X	
XJ8	1998	AJ26 4.0	Denso		X		X				X	X
	1999 - 00	AJ27 4.0	Denso		X			X (99)	X (00)		X	X
XJ12	1992	V12 5.3	Lucas 26 CU	X		X						
	1993 - 94	V12 5.3	Lucas-Marelli	X		X						
	1995 - 96	V12 6.0	Denso		X	X						
XJR	1998 - 99	AJ26 (V8) SC 4.0	Denso		X		X				X	X
	2000	AJ27 (V8) SC 4.0	Denso		X		X				X	X
XJS	1993 - 94	AJ6 (V6) 4.0	Lucas 15 CU	X		X						
XJR-S	1993	V12 6.0	Zytec	X		X						
XK8	1997 - 98	AJ26 (V8) 4.0	Denso		X			X			X	X (98)
	1999 - 00	AJ27 (V8) 4.0	Denso		X			X (99)	X (00)		X	X
XKR	2000 -	AJ27 (V8) SC 4.0	Denso		X		X				X	X
S-TYPE	2000 - 01	AJ V6 3.0	PTEC		X			X (00)	X (01)		X	X
		AJ V8 4.0	PTEC		X			X (00)	X (01)		X	X

Jaguar Engine Management Systems: Expanded Systems

Later developments in engine management control technology resulted in expanded Jaguar engine management systems. In addition to the earlier EMS control functions, expanded systems include the following:

- Electronic throttle control
- Fuel injection control with sequential fuel injection; air assisted fuel injection
- Ignition control – firing order; timing; dwell
- Ignition knock control
- Catalyst monitoring
- Variable valve timing
- Variable intake
- Enhanced evaporative emission control
- Cruise control
- Individual cylinder intervention
- ABS/TC interface
- Security interface
- Network communication

These systems are covered in detail in their respective course sections when you attend Jaguar Service Training Course 880 – V6/V8 Engine Management.

JAGUAR ENGINE MANAGEMENT SYSTEMS: ON BOARD DIAGNOSTICS REVIEW

EMS

ON-BOARD DIAGNOSTICS

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Service Training Course 801S

NATIONAL LOW EMISSION VEHICLE PROGRAM

The California Air Resource Board (CARB) initiated the Low Emission Vehicle program mandating a staged reduction in vehicle emissions for vehicles sold in the state of California. The EPA adopted this strategy for national compliance which became the **National Low Emission Vehicle Program (NLEV).**

The NLEV program has been used voluntarily by the northeastern states of the US to address increasing smog problems. The NLEV program became law in 1999 and requires all vehicles sold in northeastern states comply with the NLEV standards. Complete national phase in will be realized by 2004.

The NLEV program requires that vehicle manufactures reduce total emission levels through a series of stages over a specified time period. The total number of vehicles a manufacturer schedules to build for the given year is also factored into the equation. The stages of compliance for internal combustion engines are identified as:

TLEV = Transitional Low Emission Vehicle
LEV = Low Emission Vehicle
ULEV = Ultra Low Emission Vehicle

The vehicle components and control systems must maintain set emission levels through the life span of the vehicle (accumulated mileage).

Tailpipe emissions are categorized as:

- NMHC = Non Methane Hydrocarbon
- CO = Carbon Monoxide
- NOx = Oxides of Nitrogen

Prior to the NLEV program the most stringent national compliancy was Tier 1. The benefit of exhaust emission reductions that NLEV program provides compared with Tier 1 standards are as follows:

- TLEV - 50% cleaner
- LEV - 70% cleaner
- ULEV - 84% cleaner

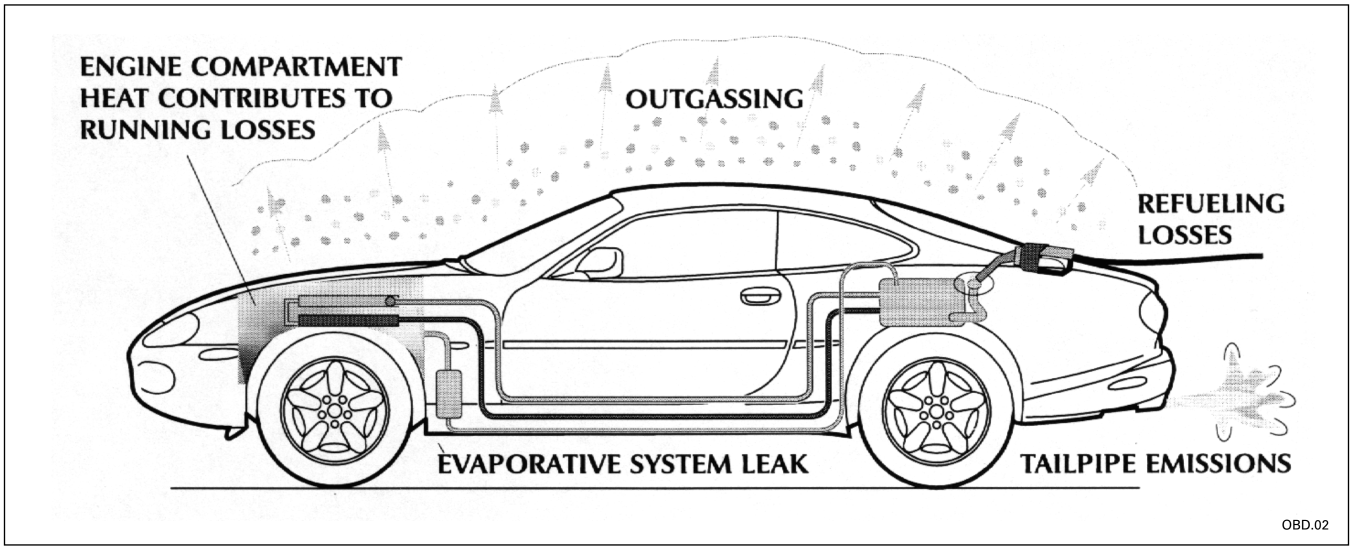
Grams per mile @ 50° F - (Cold engine start)			
Compliance Level	**NMHC**	**CO**	**NOx**
TLEV	0.250	3.4	0.4
LEV	0.131	3.4	0.2
ULEV	0.040	1.7	0.2
Grams per mile @ 50,000 Miles			
Compliance Level	**NMHC**	**CO**	**NOx**
TLEV	0.125	3.4	0.4
LEV	0.100	3.4	0.3
ULEV	0.055	2.1	0.3
Grams per mile @ 100,000 Miles			
Compliance Level	**NMHC**	**CO**	**NOx**
TLEV	0.156	4.2	0.6
LEV	0.125	4.2	0.4
ULEV	0.075	3.4	0.4

OBD.01

AUTOMOBILE EMISSION SOURCES

Tailpipe emissions are not the only contributor of pollutants from an automobile. The vehicle contributes to air pollution by emitting Hydrocarbon based gasses identified as Non Methane Organic Gasses (NMOG) and Volatile Organic Compounds (VOC). NMOG and VOC emissions are classified to stationary emission sources which escape to atmosphere and contribute to poor air quality.

NMOG and VOC are released from a vehicle through evaporation and outgassing from the fuel system evaporative system, evaporating engine oil, windshield washer fluid, paints and solvents. Gradual outgassing of petroleum based vehicle components such as plastics, rubber materials and compounds also contribute to VOC generation.



The EPA has addressed outgassing or release of VOC to atmosphere by categorizing and mandating the following:

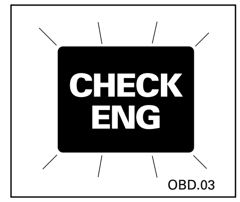
- Minimize generation of VOC outgassing caused by component materials.
- Running Loss Compliance (Integrate Non Return Fuel Systems).
- Monitor the vehicle evaporative system for leaks (OBD II Compliance).
- On-board Refueling Vapor Recovery (ORVR) Compliance.

The combination of the NLEV program and On Board Diagnostics results in a future national vehicle fleet that is cleaner and has the capability of detecting and alerting the driver of mechanical and electrical malfunctions prior to failure.

ON BOARD DIAGNOSTICS I

A large portion of technology used in engine control systems is due to the legislative requirement of complying with emission regulations to reduce air pollution. Engine control system self monitoring provides an alert system to the driver in the event of a malfunction in the emission control functions of the system. The self monitoring capabilities are called **On Board Diagnostics.**

The *California Air Resources Board* **(CARB)** established regulations for vehicles that would be sold in California beginning with the 1988 model year. These regulations are known as On Board Diagnostics - version 1 **(OBD I).** The Environmental Protection Agency (EPA) adopted the California program for all manufactures selling vehicles in the US starting with the 1988 model year.



However, Jaguar vehicles did not have an instrument cluster check engine light until the 1990 model year. 1988 & 89 vehicles have the check engine light function incorporated with the VCM. Diagnostic fault codes are also provided with the VCM.

OBD I monitoring requirements included:

- Correct function of the Engine Control Module (ECM)
- Fuel metering system
- Exhaust gas recirculation system
- Emission related components

To achieve this the OBD I system monitors all sensors used for fuel, EGR, and other emission controls for opens and shorts in the components or their circuits. Fuel trim, EGR and oxygen sensors were also monitored for functionality. Any malfunctions required:

- The Malfunction Indicator Light (MIL) to light while the malfunction was present.

- A Diagnostic Trouble Code (DTC) to be set in the Engine Control Module which is accessed with the PDU or WDS.

- A procedure for activating flashing codes of the MIL to provide fault information to all technicians for diagnosis. This procedure is not necessary for Jaguar Dealers since the JDS/PDU/WDS are used for fault code access.

Visit the CARB web site @ **http://arbis.arb.ca.gov/msprog/obdprog/obdprog.htm** for more information on the organization

ON BOARD DIAGNOSTICS II

Overview

In their continuing efforts to improve vehicle emission levels and on board monitoring capabilities, CARB implemented a more stringent program for their state requirements know as On Board Diagnostics, version 2 **(OBD II)**.

OBD II implements further refinements in the ability to monitor the proper function of a vehicle drivetrain ensuring emission levels do not exceed accepted levels. Drivetrain systems that affect emission levels if impaired include:

- Engine Management
- Transmission Control
- Traction Control

The Environmental Protection Agency (EPA) adopted the CARB program and made it a federal requirement based on the Clean Air Act amendment of 1990. The EPA required a complete phase in of OBD II compliance for all vehicles sold in the US by 1996 model year. All Jaguar vehicles sold in the US were compliant by 1995.

The complete compliance document is titled, *1968.1 Malfunction and Diagnostic System Requirements*. Visit the EPA web site at **www.epa.gov** for detailed information.

In preparation of mandating OBD II, the **EPA** and **CARB** consulted the **SAE** (Society of Automotive Engineers) to establish common standards for all vehicle manufactures ensuring consistency from one manufacture to the next. These standards include:

- **J 1930 -** common acronyms of system components.
- **J 1850 -** common Diagnostic Equipment Communication Protocol.
- **J 1962 -** common Data Link Connector (DLC), and guidelines for its location in the vehicle.
- **J 1978 -** recommended practices for common OBD II Scan Tool
- **J 1979 -** common generic scan tool software.
- **J 2190 -** common Diagnostic Test Modes.
- **J 2012 -** common Diagnostic Trouble Codes.

The standards simplify diagnosis by mandating a common scan tool communication protocol and Data Link Connector, accessing information, providing standard component names, test modes and diagnostic trouble codes (DTCs) for all vehicles.

Visit the SAE web site at **www.sae.org** for detailed information on these standards.

OBD II TERMS

When introduced, OBD II brought with it many new terms for service personnel to become familiar with. Knowing what these terms mean is necessary in order to carry out diagnosis of vehicle systems. An overview of the terms are provided on the following pages.

- Drive Cycle, Warm Up Cycle, Trip and the Federal Test Procedure (FTP) (See pages 8 & 9)
- MIL Activation Criteria (See pages 10 & 11)
- Data Link Connector (DLC) (See page 12)
- Diagnostic Trouble Codes (DTC) (See page 14)
- Readiness Codes (See page 15)
- Freeze Frame Data (See page 15)

OBD II MONITOR REQUIRMENTS

To facilitate the expanded monitoring requirements of OBD II, emission related vehicle systems require additional software capabilities and components such as:

- Post catalytic converter oxygen sensors
- Fuel tank pressure sensor
- Evaporative Fuel System Shut off valve
- Differential Pressure Feedback EGR sensor

The additional components and software programming allows the Engine Control Module to comply with OBD II regulations and monitor the following functions and systems:

- Comprehensive Component Monitor (See Page 17)
- Heated Oxygen Sensor Monitor (See Page 18)
- Catalytic Converter Efficiency Monitor (See Page 20)
- Engine Misfire Detection Monitor (See Page 22)
- Evaporative Emission Systems Monitor (See Page 25)
- Secondary Air Injection System Monitor (See Page 28)
- Fuel System Monitor (See Page 29)
- Exhaust Gas Recirculation System Monitor (See Page 30)
- Engine Coolant Thermostat Monitor (See Page 32)

Warm up, Drive Cycles & Trips

To conclusively test the function of an emission component or system function the vehicle must be operated under varied running conditions which is known as a Drive Cycle. Segments of the Drive Cycle are also identified such as Warm Up Cycle and Trip.

During the Drive Cycle the ECM activates the various emission systems to monitor their function. If faults are detected during the monitoring stages, the ECM will store the event in its memory. If it happens a second time on the next successive drive cycle, the driver is alerted via the CHECK ENGINE MIL.

Drive Cycle parameters are based on the Federal Test Procedure (FTP). The FTP is a set driving cycle established by CARB that allows the engine to warm up and the vehicle to drive through varied engine speed and load conditions ensuring the emission systems are activated and monitored.

Warm-up Cycle: operation of the vehicle to the point of warming the coolant by at least 40°F higher than the last engine off and reaching at least 160°F.

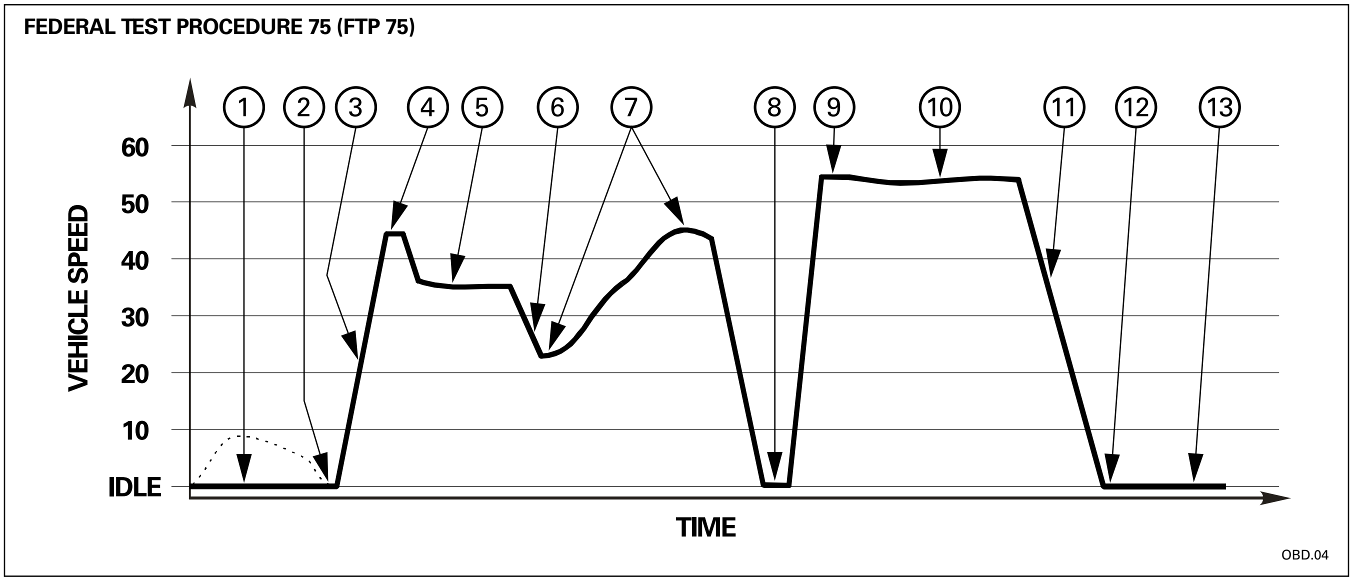
Drive Cycle: takes the warm-up cycle one step further by operating the vehicle to the point whereby it will go into closed loop control and include the operating conditions that are necessary to initiate or even complete a specific OBD II monitor. These specific Drive Cycles are provided in the DTC summary publications.

Trip: Beginning with an engine off period, after the engine is started, the vehicle must travel a specified distance to allow the following five OBD II monitors to complete all of their tests:

1. Misfires
2. Fuel System
3. Comprehensive components
4. EGR
5. HO2S

OBD II Drive Cycle

This is a very specific combination of driving conditions that have been set out by the Federal Clean Air Act adhering to Federal Test Procedure 75 (FTP 75). Completion of all the conditions of this cycle ensures that all monitors have completed their required tests. This cycle is the most comprehensive of all the cycles.

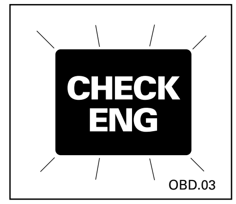


In order for all monitors to take place the following must happen:
Connect the Scan Tool or PDU to the DLC. Switch ignition on. Start the engine. Once started, the engine must not be turned off at any time during the drive cycle.

1. Allow the engine to idle or drive the vehicle for at least **4 minutes** until it is warmed up to a temperature of 180°F.
2. Idle for **45 seconds.**
3. Accelerate to 45 MPH at 1/4 throttle (elapsed time is about **10 seconds**).
4. Once 45 MPH is realized, decelerate vehicle speed to approximately 35 MPH
5. Drive at a speed between 30 and 40 MPH, maintaining a steady throttle position for at least one minute.
6. Decelerate to a speed above 20 MPH.
7. Drive until at least four minutes are spent between 20 and 45 MPH. Do not operate at WOT.
8. Decelerate and idle for at least 10 seconds.
9. Accelerate to 55 MPH at 1/2 throttle (elapsed time should be about 10 seconds).
10. Cruise at a speed between 45 and 55 MPH, maintaining a steady throttle position for at least **80 seconds.** Do not exceed posted speed limit.
11. Decelerate vehicle and stop.
12. Bring vehicle down to idle.
13. Check scan tool for on-board system readiness test results and any DTCs.

Check Engine Light (MIL)

MIL activation changed with the introduction of OBD II. The MIL is activated when the ignition is switched to the ON position before cranking which serves as a bulb check function of the instrument cluster.

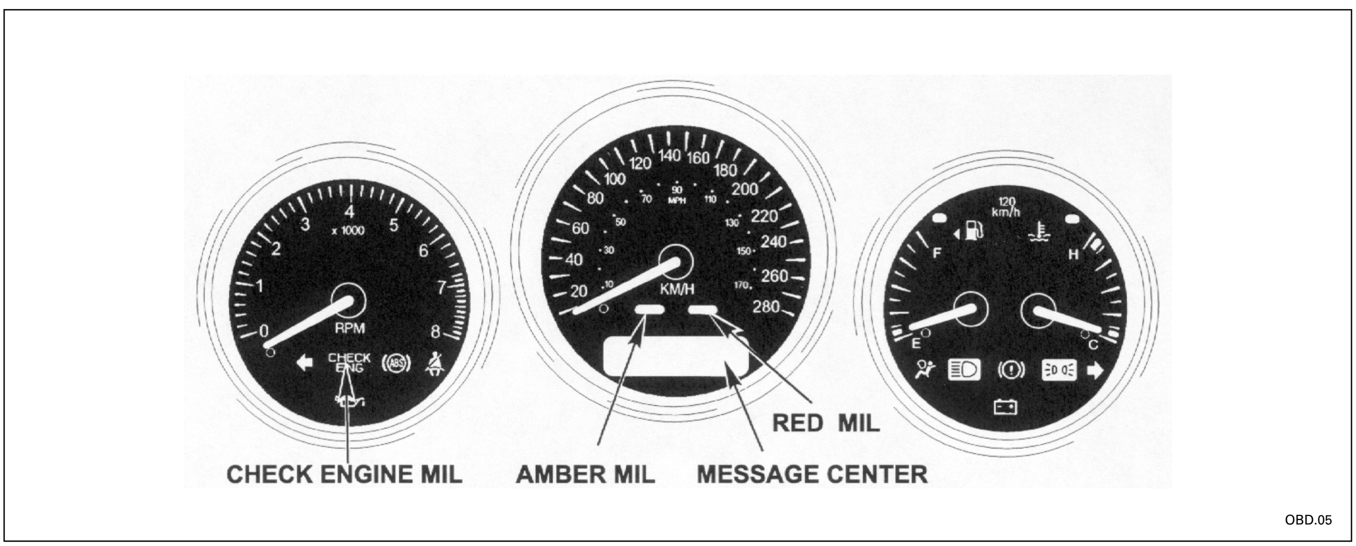


The ECM determines the activation criteria of the MIL. It signals the ECM via the SCP or CAN networks on to signal the instrument cluster starting with the 1997 model year vehicles. On pre 97 models, the MIL is signaled on via a dedicated circuit.

Illumination of the MIL is in accordance with the FTP which requires activation when:

- A malfunction of a component that can affect the emission performance of the vehicle occurs and causes emissions to exceed 1.5 times the standards required by the FTP.
- An OBD II monitored input signal is out of range, open or shorted (Comprehensive Component Monitoring).
- Misfire faults occur.
- A leak is detected in the evaporative fuel system.
- The oxygen sensors observe no purge flow from the purge valve/evaporative system.
- Engine control module fails to enter closed-loop operation within a specified time period.
- Engine or transmission control enters a limp home mode.
- Jaguar defined specifications are exceeded.

To prevent erroneous illumination, if a fault is detected once, it must also be detected a second time on the next consecutive driving cycle. At the point in which the fault is conclusively confirmed in the drive cycle, the MIL is then activated. However, faults that are monitored as catalyst damaging will cause the MIL to illuminate immediately.



Jaguar vehicle instrument clusters also inform the operator with additional information via RED and AMBER MILs along with Message Center information. Refer to the DTC summary guides.

The table illustrates example scenarios of when and how the MIL is activated (on and off) based on drive cycle fault detection.

	DRIVE CYCLE # 1			DRIVE CYCLE # 2			DRIVE CYCLE # 3			DRIVE CYCLE # 4			DRIVE CYCLE # 5			*DRIVE CYCLE # 43		
TEXT NO.	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENG	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENG	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENG	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENG	FUNCTION CHECKED	FAULT CODE SET	MIL STATUS CHECK ENG	FUNCTION CHECKED	FAULT CODE ERASED	MIL STATUS CHECK ENG
1.	YES	YES	OFF															
2.	YES	YES	OFF	YES	YES	ON												
3.	YES	YES	OFF	NO	NO	OFF	YES	YES	ON									
4.	YES	YES	OFF	YES	NO	OFF	YES	NO	OFF	YES	YES	OFF	YES	YES	ON			
5.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF			
6.	YES	YES	OFF	YES	YES	ON	YES	NO	ON	YES	NO	ON	YES	NO	OFF	YES	FAULT CODE ERASED	OFF

OBD.06

1. A fault code stored in the control module upon the first occurrence of a fault in the system being checked.

2. The MIL will not be illuminated until the completion of the second consecutive driving cycle where the previously faulted system is again monitored and a fault is still present.

3. If the second drive cycle was not complete and the specific functions was not checked as shown in the example the engine control module counts the third drive cycle as the next consecutive drive cycle. The MIL is illuminated if the function is checked and the fault is still present.

4. If there is an intermittent fault present and does not cause a fault to be set through multiple drive cycles, two complete consecutive drive cycles with the fault present are required for the MIL to be illuminated.

5. Once the MIL is illuminated it will remain illuminated unless the specific function has been checked without fault through three complete consecutive drive cycles.

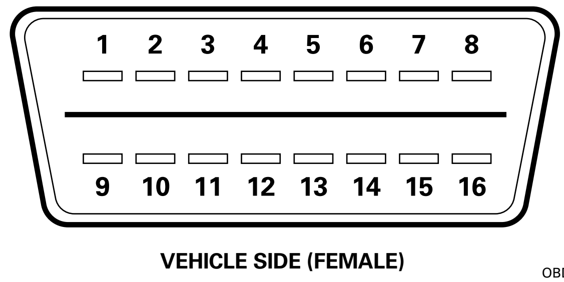
6. The fault code will also be cleared from memory automatically if the specific function is checked through **40*** consecutive drive cycles without the fault being detected or with the use of a scan tool, PDU or WDS.

   * = With catalyst damaging faults it requires **80** consecutive drive cycles without the fault being re-detected for the MIL to be switched off (or with scan tool, PDU/WDS).

Data Link Connector (DLC)

To comply with SAE specification J 1962, the DLC has a standardized shape for connection with all generic scan tools and the PDU/WDS.

Communication between the engine/powertrain control modules and the diagnostic equipment is carried out via specific communication ports in the DLC based on diagnosis or programming.



PIN Description	Application
1. Ignition Switch	Ignition Switch Position II (RUN)
2. J1850 Communication Protocol	SCP BUS (+)
3. Airbag Diagnostic Link	Serial Communication for Airbag Diagnostics **(XK Only)**
4. Chassis Ground	–
5. Signal Ground	–
6. CAN_H	CAN data link (high) **(XK/XJ Only)**
7. ISO-9141 Diag. Communication	Diagnostic communication serial data link to vehicle modules **All Models**
8. Ignition Switch	Ignition Switch Position I “ACC” **(XK/XJ Only)**
9. Battery Power (switched)	Vehicle battery power via Ignition switch or Ignition Control **(XK/XJ Only)**
10. J1850 Common Protocol	SCP BUS (–)
11. Vacant	Not utilized at this time
12. Flash EEPROM **(XK/XJ Only)**	Flash programming communication port
13. Flash EEPROM **(XK/XJ)**	Flash programming power link (power supply to module for programming)
13. Flash EEPROM **(S-TYPE)**	Flash programming communication port
14. CAN_L	CAN data link (low) **(XK/XJ Only)**
15. ISO-9141 Diag. Comm.	Diagnostic communication serial data link to vehicle modules **(XK/XJ)**
16. Battery Power	Vehicle Battery power available at all times (unswitched)

Generic Diagnostic Software and Scan Tool

To comply with SAE specifications J 1978 and 1979, OBD II compliant ECMs must be capable of communicating with a generic OBD II diagnostic scan tool and software to provide commonality for all manufactures. This mandated requirement allows independent service shops the capability of diagnosing emission related faults without purchasing manufacture specific proprietary equipment.

The generic scan tool software is divided into the following 6 modes:

Mode 1. Parameter Identification (PID), access to live data, digital and analog values for inputs and outputs etc. This is similar to the Datalogger feature of the PDU/WDS.

Mode 2. Freeze Frame Data Access. Snapshot of captured data for all emissions related values at the time of a recognized fault.

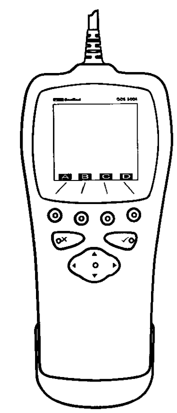
Mode 3. This enables all scan tools to retrieve stored DTCs. The DTC can be displayed alone or with descriptive text.

Mode 4. Ability to clear emission-related diagnostic information (DTCs and Freeze Frame Data).

Mode 5. Monitoring of the Oxygen Sensors to determine Catalytic Converter Efficiency.

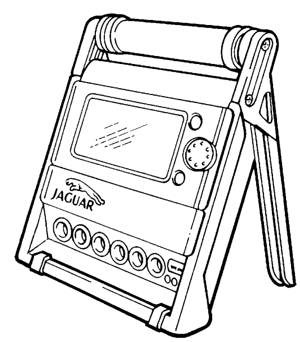
Mode 6. Provides activation of certain ECM output devices to selectively control certain outputs to determine real time functionality.

GDS 500E



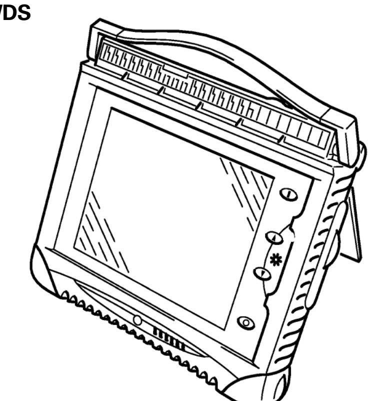
OBD.08

PDU



OBD.09

WDS



OBD.10

Jaguar Diagnostic Equipment

The Jaguar PDU/WDS are capable of performing all the mandatory functions included in the six modes of diagnosis.

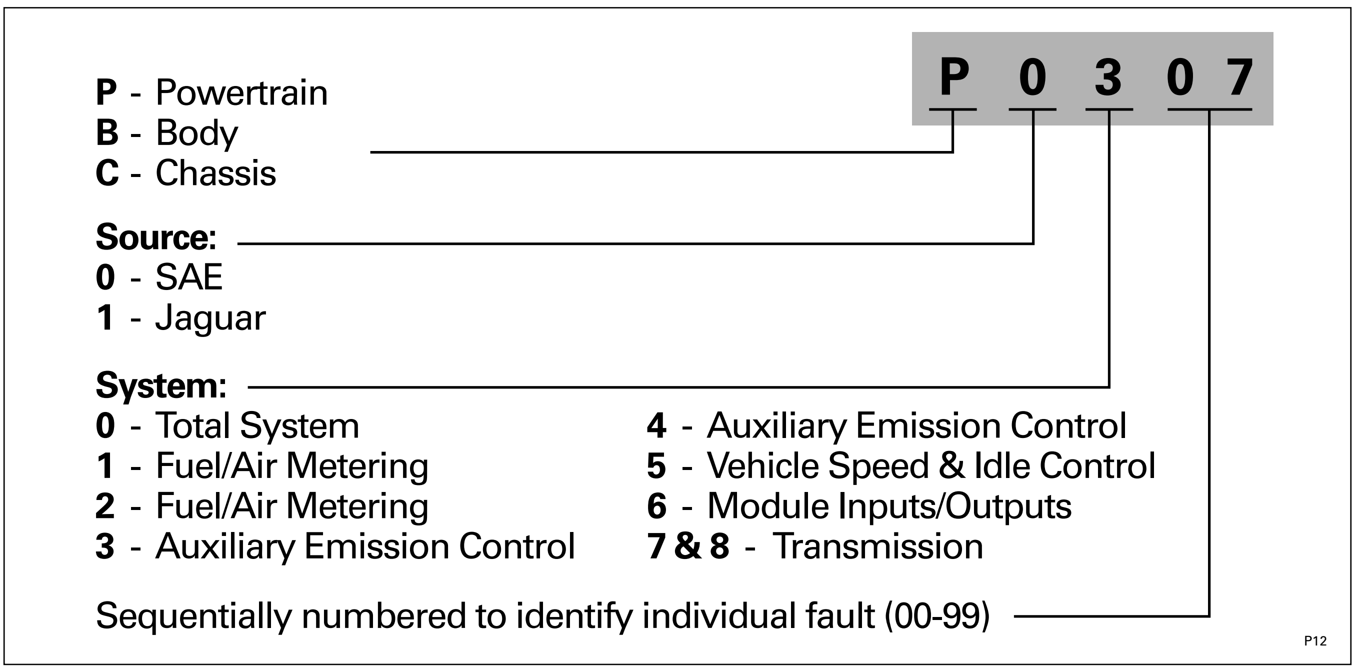
They also provide fault descriptions of Jaguar specific DTCs (P1XXX). This is not a requirement of generic software.

The WDS also provides the following features not found on generic scan tools:

- Manufacturer specific guided diagnostics
- Vehicle control system configuration
- Digital multimeter and dual trace oscilloscope
- Driveshaft balancer
- Vibration analyzer
- JTIS access

OBD II Diagnostic Trouble Codes (DTC):

- SAE specification J 2012 established the Diagnostic Trouble Codes (DTC) used for OBD II systems.
- The DTCs are designed to be identified by their alpha/numeric structure.
- The SAE has designated the emission related DTCs to start with the letter “P” for powertrain related systems.
- Jaguar also follows the SAE convention for other non OBD II monitored systems such as Chassis and Body. Their Alpha structure is identified “B” and “C” respectively.
- The source digit indicates that this particular code is one that will be found on all manufacturers products as noted by the second digit is 0. When there is a 1 in this position, the code would be specific only to a Jaguar specific component or function.



Therefore the DTC **P0307** indicates:
P- Powertrain problem
0 - SAE sanctioned
3 - Related to an ignition system/misfire
07 - The misfire has been detected at cylinder # 7.

The PDU and WDS are used to access all Jaguar vehicle system DTCs. A generic scan tool (i.e.: GDS 500E) can also be used to access OBD II specific DTCs (SAE sanctioned only).

Readiness Code

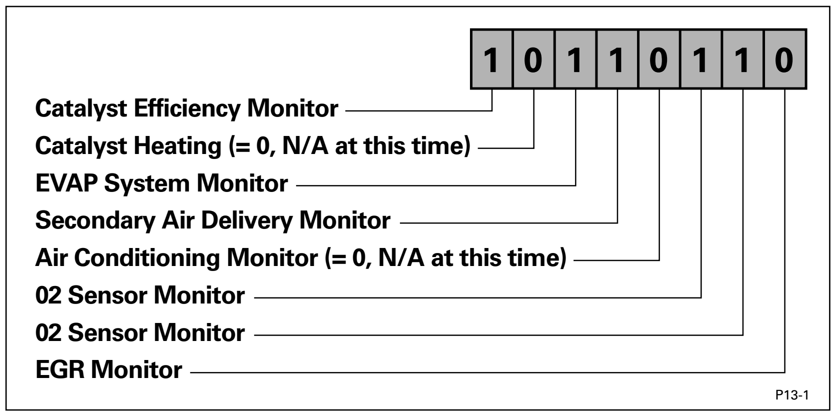
The readiness codes provide status (yes/no) of the system having completed all of the required monitoring functions. Each OBD II required monitor displays “readiness” in the PDU Toolbox and with an aftermarket scan tool. The code is binary (1/0).

0 = Test completed or Not Applicable, **1** = Test not completed.

The readiness code was established to prevent disconnecting the battery or clearing the fault memory to manipulate the results of the emissions test procedure.

Interpretation of the Readiness Code (SAE J1979)

- The complete readiness code is equal to one byte (eight bits).
- Every bit represents one complete test and is displayed by the scan tool, as required by CARB/EPA.
- When the complete, applicable readiness codes equal 0 then all tests have been completed and the system has established its readiness (all monitors completed).



P13-1

System readiness via DTCs:

- System readiness is also displayed by DTCs in the ECM fault memory.
- The DTCs are displayed with the PDU, WDS or a generic scan tool (i.e.: GDS 500).

ECM System	System Readiness **Not Complete** Since Last Memory Clear	System Readiness **Complete** Since Last Memory Clear
Denso	P1000	P1111
PTEC	P1000	—

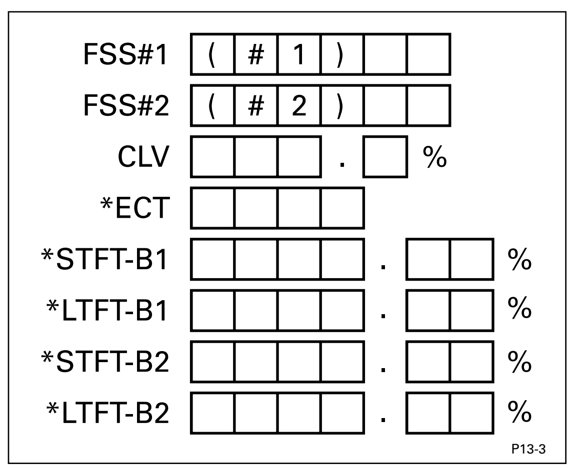
P13-2

Freeze Frame Data

When a DTC is logged, a freeze frame of engine operating parameters are also memorized and available for display with the PDU/WDS or a generic scan tool.

This information is helpful for diagnosing what was occurring with the vehicle and its environment when the DTC was flagged.

This information is also required when filling out the OBD II Report form (see page 18).



P13-3

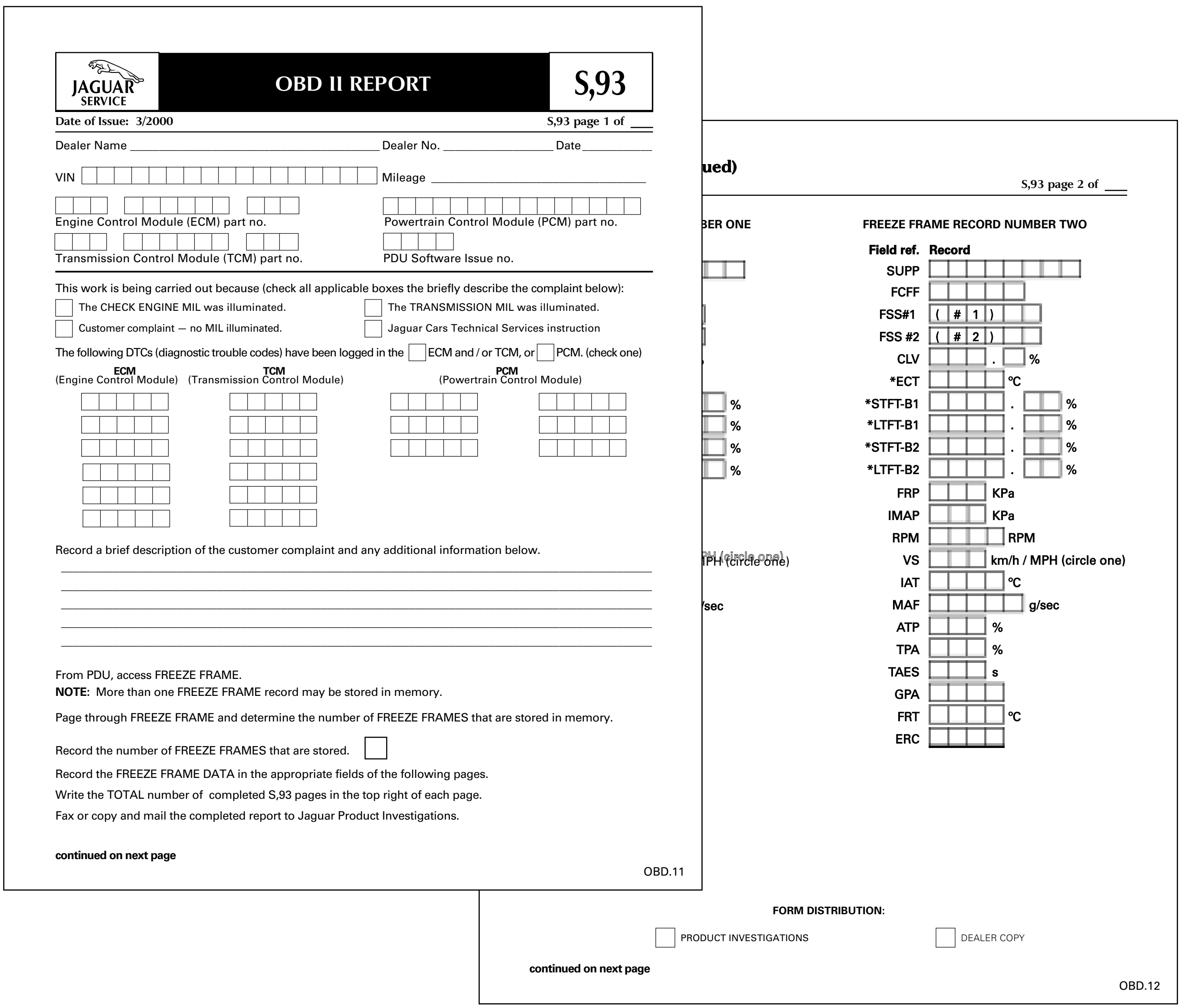
OBD II Report Form

When servicing a vehicle with Engine or Transmission Control malfunctions, remember to fill out a OBD II Report Form (S93). The form must be filled out with the pertinent information and sent to the Product Investigations Department in Mahwah, New Jersey. Jaguar Cars pays 1/2 hour per individual form submittal.

- Fax number = 1 973-818-9763.

Record the applicable data on the form including the part number of the affected control module and the diagnostic software currently loaded in your PDU/WDS. DTCs and FREEZE FRAME DATA must be extracted from the PCM, ECM and/or TCM with the PDU/WDS or generic scan tool.

The data compiled from these forms provides a national focus on product technical issues and an expedited resolve ultimately improving customer satisfaction.


JAGUAR SERVICE

OBD II REPORT

S,93

Date of Issue: 3/2000

S,93 page 1 of ___

Dealer Name ______ Dealer No. ______ Date ______

VIN

Mileage ______

Engine Control Module (ECM) part no.

Powertrain Control Module (PCM) part no.

Transmission Control Module (TCM) part no.

PDU Software Issue no.

This work is being carried out because (check all applicable boxes the briefly describe the complaint below):

- The CHECK ENGINE MIL was illuminated.
- The TRANSMISSION MIL was illuminated.
- Customer complaint — no MIL illuminated.
- Jaguar Cars Technical Services instruction

The following DTCs (diagnostic trouble codes) have been logged in the ECM and / or TCM, or PCM. (check one)

ECM (Engine Control Module) TCM (Transmission Control Module) PCM (Powertrain Control Module)

Record a brief description of the customer complaint and any additional information below.

From PDU, access FREEZE FRAME.

NOTE: More than one FREEZE FRAME record may be stored in memory.

Page through FREEZE FRAME and determine the number of FREEZE FRAMES that are stored in memory.

Record the number of FREEZE FRAMES that are stored.

Record the FREEZE FRAME DATA in the appropriate fields of the following pages.

Write the TOTAL number of completed S,93 pages in the top right of each page.

Fax or copy and mail the completed report to Jaguar Product Investigations.

continued on next page

OBD.11

ued)

S,93 page 2 of ___

BER ONE

FREEZE FRAME RECORD NUMBER TWO

Field ref.	Record
SUPP	
FCFF	
FSS#1	(# 1)
FSS #2	(# 2)
CLV	. %
*ECT	°C
*STFT-B1	. %
*LTFT-B1	. %
*STFT-B2	. %
*LTFT-B2	. %
FRP	KPa
IMAP	KPa
RPM	RPM
VS	km/h / MPH (circle one)
IAT	°C
MAF	g/sec
ATP	%
TPA	%
TAES	s
GPA	
FRT	°C
ERC	

FORM DISTRIBUTION:

PRODUCT INVESTIGATIONS

DEALER COPY

continued on next page

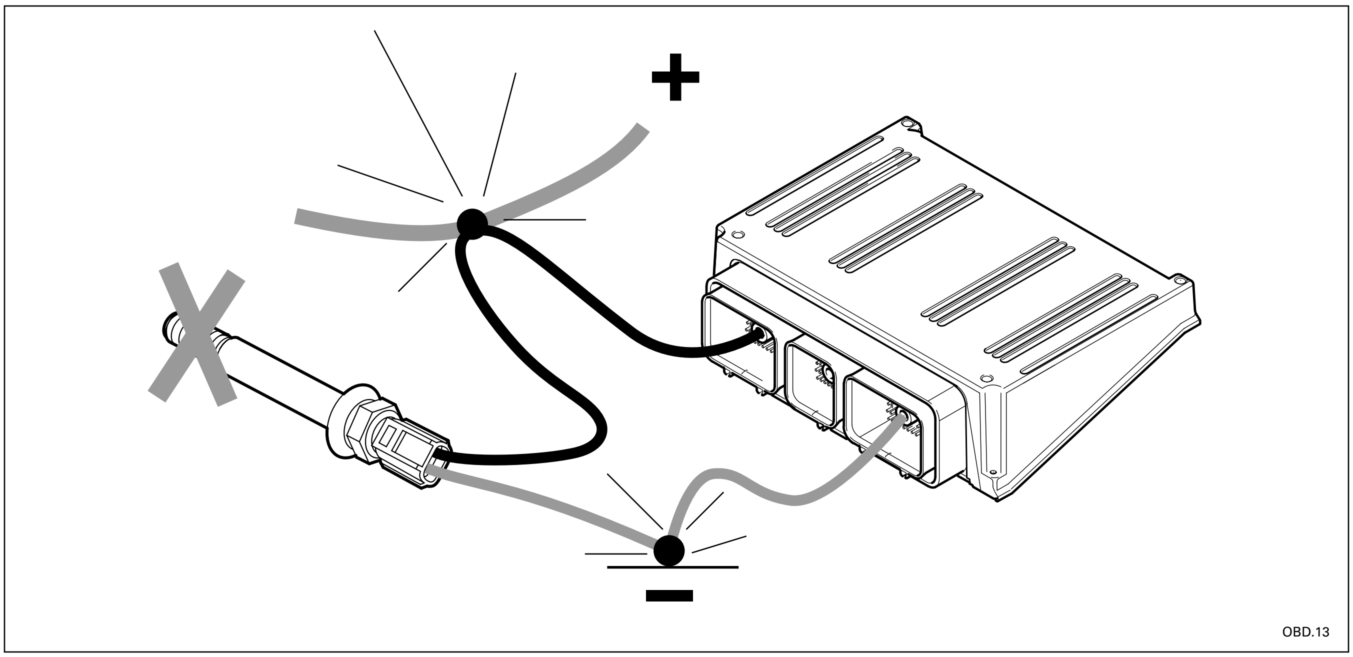
OBD.12

Monitored Systems

Comprehensive Component Monitor

As part of the OBD II requirements, all engine management input and output control components are monitored for shorts to power and ground and for open circuits. Additionally, engine management input signals are monitored for plausible signal range.

The comprehensive component monitor is continual through each drive cycle.
Detected faults of this type are logged when first detected. On the next trip, if the fault is still present the fault is logged and the MIL is illuminated.



- Intake Air Temperature (P0112, P0113),
- Engine Coolant Temperature (P0117, P0118),
- Cylinder Head Temperature (P1289, P1290),
- Mass Air Flow (P0102, P0103)

Oxygen Sensor Monitor

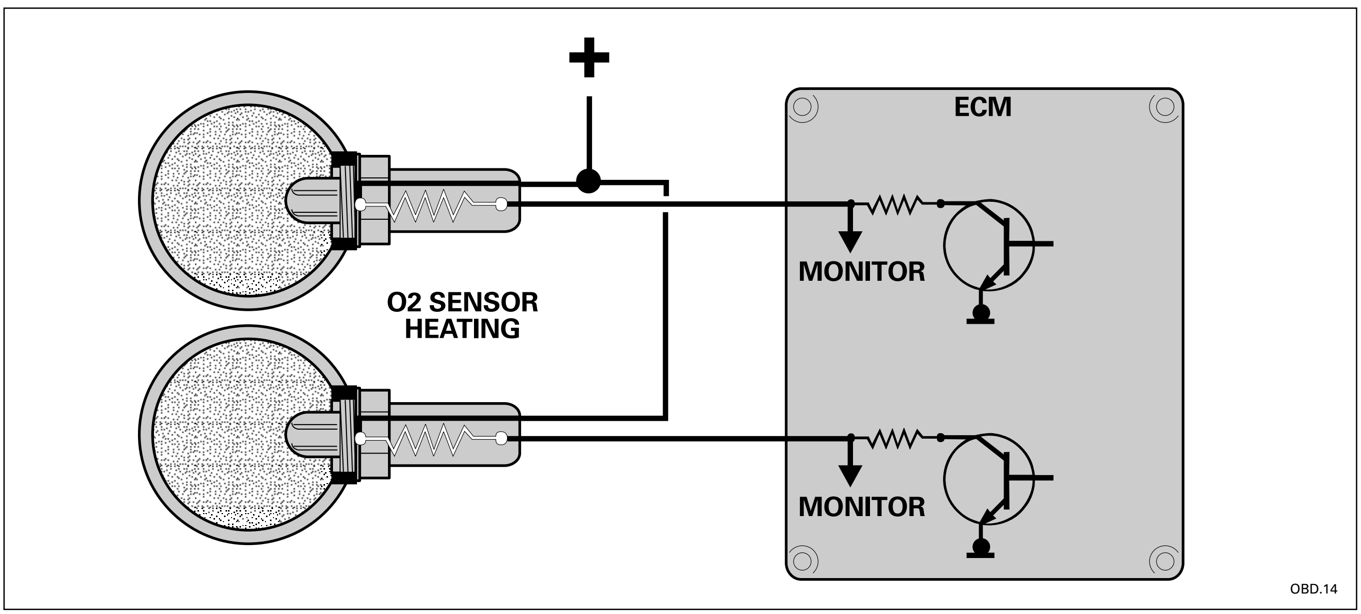
As part of the OBD II requirements, all oxygen sensors must be monitored for:

- electrically integrity (comprehensive component monitor)
- heater operation
- signal switching and response time.

Electrical Integrity: All oxygen sensors and their integrated heaters are monitored by the comprehensive component monitor function of OBD II which includes detection of opens or shorts in the sensor/heater circuits and deviations in the sensor's ability to produce a plausible signal. The comprehensive component monitor is continual through each drive cycle.

Heater Operation: All Heated Oxygen Sensors are also monitored for correct heater function. This monitor is achieved through current monitoring when the heaters are switched on. The ECM performs this monitor once per drive cycle.

An oxygen sensor heater fault is determined by turning the heater on and off and monitoring the corresponding voltage change in the heater output driver in the ECM. A current monitoring circuit monitors the heater current once per drive cycle. If the current does not exceed a predetermined value, the heater is assumed to be degraded or malfunctioning.



Oxygen sensor signal switching time and response rate monitor:

The oxygen sensor signal is a direct correlation to sensed amount of oxygen in the exhaust gas. This input is required to maintain accurate closed loop fuel injection and to monitor the efficiency of the catalytic converters (post catalyst sensor).

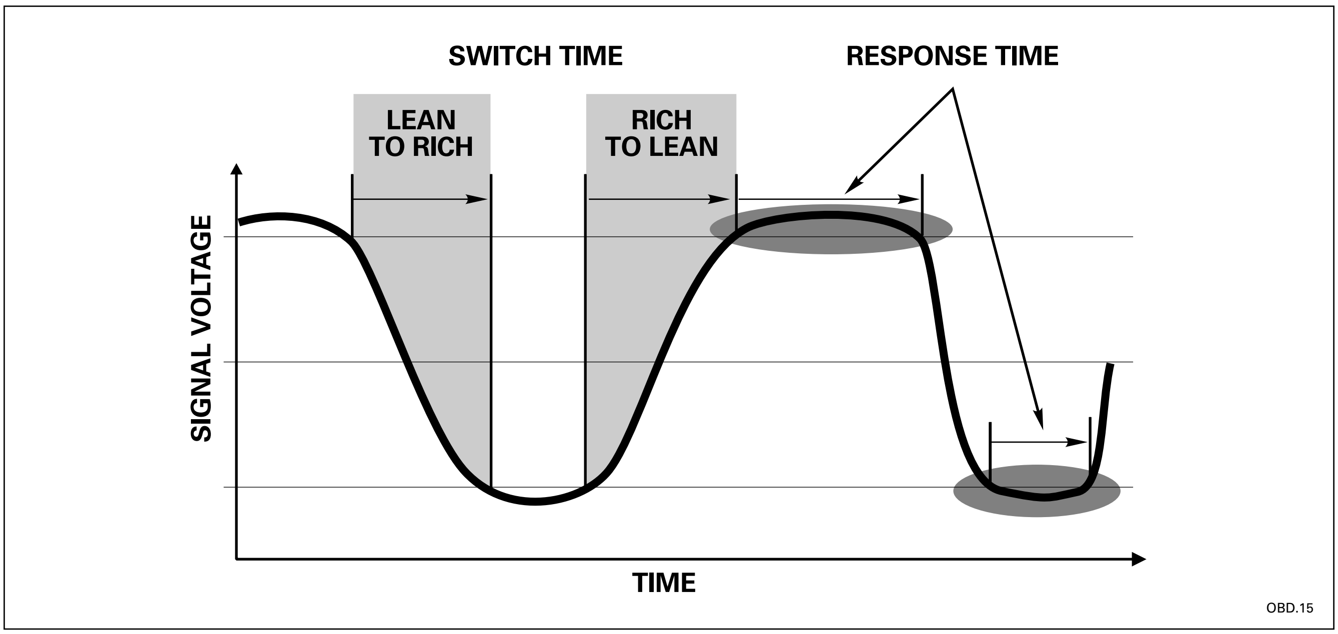
As the sensors age or become contaminated, the speed at which they respond to changes in the detected oxygen levels in the exhaust gas diminishes. To meet OBD II requirements, the ECM must determine if the sensor response and switch rate is acceptable to maintain efficient oxygen monitoring.

Switch Time Monitoring:

The transition (switching) time from lean to rich and rich to lean is measured and compared to a predetermined value dependent on engine speed and air mass/load. A sampling of 10 signal switches is monitored and compared to a predetermined time value to determine how quickly the sensor signal changes from lean to rich and rich to lean.

Since switching time fluctuations can occur, the measured results are averaged over the total number of sampled switches. If the maximum time value is exceeded, the fault is logged in the ECM. Whenever switching time is again monitored and the maximum time value is again exceeded, the CHECK ENGINE MIL is illuminated and a DTC is stored.

Switch time can also be affected by malfunctions in the fuel delivery system.



Response Time Monitoring:

The response rate of the oxygen sensor signal is also dependant on engine speed and load. For the ECM to determine that the oxygen sensor signal is cycling correctly, the length of time a signal remains at rest in either the lean or rich condition is measured and compared with a predetermined value. If the maximum at rest threshold is exceeded, the CHECK ENGINE MIL will be illuminate following the same criteria as with Switch Time Monitoring.

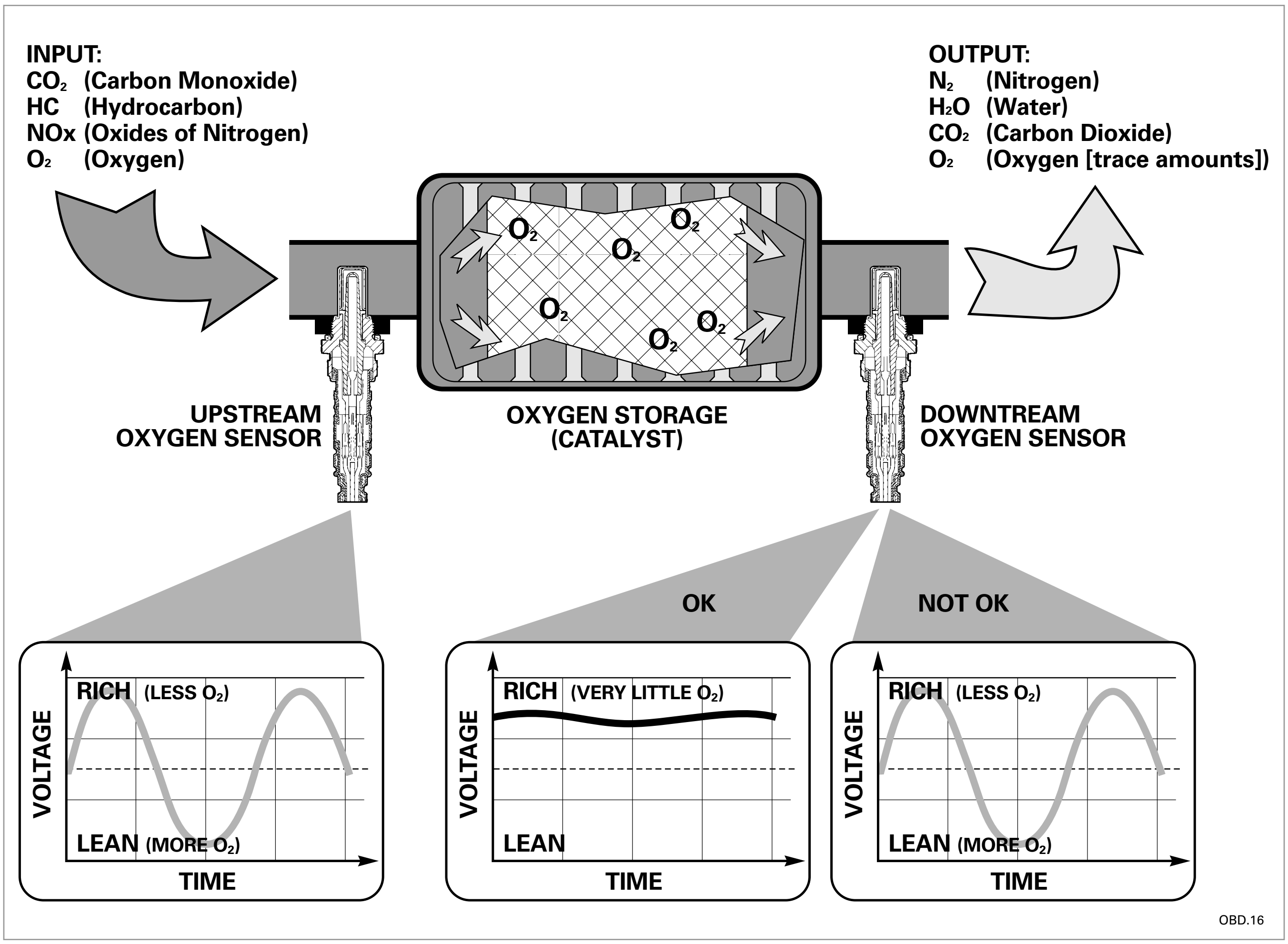
The typical monitor conditions are:

- Short term fuel trim (SHRTFT) is +/- 30%.
- Engine coolant temperature (ECT) is between 150˚ F (65.5 ˚C) and 240˚ F (115.5 ˚C).
- Intake air temperature (IAT) is less than 140˚ F (60 ˚C).
- Engine load is between 20 and 50 percent.
- Vehicle speed is between 30 MPH and 65 MPH.
- Engine rpm is between 1,000 and 2,200 rpm.
- Minimum time of 10 seconds in closed loop operation.

Catalyst Efficiency Monitor

- The Catalyst Efficiency Monitor uses an oxygen sensor before and after a catalyst to confirm efficiency based on oxygen storage capacity. Under normal closed-loop fuel conditions, catalysts have significant oxygen storage which makes the switching frequency of the rear HO2S quite slow compared with the switching frequency of the front HO2S.

- As catalyst efficiency deteriorates due to age, contamination or damage its ability to store oxygen declines and the post-catalyst HO2S signal begins to switch more rapidly, approaching the switching frequency of the pre-catalyst HO2S.
- In order to assess catalyst oxygen storage, the monitor counts upstream and downstream HO2S switches during closed-loop fuel conditions after the engine is warmed-up and catalyst temperature is within limits.



- When the switch rate exceeds a threshold value (typically 0.75 switch ratio) during successive drive cycles, a code is stored and the MIL illuminates.

- The catalyst efficiency is monitored once per trip while the vehicle is in closed loop operation. The evaluation period of the sensor signals is performed over a predefined number of oscillation cycles.

- The catalyst monitoring process is stopped once the predetermined number of cycles are completed until the next drive cycle.

- Refer to the DTC Summary Guide for troubleshooting procedures.

Catalyst Efficiency Monitor: Before the catalyst efficiency is monitored, the following conditions must be met:

- Oxygen sensor monitor completed and OK
- Evaporative System monitor completed and OK
- No DTCs stored for IAT, VSS, ECT, CPS and TP
- Intake air temperature between 20 and 180 degrees F.
- Part load throttle position
- Elapsed time since engine start up minimum 5.5 minutes
- Engine load minimum 10%
- Vehicle speed between 5 & 70 MPH

Misfire Monitor

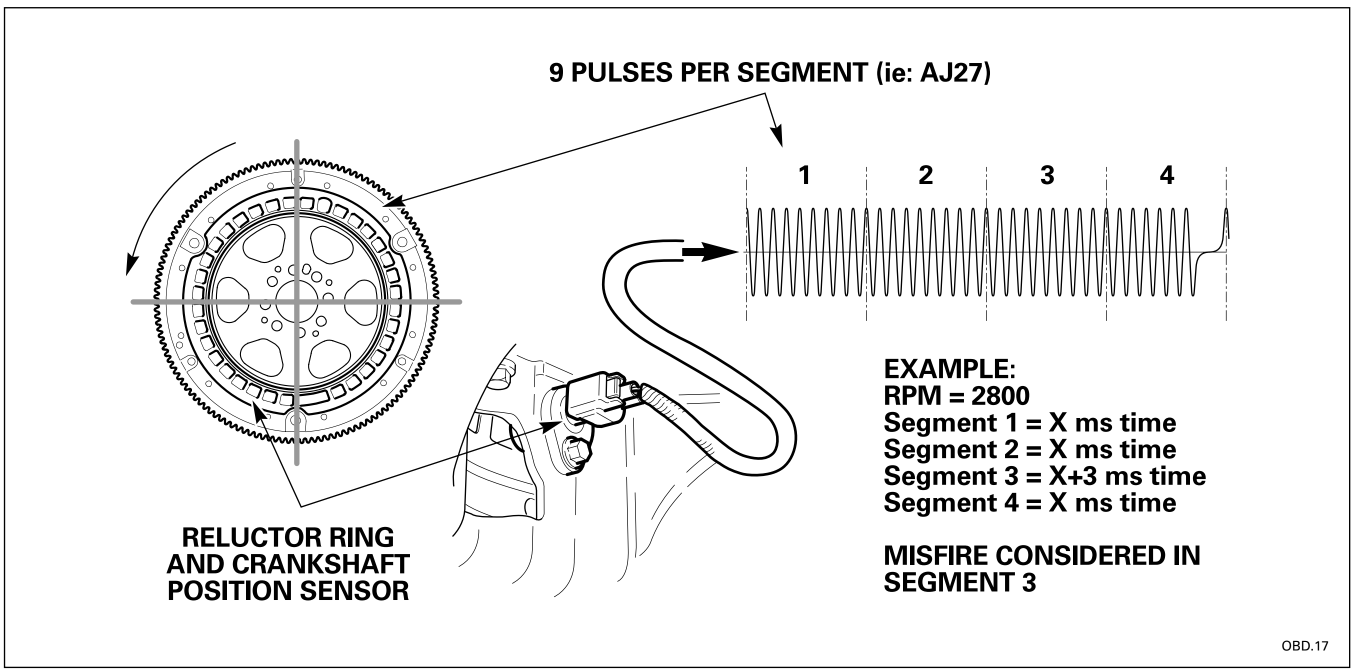
To comply with OBD II regulations, the ECM must monitor for engine misfire events to prevent damage to the catalyst and excessive tailpipe emissions. The ECM must also identify which cylinder(s) is/are causing the misfire and its severity within two categories:

- Type A - Catalyst damaging (severe misfire)
- Type B - Emissions compliant relevant (mild misfire)

To achieve this, the ECM monitors crankshaft torque acceleration during the firing down stroke of each cylinder. Misfires are detected by recognizing changes in the velocity of the crankshaft. Crankshaft velocity is determined by measuring the amount of time it takes the crankshaft to travel a specified crank angle. *Acceleration is the change in velocity.*

By comparing the crankshaft acceleration contributed by the combustion of each cylinder the Misfire Monitor can determine if any of the cylinders are not producing the expected acceleration. A cylinder that lacks combustion exhibits a lower acceleration compared to the others.

- To do this, the ECM divides the 360° crankshaft circumference into segments. It continually monitors engine speed via the crankshaft position sensor and reluctor ring.



- The sensor's input pulses are counted and compared to a programmed time value for the given engine speed.
- If the combustion process in all cylinders is functioning correctly, the period duration for each segment is the same.

- During constant/stable engine speeds, if the period duration of one (or more) segment is detected as longer than all the other segments, a cylinder specific misfire is “considered”. The measured time values are also corrected based on *engine load and engine temperature*.

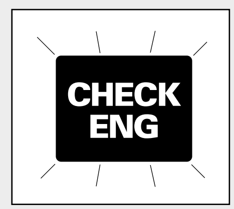
- Additionally, the ECM evaluates the suspect misfiring event for noise. Mechanical noise, such as rough road conditions derived from ABS/IVD road speed sensor frequency irregularities or high rpm/light load conditions, will produce piston acceleration variations. Misfire events of this type are considered noise. Noise-free deviant acceleration exceeding a given threshold is labeled a misfire.

- If the expected period duration is greater than the permissible programmed value, and noise is conclusively factored out, the ECM will set a misfire DTC and illuminate the MIL based on the misfire severity; **(Type A)** or **(Type B).**

Type A Misfires (Catalyst damaging)

- Evaluation of **Type A** misfires are concluded within **200** crankshaft revolutions. At the end of the evaluation period, the total misfire rate and the misfire rate for each individual cylinder is computed. The monitor compares the actual percentage of misfires to a threshold percent obtained from a speed/load table.

- If the misfire percentage is above the threshold and the catalyst temperature model indicates that the catalyst is being damaged, the MIL blinks at a rate of once per second while the misfire is present.



- For XK and XJ vehicles through model year 1997, the MIL flashes when a Type A catalyst damaging misfire is present on the first drive cycle and the MIL will stay on.

- Starting with 1998 model year, the regulations changed to allow the Misfire Monitor to act like all other OBD II monitors. This means that the MIL will still flash but does not stay on until there is a fault on the second drive cycle. This regulation change was intended to reduce MIL illumination due to unrepeatable misfires.

- S-TYPE vehicles follow the 1998 regulations. These systems will also inhibit fuel injection on up to two misfiring cylinders to prevent catalyst damage. The PCM reactivates injection for the misfiring cylinders during the drive cycle to see if the condition was still exists.

Type B Misfires

Evaluation of **Type B** misfires are concluded within **1000** crankshaft revolutions. At the end of the evaluation period, the monitor then compares the actual percentage of misfires to a threshold value. If the percent misfire is above the emission threshold value, the MIL is illuminated on the **second drive cycle**.

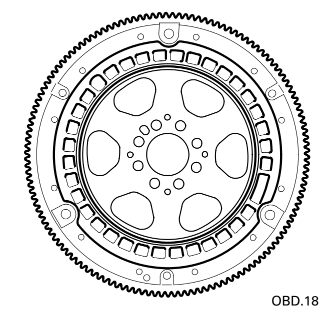
Misfire detection is an ongoing monitor that continues through the entire driving cycle.

The following conditions must be met for the misfire monitor to start:

- No DTCs stored for CKP or CMP
- Elapsed time since engine start up between 0 and 5 seconds.
- Engine temperature between 20 and 250 degrees F.
- Engine RPM range between idle and 2500.

The Misfire Monitor can be temporarily disabled for select conditions including:

- Closed throttle deceleration (see reluctor ring adaptation).
- Traction Control Regulation
- Rough Road Recognition
- Fuel cutoff due to vehicle speed or engine rpm limiting mode.



OBD.18

Reluctor Ring Adaptation

The ECM must also 'learn' and correct for mechanical irregularities in the reluctor ring gap spacing when the engine is new or when the control module has been disconnected. Slight irregularities are detected and learned.

The learning process requires three 60 to 40 MPH closed throttle engine decelerations with out applying the brakes. The learned corrections improve the high-rpm capability of the monitor. The misfire monitor is not active until a profile has been learned to prevent erroneous MIL activation.

Service Note. If the reluctor ring (torque converter flex plate/ starter ring gear) is replaced, disconnect the power source to the ECM to clear the existing learned values.

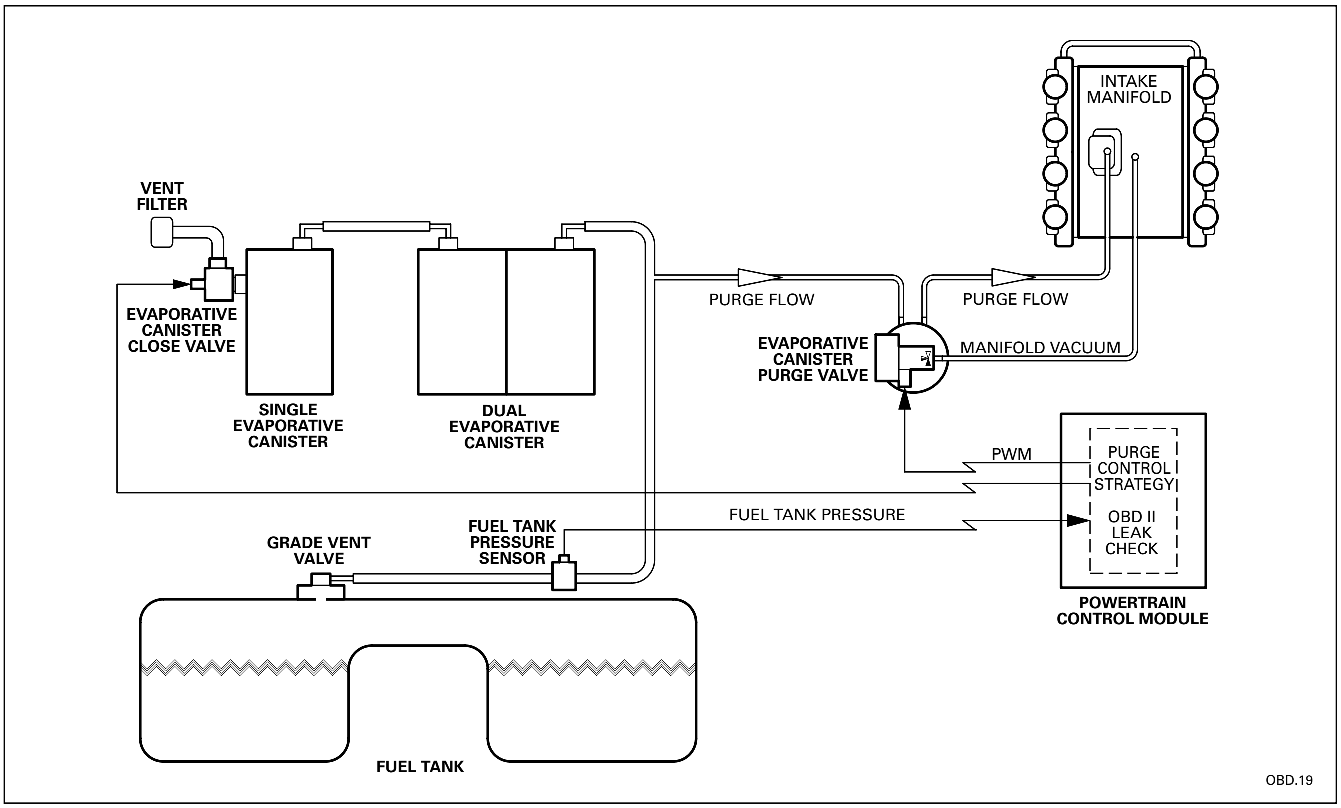
EVAP System Monitor

OBD II regulation requires monitoring the function of evaporative system purging and the sealed integrity of the entire fuel system (evaporative system leak diagnosis).

Purge Flow Monitoring

The ECM detects purge flow two ways: if closed loop fuel metering indicates a large correction when purge is enabled, or if the idle air control valve corrects for increased air flow when purging is enabled, the ECM has confirmation that purging is taking place.

If, during these functional conditions, the additional air introduced into the system is not detected on successive drive cycles, the ECM will flag a DTC and illuminate the MIL.



EVAP System Leak Check Monitoring

The evaporative system leak test is done in four phases:

Phase 1 - Initial vacuum pulldown:

- The test starts out with a closed Evaporative Purge Valve. The ECM goes into open loop injection and closes the Canister Close Valve to seal the system from ambient air. The ECM monitors a slight generation of vapor in the system via the Fuel Tank Pressure Sensor. The slight positive pressure value is recorded.
- The EVAP purge valve is opened to pull a vacuum on the system. The ECM detects the vacuum via the Fuel Tank Pressure Sensor input. The rate at which the vacuum signal changes is based on fuel tank level and must be within a predetermined value.
  - If the sensor signal does not change or is very slight, the ECM determines a large system leak which is most likely caused by a fuel cap that was not installed properly, disconnected or kinked vapor lines (intake side of purge valve), a Canister Close Valve that is stuck open or a purge valve that is mechanically stuck closed.
  - If the vacuum signal is excessive, a vacuum malfunction is indicated. This could be caused by kinked vapor lines (EVAP system side of purge valve) or the purge valve is stuck open.

Phase 2 - Vacuum stabilization, hold and decay:

- If the target vacuum signal is achieved in phase 1, the EVAP purge valve is closed and vacuum is allowed to stabilize. This initial vacuum signal is noted in memory.
- Next, the vacuum is held for a calibrated time and the vacuum level is again recorded at the end of this time period. The starting and ending vacuum signals are compared to determine if the change in held vacuum exceeds the test criteria.
- The monitor will abort if there is an excessive change in load, fuel tank pressure or fuel level input since these are all indicators of fuel tank instability (fuel slosh). If the monitor aborts, it will attempt to run again once conditions are detected as stable.
- If the vacuum bleed-up is not exceeded, the small leak test is considered a pass.
- If the vacuum bleed-up is exceeded on two successive monitoring events, a 0.040” dia. leak is likely and a final vapor generation check is done to verify the leak, phases 3-4.

Phase 3 - Vacuum release:

The vapor generation check is done by opening the canister close valve to release the stored vacuum.

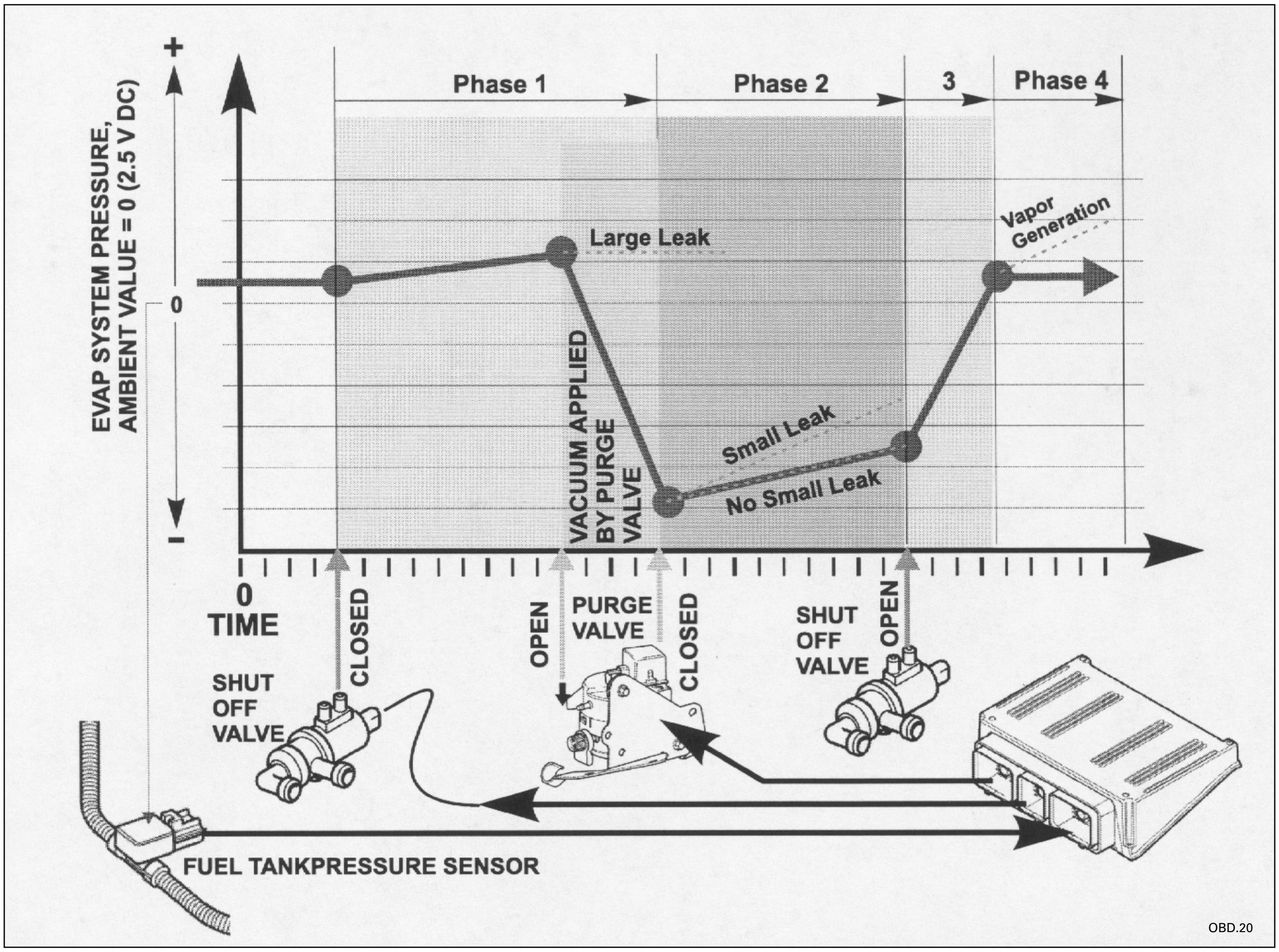
Phase 4 - Vapor generation:

The pressure is monitored over a short period of time to determine if tank pressure remains low or if it rises due to excessive vapor generation. If the pressure rise due to vapor generation is above the threshold limit for absolute pressure and change in pressure, a P0442 DTC is stored.

EVAP System Leak Check Monitor Diagnostic Preconditions

Before the system is tested, the following conditions must be met:

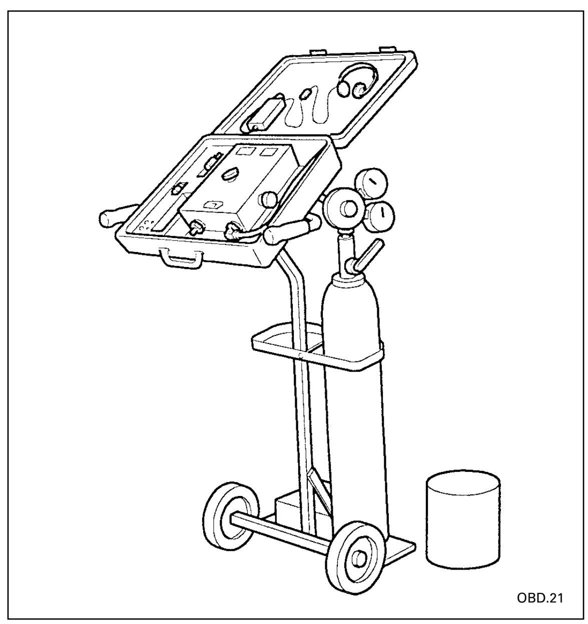
- Oxygen sensor monitor completed and OK
- No DTCs stored for MAF, IAT, VSS, ECT, CKP and TP
- More than six hours elapsed time since completion of last drive cycle.
- Fuel level between 15% & 80%.
- Intake air temperature between 40° and 110° F.
- Vehicle elevation no higher than 8,000 feet.
- Elapsed time since engine start up between 5.5 and 30 minutes
- Engine load between 20% and 70%.
- Vehicle speed between 40 & 70 MPH



Evaporative System Leak Troubleshooting

When a leak is confirmed via DTC, use the evaporative system leak tester to determine the location of the leak on the vehicle.

- Refer to TSB 05.1-29 for complete instructions.



Secondary Air Monitor (AIR) – AJ 16 & 6.0 Liter V12 Engines Only

To reduce exhaust gas emission pollutants, the Secondary Air Injection system is required on the AJ 16 and 6.0 liter V12 engines during cold start conditions. When cold, fuel injector on time is increased providing cold start enrichment to start the engine. However, the rich mixture contributes to high levels of hydrocarbons during warm up.

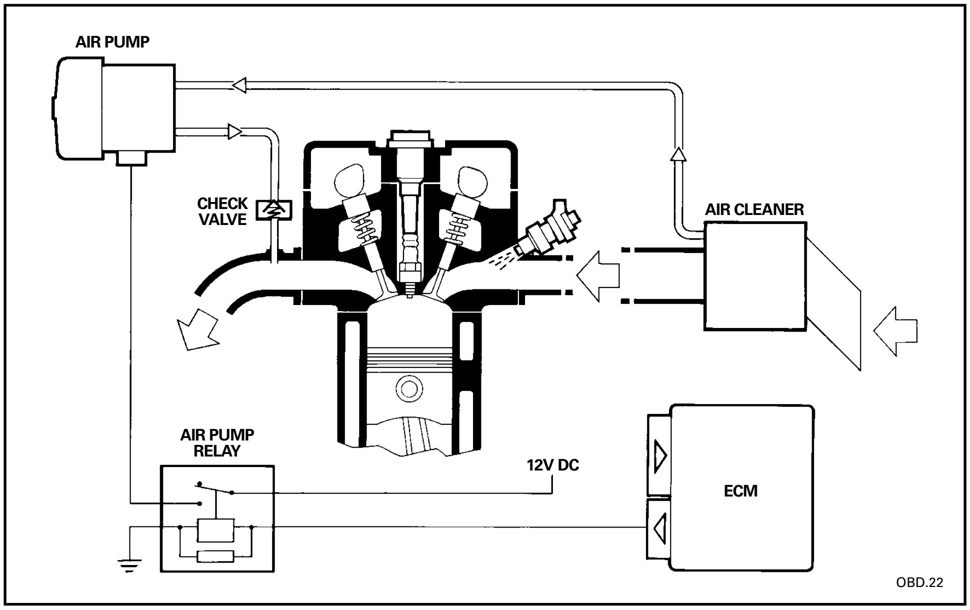
Secondary air injection;
- accelerates oxidation of hydrocarbons during cold start
- reduces catalytic converter warm up time (light off achieved earlier)

The secondary air injection system adds air to the hydrocarbon enriched exhaust gas ensuring its continued combustion.

This quickly heats the catalyst up as the burning gas mixture flows through the catalytic converter.

To comply with OBD II regulations, the secondary air injection system is monitored for proper function.

The ECM monitors the system's electrical integrity through comprehensive component monitoring. It also confirms that air is actually injected into the exhaust system via oxygen sensor feedback during normal operation.



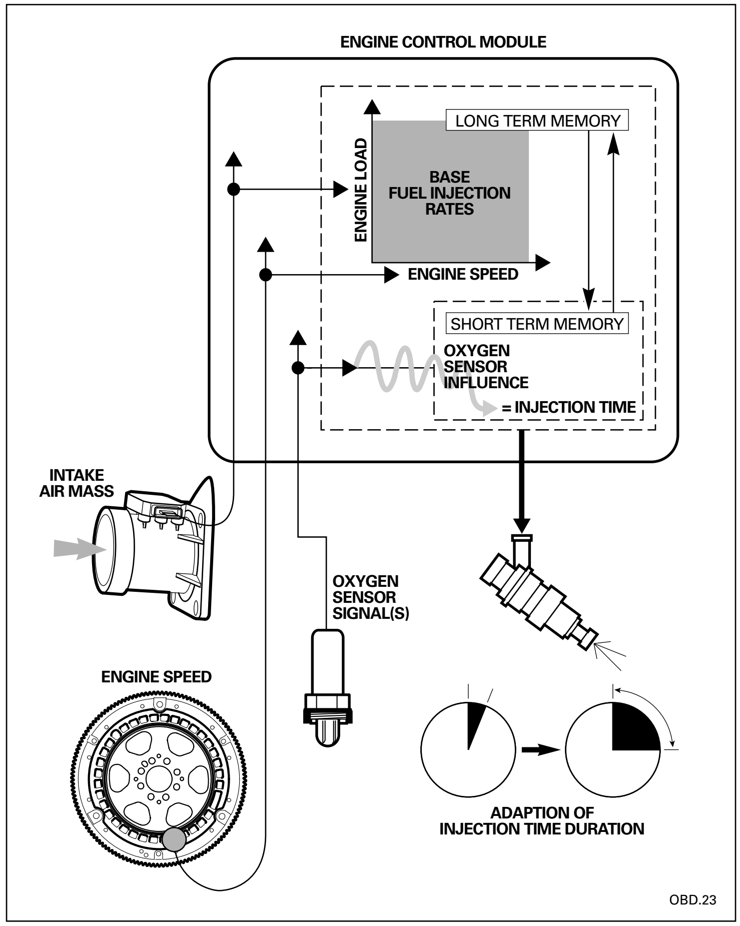
To perform this monitoring function, the ECM switches to open loop fuel injection. The oxygen sensors provide a stable rich signal. The air injection system is activated on. The ECM monitors the oxygen sensor signals and when a shift to lean is detected, the ECM confirms the system is functioning correctly.

Later Jaguar engines (AJV8 and V6) achieve fast catalyst light off through an ignition timing emission reduction strategy during cold start conditions. In addition, catalyst locations are close to hot exhaust exiting the engine exhaust parts. Therefore, these vehicles do not require the secondary air injection system.

Fuel System Monitor

Fuel System monitoring is an OBD II requirement which monitors the calculated fuel injection on time in relation to engine speed, load and the upstream oxygen sensor signals.

- The ECM uses the upstream catalyst oxygen sensor signals to provide closed loop injector control (except AJ16).
- The fuel system monitor determines the fuel delivery needed (long/short term fuel trim).
- If components change beyond normal limits or if a malfunction occurs, the long term fuel trim will reach a limit.
- If too much or not enough fuel is delivered over a predetermined time frame during the drive cycles, a DTC is set and the MIL is turned on.
- Long term fuel trim corrections at their limits in conjunction with a calibrateable deviation in short term fuel trim, indicate a rich or lean fuel system malfunction.



Fuel System Monitoring: The fuel system monitor is continuous while in closed loop fuel control. Additionally, the following conditions must be met:

- Fuel system pressure sensor OK (PTEC)
- Engine speed between idle and 4,000 RPM
- Air Mass Range between .75 and 8.0 lbs per minute.
- Evaporative Purge not active

Typical Fuel Monitor malfunction thresholds:

Lean malfunction: Long Term Fuel Trim (LTFT) > 25%, Short Term Fuel Trim (STFT) > 5%

Rich malfunction: Long Term Fuel Trim (LTFT) < 25%, Short Term Fuel Trim (STFT) < 10%

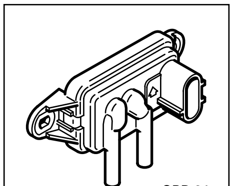
Exhaust Gas Recirculation (EGR) System Monitor

EGR System monitoring is an OBD II requirement which monitors a series of electrical tests and functional tests for EGR system operation. Jaguar vehicles have various types of EGR systems depending on the vehicle. For example:

- *AJ16* = Electrically operated and monitored system.
- *V6 PTEC* = Electrically regulated Vacuum operated system/electrically monitored.

The EGR OBD II monitor overview presented here is based on the V6 PTEC system.

Comprehensive Component Monitor:


OBD.24

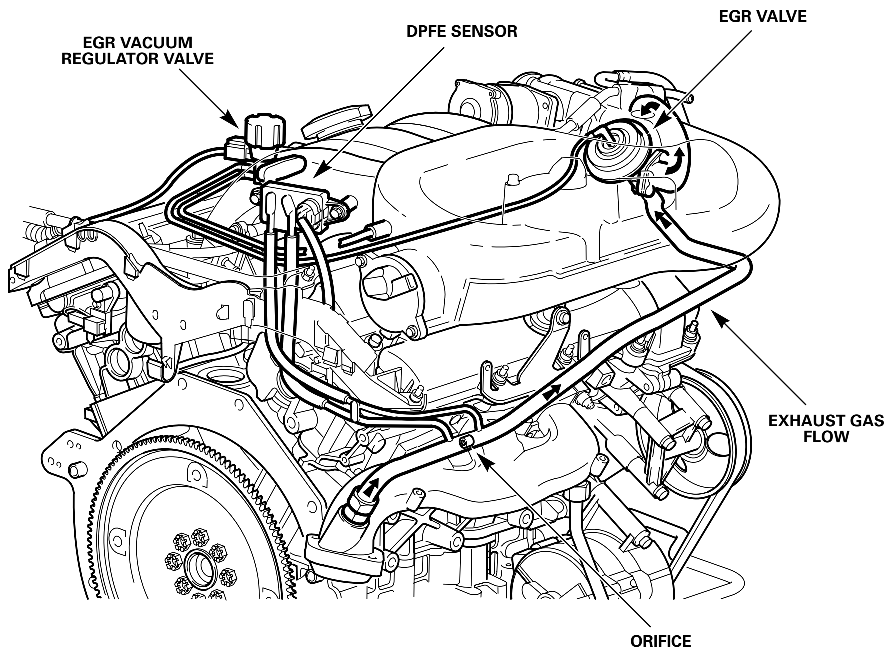
- First, comprehensive component monitoring for the Differential Pressure Feedback EGR (DPFE) sensor input circuit is checked for out of range values (P1400 P1401).

- The Electronic Vacuum Regulator (EVR) output circuit is checked for opens and shorts (P1409).

Hose Monitor:

- After the vehicle is started, during vehicle acceleration, the differential pressure indicated by the DPFE sensor at zero EGR flow is checked to ensure that both hoses to the DPFE sensor are connected. Under this condition, the differential pressure should be zero.

- If the differential pressure indicated by the DPFE sensor exceeds a maximum threshold or falls below a minimum threshold, an upstream or downstream DPFE hose malfunction is indicated (P1405 P1406).



OBD.25

Flow Monitor:

- After the vehicle has warmed up and normal EGR rates are being commanded by the PCM the Flow flow check is performed. Since the EGR system is a closed loop system, the EGR system will deliver the requested EGR flow as long as it has the capacity to do so.

- If the EVR duty cycle is very high (greater than 80% duty cycle), the differential pressure indicated by the DPFE sensor is evaluated to determine the amount of EGR system restriction. If the differential pressure is below a calibrated threshold, a low flow malfunction in indicated (P0401).

Valve Mechanical Monitor:

- Finally, the differential pressure indicated by the DPFE sensor is also checked at idle with zero requested EGR flow to perform the high flow check.

- If the differential pressure exceeds a calibrated limit (>0.6 volt compared with initial key on at start of current drive cycle) it indicates a stuck open EGR valve or debris temporarily lodged under the EGR valve seat (P0402).

Before each of the tests are performed, the following conditions must be met:

Comprehensive Component Monitor:
- EGR system must be active with no faults

Hose Check:
- EVR Duty Cycle 0%
- Mass air flow maximum 8 lb/min.

Flow Check:
- EVR duty cycle between 80% and 100%.
- Engine Speed 2500 RPM maximum
- Maximum 6% deviation in intake air mass
- Manifold vacuum between 6 and 10 in hg.

Valve Mechanical Check:
- EVR duty cycle at 0%.

Thermostat Monitoring

- OBD II regulations require the ECM to monitor the mechanical function of the engine cooling system thermostat beginning with the 2000 MY.

- The thermostat is considered malfunctioning if the engine does not warm-up in a predictable manner, as monitored from the engine coolant temperature (ECT) sensor or the cylinder head temperature (CHT) sensor signals.

- A timer is counted while the engine is at moderate load or greater and the vehicle is moving. The target/minimum timer value is based on ambient air temperature at start-up. If the timer exceeds the target time and ECT/CHT has not warmed up to the target temperature, a malfunction is indicated.

- The test runs only after a 2 hour engine-off soak time, in order to permit engine coolant temperature to drop below the target warm-up temperature on a hot engine.

- The target temperature is calibrated to the thermostat regulating temperature minus 20°F,
  (i.e: 195°F rated thermostat = 175°F calibrated warm up temperature.)

Contents

Overview

The AJ16 Engine Management System (EMS) is controlled through a digital Electronic Control Module (ECM) containing a microprocessor. The system maintains optimum performance over the engine operating range by precisely controlling all fuel injection, ignition and emission control functions. In addition, the ECM provides various interface outputs and incorporates an on-board diagnostic facility.

The AJ16 EMS complies with OBD II (on-board diagnostics II), the second generation environmental legislative regulations that set the acceptable maximum level of motor vehicle exhaust emission and the required engine control systems self diagnosis capabilities.

The previous EMS used on the AJ6 4.0 liter engine complied with OBD I, which required that the following performance and diagnostic standards be met:

OBD I (AJ6 EMS 1990 – 94 MY)

- Exhaust emission level
- Monitoring and diagnosis of electrical fuel system faults
- Monitoring of both open and closed circuit faults
- Visual warning to driver: MIL (CHECK ENGINE)
- Fault code provided to technician: Diagnostic Trouble Code — DTC (Fuel Fail Code — FF) and Flash Code output of the MIL

OBD II requires lower exhaust emission levels, standardized diagnostics and failure prediction.

OBD II (AJ16 EMS)

- Exhaust emission level reduced
- Industry standardized DTCs
- Generic (after-market) scan tool capable of DTC retrieval
- Expanded self diagnostics to include monitoring and diagnosis of any power train system fault that will likely cause exhaust emission to exceed 1.5 times the standard level.
- Failure prediction of subsystems by performance observation over the life of the power train including: catalyst efficiency, engine misfire, exhaust gas recirculation, and secondary air injection.

NOTES

Engine Control Module (ECM)

GEMS 6 Engine Control Module

The AJ16 EMS is microprocessor based using a Sagem / Lucas GEMS 6 ECM as the heart of the system. The ECM has a 1.5 megabyte memory with a microprocessor running at a clock speed of 12/24 MHz. The ECM uses discrete components plus analog-to-digital circuits to interface between the microprocessor, the input sensors and the output devices. Software is programmed into two EPROMs and one EEPROM. The EPROMs are used for control and data. The EEPROM is used for On-Board Diagnostics and adaptive functions. The ECM has nonvolatile memory so that on-board diagnosis and adaptive information is maintained if the vehicle battery is disconnected.

⚠ CAUTION: ECMs must not be switched from one vehicle to another, because fuel metering, idle air adaptions and the VIN cannot be reprogrammed using PDU.

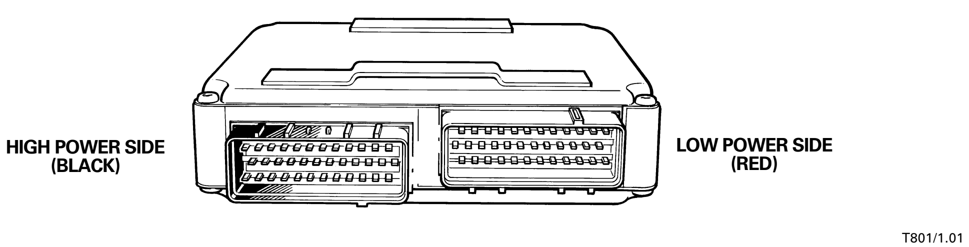
The ECM contains two double sided printed circuit boards. One is a low power board and the other is a high power board. The red and black 36-way connectors are therefore referred to as the low and high power connectors respectively. Most of the input signals from engine mounted sensors, and interfaces with other systems, are located on the low power (red) connector. The high power connector (black) mainly serves outputs such as fuel injector drive, ignition coil drive, and relay activation.

The expanded capacity of the ECM is used to store emission control strategies, diagnostics, semi-sequential fuel injection, and direct ignition. Sixty percent of the ECM software is used for OBD II diagnostics.

An ECM controlled relay remains energized for approximately 15 seconds after power-down. This action enables the ECM to perform idle air control valve positioning and other initializing functions, yet allows for reduced quiescent drain after switch-off.

ECM Monitoring for OBD II

GEMS 6 ENGINE CONTROL MODULE

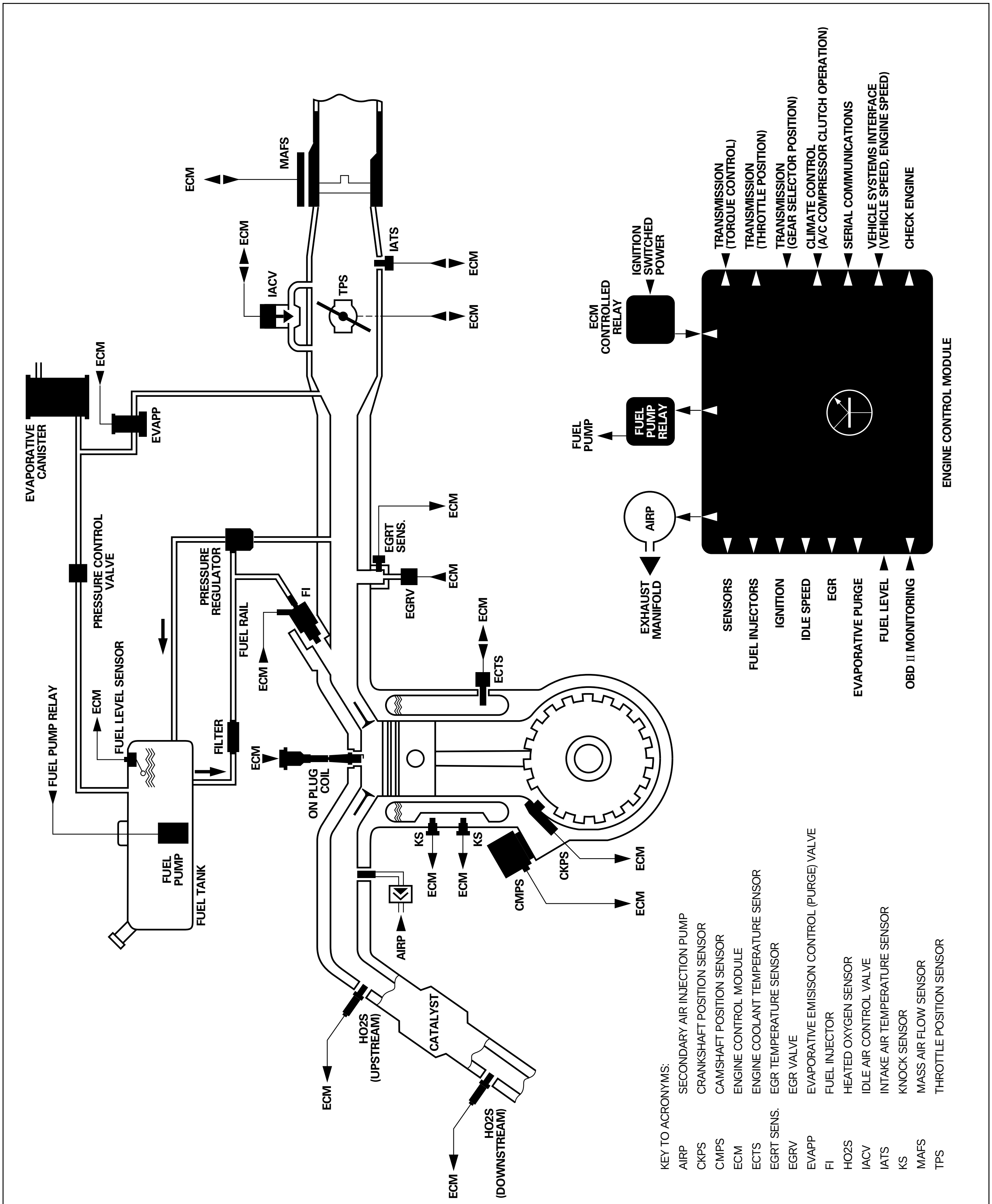


On each power-up, the ECM runs an internal EEPROM check. If a retrieved parameter does not correspond to what the ECM knows to be a serviceable value, a fault is present and the CHECK ENGINE MIL will immediately be activated.

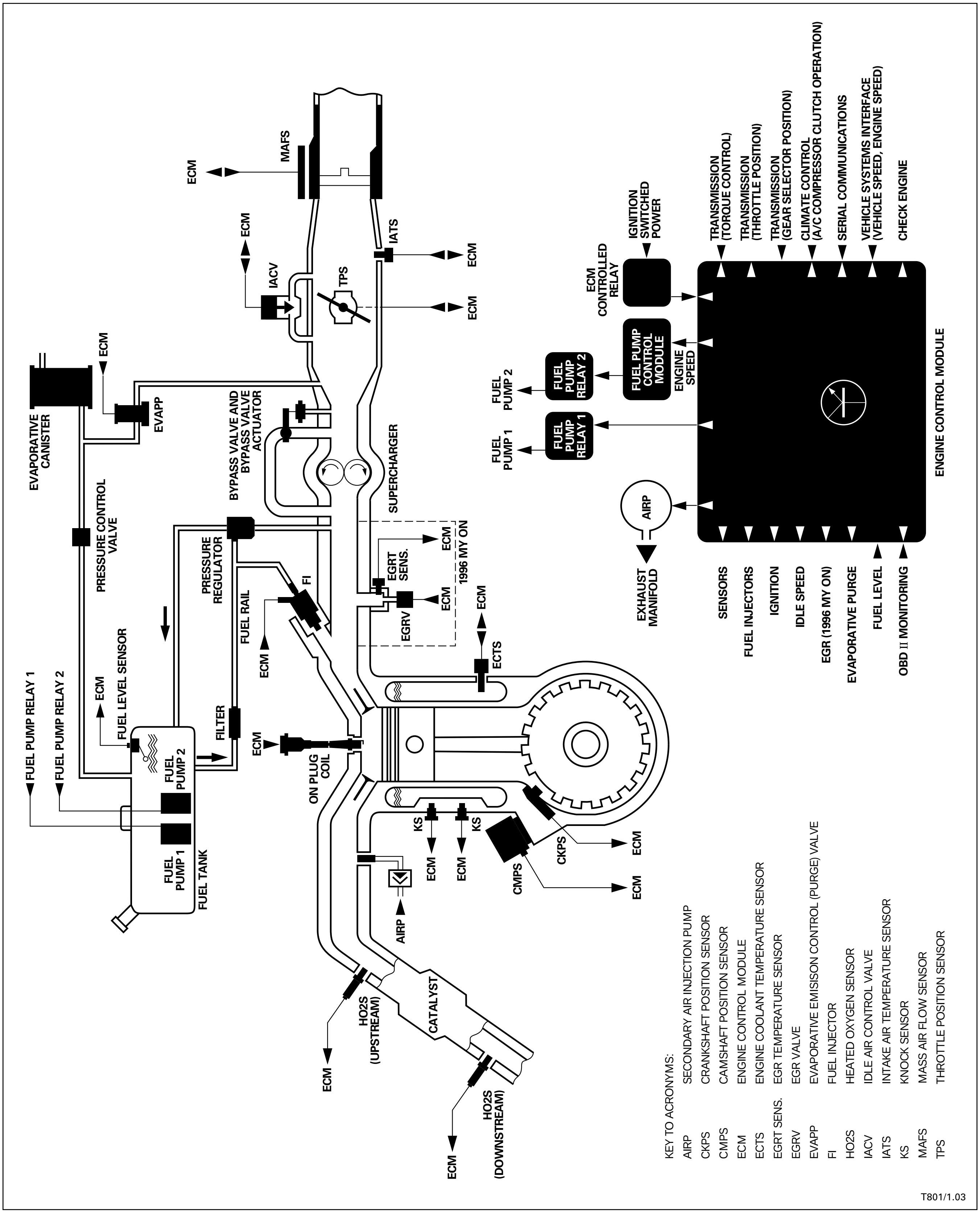
NOTES

Engine Control Module (ECM) (continued)

Engine Management Logic: Normally Aspirated Engines

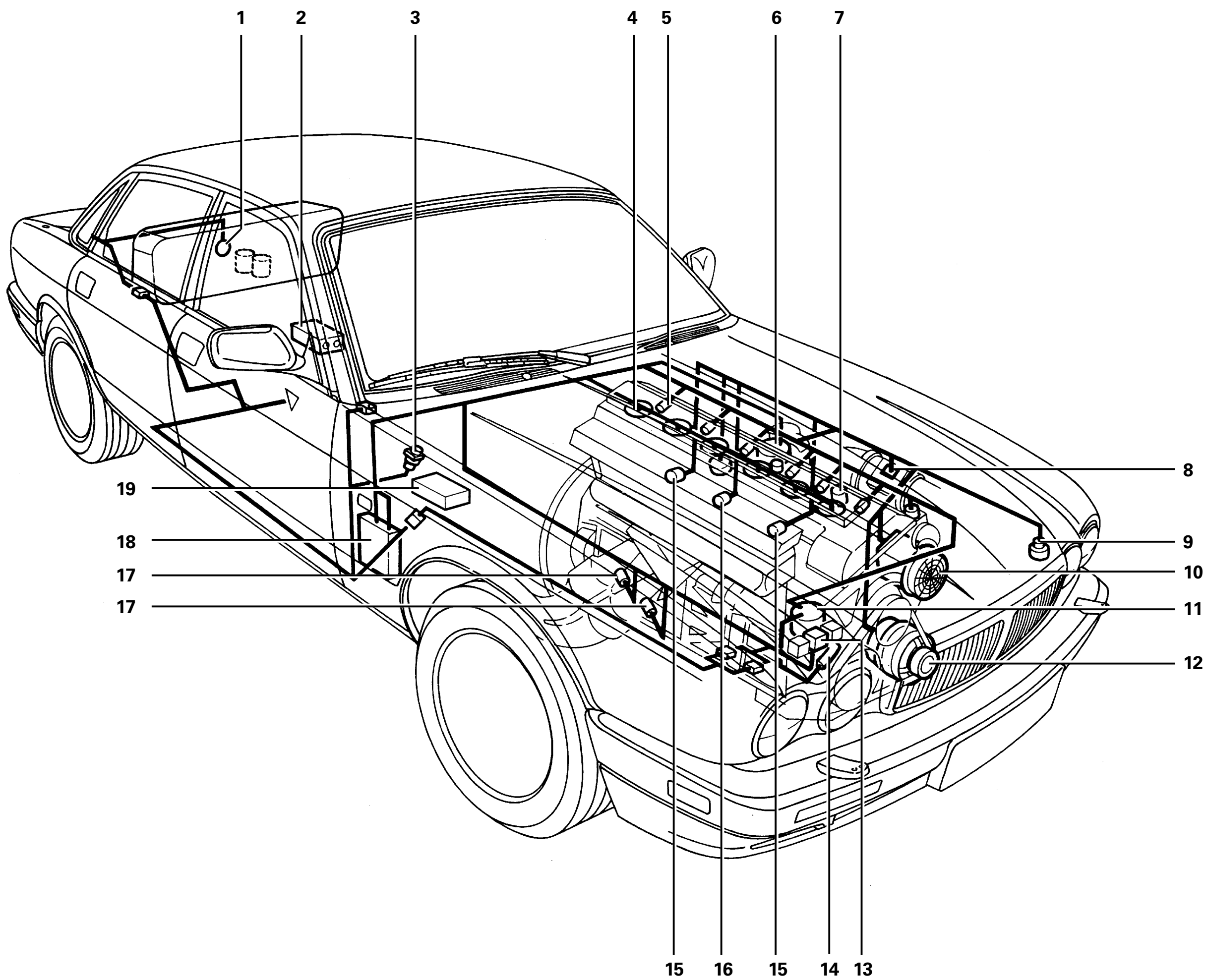


Engine Management Logic: Supercharged Engines



EMS Component Location

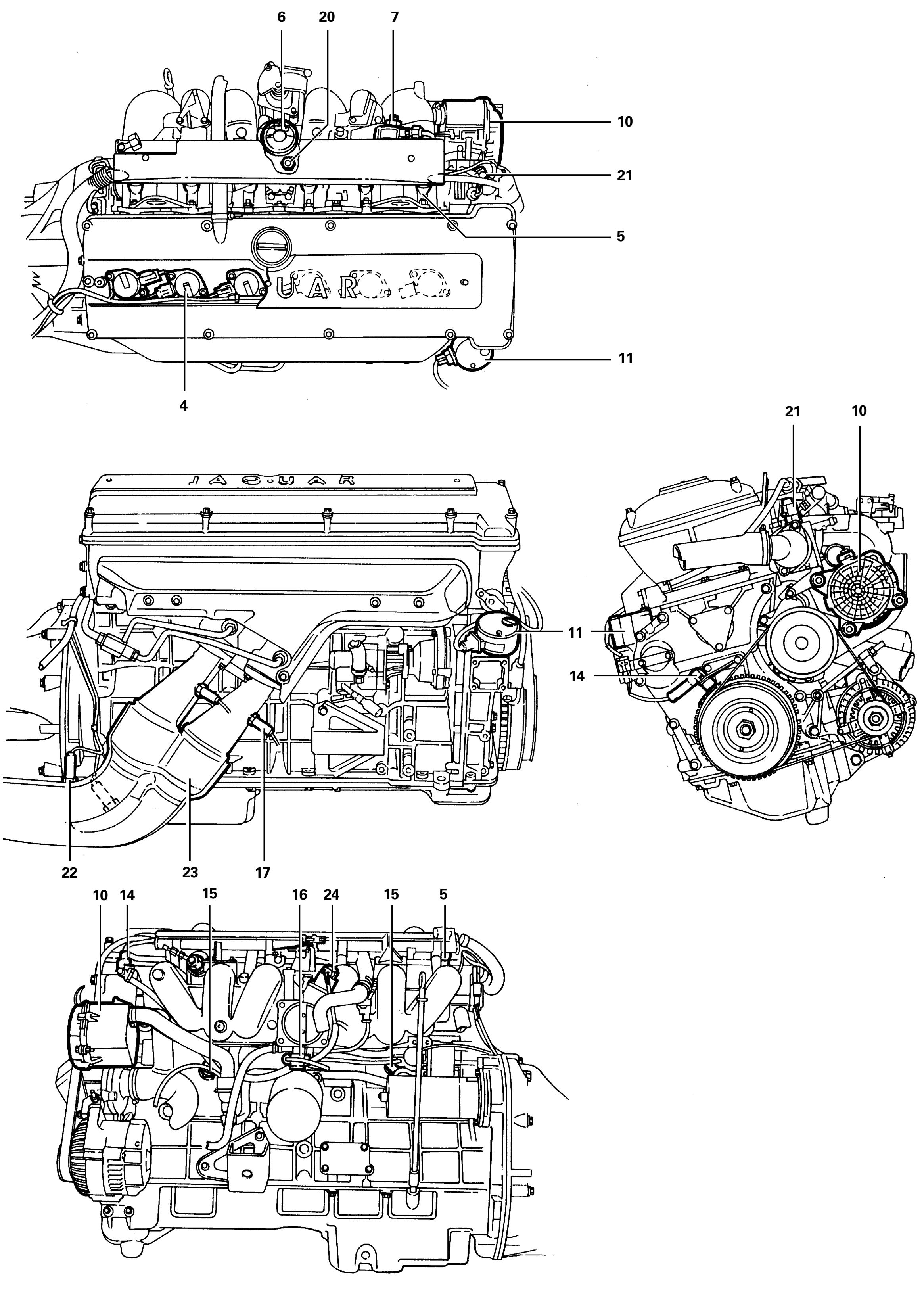
Normally Aspirated Engines: Sedan Range



KEY TO ILLUSTRATION
(ALSO APPLIES TO ILLUSTRATION AT RIGHT)

1	FUEL LEVEL SENSOR	13	EMS MAIN RELAY
2	EVAPORATIVE CANISTER	14	CRANKSHAFT POSITION SENSOR (CKPS)
3	INERTIA SWITCH	15	KNOCK SENSOR (KS)
4	SPARK PLUG WITH INTEGRAL COIL	16	THROTTLE POSITION SENSOR (TPS)
5	FUEL INJECTOR (FI)	17	UPSTREAM HEATED OXYGEN SENSOR (HO2S)
6	EGR VALVE (EGRV)	18	ENGINE CONTROL MODULE (ECM)
7	FUEL PRESSURE REGULATOR	19	TRANSMISSION CONTROL MODULE
8	MASS AIR FLOW SENSOR (MAFS)	20	EGR TEMPERATURE SENSOR (EGRT SENSOR)
9	EVAPORATIVE EMISSION CONTROL VALVE (EVAPP)	21	ENGINE COOLANT TEMPERATURE SENSOR (ECTS)
10	SECONDARY AIR INJECTION PUMP (AIRP)	22	DOWNSTREAM HEATED OXYGEN SENSOR (HO2S)
11	CAMSHAFT POSITION SENSOR (CMPS)	23	CATALYST
12	GENERATOR	24	IDLE AIR CONTROL VALVE (IACV)

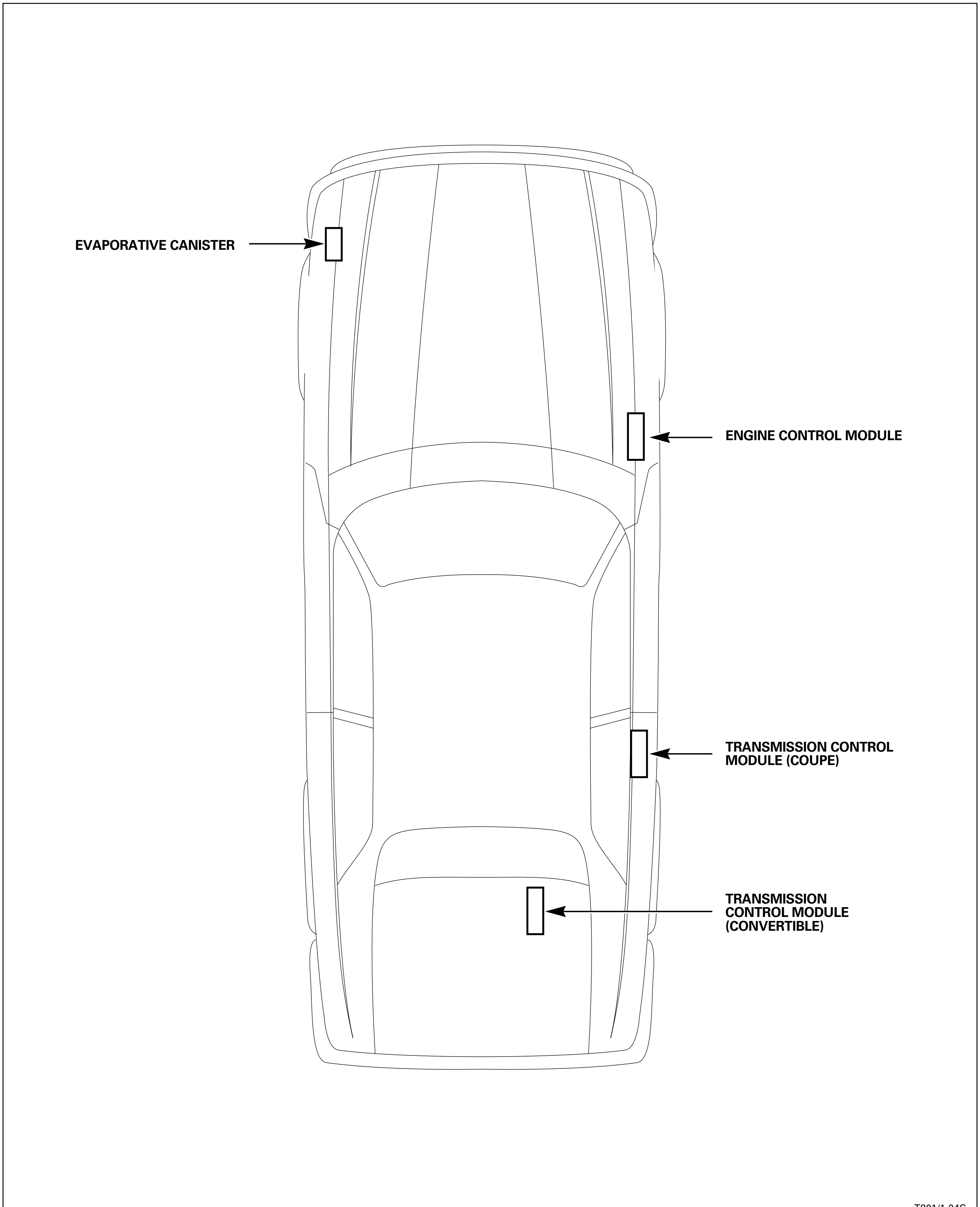
T801/1.04A



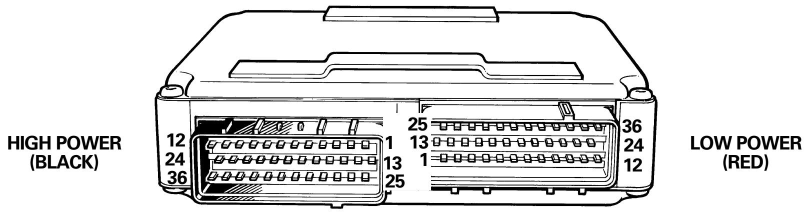
T801/1.04B

EMS Component Location

XJS Range (where different from Sedan Range)

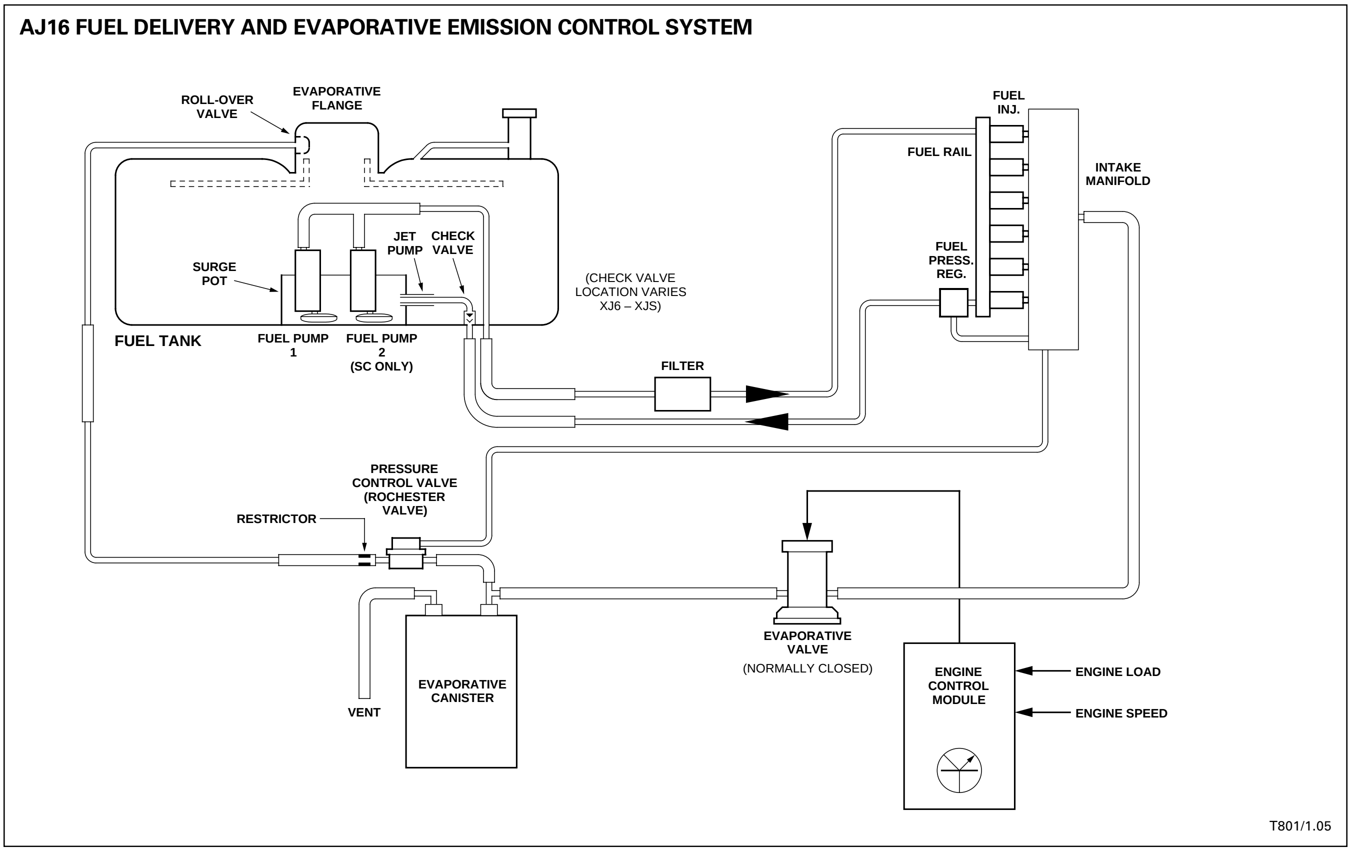


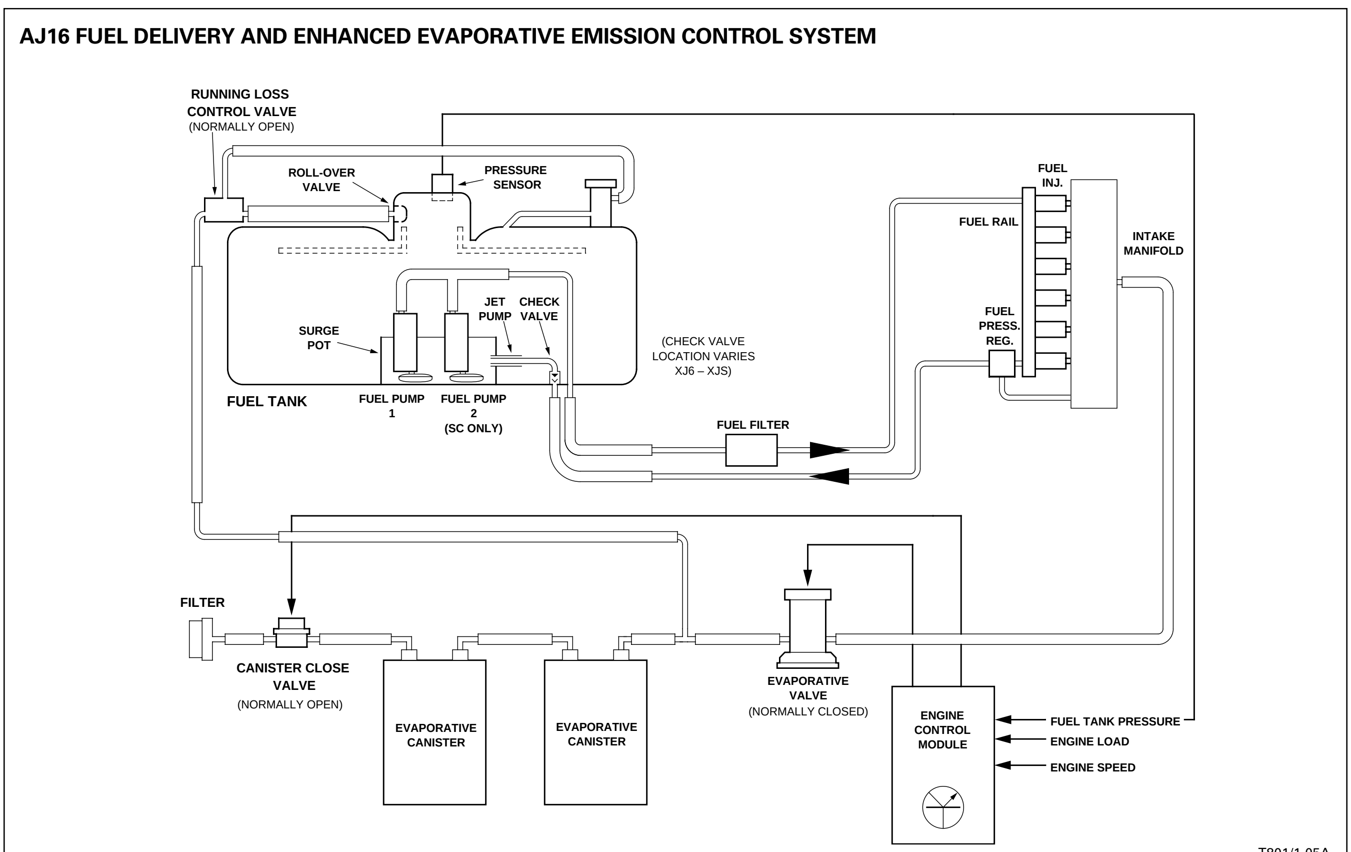
ECM Pin Out Information



ECM Black Connector A (High Power)		ECM Red Connector B (Low Power)	
1	Power ground – input	1	Intake air temperature – input
2	Fuel injector 1 – output	2	Not used
3	Idle speed control 1 – output	3	EGR valve function – input
4	Oxygen sensor heaters, downstream – output	4	Mass air flow (load) – input
5	Ignition coil 4 – output	5	Not used
6	Ignition coil 3 – output	6	Oxygen sensor 3 – input
7	Air pump – output	7	Sensor 5v ground – input
8	Ignition coil 2 – output	8	Oxygen sensor signal ground – input
9	Ignition coil 5 – output	9	Knock sensor ground – input
10	Ignition coil 1 – output	10	Bidirectional serial communication – input / output
11	Ignition coil 6 – output	11	Sensor 5v supply – output
12	Power ground – input	12	Throttle position – input
13	Fuel injector 4 – output	13	Not used
14	Fuel injector 3 – output	14	Engine coolant temperature – input
15	Fuel injector 2 – output	15	EGR valve position – input
16	Idle air control 2 – output	16	Oxygen sensor 1 – input
17	Fuel used – output	17	Battery voltage common supply – input
18	ECM controlled relay – output	18	Oxygen sensor 2 – input
19	Fuel pump – output	19	Oxygen sensor 4 – input
20	MIL – output	20	Fuel tank level – input
21	A/C compressor relay – output	21	Knock sensor A – input
22	Engine speed – output	22	Not used
23	Crankshaft position sensor positive – input	23	Not used
24	ECM controlled relay – input	24	Camshaft position sensor 12v supply – output
25	Fuel injector 6 – output	25	Not used
26	Crankshaft position sensor negative – input	26	Transmission ignition control – input
27	Fuel injector 5 – output	27	Park / neutral position – input
28	Idle speed control 4 – output	29	Mass air flow sensor ground – input
30	Oxygen sensor heaters, upstream – output	30	Small signal ground – input
31	Not used	31	Engine coolant temperature sensor ground – input
32	Throttle position (transmission) – output	32	Knock sensor B – input
33	Engine torque – output	33	Ignition ON – input
34	Evaporative emission control valve – output	34	Camshaft position – input
35	EGR valve – output	35	Not used
36	Power ground – input	36	Air conditioning ON request

Fuel Delivery and Evaporative Emission Control



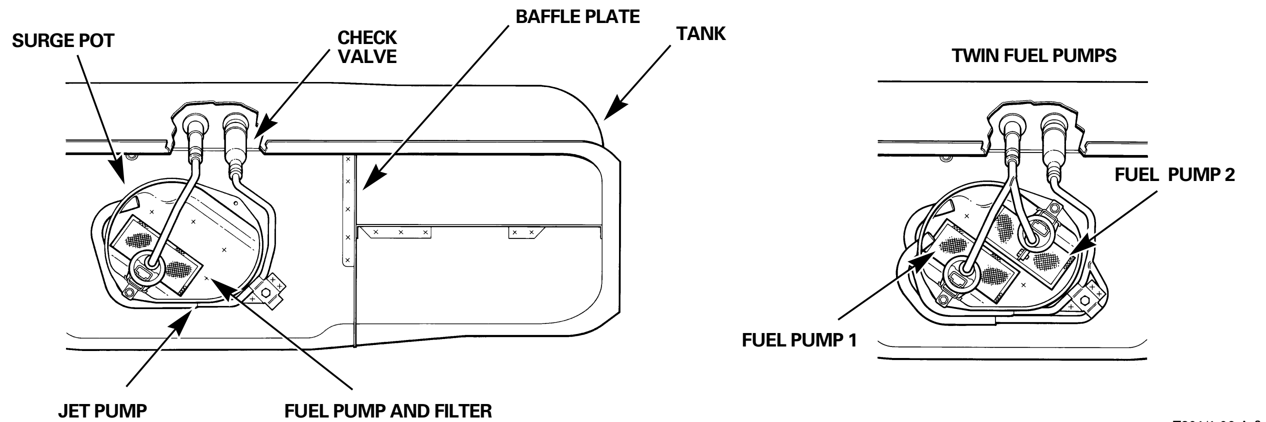


Fuel Tank

The fuel tank has been revised to incorporate a new fuel pump (two pumps for Supercharged engines) and the necessary plumbing for fuel supply and return. The tank uses baffle plates to reduce fuel surge and a surge pot to ensure that a constant supply of fuel is available for the pump(s). Each pump is located by a rubber mount and clamp attached to the surge pot. The tank interior piping incorporates a jet pump and a check valve in the fuel return line. Returning fuel flows through the jet pump, which draws additional cool fuel from the tank for supply to the surge pot. This supplemented return flow ensures that the surge pot remains full of fuel. The return check valve prevents reverse flow through the fuel return line.

Access to the tank interior is through the evaporative flange at the top of the tank.

FUEL TANK ARRANGEMENT (SEDAN RANGE)



T801/1.06 A & B

Fuel Pump

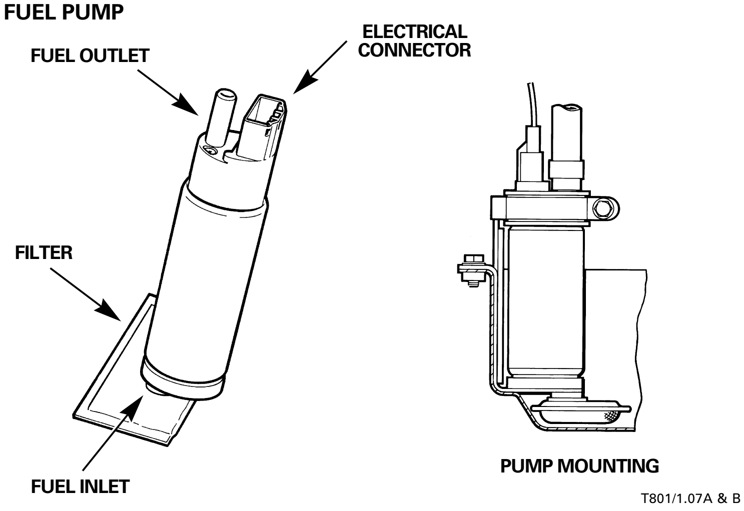
A simplified fuel pump assembly is used for fuel delivery. The pump unit consists of a turbine driven by a DC motor, a check valve and an inlet filter. The fuel output from the turbine pump provides a cooling flow around the motor before being discharged through the outlet check valve. The check valve prevents reverse flow when the engine is switched off.

Specifications

Nominal pump delivery –
26.45 gallons per hour at 43.5 psi (3 bar)

Current draw –
7 amps at 13.2V (3 bar)

FUEL PUMP



T801/1.07A & B

In-Line Fuel Filter

A replaceable in-line fuel filter is located in the supply line above the rear axle on the left side.

NOTES

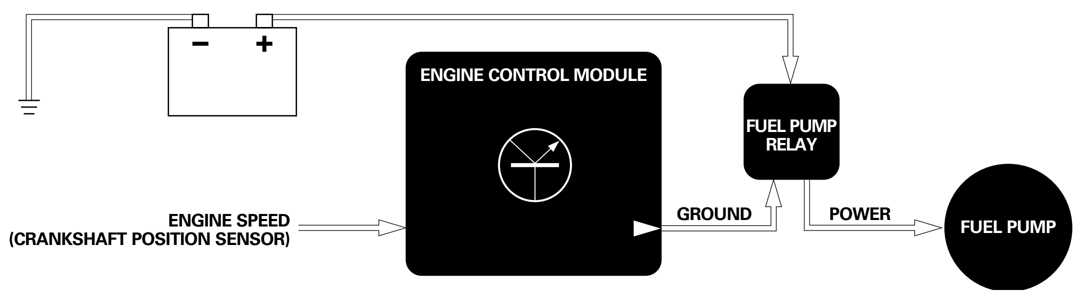
Fuel Delivery and Evaporative Emission Control (continued)

Fuel Pump Control: Single Fuel Pump

The electrically powered fuel pump is controlled by the ECM via the fuel pump relay. After the ignition is turned on (position II), the pump runs for about 1 second to build fuel pressure for starting. When the ECM receives an engine speed signal from the crankshaft position sensor, it activates the fuel pump relay, which in turn switches on the fuel pump. The fuel pump will continue to run either until the ignition is turned off or until approximately 1 second after there is no speed signal.

NOTE: In the event of a vehicle collision, the inertia switch will switch off all ignition powered circuits, including the EMS power relay. This action will remove power from the ECM and cause the fuel pump relay to de-energize, switching off the fuel pump.

SINGLE FUEL PUMP CONTROL



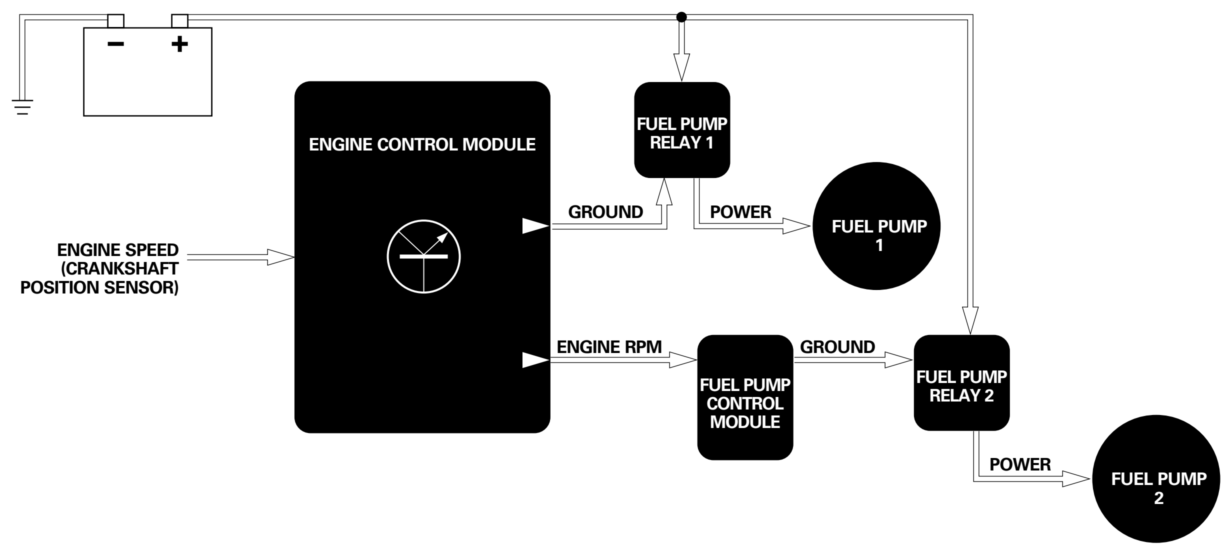
T801/1.08

NOTES

Fuel Pump Control: Twin Fuel Pumps

Supercharged engines use twin fuel pumps to ensure adequate fuel supply under high engine loads. Fuel pump 1 operates as described for the single pump installation. Fuel pump 2 is controlled via a fuel pump control module and operates only in the higher engine speed range. The fuel pump control modules receives an engine speed input from the ECM and switches on fuel pump 2 at 4000 rpm and off at 3200 rpm.

TWIN FUEL PUMP CONTROL



T801/1.09

NOTES

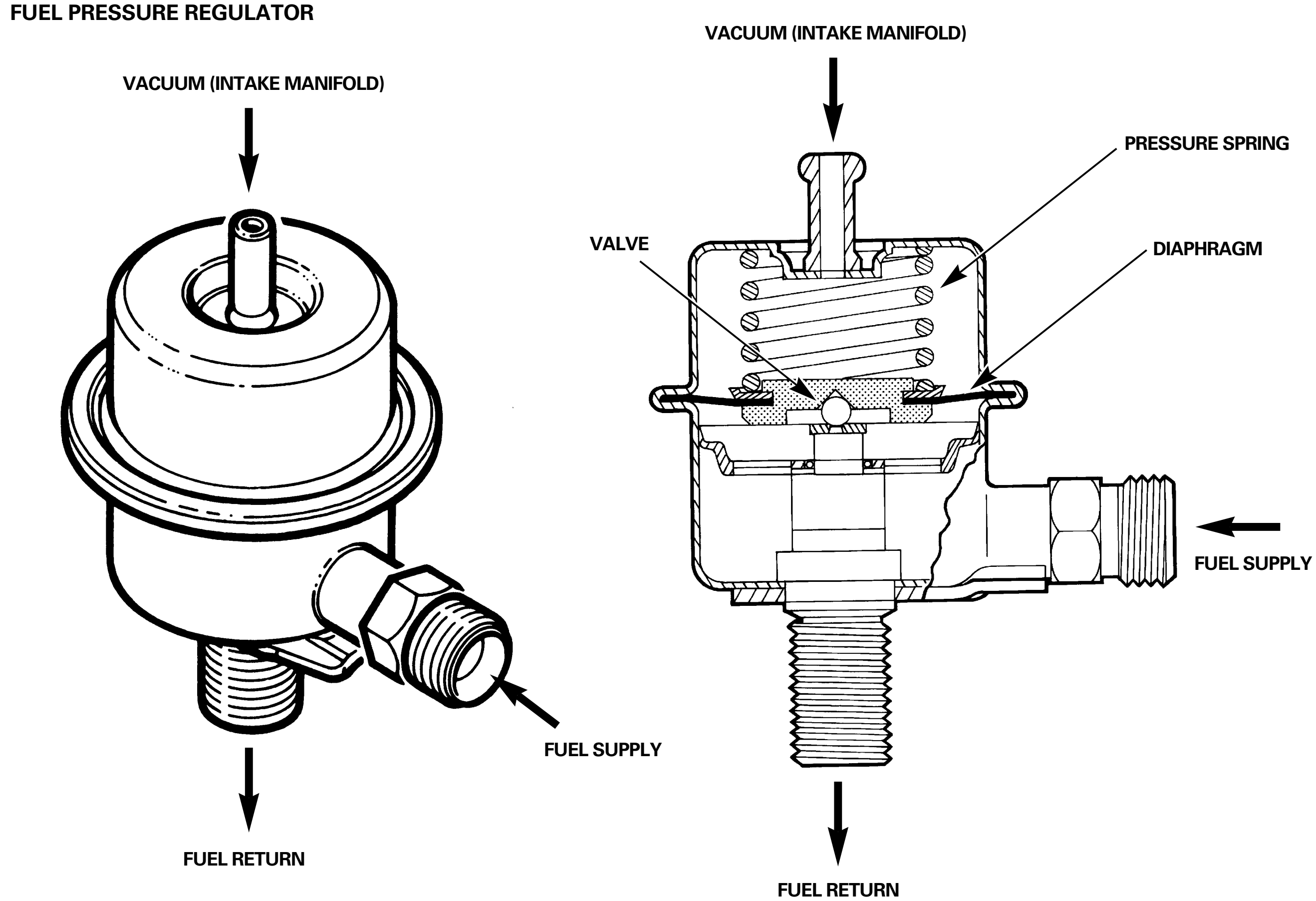
Fuel Delivery and Evaporative Emission Control (continued)

Fuel Rail and Pressure Regulator

Fuel is pumped to the fuel rail and injectors, where fuel pressure is controlled by the fuel pressure regulator. The pressure regulator is a carry-over component from the AJ6 EMS. Excess fuel, above the engine requirement, is returned to the fuel tank. The pressure regulator spring chamber above the diaphragm is referenced to intake manifold vacuum. The differential pressure across the fuel injector nozzles is therefore maintained constant at 44 psi (3.0 bar) and the quantity of fuel injected for a given injector pulse duration is also constant. On normally aspirated engines, fuel pressure measured on a test gauge will vary between 32 psi (2.3 bar) at overrun to 44 psi (3.0 bar) at full load to compensate for intake manifold absolute pressure. On supercharged engines, the measured fuel pressure will reach 54 psi (3.66 bar) at full load.

The fuel pressure regulator is located as close as possible to the fuel rail so that good dynamic control of fuel pressure is achieved. This design provides the same pressure across each injector, and delivers an equal quantity of fuel to each of the six cylinders.

FUEL PRESSURE REGULATOR



T801/1.10 A & B

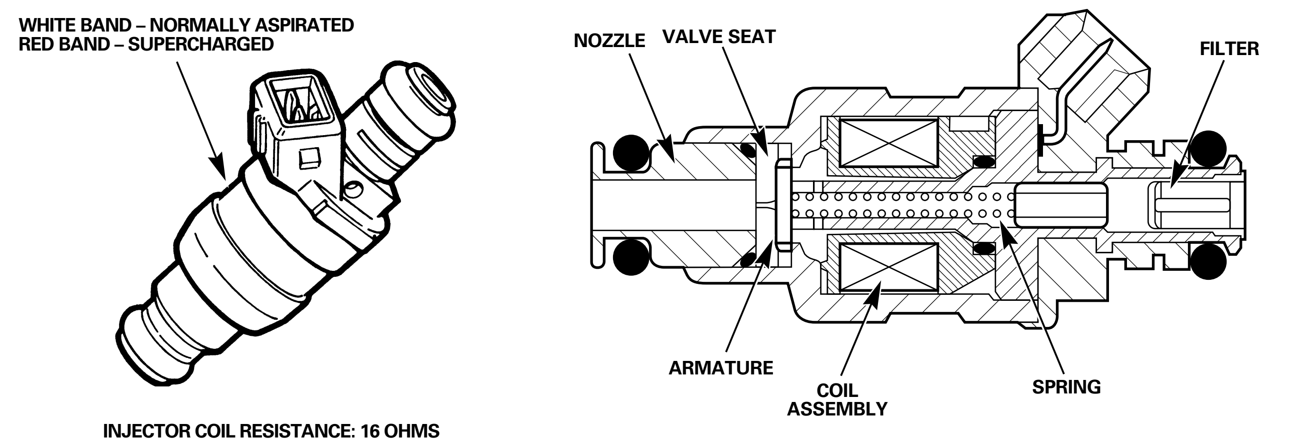
NOTES

Fuel Injectors

The fuel injectors are plate-type, twin-spray injectors as used on the 1993 / 94 model year AJ6 engine, but with revised flow rates and coil resistance. The plate-type, twin-spray injector design has several benefits: it aims a fuel spray at each intake valve throat, it is quieter in operation, and the tip is less prone to contamination. The injectors are secured to the fuel rail with custom clips that ensure the twin jets of fuel are directed to the intake valve throats. AJ16 normally aspirated injectors are identified by a white band around the injector body; supercharged injectors are identified by a red band.

NOTE: All AJ6 and AJ16 fuel injector service replacements have green identification bands. Be sure to verify the correct part number stamped on the injector before installation.

TWIN-SPRAY FUEL INJECTOR AND CROSS SECTION



T801/1.11 A & B

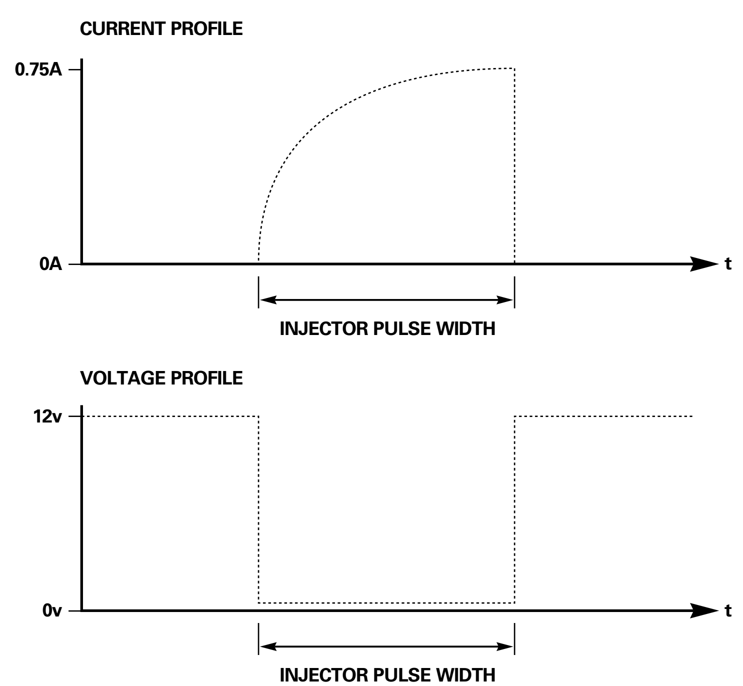
The AJ16 injector drive signal is a single-width modulated pulse. (The AJ6 injector has a large opening pulse followed by a series of hold-on pulses.)

Fuel Injector Monitoring for OBD II

Two tests are used to check injector operation. The first test monitors injector performance while the engine is running. The second test occurs at engine stall or power down to check for an open or short circuit to the injectors. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

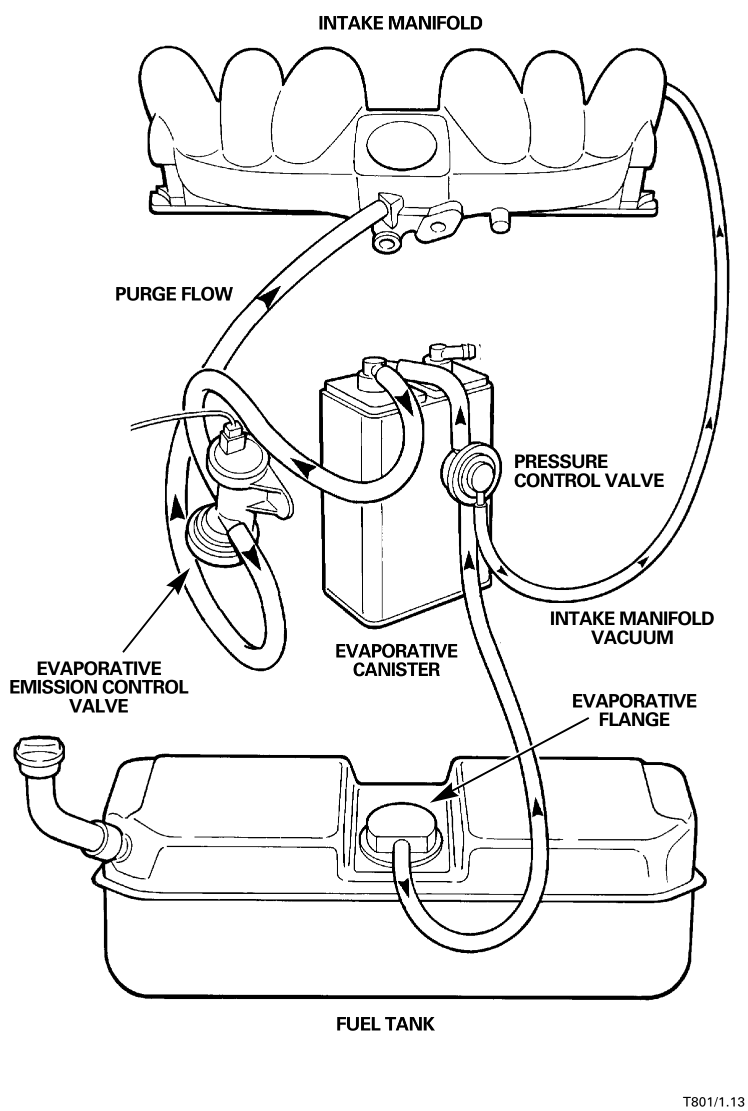
FUEL INJECTOR CHARACTERISTIC



T801/1.12

Fuel Delivery and Evaporative Emission Control (continued)

EVAPORATIVE EMISSION CONTROL SYSTEM (XJ6 SEDAN RANGE)



Evaporative Emission Control

The fuel tank can be filled to approximately 90% of its capacity. The additional 10% of volume allows for expansion of the fuel without escape to the atmosphere.

When the engine is switched off, the fuel tank pressure is maintained at a positive pressure of 1.0 – 1.33 psi by the pressure control valve. Pressure above 1.33 psi is released by the valve to the charcoal canister.

When the engine is running, manifold vacuum acts on the pressure control valve, which opens the vent line from the fuel tank to the charcoal canister. Air enters the charcoal canister and flows to the tank to replace the fuel delivered to the engine and maintain atmospheric pressure in the tank.

If the pressure control valve fails, the fuel tank cap will vent the fuel tank pressure at 2.0 – 2.5 psi.

Canister purge

When canister purge is enabled, the ECM meters purge flow to the intake manifold through the normally closed evaporative emission control (purge) valve (EVAPP). Canister purge is enabled by the ECM based on engine coolant temperature only when closed loop fuel metering control is operational.

During most operating modes, the purge rate is determined from an engine speed against engine load strategy. When the throttle is closed, the purge rate is determined from an engine speed only strategy.

Purge Flow Monitoring for OBD II

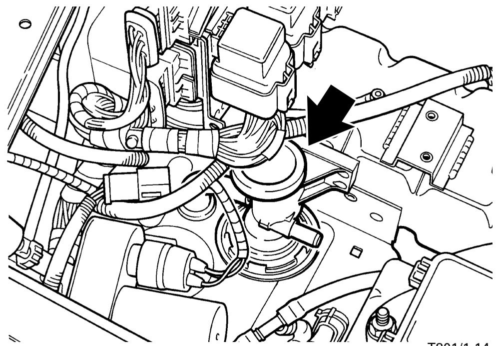
The ECM detects purge flow in two ways: if closed loop fuel metering correction indicates a large movement toward lean when purging is enabled, or if the idle air control valve corrects for increased air flow when purging is enabled, the ECM has confirmation that purging is taking place. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated.

NOTES

Evaporative Emission Control Valve (EVAPP)
The new evaporative emission control (purge) valve is a normally closed design. The amount of valve opening (and canister purge flow) is determined by the ECM drive signal allowing the ECM to accurately control purge flow for the prevailing engine operating conditions.

On XJ6 Sedan Range vehicles, the new EVAPP is mounted below the left headlight. On XJS Range vehicles, the EVAPP is mounted on the canister bracket.

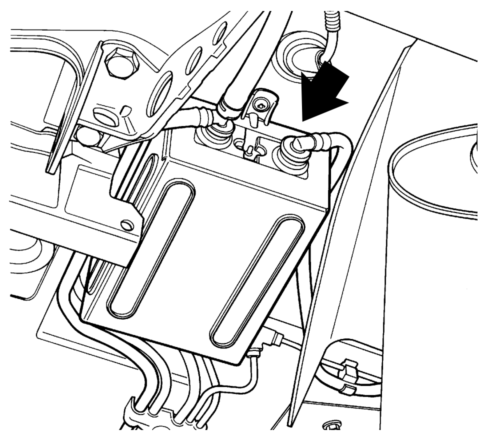
EVAPORATIVE EMISSION CONTROL VALVE (XJ6 SEDAN RANGE)



T801/1.14

Evaporative Canister
The new reshaped evaporative canister (charcoal canister) is identical in operation to previous canisters. On XJ6 Sedan Range vehicles, the canister is located under the vehicle near the intermediate mufflers. On XJS Range vehicles, the canister is located in the left front fender, behind the headlight.

EVAPORATIVE CANISTER (XJ6 SEDAN RANGE)

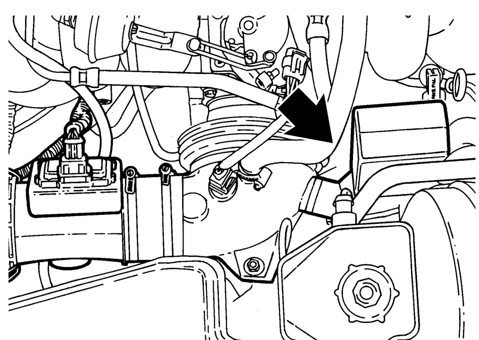


T801/1.15

Air Intake System

A resonance chamber has been added to the air intake elbow on XJ6 Sedan Range vehicles to reduce intake noise. This chamber is called a Helmholtz resonator.

HELMHOLTZ RESONATOR



T801/1.17

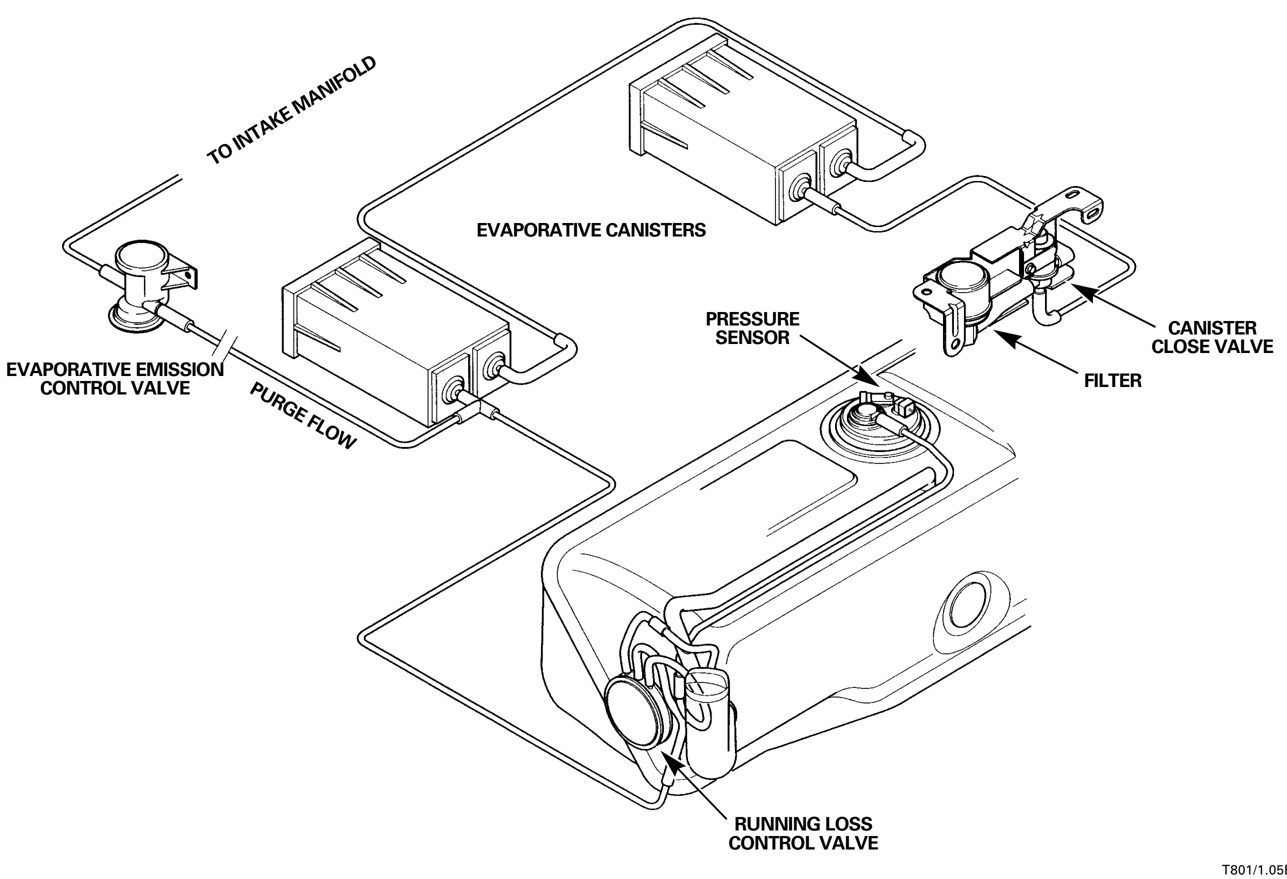
NOTES

Fuel Delivery and Evaporative Emission Control (continued)

Enhanced Evaporative Emission Control

A percentage of 1996 MY ON Sedan Range vehicles are equipped with a twin canister enhanced evaporative emission system that provides reduced evaporative emissions and enhances the system's on-board diagnostic capabilities.

ENHANCED EVAPORATIVE EMISSION SYSTEM (1996 MY XJ6 SEDAN RANGE ONLY)



The enhanced evaporative emission system consists of the following components:

- Fuel tank pressure sensor
- Running loss control valve
- Two evaporative canisters
- Canister close valve and filter
- Evaporative emission valve
- P-Cap flexible vapor lines

NOTES

Enhanced Evaporative Emission Control System Operation

When the engine is switched off, the normally open running loss control valve allows fuel tank vapors through the vent line to the canisters. To maintain atmospheric pressure in the tank, air enters the canisters through a filter via the normally open canister close valve .

When the engine is running and canister purge is enabled, the ECM meters purge flow from the canisters and tank via the evaporative emission control (purge) valve (EVAPP). The ECM enables canister purge using parameters similar to the single canister system, but with different mapping.

During refueling the engine must be switched off. The incoming fuel creates a pressure differential between the tank interior and the filler neck. The running loss control valve senses the pressure differential and closes the vent line to the canisters.

Flexible vapor lines are constructed of P-Cap tubing to reduce vapor loss through their walls. Individual system components connect to the vapor lines with Viton hoses and spring clamps.

NOTE: Engine compartment fuel lines are also P-Cap and include pulse dampers to prevent fuel injector pulses from causing a knocking noise in the lines.

Enhanced Evaporative Emission System Diagnostic Monitoring

Purge flow monitoring – The ECM detects purge flow two ways: if closed loop fuel metering correction indicates a large movement toward lean when purge is enabled, or if the idle air control valve corrects for increased air flow when purging is enabled, the ECM has confirmation that purging is taking place.

NOTES

Fuel Delivery and Evaporative Emission Control (continued)

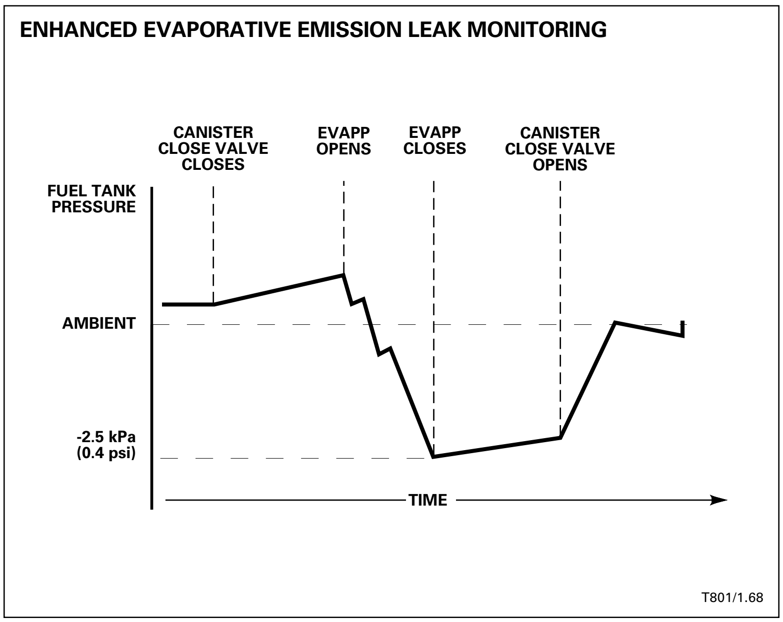
Enhanced Evaporative Emission Control Leak monitoring

The ECM can detect system leaks as small as 1 mm (0.040 in) in diameter. The system is tested once during every “trip” (refer to Trip and Drive Cycle page 52). The leak monitoring test cycle takes 25 to 30 seconds.

Parameters to initiate leak monitoring:

- Engine warmed to normal operating temperature from a ”cold” start
- Approximately 15 minutes elapsed since engine cranking
- Fuel level between 1/4 and 3/4 full
- Vehicle stopped with engine at idle speed after approximately one minute of steady speed operation above 30 mph (48 km/h)

NOTE: If the engine speed is raised above idle, the test will terminate .



Leak monitoring test sequence

The ECM ensures that the EVAPP valve is closed.

The ECM closes the normally open canister close valve for approximately 5 seconds causing the fuel tank vapor pressure to rise. (Fuel tank pressure is monitored by the ECM via the pressure sensor.)

The ECM progressively opens the evaporative emission valve and monitors fuel tank pressure drop. (If the ECM detects no pressure drop, the test is terminated.)

When fuel tank pressure drops to 2.5 kPa (0.4 psi) below the ambient pressure, the ECM closes the EVAPP valve and monitors the vacuum in the fuel tank for approximately five seconds.

The ECM opens the canister close valve and the evaporative emission system returns to its normal function.

If any of the following faults are detected, the ECM will flag a DTC identifying the condition:

- Vacuum leak
- Canister close valve / circuit electrical fault
- Fuel tank pressure sensor out of range
- Fuel tank pressure too low or too high

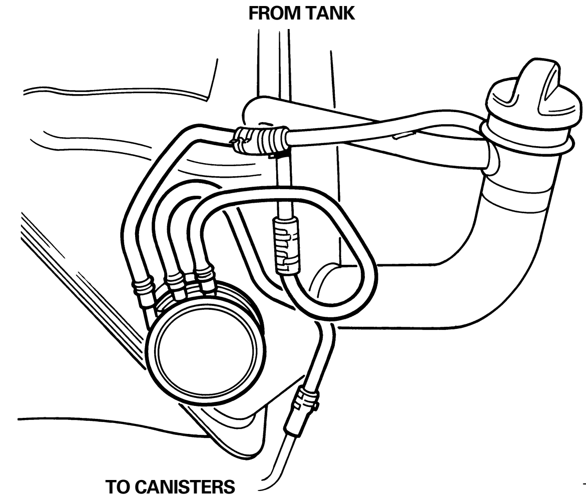
Refer to DTC Summary page 69.

NOTES

Running Loss Control Valve
The normally open running loss control valve is located on the fuel tank near the filler neck, connecting the fuel tank evaporative loss flange to the carbon canisters. During refueling, the pressure imbalance between the inside of the tank and the filler neck causes the valve to close the vent line to the canisters. This action prevents the refueling pressure imbalance from forcing excess vapors or fuel into the canisters.

Evaporative Canister
A second canister is installed in series with the first canister to increase vapor storage capacity. The canister is located under the vehicle below the right rear seat pan. The atmospheric vent for the canisters is controlled by the canister close valve and filter.

RUNNING LOSS CONTROL VALVE



T801/1.69

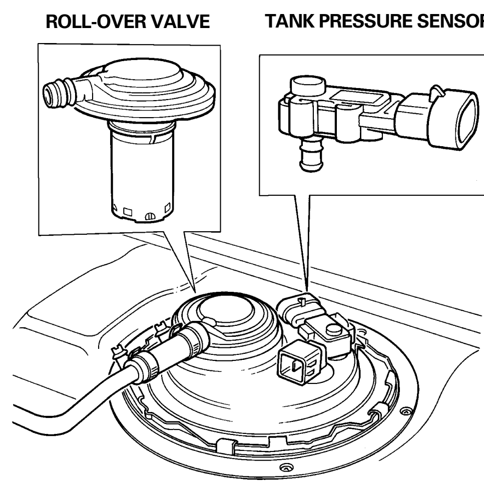
Evaporative Loss Flange

All Sedan Range models from the 1996 MY ON utilize a steel evaporative loss flange. The new roll-over valve and fuel pump electrical connectors are installed in grommets in the flange.

Fuel Tank Pressure Sensor
The fuel tank pressure sensor is installed in a grommet in the evaporative loss flange of enhanced evaporative emission equipped vehicles. The sensor provides a fuel tank pressure signal to the ECM for system diagnostics.

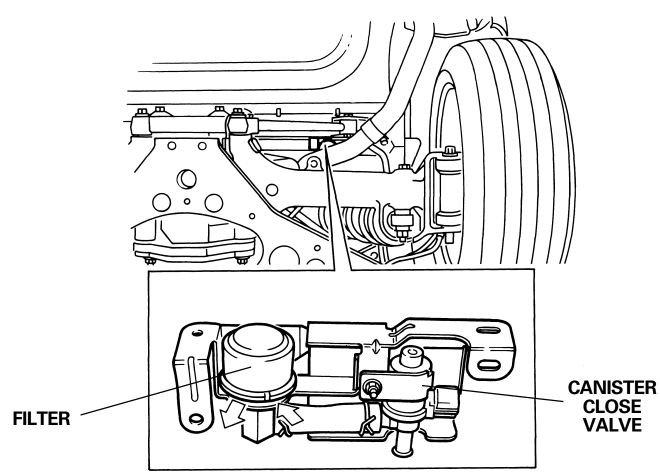
Canister Close Valve and Filter
The ECM controlled canister close valve and filter assembly is installed above the right axle shaft. The normally open valve is used to close the canister atmospheric vent line during system diagnostics. The non-serviceable filter prevents contamination of the valve during canister purge.

EVAPORATIVE LOSS FLANGE



T801/1.67

CANISTER CLOSE VALVE AND FILTER



T801/1.66

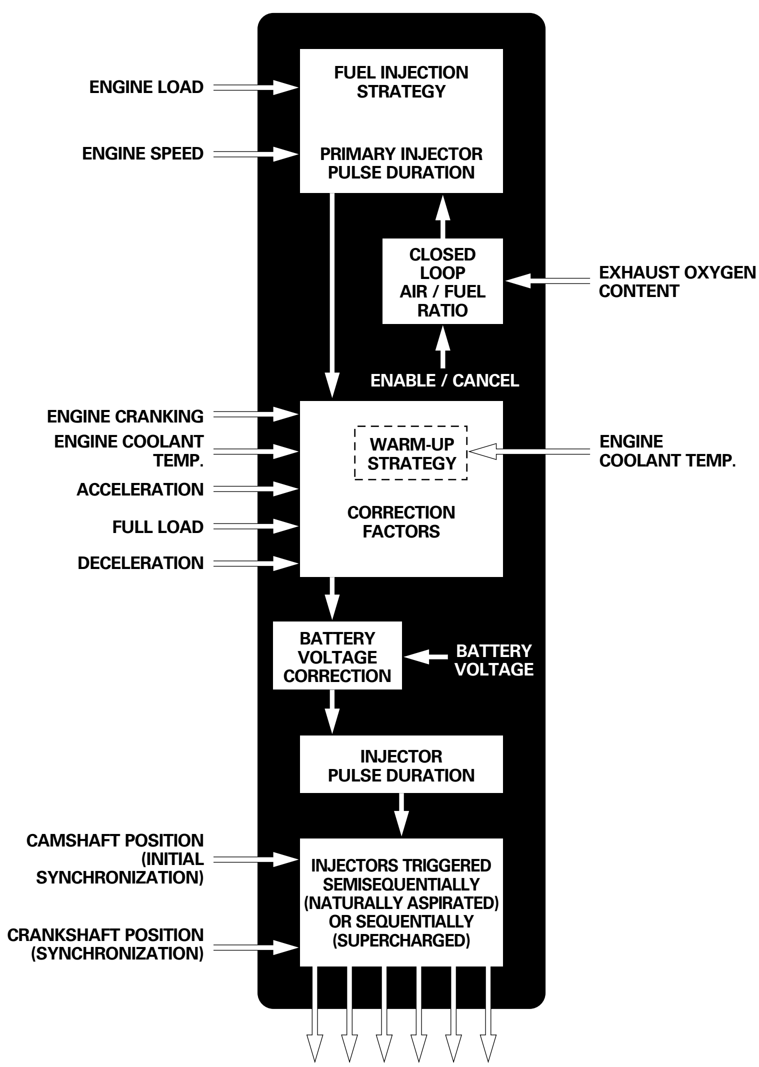
NOTES

Fuel Injection

Fuel metering is obtained by controlling the injector pulse duration during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups — primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, cranking signal, throttle movement and position and exhaust oxygen content. The injector pulse is then corrected for actual battery voltage. On normally aspirated engines, the injectors are pulsed semisequentially. Semisequentially means twice per engine cycle (once per engine revolution) in the engine firing order. On supercharged engines, the injectors are pulsed sequentially. Sequentially means once per engine cycle (once every two engine revolutions) in the engine firing order.

Fuel metering strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing injector pulse duration in milliseconds fill each site and cover the entire engine load and speed range. Fuel metering correction is applied for all six cylinders simultaneously, not for individual cylinders.

FUEL INJECTION PRIMARY AND SECONDARY CONTROL



T801/1.16

Sequential fuel injector pulsing is ECM controlled. The ECM “learns” the compression stroke synchronization at each engine start from the camshaft position sensor (CMPS) and crankshaft position sensor (CKPS) inputs. After the firing synchronization is learned, the ECM uses the CKPS input for engine speed and position. Refer to the CMPS description on page 27 and the CKPS description on page 26.

Additional fuel injection controls are used for overrun fuel cutoff, engine overspeed prevention and fuel cutoff during wide-open-throttle cranking.

Fuel Injection Primary Control

Fuel metering is controlled primarily as a function of engine load and speed. Engine load is sensed by a mass air flow sensor (MAFS) located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft position sensor (CKPS) located behind the front pulley. The ECM processes the input from the MAFS and the CKPS to access pulse duration from the fuel metering strategy.

NOTES

Fuel Injection Secondary Control

Secondary fuel metering control adjusts for engine coolant temperature, cranking signal, throttle movement and position, exhaust oxygen content and battery voltage.

Cranking and after-start enrichment
The ECM provides fuel metering enrichment for cranking and after-start conditions by increasing the injector pulse duration. Engine cranking is determined by an engine speed between 0 and 400 rpm. The injector pulse duration, and the rate at which the enrichment is decreased back to the warm-up phase, are dependent upon engine coolant temperature measured by the engine coolant temperature sensor.

Warm-up
The programmed warm-up enrichment provides extra fuel during engine warm-up based on the engine temperature measured by the coolant temperature sensor. The warm-up phase is applied when the coolant temperature is between 40˚F and 160˚F (5˚C and 70˚C).

Acceleration enrichment
When the ECM senses that the throttle is opening (throttle position sensor input), the injector pulse duration is lengthened by an amount dependent upon the rate at which the throttle is opened and on engine coolant temperature.

Full load enrichment
If the ECM senses a full throttle input from the throttle position sensor, full load enrichment is applied and closed loop operation is temporarily canceled.

Deceleration leaning
When the ECM senses that the throttle is closing (throttle position sensor input), the injector pulse duration is shortened dependent on the rate at which the throttle closed, preventing a momentary rich condition.

Battery voltage correction
Because the time to achieve full lift of the injector plate decreases as voltage increases, the amount of fuel delivered by the injector for a given pulse duration is dependent upon the injector operating voltage. The ECM is programmed with a voltage correction strategy. The supply voltage is monitored by a software routine and the correction applied to the pulse duration.

Closed loop fuel metering
In order to significantly reduce exhaust emission, the exhaust system incorporates two primary and one secondary 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible. A closed loop system between fuel injection, ECM control, and exhaust oxygen content feedback is used to maintain an optimum air / fuel ratio as close to 14.7 : 1 as possible. In response to oxygen sensor voltage swings, the ECM continuously drives the air / fuel ratio rich-lean-rich by adding to, or subtracting from the baseline injector pulse duration.

NOTES

Fuel Injection (continued)

Additional Fuel Injection Controls

Overrun fuel cutoff
In order to improve fuel economy and aid in controlling exhaust emission, the ECM cancels fuel injection during engine overrun conditions. The ECM determines overrun conditions from inputs received from the throttle position sensor (TPS), crankshaft position sensor (CKPS) and engine coolant temperature sensor (ECTS). Overrun fuel cutoff is enabled when the coolant temperature is above 75°F (35°C). Fuel injection is cancelled when the throttle is closed and the engine speed is greater than 200 rpm.

Engine overspeed control
An engine overspeed control function limits the maximum engine speed by canceling fuel injection. Fuel injection is cancelled when the engine speed is above 5500 rpm.

Wide-open-throttle during cranking
If the ECM senses that the throttle is wide open (throttle position sensor input) during cranking, fuel injection is canceled to help clear a flooded engine.

NOTES

EMS Main Sensing Components

The inputs provided by the engine management system main sensing components are used by the ECM to control a variety of subsystems and functions.

Engine Load

Mass air flow sensor (MAFS)

The new mass air flow sensor (MAFS) has an improved and simplified design with revised calibrations for the GEMS 6 ECM.

The MAFS is a hot wire type that measures air flow volume by the cooling effect of air passing over a heated platinum wire, altering the electrical resistance of the wire. The electrical resistance value is converted to an analog output voltage supplied to the ECM as a measure of air flow volume (engine load).

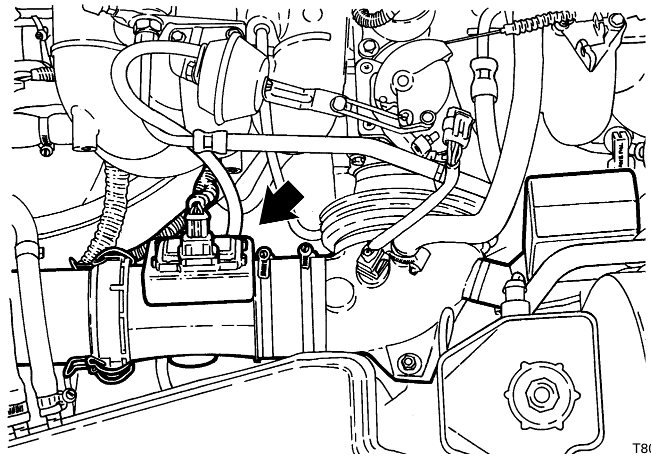
The heated wire sensor is located in the central column that is an integral part of the casting. The column has a central tube entry and four exit slots. A small portion of the intake air flows through the entry tube and passes over the heated wire sensor before returning to the main air flow through the four exit slots. The heated sensor is an integral part of the heat sink and control unit mounted on the main casting. The intake screen stabilizes the air flow through the MAFS and protects the sensor from debris in the air stream.

MAFS Monitoring for OBD II

The range of the MAFS signal is checked for values outside of the normal limits and for open and short circuits. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

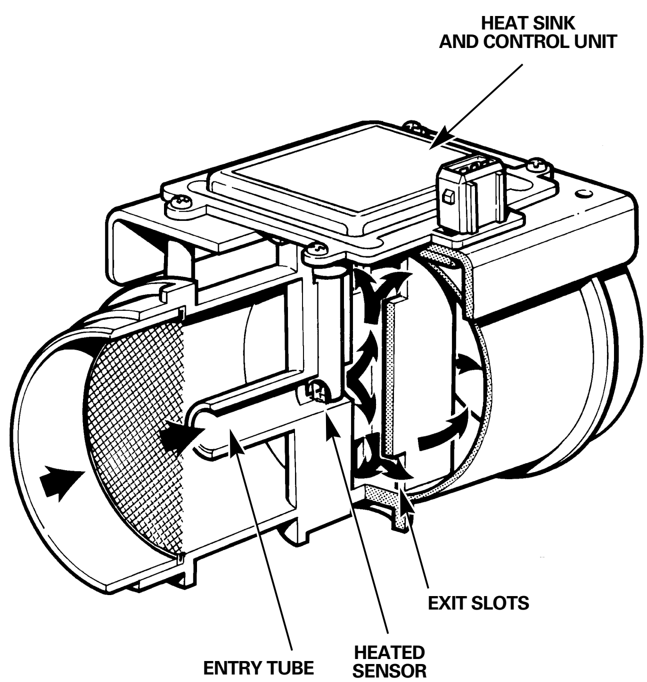
NOTES

MAFS LOCATION (XJ6 SEDAN RANGE)



T801/1.17

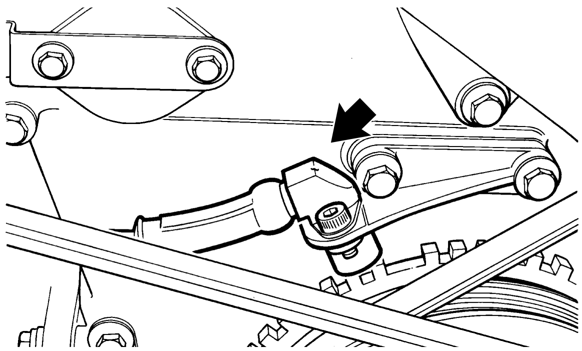
MAFS CROSS SECTION



T801/1.18

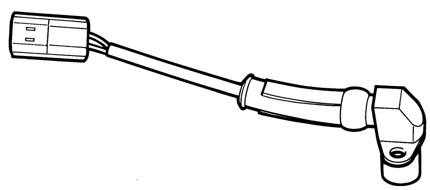
EMS Main Sensing Components (continued)

CRANKSHAFT POSITION SENSOR LOCATION



T801/1.19

CRANKSHAFT POSITION SENSOR



T801/1.20

Engine Speed and Crankshaft Position

Crankshaft position sensor (CKPS)
The sensor portion of the crankshaft position sensor is identical to the AJ6 sensor with a revised electrical lead and bracket.

The CKPS provides the primary input to the ECM for engine speed and engine position. The sensor is a variable reluctance device, consisting of a bobbin coil with a magnetic core. The steel teeth on the crankshaft timing ring form a rotor. As the rotor teeth pass by the crankshaft position sensor, pulses are generated.

The rotor has 60 tooth positions set at 6° intervals with one tooth missing. The gap identifies the TDC position of cylinders 1 and 6. The rotor thus provides both engine speed and crankshaft position information to the ECM. Each tooth pulse represents 6° of crankshaft rotation. Thus the frequency of the toothed pulses are a measure of engine speed. The sensor is mounted to the timing cover on the front of the engine. The air gap between the sensor and the rotor should be 0.020 – 0.040 in.

NOTES

Initial Cylinder Synchronization for Engine Starting

Camshaft position sensor (CMPS)

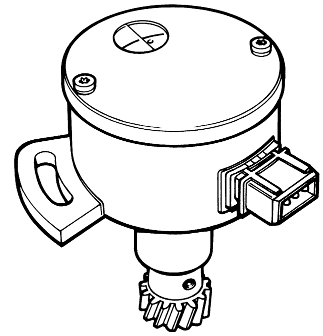
The camshaft position sensor is a Hall-effect sensor which provides the ECM with a sequencing input so that correct ignition and fuel injection will begin within two-thirds of an engine revolution at engine start. The CMPS rotor has six "windows" of different width to positively identify each cylinder. As a window passes the sensor, the ECM is able to identify the cylinder (1 through 6).

The CMPS is necessary because the crankshaft position sensor (CKPS) gap identifies TDC position for *both* cylinders 1 and 6. Without the CMPS sequencing input, the ECM would attempt engine start by trial and error, firing each cylinder in sequence; several engine revolutions might be required for successful engine start. CMPS input is not required by the ECM once the engine is running.

CMPS installation procedure

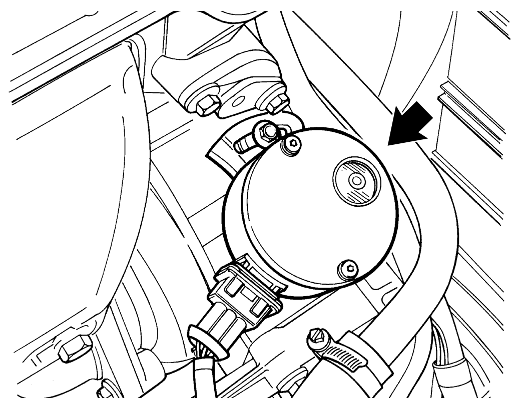
With the engine at cylinder 1 compression TDC, the dot on the CMPS rotor should align with the circle in the inspection window.

CAMSHAFT POSITION SENSOR



T801/1.21

CAMSHAFT POSITION SENSOR LOCATION



T801/1.22

CKPS and CMPS Monitoring for OBD II

The CKPS and CMPS are tested by cross-checking the output of the sensors. The engine will not run with a CKPS fault. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

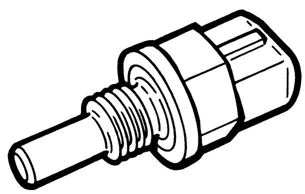
EMS Main Sensing Components (continued)

Engine Coolant Temperature

Engine coolant temperature sensor (ECTS)

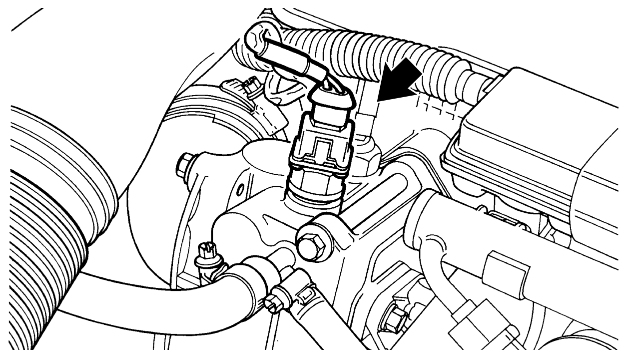
The engine coolant temperature sensor is a negative temperature coefficient (NTC) thermistor. It is identical to the sensor used in AJ6 engine management systems, however, the connector and leads are revised. Engine coolant temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

ENGINE COOLANT TEMPERATURE SENSOR



T801/1.23

ENGINE COOLANT TEMPERATURE SENSOR LOCATION



T801/1.24

Coolant temperature sensor – temperature versus resistance:

Coolant temperature °F	°C	Resistance (kilo ohms)
14	-10	9.20
32	0	5.90
50	10	3.70
68	20	2.50
86	30	1.70
104	40	1.18
122	50	0.84
140	60	0.60
158	70	0.435
176	80	0.325
193	90	0.25
212	100	0.19

Coolant temperature sensor – temperature versus typical approx. voltage:

Coolant temperature °F	°C	Voltage
14	-10	4.05
32	0	3.64
59	15	2.89
78	25	2.42
86	30	2.20
104	40	1.78
122	50	1.44
140	60	1.17
158	70	0.95
176	80	0.78
193	90	0.65
212	100	0.55

ECTS Monitoring for OBD II

Three tests are performed to check the ECTS:

1 The range of the sensor is checked for values outside the normal range.

2 A “time to warm-up” test check that the sensor responds to a rise in coolant temperature.

3 A third test checks for an abnormal fall in coolant temperature once the temperature rise is confirmed. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

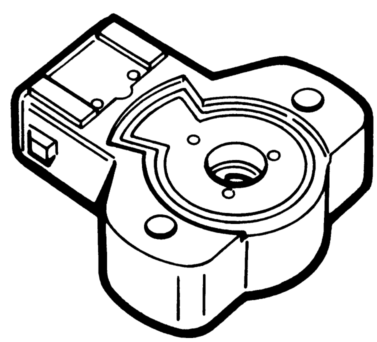
NOTES

Throttle Position

Throttle position sensor (TPS)

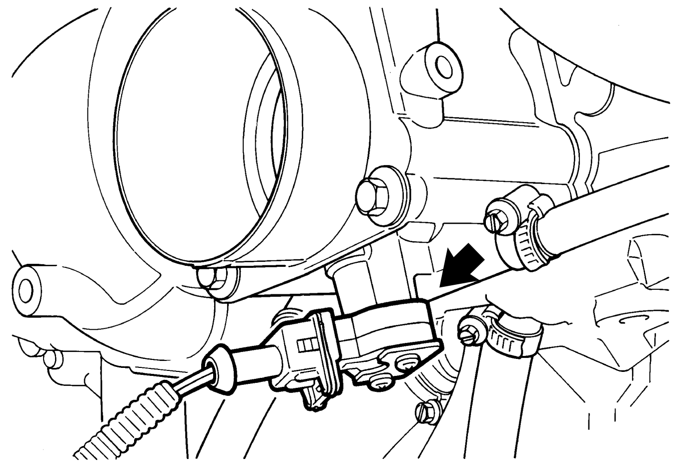
The throttle position sensor is a nonadjustable single-track potentiometer connected to the spindle on the throttle shaft. The ECM adapts to the TPS idle position to compensate for aging and component wear. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to determine throttle position: low voltage – closed throttle, high voltage – opened throttle.

THROTTLE POSITION SENSOR



T801/1.25

THROTTLE POSITION SENSOR LOCATION



T801/1.26

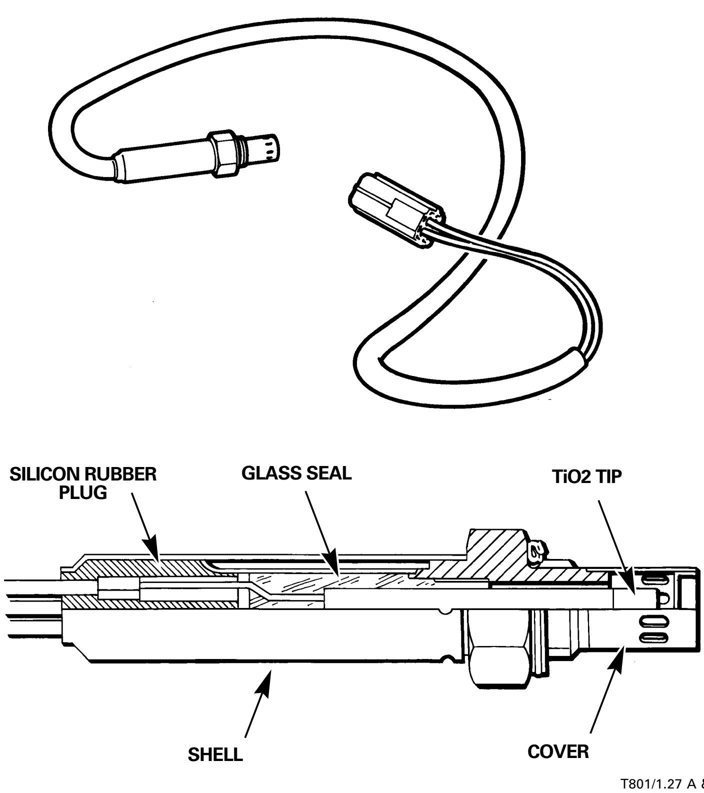
TPS Monitoring for OBD II

The range of the TPS is checked for values outside of normal limits. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

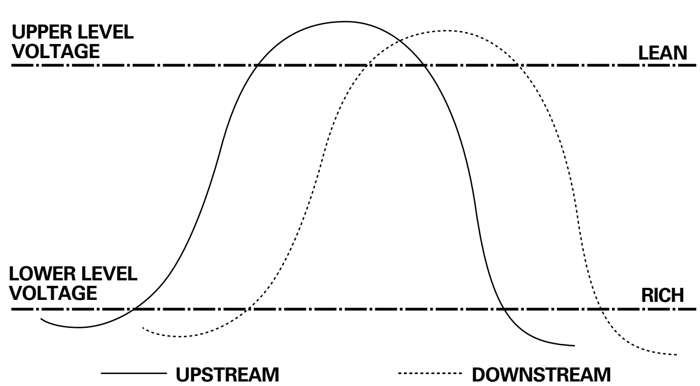
NOTES

EMS Main Sensing Components (continued)

OXYGEN SENSOR AND CROSS SECTION



OXYGEN SENSOR CHARACTERISTIC



Exhaust Gas Oxygen Content

Heated oxygen sensors (HO2S)

The AJ16 EMS uses four heated oxygen sensors that provide improved heater temperature control and reduced warm-up time.

The heated oxygen sensors are of the Titanium Dioxide type that have a tip composed of an alumina substrate with a thick film titanium dioxide element. This type of sensor does not require reference air to detect the oxygen content of the exhaust, so wetting or contamination of the sensor exterior will not affect sensor performance.

The resistance of the sensor element varies greatly with the partial presence of oxygen in the exhaust gas. The change in resistance is converted to a voltage output to the ECM via a constant voltage source and variable sensor resistance. Whenever the fuel / air mixture ratio passes 14.7:1 (Lambda = 1), the sensor delivers a voltage swing:

Air / fuel mixture **leaner** than 14.7:1 – reference voltage **high** (maximum 4.89 V)

Air / fuel mixture **richer** than 14.7:1 – reference voltage **low** (minimum 0.015 V)

The heater is used to bring the sensor to the active temperature of approximately 500˚C in approximately 20 seconds after engine start.

NOTES

Four oxygen sensors are installed on the exhaust system, two upstream and two downstream of the primary catalysts. The two downstream sensors are used by the ECM for closed loop fuel metering correction. The upstream sensors are used for OBD catalyst monitoring. Refer to Catalytic Converters on page 48.

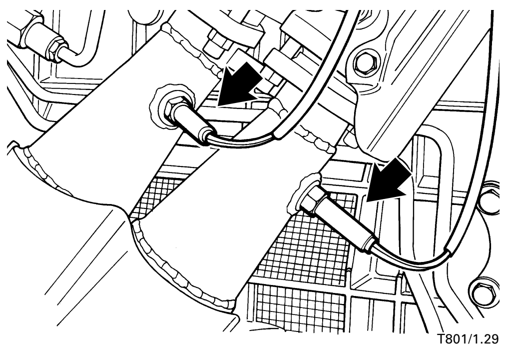
If the oxygen sensors are to be removed or the exhaust system replaced, the sensors and harness connectors must be labeled to ensure that they are installed in their original locations.

Oxygen Sensor Orientation

If the sensors and connectors are not installed in their original locations, the ECM can be reprogrammed using PDU to match the sensor locations to the ECM. This PDU routine is called Oxygen Sensor Orientation.

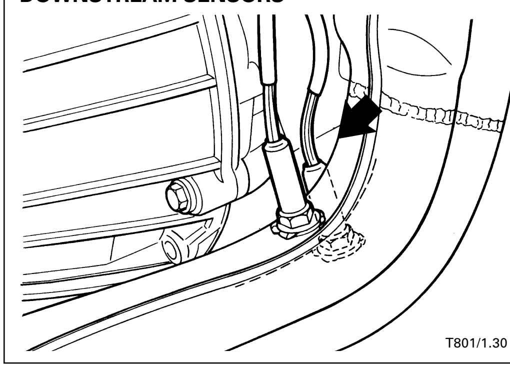
⚠ CAUTION: When a new ECM or new sensors are installed or the wiring harness is changed, the ECM must be reprogrammed using PDU.

UPSTREAM OXYGEN SENSORS



T801/1.29

DOWNSTREAM SENSORS



T801/1.30

HO2S Monitoring for OBD II

Both the oxygen sensor and tip heater circuits are monitored. When the key is switched on, the sensors are tested for voltage outside the normal range. The oxygen sensors are also tested when a fuel system fault is suspected. Periodically, the sensor response rate is compared to a standard. The tip heater circuits are checked for open and short circuits.

A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

Ignition Control

Ignition Timing and Spark Distribution

Ignition timing and spark distribution are controlled by the engine control module (ECM) according to sensor inputs. As with fuel injection, the sensed control inputs form two groups: primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature, throttle movement and position, transmission upshift and knock control.

Ignition timing strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing ignition timing values fill each site. The resulting 256 ignition timing values cover the entire engine load and speed range. Ignition timing is then calculated from the ignition timing strategy according to secondary input correction factors.

Spark distribution, in the engine firing order, is ECM controlled. The ECM "learns" the compression stroke synchronization at each engine start from the camshaft position sensor (CMPS) input. After starting the ECM uses the crankshaft position sensor (CKPS) input for spark timing. Refer to the CMPS description on page 27 and the CKPS description on page 26.

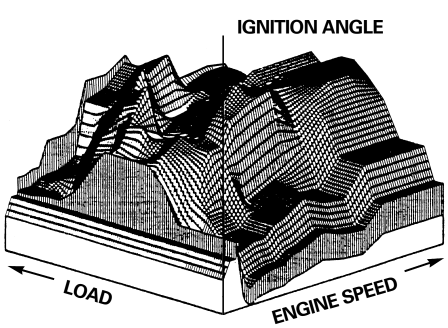
NOTES

Ignition Primary Control

Ignition timing is controlled primarily as a function of engine load and speed. Engine load is sensed by the mass air flow sensor (MAFS) located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft position sensor (CKPS) located behind the engine damper. The ECM processes the inputs from the MAFS and the CKPS and accesses ignition timing from the ignition timing strategy.

Six individual “on-plug” ignition coils are located above each spark plug. The ECM provides switching for each primary circuit. The correct firing sequence and timing of the six individual on-plug ignition coils is determined by the ECM from the cylinder synchronization input provided by the camshaft position sensor (CMPS) (initial learning at engine start) and the crankshaft position sensor (CKPS). Refer to the CMPS description on page 27 and the CKPS description on page 26.

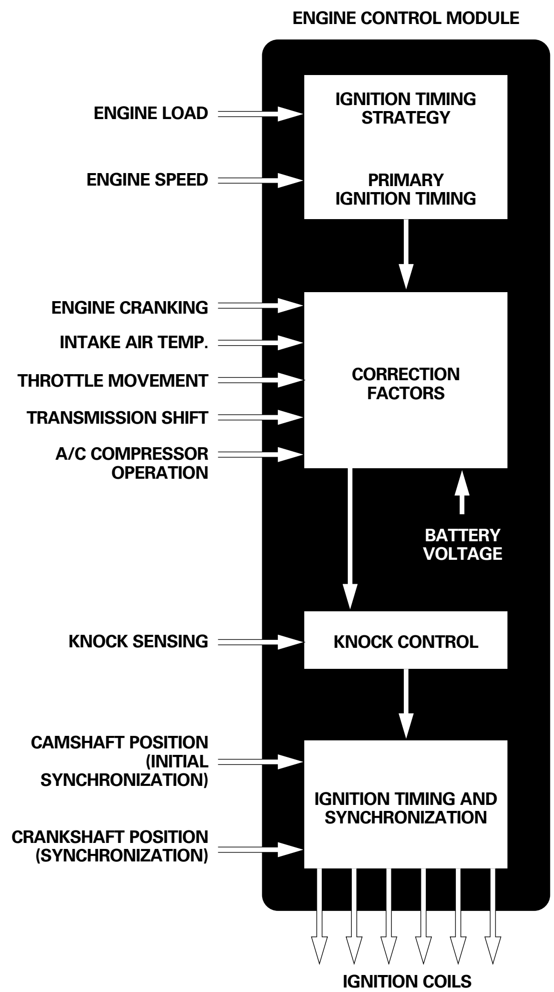
IGNITION TIMING STRATEGY



T801/1.31B

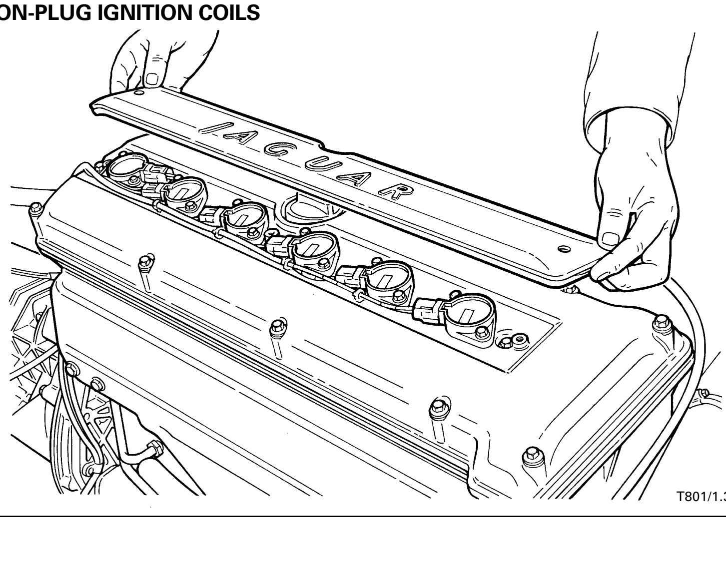
NOTES

IGNITION PRIMARY AND SECONDARY CONTROL



T801/1.31A

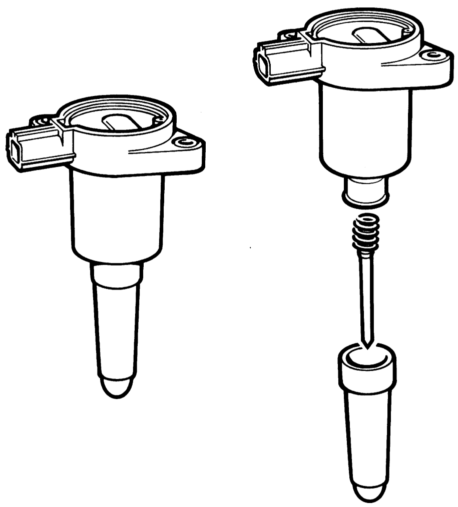
ON-PLUG IGNITION COILS



T801/1.32

Ignition Control (continued)

IGNITION COIL



T801/1.33

Ignition Coils

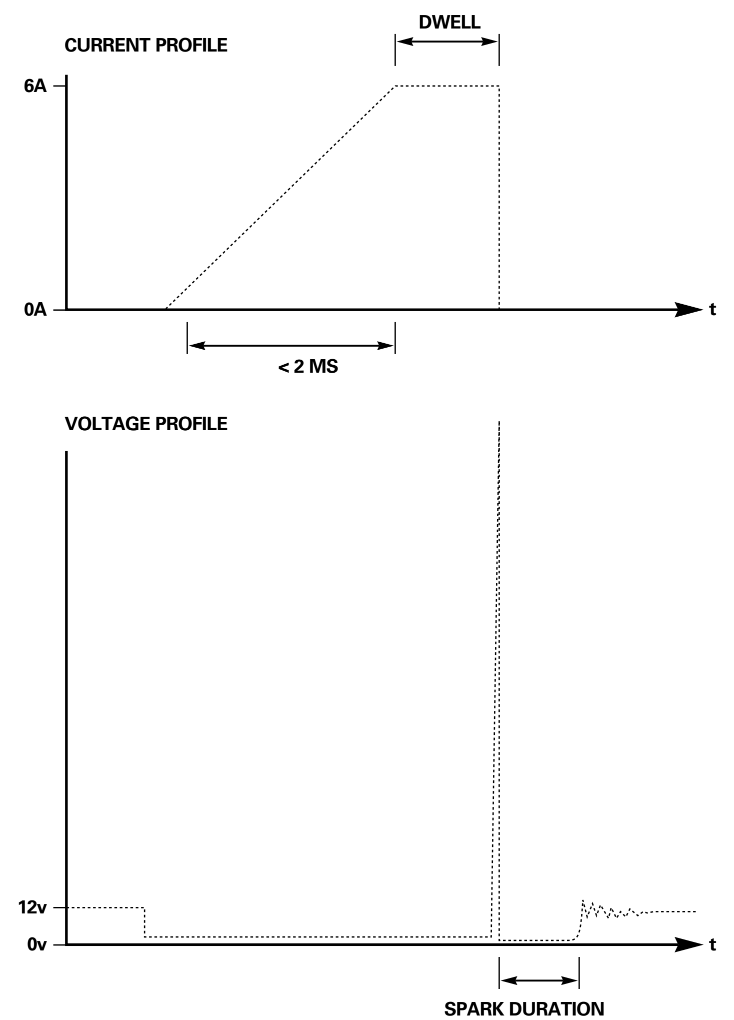
Each ignition coil assembly is made up of a coil body with an integral two-pin connector plug (for connection to the ECM), a central electrode and an extension housing.

Ignition Coil Monitoring for OBD II

During normal running, the coil primary switching signal is monitored for current flow and for early activation. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

IGNITION COIL PRIMARY CIRCUIT CHARACTERISTIC



T801/1.34

Ignition Secondary Control

Secondary ignition timing control inputs consist of battery voltage, engine coolant temperature, intake air temperature, throttle movement and position, transmission upshift, and knock control.

Dwell control

The dwell angle and peak coil current are ECM controlled to maintain the required spark energy required throughout the operating range of the engine while keeping dwell to a minimum to avoid overheating of the ignition coils.

Engine coolant temperature correction

Ignition timing is corrected for engine coolant temperature by the ECM.

Intake air temperature correction

Ignition timing is corrected by the ECM for engine intake air temperature measured by the air temperature sensor mounted in the air inlet elbow.

Closed throttle / idle correction

Separate closed throttle idle ignition strategies for gear positions Neutral and Drive are used. Refer to Idle Control, page 36.

Full load correction

The ECM corrects ignition timing to compensate for full load conditions.

NOTES

Ignition Control (continued)

Ignition Secondary Control (continued)

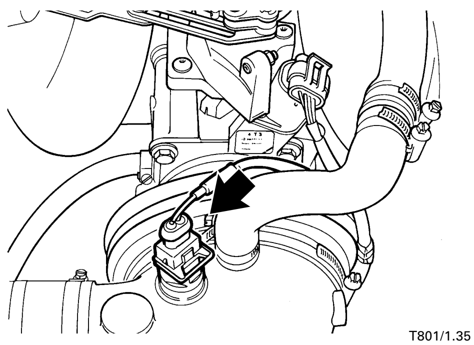
Intake air temperature sensor (IATS)

The intake air temperature sensor (IATS) is a negative temperature coefficient (NTC) thermistor identical to the sensor used in AJ6 engine management systems, however, the connector and leads are revised. Intake air temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

IATS Monitoring for OBD II

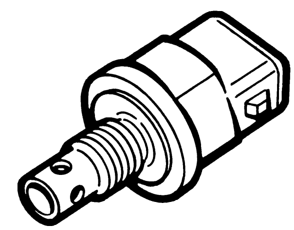
The IATS range is checked for values outside of normal limits. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

INTAKE AIR TEMPERATURE SENSOR LOCATION



T801/1.35

INTAKE AIR TEMPERATURE SENSOR



T801/1.36

Intake air temperature sensor – temperature versus resistance:

Intake air temperature °F	°C	Resistance (kilo ohms)
14	-10	9.20
32	0	5.90
50	10	3.70
68	20	2.50
86	30	1.70
104	40	1.18
122	50	0.84
140	60	0.60
158	70	0.435
176	80	0.325
193	90	0.25
212	100	0.19

Intake air temperature sensor – temperature versus typical approx. voltage:

Intake air temperature °F	°C	Voltage
14	-10	4.05
32	0	3.64
59	15	2.89
78	25	2.42
86	30	2.20
104	40	1.78
122	50	1.44
140	60	1.17
158	70	0.95
176	80	0.78
193	90	0.65
212	100	0.55

Torque-based transmission shifting

Transmission shift quality is enhanced by "torque-based shifting". The ECM continuously provides the transmission control module (TCM) with a pulse width modulated (PWM) signal that represents the engine load. This signal is generated by the ECM based on the injector pulse duration.

When a shift is to occur, the TCM calculates the necessary torque reduction and provides a PWM "ignition retard request" signal to the ECM. The PWM torque reduction signal will vary between 20% and 90% (20% = 0° ignition retard; 90% = maximum ignition retard). The actual amount of retard is applied to the ignition advance angle after other corrections are applied.

NOTES

Knock control

Individual, cylinder specific ignition retard to control knock and optimize engine power is provided through the ECM. Two knock sensors (KS) are positioned on the cylinder block to sense engine combustion knocks. One KS is positioned at the number 2 cylinder (for cylinders 1 – 3) and one is positioned at the number 5 cylinder (for cylinders 4 – 6). Each knock sensor has a piezo electric sensing element to detect broad band (2 – 20 kHz) engine accelerations.

If a knock occurs, the ECM determines which cylinder is firing from the crankshaft position sensor (CKPS) input, and retards the ignition timing for that cylinder only. If, on the next firing of that cylinder, the knock reoccurs, the ECM will further retard the ignition timing; if the knock does not reoccur on the next firing, the ECM will advance the ignition timing incrementally with each firing.

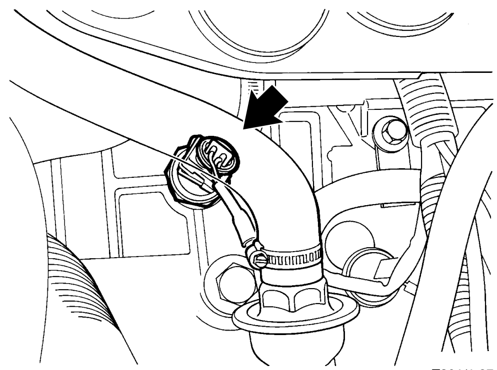
The knock sensing ignition retard / advance process can continue for a particular cylinder up to a maximum retard of 9 degrees.

KS Monitoring for OBD II

Knock sensing faults are detected by using two tests. One test checks for background noise; the other test checks for sensor voltage outside of the normal range. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

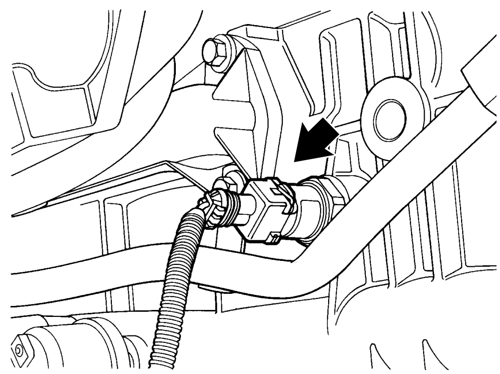
NOTES

KNOCK SENSOR A LOCATION



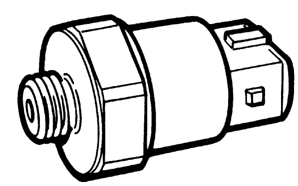
T801/1.37

KNOCK SENSOR B LOCATION



T801/1.38

KNOCK SENSOR



T801/1.39

Idle Control

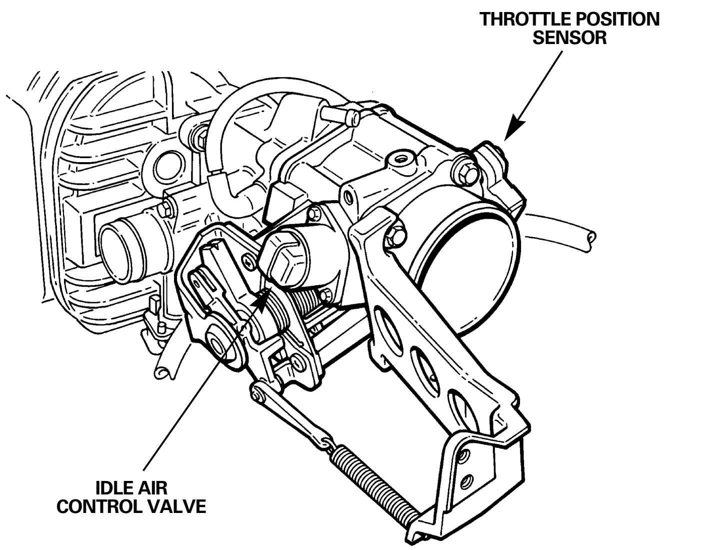
Idle speed is regulated by idle air control and ignition timing.

The idle air control valve (IACV) is driven by the ECM. The ECM uses inputs received from ignition ON, the crankshaft position sensor (CKPS), engine coolant temperature sensor (ECTS) and throttle position sensor (TPS) as well as inputs for ignition ON / OFF, gear position, air conditioning compressor operation and road speed to control idle.

Throttle Body and Idle Air Control Valve (IACV)

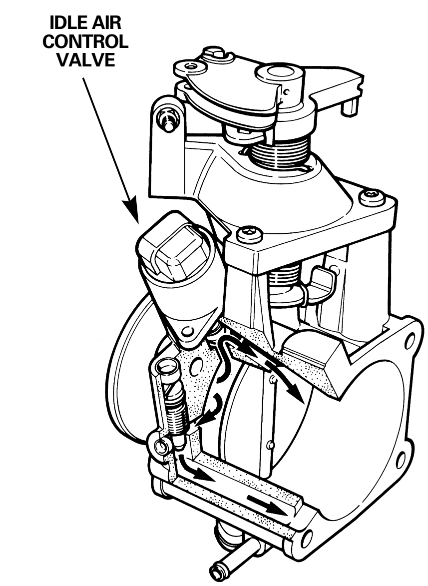
The throttle body assembly incorporates the throttle value, a fixed idle air bypass, an idle air control valve (IACV), and a fixed single track throttle position sensor (TPS). The throttle body is heated by engine coolant to prevent ice formation around the throttle area.

THROTTLE BODY ASSEMBLY: SUPERCHARGED ENGINES



T801/1.41

THROTTLE BODY ASSEMBLY : NORMALLY ASPIRATED ENGINES



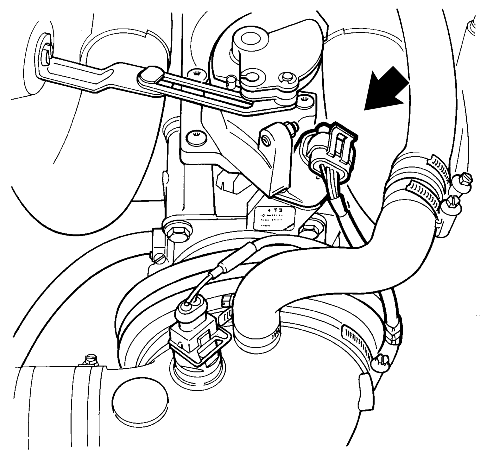
T801/1.40

NOTES

The nonadjustable fixed idle air bypass provides a base idle setting. The ECM-driven IACV provides a variable idle air bypass enabling ECM idle air control. The nonadjustable throttle position sensor provides the ECM with a throttle position input. Refer to page 29. The throttle valve will not require setting during service.

The IACV regulates a variable bypass passage. The flow of air through the variable passage is regulated by a stepper motor connected to a cone-shaped valve. The stepper motor has two coils that are pulsed by the ECM. The pulses are phased 90˚ apart. The order in which the coils are pulsed determines the direction of stepper motor travel. The stepper motor has a total travel from fully opened to fully closed of approximately 230 steps.

IDLE AIR CONTROL VALVE



T801/1.42

IACV Monitoring for OBD II

IACV faults are detected by using two tests. During power down, the stepper motor coils are checked for open and short circuits. A closed loop test monitors the idle speed control steps for values outside normal limits without causing a change in idle speed. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

Idle Control (continued)

ECM Idle Speed Control

ECM idle speed control occurs at closed throttle when road speed is less than 3 mph. The programmed idle speed accounts for engine temperature and the loads placed on the engine by the transmission (gear position N, D, etc.), and air conditioning compressor clutch operation.

Target stable idle speeds:	Park / Neutral – 700 rpm
(normal operating temperature)	Drive / R, D 2, D 3 – 580 rpm

Idle speed ± 30 rpm when coolant temperature is less than 86˚F (30˚C)
Idle speed ± 20 rpm when coolant temperature is 86˚F or higher

An ECM adaption function allows for a correction to the idle speed “base line” as the engine base idle changes with age. The adaption values are held in nonvolatile memory (EEPROM) and will be retained even if the battery is disconnected.

NOTE: At road speeds above 3 mph, the idle air control valve (IACV) is opened to limit overrun intake manifold pressure. The amount that the valve is opened is based on engine speed, engine temperature and throttle opening.

Engine start-up

ECM idle speed control begins shortly after the engine is started, provided the throttle is closed (throttle position sensor at idle) and the road speed is less than 3 mph. The stepper motor in the control valve is closed in stages until the target idle speed is reached.

Gear position

When the gear selector is in Park or Neutral, the engine management ECM receives a ground signal from the transmission decoder module (XJ6 Sedan Range) or rotary switch (XJS Range). The ECM then closes the idle air control valve a predetermined number of steps in anticipation the reduced engine load. At idle, the ECM applies ignition timing from separate closed throttle ignition strategies for gear positions Neutral and Drive.

Air conditioning compressor clutch operation

When the air conditioning compressor clutch is energized, the ECM opens the idle air control valve a predetermined number of steps and advances the ignition timing to adjust for the change in engine load.

Ignition switched OFF

When the ignition is switched OFF, the idle air control valve indexes to a known parked position. The reference is from the fully closed position approximately 10 seconds after the ignition is switched OFF.

NOTES

Adaptive Idle Fuel Metering

Adaptive idle fuel metering is used to allow for minor engine mechanical variability and engine aging.

The ECM contains an adaptive idle fuel metering software function that automatically makes a baseline correction to the idle fuel metering strategy using long-term information from the oxygen sensors. The adaption values are held in nonvolatile memory (EEPROM) and will be retained even if the battery is disconnected.

Adaptive Idle Fuel Metering Monitoring for OBD II

Adaptive fuel metering corrections are monitored for values outside of normal limits. There are limits for both the fuel flow rate and air mass flow rate. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

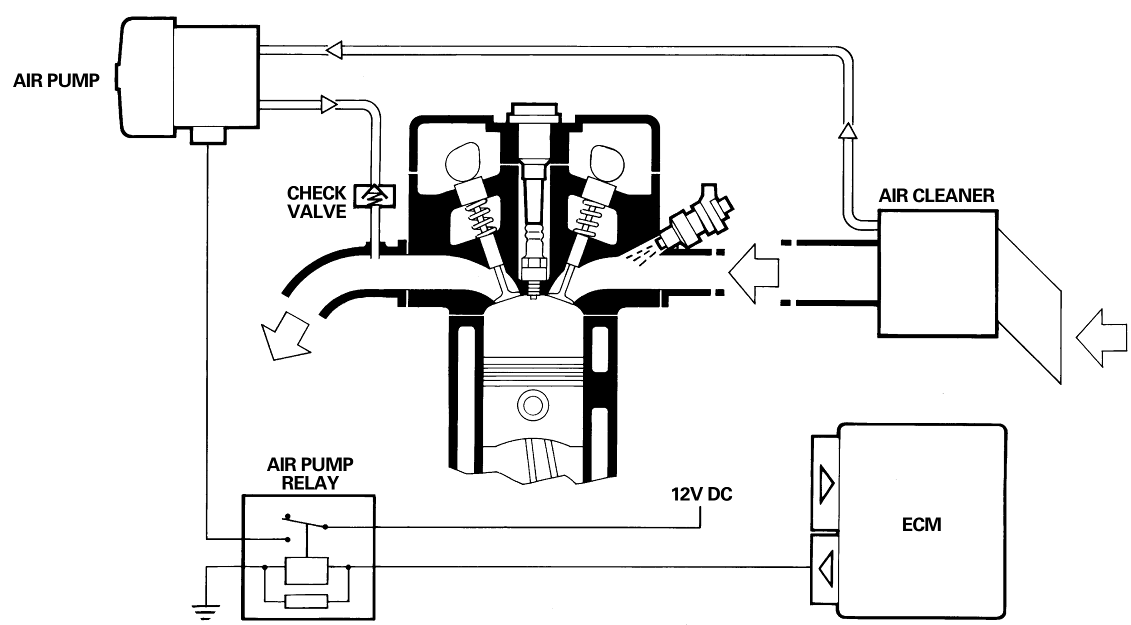
Secondary Air Injection

Secondary air injection is employed to reduces catalyst "light off" to a minimum. "Light off" is the term used to describe the time taken to bring the catalyst to the ideal operating temperature. After engine start, the fuel / air mixture is initially rich. The exhaust from this rich mixture is still burning when it enters the catalyst. Air is delivered to the exhaust system to prolong the catalyst burning time and therefore raise the catalyst operating temperature to the ideal level as soon as possible.

Secondary air injection operates immediately after start-up for a period mapped against engine coolant temperature.

When the engine coolant temperature is at or above 60˚F (16˚C), the ECM activates air injection for 15 seconds. When the coolant temperature is below 60˚F (16˚C), operation occurs up to a maximum of 4 minutes. Air injection is cancelled at high engine speed and / or load to prevent excessive exhaust pressure.

SECONDARY AIR INJECTION SYSTEM



T801/1.45

Secondary Air Injection Monitoring for OBD II

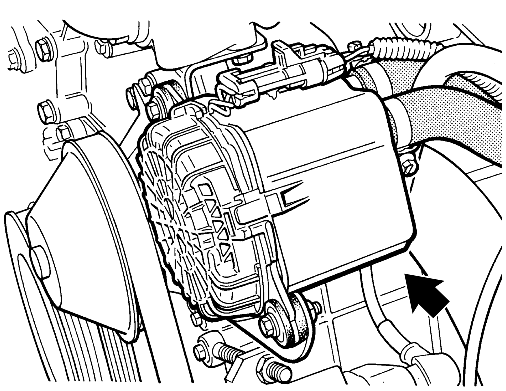
Secondary air injection is monitored for decreased flow. The ECM can determine the air injection flow volume by monitoring the drift in oxygen sensor response. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test on page 53.

NOTES

Secondary Air Injection Pump (AIRP)

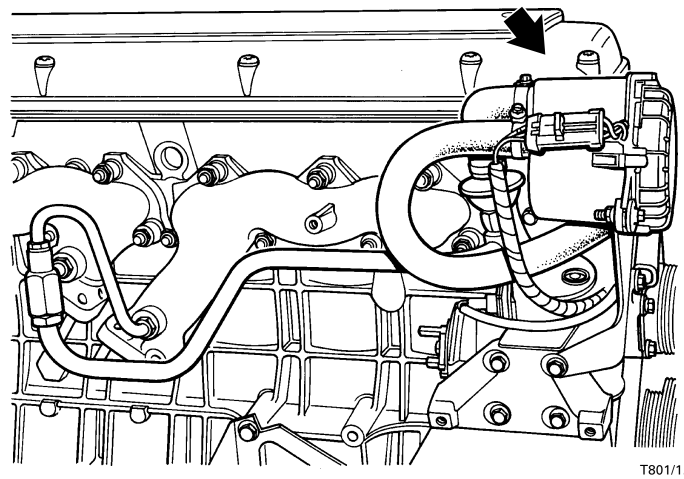
The secondary air injection pump (AIRP) is an electrically powered regenerative turbine-type pump that is permanently lubricated and requires no periodic maintenance. The AIRP incorporates an integral solenoid operated stop valve, which is activated to open when the pump operates to allow air flow to the exhaust manifolds. The stop valve closes when current is switched off to prevent air flow through the pump. The pump and stop valve are controlled by the ECM via the air injection relay.

SECONDARY AIR INJECTION PUMP: NORMALLY ASPIRATED ENGINES



T801/1.44

SECONDARY AIR INJECTION PUMP: SUPERCHARGED ENGINES



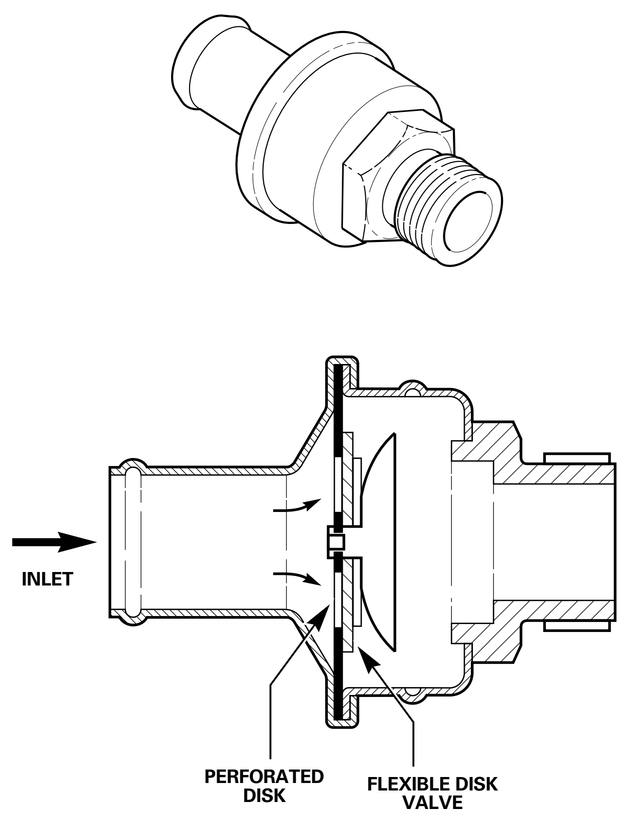
T801/1.43

NOTES

Secondary Air Injection (continued)

Secondary Air Injection Check Valve (AIRC)

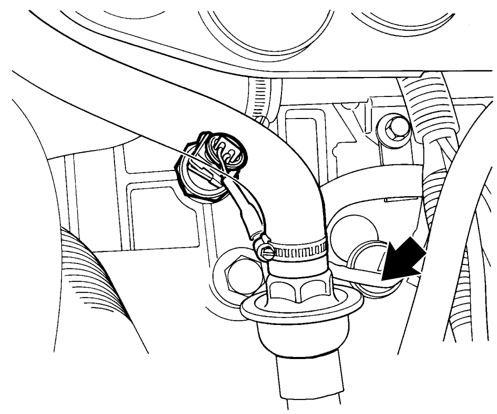
SECONDARY AIR INJECTION CHECK VALVE



T801/1.47 A & B

The secondary air injection check valve (AIRC), located in the delivery tube behind the air pump, prevents the back-flow of exhaust gas to the air pump.

SECONDARY AIR INJECTION CHECK VALVE LOCATION



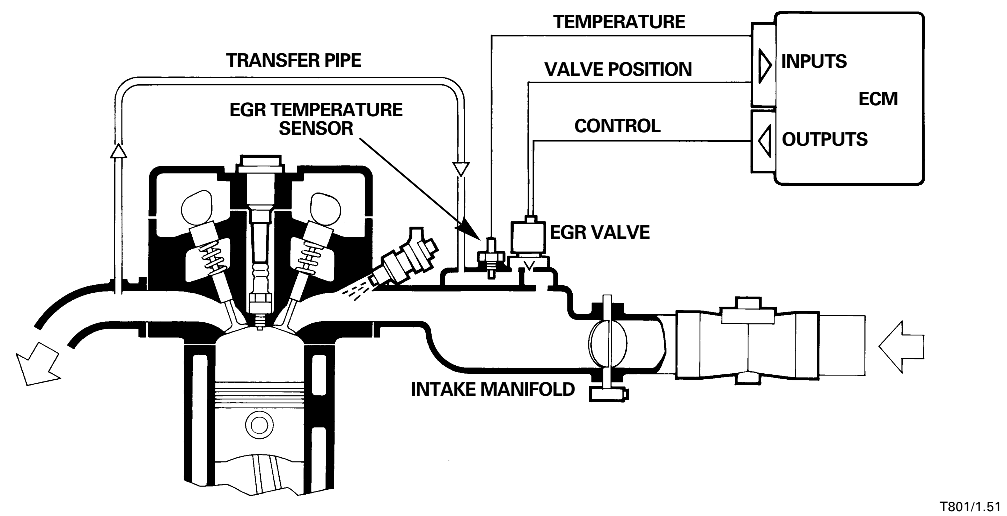
T801/1.46

NOTES

Exhaust Gas Recirculation (EGR)

EGR lowers combustion temperature, which in turn aids in the reduction of NOx exhaust emission. If the EGR valve is seized closed, uncontrolled production of NOx will result; if the valve is seized open, the combustion temperature will lower resulting in high HC and CO exhaust emission and poor engine performance. EGR operation is mapped against engine load and speed, throttle position, and coolant temperature.

EGR SYSTEM



EGR Monitoring for OBD II

EGR operation is monitored by the ECM via the EGR temperature sensor. When EGR is enabled, the ECM monitors EGR temperature and compares it with the expected temperature for a given EGR valve opening. The valve opening is determined by feedback from the pintle position sensor (see EGR Valve on page 46). A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

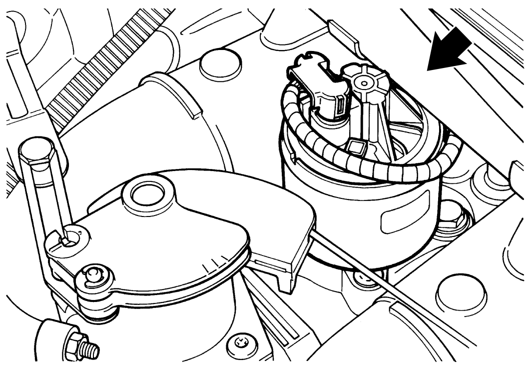
NOTES

Exhaust Gas Recirculation (EGR) (continued)

EGR Valve (EGRV)

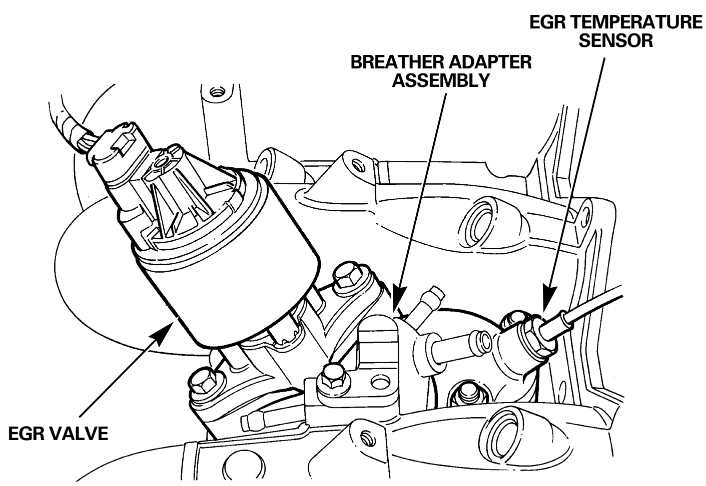
The electronically operated and controlled EGR valve (EGRV) is located on the intake manifold. The EGRV consists of three main parts: the solenoid, the pintle and seat, and the pintle position sensor. When energized by the ECM, the solenoid pulls the pintle away from the seat to allow exhaust gas flow into the intake manifold. Movement of the armature and pintle is resisted by three forces: the pressure drop across the pintle and seat area, gravity, and the spring load from the pintle position sensor.

EGR VALVE LOCATION (EARLY PRODUCTION)



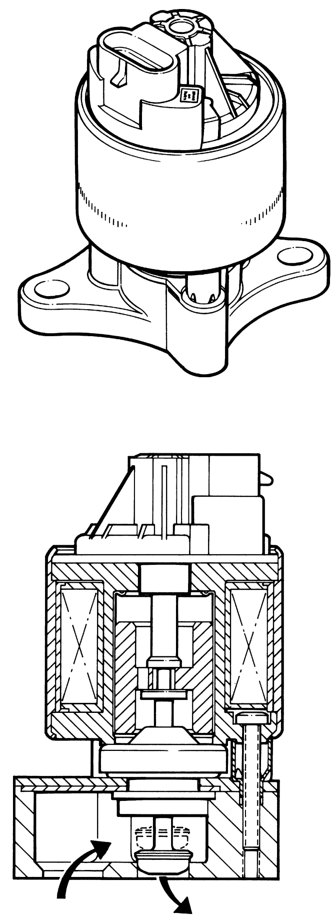
T801/1.48

EGR VALVE AND TEMPERATURE SENSOR (LATER PRODUCTION)



T801/1.49

EGR VALVE



T801/1.50 A & B

The EGRV pintle position sensor provides feedback to the ECM for closed loop control. In addition to closed loop EGR control, the ECM uses the EGRV position feedback to calculate fuel metering and ignition corrections.

NOTES

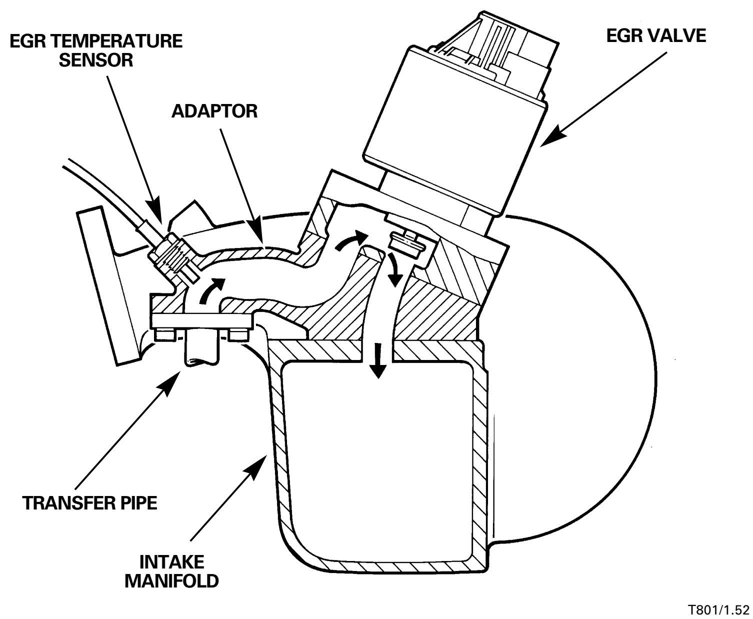
EGR Temperature Sensor (EGRT Sensor)

The EGR temperature sensor is a negative temperature coefficient (NTC) thermistor. It is identical to the EGR temperature sensor used in AJ6 engine management systems, however, the connector and leads are revised. The ECM applies 5 volts to pin 1 of the sensor and monitors the voltage across the sensor pin to ground. The theoretical full voltage range is from 5 to 0 volts representing maximum cold to maximum hot.

EGR temperature sensor – temperature versus resistance

EGR temperature °F	°C	Resistance (kilo ohms)
122	50	600
212	100	90
302	150	11
392	200	5
482	250	2
572	300	0.8
662	350	0.3
752	400	0.1

EGR VALVE INSTALLATION



NOTES

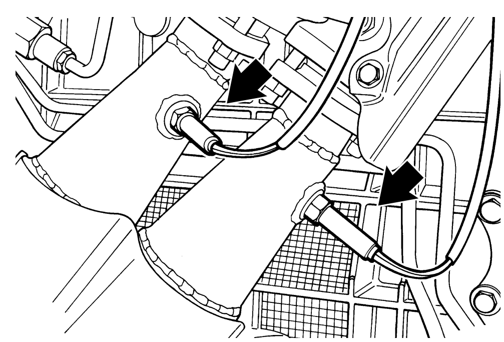
Catalytic Converters

Catalyst Monitoring for OBD II

Deterioration of catalytic conversion efficiency will create higher than acceptable HC, CO and NOx exhaust emission.

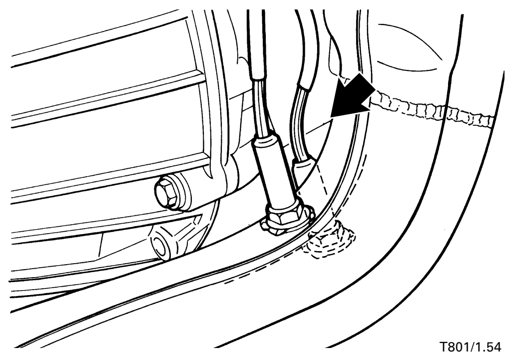
The efficiency of the primary catalytic converters is monitored and any deterioration in efficiency is flagged as a fault by the ECM. Monitoring for catalyst efficiency is achieved by sampling both the incoming and outgoing exhaust at the primary catalysts. Two oxygen sensors are positioned in each exhaust downpipe assembly — one upstream of the primary catalyst and one downstream of the primary catalyst.

UPSTREAM OXYGEN SENSORS



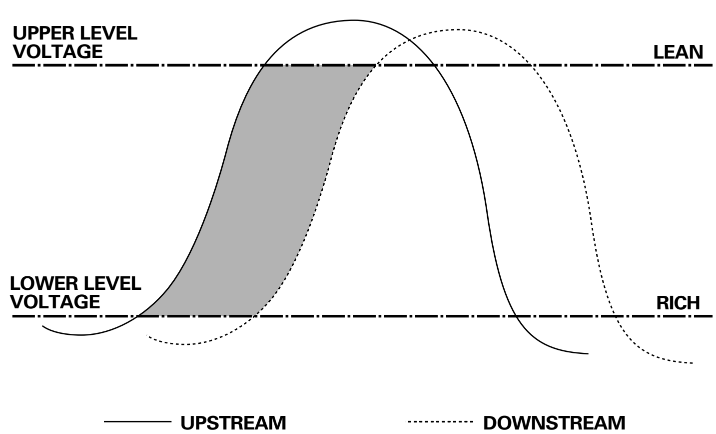
T801/1.53

DOWNSTREAM OXYGEN SENSORS



T801/1.54

OXYGEN SENSOR AREA DIFFERENCE



T801/1.55

By comparing the voltage swings of each set of sensors, the ECM can detect when catalyst efficiency drops off. An "area difference" technique is used to compare successive oxygen sensor swing measurements.

NOTE: The CHECK ENGINE MIL will not be activated for catalyst monitoring faults on 1995 model year vehicles, however, a DTC will be flagged by the ECM. A fault must occur on two consecutive trips before a DTC is flagged.

NOTES

Engine Misfire

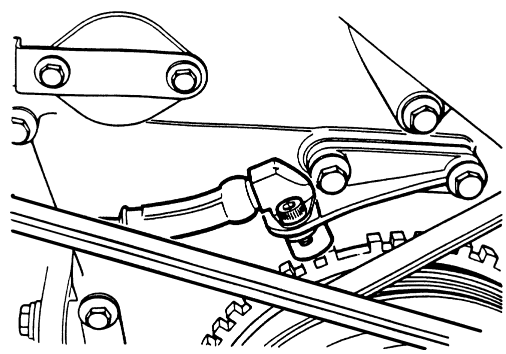
Misfire Monitoring for OBD II

Engine misfire may cause catalytic converter damage and/or cause a vehicle to fail an emission inspection.

The ECM monitors the engine for misfire via the crankshaft position sensor (CKPS). The steel teeth on the crankshaft timing ring are used as a rotor for the sensor. The rotor has 60 tooth positions set at 6 degree intervals with one tooth missing. The gap identifies the TDC position of cylinders 1 and 6 during one complete engine cycle (two crankshaft revolutions). The ECM uses the gap as a position reference.

At each cylinder firing, the crankshaft momentarily accelerates. The ECM records and compares the time intervals between cylinder firings and the rotor gap to detect a misfire.

CRANKSHAFT POSITION SENSOR



T801/1.56

If a persistent misfire occurs, the ECM will identify the cylinder and switch off the fuel injector.

NOTE: The CHECK ENGINE MIL will not be activated for misfire monitoring faults on 1995 model year vehicles, however, a DTC will be flagged by the ECM.

There are two levels of misfire that may be detected:

Level 1 If the misfire is not severe, the fault must occur on two consecutive trips before a DTC is flagged.

Level 2 If the misfire is severe enough that catalyst damage may occur, the DTC is flagged immediately.

NOTES

Vehicle Systems Interfaces

The engine management system interfaces with the instrument pack, the air conditioning compressor clutch circuit, and the transmission control module to provide data and sensor input, and operational control.

Instrument Pack

Vehicle road speed
The instrument pack outputs a road speed signal (pulsed signal) to the ECM. The ECM uses the signal to determine idle speed control and OBD functions.

Low fuel level
The instrument pack outputs a fuel level voltage signal to the ECM. When the voltage drops below a specified value, fuel metering diagnostics (OBD) are canceled. Canceling the fuel metering diagnostics prevents the ECM from flagging DTCs caused by the vehicle running out of fuel.

Engine speed
The ECM provides an engine speed signal (pulsed signal) to the instrument pack for operation of the tachometer.

CHECK ENGINE MIL
If the OBD system detects a fault, the ECM outputs a warning signal (ground) to the instrument pack for operation of the CHECK ENGINE MIL. Refer to On-Board Diagnostic Facility on pages 52 – 53.

CHECK ENGINE MIL Monitoring for OBD II
The MIL circuit is checked for open and short circuits during the instrument pack bulb check period. A fault must occur on two consecutive key ON cycles before the ECM flags a DTC.

Climate Control / Air Conditioning

The ECM controls air conditioning compressor clutch operation from a request made by the climate control module. When an air conditioning compressor ON request (12 volt signal) is received from the climate control module, the ECM switches ON the compressor (via the air conditioning compressor relay). The ECM cancels (or does not switch ON) air conditioning during a full throttle demand, and when high engine coolant temperatures occur.

NOTES

Automatic Transmission

Throttle position
The ECM processes the throttle position input signal from the single track throttle position sensor (TPS) and supplies the TCM with a pulse width modulated signal to indicate throttle position.

Gear selector position
On XJ6 Sedan Range vehicles, gear position signals are output to the ECM by the decoder module (NA) or the linear gear position switches (SC). On XJS Range vehicles, gear position signals are output to the ECM by the rotary switch. When the gear selector is in R, D, 2 or 3, the signal is 5 volts; when the gear selector is in P or N, the signal is ground or 0 volts. The ECM uses the gear position inputs to control idle speed. Refer to Ignition Control, pages 32 – 37, and Idle Control, pages 38 – 41, for a detailed explanation.

Gear Selector Position Monitoring for OBD II
Gear selector position faults are detected by using two tests. One test monitors for high engine load or gear change request signals while the gear position is P or N. The other test monitors for engine starting when the gear position is not P or N. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

Engine speed and torque
The ECM supplies the TCM with engine speed and torque signals. Speed is supplied as a pulsed voltage signal that decreases as rpm increases; torque (derived from injector pulse duration) is supplied as a pulse width modulated (PWM) signal.

Serial Communication

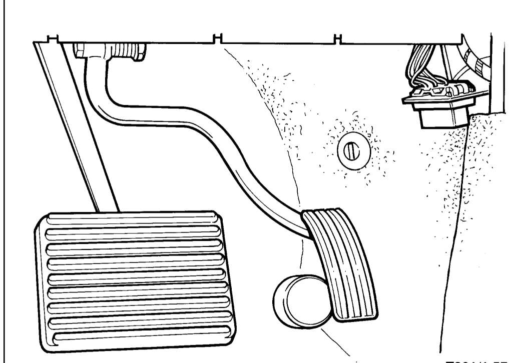
Serial communication between the engine management system and PDU takes place via the serial communication data link. Only one bidirectional serial line connects to the ECM. Serial communication is used for engine setup, accessing stored DTCs, fault diagnosis and erasing DTCs.

NOTES

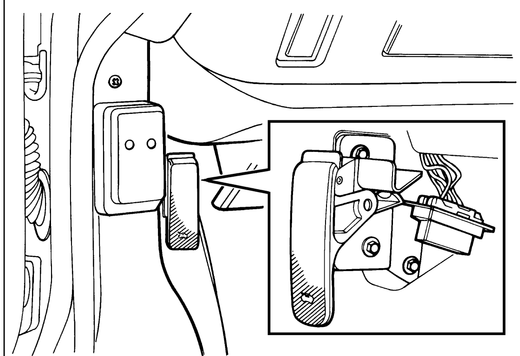
On-Board Diagnostic Facility – OBD II

The OBD facility has greatly expanded diagnostic capability, as described previously. The OBD facility continuously monitors the operation of the engine management sensors and components. In addition the OBD facility predicts failure of subsystems by performance observation. If a fault is detected by OBD monitoring or testing, a fault is registered and reported to the Diagnostic Status Manager (DSM) (ECM internal software). The DSM decides whether to flag a DTC and activate the CHECK ENGINE MIL. Except in cases where EMS system operation would be seriously impaired, a fault must be detected on two consecutive trips before the CHECK ENGINE MIL is activated.

DATA LINK CONNECTOR – SEDAN RANGE



DATA LINK CONNECTOR – XJS



If, after the MIL is activated, three sequential trips are made with no recurrence of the fault(s) and no occurrence of additional fault(s), the MIL will extinguish on the next trip. The fault(s) will remain stored in memory. The DSM will erase any fault code that has not recurred in 40 consecutive engine warm-up cycles.

Faults stored in the ECM memory can only retrieved through serial communication via the data link. DTCs are held in nonvolatile memory (EEPROM) so that disconnecting the battery does not erase stored codes.

Transmission Faults – ZF

Upon detection of a transmission fault, the TCM activates the TRANSMISSION MIL immediately. If the same fault is detected on two consecutive trips, the TCM signals the ECM to immediately activate the CHECK ENGINE MIL. If the transmission fault is “self corrected” by the TCM, the TRANSMISSION MIL will extinguish at the end of the ignition cycle; however, the CHECK ENGINE MIL will remain activated until an additional three consecutive fault-free trips have occurred.

Transmission Faults – Powertrain (Hydra-Matic)

Upon detection of a transmission fault, the TCM activates the TRANSMISSION MIL immediately, and signals the ECM to immediately activate the CHECK ENGINE MIL. If the transmission fault is “self corrected” by the TCM, the TRANSMISSION MIL will extinguish at the end of the ignition cycle; however, the CHECK ENGINE MIL will remain activated until an additional three consecutive fault free trips have occurred.

Trip and Service Drive Cycle

“Trip” and “Service Drive Cycle” are terms used in conjunction with OBD II.

A “Trip” means vehicle operation, following an engine-off period, of duration and driving mode such that all EMS components and subsystems are checked at least once by the diagnostic system, with the exception of catalyst efficiency and evaporative system monitoring. Catalyst efficiency and evaporative system monitoring require a steady vehicle speed check.

NOTES

To check for a reoccurrence of a DTC, a vehicle must be operated over a “Service Drive Cycle”.

A “Service Drive Cycle” is a planned routine of operating a vehicle so that the EMS components and subsystems that are being monitored will be tested. For certain DTCs, such as that for the ECTS, the Service Drive Cycle is simple and includes:

- ignition ON
- engine start
- engine run to normal operating temperature
- ignition OFF

For more complex diagnostic routines, such as that for EGR, additional operating modes are required.

Systems Readiness Test

It can be determined if the Service Drive Cycle was of sufficient length to test for DTC reoccurrence by performing a PDU “Systems Readiness Test”.

The Systems Readiness Test occurs automatically when the PDU reads the DTCs from the ECM memory and reports if a full OBD check has NOT been completed since the memory was last cleared.

OBD II Reports to Jaguar Cars

Whenever the CHECK ENGINE MIL is activated, a DTC and accompanying “freeze frame” data will be stored in the ECM memory. This information must be retrieved using the PDU “OBD II Report” and reported to Jaguar Cars on form S93.

Limp Home Default

In order to allow vehicle operation if a malfunction occurs, “limp home” default values are incorporated as an ECM facility. If a sensor fault is detected by OBD, the ECM will substitute a nominal value for the missing input(s).

Diagnostic Trouble Codes

The number of possible diagnostic trouble codes (DTCs) has been greatly increased. Each DTC is a five place standard SAE (Society of Automotive Engineers) code that describes a subsystem and the specific fault. Refer to the Service Manual for a complete DTC listing.

DTCs are arranged in seven major groups as follows.

PX1XX	Fuel and air metering
PX2XX	Fuel and air metering
PX3XX	Ignition system or misfire
PX4XX	Auxiliary emission controls
PX5XX	Vehicle speed; idles control; auxiliary inputs
PX6XX	Computer and auxiliary inputs
PX7XX	Transmission control

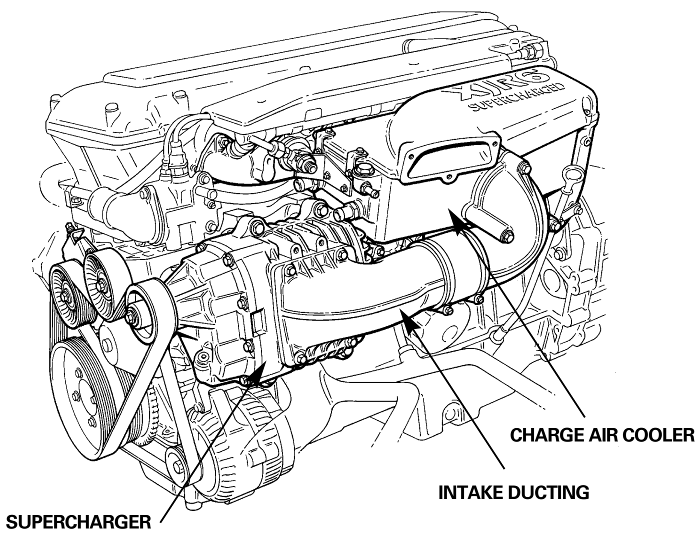
Fault diagnostics

The Service Manual contains a Diagnostics section for OBD II specific fault finding and repair.

NOTES

Engine Supercharger

SUPERCHARGER INSTALLATION



T801/1.59

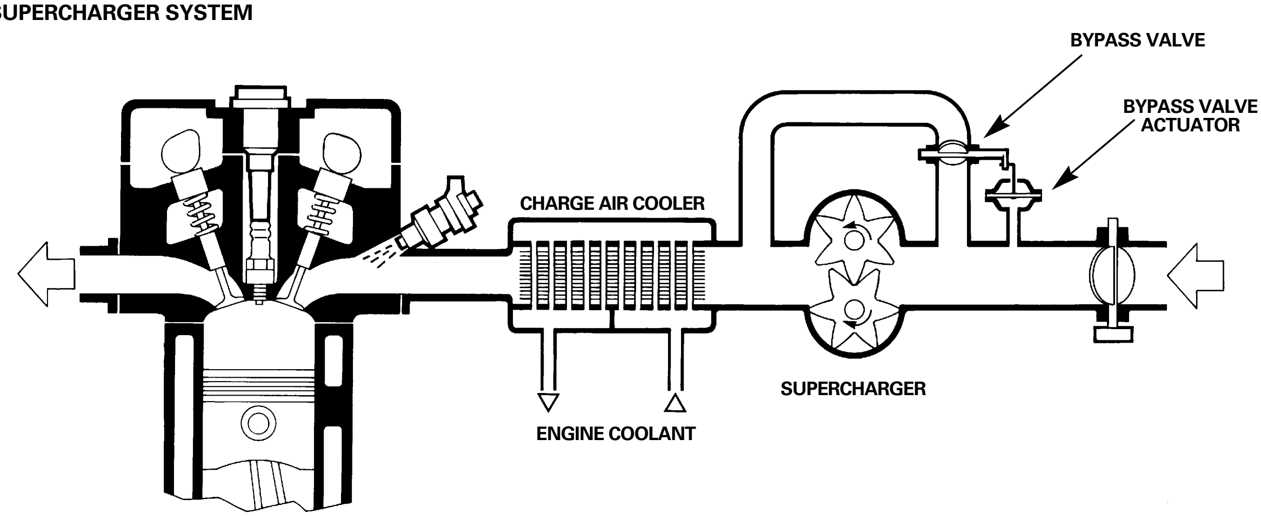
The AJ16 supercharged engine has a throttle body adaptor, a supercharger and a charge air cooler, together with associated ducting. These components are installed between the throttle body and the intake manifold.

Air from the throttle body passes through the throttle body adaptor to the supercharger, where it is compressed and directed through ducts to the charge air cooler. The charge air cooler extracts some of the heat added to the air during compression. The compressed and cooled air then enters the intake manifold.

A port in the supercharger outlet duct connects with a bypass valve, which bypasses excess compressed air back to the supercharger intake, effectively taking the supercharger off load for a large proportion of the driving cycle.

NOTE: 1995 model year Supercharged engines do not have exhaust gas recirculation (EGR).

SUPERCHARGER SYSTEM



T801/1.60

NOTES

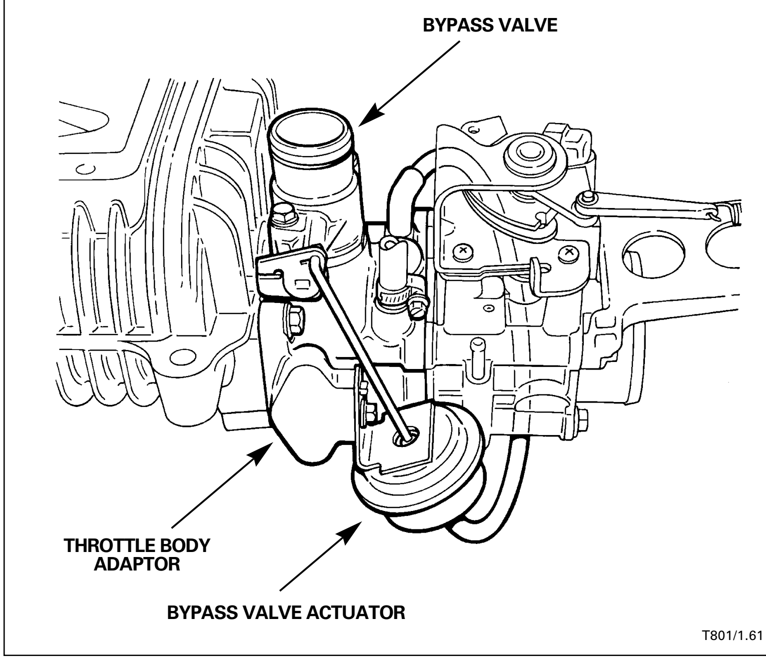
Throttle body adaptor
The throttle body adaptor is located between the throttle body and the supercharger. It incorporates those components and connections that are on the intake manifold of normally aspirated engines. Connections for the bypass valve and actuator are also installed.

Bypass valve
The bypass valve consists of a butterfly valve contained in an aluminum housing installed between the outlet duct of the supercharger and the throttle body adaptor. A bypass valve actuator and a spring are attached to the spindle of the valve.

With a closed or partially open throttle, the vacuum actuator overcomes spring pressure to hold the bypass valve fully open, allowing excess air back to the supercharger intake. As the throttle opens, the depression in the manifold decreases, and the spring progressively overcomes the pull of the vacuum actuator to close the valve, increasing the pressure of the air supplied to the intercooler and intake manifold.

Bypass valve actuator
The bypass valve actuator is a vacuum actuator attached to the spindle of the bypass valve. The actuation pipe of the actuator connects to the throttle body adaptor at the intake to the supercharger.

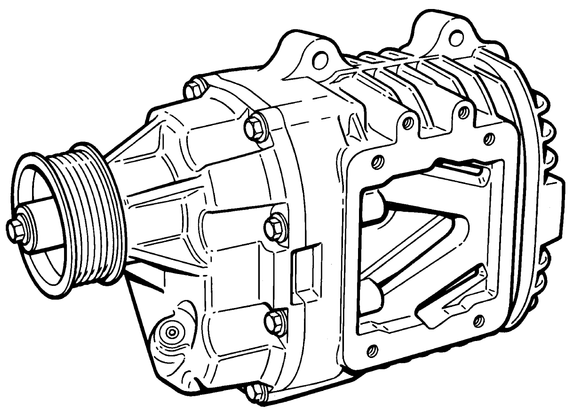
THROTTLE BODY



NOTES

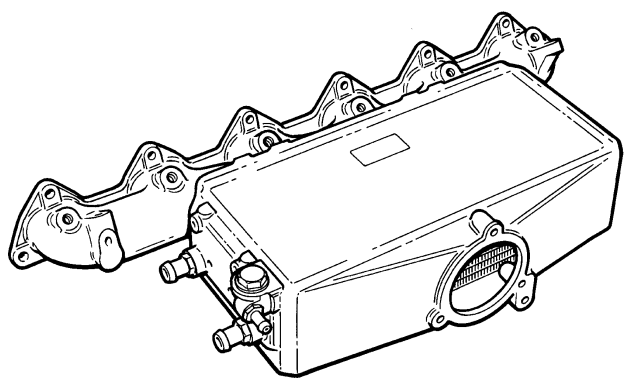
Engine Supercharger (continued)

SUPERCHARGER



T801/1.62

CHARGE AIR COOLER



T801/1.63

Supercharger

The supercharger is second generation version of the Eaton M90, installed on the front left side of the engine above the coolant pump. A cast bracket attaches the supercharger to four bosses on the cylinder block.

The belt-driven supercharger has a gearbox driving two meshed helix rotors, producing a maximum pressure increase of approximately 0.7 bar (10.2 psi) at 2750 engine rpm. A seven-ribbed belt, driven by the crankshaft, turns the supercharger pulley at 2.5 times engine speed. The supercharger is a sealed unit with an internal lubrication system.

Charge air cooler

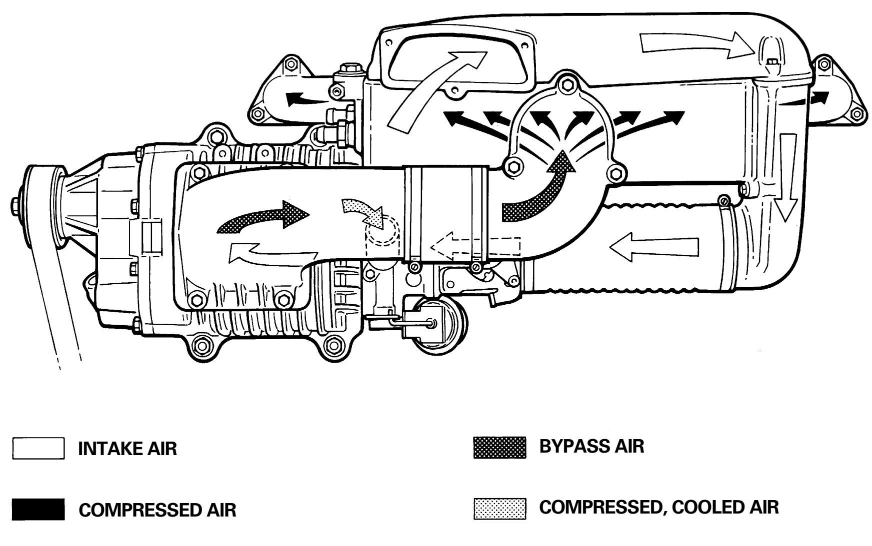
The charge air cooler is a fin-and-tube, air-to-liquid heat exchanger integrated into the intake manifold. It cools the air leaving the supercharger to increase the mass of air entering the engine. Coolant flow is supplied by an electrically powered pump.

NOTES

Intake ducting

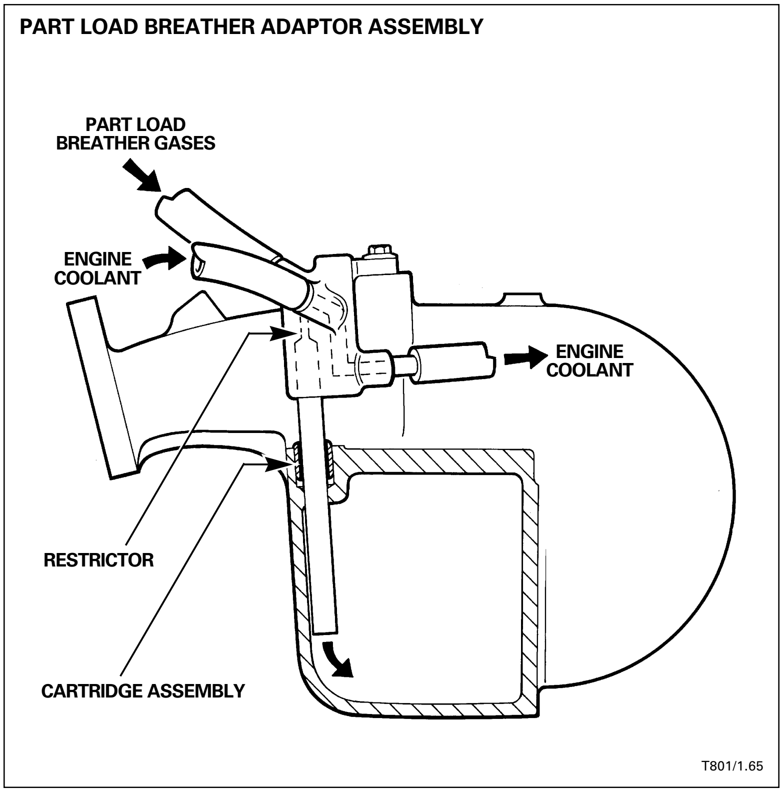
A corrugated flexible hose connects the MAFS to a cast duct attached to the charge air cooler. The cast duct guides the air rearwards and below the cooler. A reinforced corrugated hose connects the downstream end of the cast air duct to the throttle body. A short length of high-temperature hose connects an the supercharge outlet to an elbow on the charge air cooler intake. The joints between the cast aluminum elbows and their respective components are sealed with O-rings.

AIR FLOW THROUGH INTAKE



NOTES

Crankcase Emission Control



The crankcase emission control arrangement is similar to the 1994 AJ6 arrangement. Crankcase vapor is collected from the camshaft cover. At part throttle, the gases are fed into the intake manifold through a coolant heated restrictor. During full load operation the gases are fed into the engine through both the coolant heated restrictor and air intake elbow connection.

The necessary crankcase vacuum is balanced by the part throttle restrictor and the full throttle orifice in the inlet elbow. The restrictor and orifice sizes have been carefully chosen to control the crankcase vacuum while not flowing so much gas that idle speed is affected.

The part throttle restrictor is coolant heated to prevent icing during cold weather operation.

NOTES

The following DTC section is extracted from the DTC Summaries manual and is included here as an aid to understanding the system. Do not use this information to diagnose vehicle faults.

Always refer to the Model Year specific section contained in the DTC Summaries manual for accurate information.

DTC Summary
4.0 Liter AJ16 Engine Management System – 1995

OBD II MONITORING CONDITIONS:

When testing for DTC reoccurrence, it can be determined if the Service Drive Cycle was of sufficient length by performing a PDU "Systems Readiness Test".

Use the PDU "Scantool Application" disc to communicate with the EMS ECM.

The Systems Readiness Test occurs automatically when PDU establishes communication with the ECM. PDU will report if any portion of the Systems Readiness Test has not been completed in the following format:

The following tests have been identified as incomplete:

- Module $51 (identifies EMS ECM)
  Catalyst
  Evaporative purge system
  Secondary air system
  O_2 sensor
  EGR system

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
1	P0101	MAFS range / performance	Drive > 1500 rpm > 4 seconds	2	TPS signal voltage high, but undetected Blocked air filter Blocked exhaust system Air intake leak MAPS to ECM sensing circuit high resistance MAPS to ECM sensing circuit intermittent short circuit to ground MAFS supply circuit high resistance MAFS failure
	P0102	MAFS sense circuit low voltage	Engine run > 4 seconds	2	Blocked air filter Blocked exhaust system MAPS to ECM sensing circuit high resistance or open circuit MAPS to ECM sensing circuit intermittent short circuit to ground MAFS supply circuit open circuit MAFS supply circuit short circuit to ground MAFS failure
	P0103	MAFS sense circuit high voltage	Engine idle < 1000 rpm > 4 seconds	2	MAPS to ECM signal ground wire open circuit MAPS to ECM sensing circuit short circuit to B+ voltage MAFS failure
2	P0112	IATS sense circuit high voltage (low air temperature)	Ignition ON > 4 seconds	2	IATS disconnected IATS to ECM wiring open circuit or high resistance IATS to ECM sensing circuit short circuit to B+ voltage IATS internal failure
	P0113	IATS sense circuit low voltage (high air temperature)	Ignition ON > 4 seconds	2	IATS to ECM wiring short circuit to ground IATS internal failure
3	P0116	ECTS range / performance	Engine at normal operating temperature; drive at highway speed	2	Low coolant level Engine thermostat stuck open ECTS to ECM sensing circuit high resistance when hot ECTS to ECM sensing circuit intermittent high resistance ECTS internal failure
	P0117	ECTS sense circuit high voltage (low coolant temperature)	Engine run > 4 seconds	2	ECTS disconnected ECTS to ECM sensing circuit high resistance ECTS to ECM sensing circuit open circuit ECTS to ECM sensing circuit short circuit to B+ voltage ECTS internal failure
	P0118	ECTS sense circuit low voltage (high coolant temperature)	Engine run > 4 seconds	2	Engine overheat condition ECTS to ECM wiring short circuit to ground ECTS internal failure
4	P0122	TPS sense circuit low voltage	Ignition ON > 1 second	2	TPS disconnected TPS supply circuit high resistance or short circuit to ground TPS to ECM position sense circuit open circuit or short circuit to ground TPS internal failure
	P0123	TPS sense circuit high voltage	Drive steadily < 35% load > 25 seconds	2	TPS to ECM signal ground circuit open circuit TPS to ECM wiring (supply, sense) short circuit to each other TPS position sense circuit short circuit to B+ voltage MAFS signal voltage low, but undetected TPS internal failure
3	P0125	Insufficient coolant temperature for closed loop fuel control	Engine run > 7 minutes	2	Low coolant level Engine thermostat stuck open ECTS to ECM sensing circuit high resistance ECTS internal failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
5	P0131	HO2S sense circuit low voltage – cyl 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	HO2S sense wire short circuit to ground HO2S failure HO2S heater malfunction (tip temperature too hot)
	P0132	HO2S sense circuit high voltage – cyl 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	HO2S disconnected HO2S signal ground wire open circuit HO2S sense wire open circuit HO2S sense wire short circuit to B+ voltage HO2S failure HO2S heater malfunction (tip temperature too cold)
	P0133	HO2S sense circuit slow response – cyl 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	HO2S contaminated HO2S wiring harness high resistance fault HO2S failure
	P0137	HO2S sense circuit low voltage – cyl 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
	P1137	HO2S sense circuit lack of "swing" – cyl 1, 2, 3 (A bank), downstream (2) Sense circuit indicates lean combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Downstream HO2S harness connectors (cyl 1, 2, 3 / cyl 4, 5, 6) reversed (Perform HO2S orientation) HO2S loose in exhaust pipe screw threads HO2S sense wire open circuit Exhaust leak before catalyst HO2S heater malfunction (tip temperature too cold) HO2S failure
	P0138	HO2S sense circuit high voltage – cyl 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
	P1138	HO2S sense circuit lack of "swing" – cyl 1, 2, 3 (A bank), downstream (2) Sense circuit indicates rich combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Downstream HO2S harness connectors (cyl 1, 2, 3 / cyl 4, 5, 6) reversed (Perform HO2S orientation) HO2S sense wire short circuit to ground HO2S heater malfunction (tip temperature too hot) HO2S failure
	P0139	HO2S sense circuit slow response – cyl 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Refer to P0133 possible causes
	P0151	HO2S sense circuit low voltage – cyl 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
	P0152	HO2S sense circuit high voltage – cyl 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
	P0153	HO2S sense circuit slow response – cyl 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Refer to P0133 possible causes
	P0157	HO2S sense circuit low voltage – cyl 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
	P1157	HO2S sense circuit lack of "swing" – cyl 4, 5, 6 (B bank), downstream (2) Sense circuit indicates lean combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Downstream HO2S harness connectors (cyl 1, 2, 3 / cyl 4, 5, 6) reversed (Perform HO2S orientation) HO2S loose in exhaust pipe screw threads HO2S sense wire open circuit Exhaust leak before catalyst HO2S heater malfunction (tip temperature too cold) HO2S failure
	P0158	HO2S sense circuit high voltage – cyl 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
	P1158	HO2S sense circuit lack of "swing" – cyl 4, 5, 6 (B bank), downstream (2) Sense circuit indicates rich combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Downstream HO2S harness connectors (cyl 1, 2, 3 / cyl 4, 5, 6) reversed (Perform HO2S orientation) HO2S sense wire short circuit to ground HO2S heater malfunction (tip temperature too hot) HO2S failure
	P0159	HO2S sense circuit slow response – cyl 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Refer to P0133 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
6	P0171	Cylinders 1, 2, 3 (A bank) combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Fuel injector blockage Fuel injector wiring open circuit Engine misfire Intake manifold air leak Exhaust air leak (before catalyst)
	P1171	All cylinders combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Fuel filter, system blockage Fuel system leak Fuel pressure regulator failure (low fuel pressure) Low fuel pump output Fuel injectors blocked MAFS signal fault (low voltage) SC engine – Incorrect MAFS installed
	P0172	Cylinders 1, 2, 3 (A bank) combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Exhaust air leak (before catalyst) Fuel injector blockage Engine misfire
	P1172	All cylinders combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Fuel return pipe blocked Fuel pressure regulator failure (high fuel pressure) Fuel injectors leaking MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed
	P0174	Cylinders 4, 5, 6 (B bank) combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Refer to P0171 possible causes
	P0175	Cylinders 4, 5, 6 (B bank) combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Refer to P0172 possible causes
	P1176	Adaptive fuel metering trim too lean (fuel flow rate)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Fuel injector supply wiring short circuit to ground Fuel filter, system blockage Fuel system leak Fuel pressure regulator failure (low fuel pressure) Low fuel pump output Fuel injectors blocked MAFS signal fault (low voltage) SC engine – Incorrect MAFS installed
	P1177	Adaptive fuel metering trim too rich (fuel flow rate)	Engine at normal operating temperature; drive steadily at > 20 mph for > 25 seconds	2	Fuel return pipe blocked Fuel pressure regulator failure (high fuel pressure) Fuel injectors leaking MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed SC engine – Intake air leak
	P1178	Adaptive fuel metering trim too lean (air flow rate)	Engine at normal operating temperature; idle > 3 minutes; drive steadily at > 20 mph for > 3 minutes; idle > 3 minutes	2	Air intake leak Low fuel pressure at idle Blocked injector MAFS signal fault (low voltage)
	P1179	Adaptive fuel metering trim too rich (air flow rate)	Engine at normal operating temperature; idle > 3 minutes; drive steadily at > 20 mph for > 3 minutes; idle > 3 minutes	2	High fuel pressure at idle MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
7	P1187	HO2S heater circuit open circuit – both upstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	Both HO2S heater circuits high resistance HO2S heater harness wiring high resistance HO2S heater harness wiring open circuit MAFS signal fault Ignition fault (ignition retard causing high exhaust gas temperature)
	P1188	HO2S heater circuit high resistance – both upstream sensors	Engine idle > 25 seconds	2	ECM to HO2S heater wiring open circuit (or intermittent open circuit) ECM to HO2S heater wiring short circuit to ground Both HO2S heater circuits high resistance or open circuit Both HO2S heaters failure
	P1190	HO2S heater circuit low resistance – both upstream sensors	Engine idle > 25 seconds	2	High battery voltage (>17 V) producing excess heater current ECM to HO2S heater wiring short circuit to B+ voltage Both HO2S heater circuits short circuit to ground Both HO2S heaters failure
	P1193	HO2S heater circuit open circuit – both downstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	Refer to P1187 possible causes
	P1194	HO2S heater circuit high resistance – both downstream sensors	Engine idle > 25 seconds	2	Refer to P1188 possible causes
	P1196	HO2S heater circuit low resistance – both downstream sensors	Engine idle > 25 seconds	2	Refer to P1190 possible causes
8	P1199	Fuel level sense circuit malfunction	Start and run engine	2	Instrument pack to ECM fuel level signal circuit open circuit Instrument pack to ECM fuel level signal circuit short circuit to ground Instrument pack to ECM fuel level signal circuit short circuit to B+ voltage Instrument pack fault (incorrect fuel level signal) Fuel level sensor failure
9	P0201	Fuel injector circuit malfunction – cylinder 1	Engine running > 2 seconds	2	Injector disconnected Injector harness wiring open or short circuit Injector failure
	P1201	Fuel injector circuit open or short circuit – cylinder 1	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
	P0202	Fuel injector circuit malfunction – cylinder 2	Engine running > 2 seconds	2	Refer to P0201 possible causes
	P1202	Fuel injector circuit open or short circuit – cylinder 2	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
	P0203	Fuel injector circuit malfunction – cylinder 3	Engine running > 2 seconds	2	Refer to P0201 possible causes
	P1203	Fuel injector circuit open or short circuit – cylinder 3	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
	P0204	Fuel injector circuit malfunction – cylinder 4	Engine running > 2 seconds	2	Refer to P0201 possible causes
	P1204	Fuel injector circuit open or short circuit – cylinder 4	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
	P0205	Fuel injector circuit malfunction – cylinder 5	Engine running > 2 seconds	2	Refer to P0201 possible causes
	P1205	Fuel injector circuit open or short circuit – cylinder 5	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
	P0206	Fuel injector circuit malfunction – cylinder 6	Engine running > 2 seconds	2	Refer to P0201 possible causes
	P1206	Fuel injector circuit open or short circuit – cylinder 6	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
10	P0300**	Random misfire detected	Run engine steady > 2 minutes	1 or 2	Fuel contaminated Fuel injector(s) blocked or leaking Ignition secondary circuit breakdown (coils, spark plugs) Fuel pressure low Cylinder compression low Broken valve spring(s) CKPS circuit fault (CKPS DTCs also flagged) Fuel injector(s) circuit fault(s) (Injector DTCs also flagged) Ignition coil primary circuit fault(s) (Ignition coil DTCs also flagged)
	P0301**	Misfire detected – cylinder 1	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0302**	Misfire detected – cylinder 2	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0303**	Misfire detected – cylinder 3	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0304**	Misfire detected – cylinder 4	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0305**	Misfire detected – cylinder 5	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0306**	Misfire detected – cylinder 6	Run engine steady > 2 minutes	1 or 2	Refer to P0300 possible causes
	P1313	Catalyst damage misfire detected – cyl 1, 2, 3 (A bank)	Run engine steady > 2 minutes	1	Refer to P0300 possible causes
	P1314	Catalyst damage misfire detected – cyl 4, 5, 6 (B bank)	Run engine steady > 2 minutes	1	Refer to P0300 possible causes
	P1315**	Persistent misfire (one cylinder identified and injector switched off)	Run engine steady > 2 minutes	1	Refer to P0300 possible causes
	P1316	Misfire excess emission	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
11	P0327	Knock sensing circuits out of range (low voltage)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	One or both knock sensors loose in block ECM to knock sensors wiring open circuit ECM to knock sensors wiring short circuit to ground ECM to knock sensors wiring high resistance Knock sensor(s) failure
	P0332	Knock sensing circuits out of range (high voltage)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Knock sensor harness wiring shield condition (RFI interference) Knock sensor(s) failure
12	P0335	CKPS circuit malfunction	Engine idle > 10 seconds	2	CKPS mounting bracket loose CKPS / reluctor ring alignment CKPS to ECM sensing circuit open circuit CKPS to ECM sensing circuit short circuit to ground CKPS to ECM sensing circuit short circuit to B+ voltage CKPS internal failure
	P0336	CKPS range / performance	Engine idle > 10 seconds	2	Foreign material on CKPS face Reluctor ring damaged CKPS harness wiring shield condition (RFI interference) CKPS internal failure
	P0340	CMPS circuit malfunction	Engine idle > 10 seconds	2	CMPS alignment CMPS tooth damage CMPS harness wiring shield condition (RFI interference) CMPS internal failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

** DTCs P1313, P1314, P1315 and P1316 will not activate the CHECK ENGINE MIL on 1995 Model Year vehicles. If DTCs P1313, P1314 or P1316 are flagged, one or more of the cylinder identification DTCs will also be flagged (random misfire P0300 or individual cylinder P0301 – P0306). If DTC P1315 is flagged, one or more of the individual cylinder identification DTCs will also be flagged P0301 – P0306.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
13	P1361	Ignition coil primary circuit malfunction – cylinder 1	Engine running > 1 second	2	ECM to ignition coil primary circuit open circuit ECM to ignition coil primary circuit high resistance ECM to ignition coil primary circuit short circuit to ground CKPS malfunction (refer to P0335, P0336) Ignition coil failure
	P1362	Ignition coil primary circuit malfunction – cylinder 2	Engine running > 1 second	2	Refer to P1361 possible causes
	P1363	Ignition coil primary circuit malfunction – cylinder 3	Engine running > 1 second	2	Refer to P1361 possible causes
	P1364	Ignition coil primary circuit malfunction – cylinder 4	Engine running > 1 second	2	Refer to P1361 possible causes
	P1365	Ignition coil primary circuit malfunction – cylinder 5	Engine running > 1 second	2	Refer to P1361 possible causes
	P1366	Ignition coil primary circuit malfunction – cylinder 6	Engine running > 1 second	2	Refer to P1361 possible causes
	P1371	Ignition coil primary circuit: incorrect spark timing – cylinder 1	Engine running > 1 second	2	ECM to ignition coil primary circuit short circuit Ignition coil failure
	P1372	Ignition coil primary circuit: incorrect spark timing – cylinder 2	Engine running > 1 second	2	Refer to P1371 possible causes
	P1373	Ignition coil primary circuit: incorrect spark timing – cylinder 3	Engine running > 1 second	2	Refer to P1371 possible causes
	P1374	Ignition coil primary circuit: incorrect spark timing – cylinder 4	Engine running > 1 second	2	Refer to P1371 possible causes
	P1375	Ignition coil primary circuit: incorrect spark timing – cylinder 5	Engine running > 1 second	2	Refer to P1371 possible causes
	P1376	Ignition coil primary circuit: incorrect spark timing – cylinder 6	Engine running > 1 second	2	Refer to P1371 possible causes
14	P0400	EGR temperature sensor circuit malfunction	Engine at normal operating temperature; drive at 35% load > 5 minutes	2	ECM to EGR temp. sensor sense wire open circuit EGR temp. sensor "coked up" EGR valve, pipework blocked (insufficient EGR flow) EGR pipework leak (insufficient EGR flow) EGR temp. sensor failure
	P1400	EGR valve position malfunction	Ignition ON > 1 second	2	EGR valve sticky, dirty or seized ECM to EGR valve position signal wire short or open circuit
	P1401	EGR position circuit out of range (low or high voltage)	Ignition ON > 1 second	2	ECM to EGR valve position signal wire open circuit ECM to EGR valve position signal wire short circuit to ground ECM to EGR valve position signal wire short circuit to B+ voltage EGR valve position sensor supply wire short or open circuit EGR valve position sensor ground wire short circuit to supply wire or open circuit EGR valve position sensor failure (EGR valve assembly)
	P1408	EGR temperature sensor circuit out of range (high voltage)	Ignition ON > 1 second	2	ECM to EGR temp. sensor sense wire short circuit to ground ECM to EGR temp. sensor sense wire short circuit to supply wire EGR temp. sensor failure
	P1409	EGR valve drive circuit malfunction	Ignition ON > 1 second	2	ECM to EGR valve drive wire open circuit ECM to EGR valve drive wire short circuit to ground EGR valve failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
15	P0411	AIR system insufficient air flow to exhaust	Engine at normal operating temperature; start; idle 30 seconds	2	Sedan Range up to VIN 734672, XJS Range up to VIN 199153 – Incorrect air pump to check valve hose. Refer to Technical Bulletin 18-47 AIR system pipework blocked or leaking AIR pump stuck ON or OFF AIR pump control circuit fault AIR pump supply circuit fault AIR pump failure
	P0413	AIR pump relay drive (coil) circuit open circuit	Ignition ON > 1 second	2	Air injection relay removed Air injection relay (coil circuit) open circuit ECM to air injection relay (coil) wiring open circuit ECM to air injection relay (coil) wiring short circuit to B+ voltage
	P0414	AIR pump relay drive (coil) circuit short circuit	Ignition ON > 1 second	2	Air injection relay (coil circuit) short circuit ECM to air injection relay (coil) wiring short circuit to ground
16	P0420	Catalyst efficiency below threshold – cyl 1, 2, 3 (A bank)	Engine at normal operating temperature; drive steadily > 20 mph > 1 minute, 10 seconds	****	Exhaust leak Upstream HO2S slow response Upstream HO2S sense wire open or short circuit Intake air leak MAFS fault
	P0430	Catalyst efficiency below threshold – cyl 4, 5, 6 (B bank)	Engine at normal operating temperature; drive steadily > 20 mph > 1 minute, 10 seconds	****	Refer to P0420 possible causes
17	P0441	EVAP system incorrect purge flow	Engine at normal operating temperature; varied driving for 15 minutes; hot idle > 1 minute	2	EVAP valve sticking EVAP valve blocked EVAP purge hose blocked or disconnected EVAP canister atmosphere vent blocked EVAP valve failure AIR pump stuck ON
	P0443	EVAP valve circuit malfunction	Ignition ON > 1 second	2	EVAP valve disconnected ECM to EVAP valve "drive" circuit open circuit ECM to EVAP valve "drive" circuit short circuit to ground ECM to EVAP valve "drive" circuit short circuit to B+ voltage EVAP valve failure
18	P0500	Vehicle speed sensor malfunction (signal from instrument pack)	Drive > 1900 rpm; high load > 40 seconds; 40 gear changes	2	ECM to instrument pack wiring open circuit, short circuit or high resistance Vehicle speed signal from instrument pack incorrect TCM fault – requests torque reduction while vehicle stopped ABS / TC CM vehicle speed signal incorrect ABS wheel speed sensor fault

* Number of consecutive trips required to activate CHECK ENGINE MIL.

**** Three successive fail judgments. Diagnostic tests are performed continuously. Use PDU "Scantool" Systems Readiness Test to determine if tests are complete.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 59)	TRIPS*	POSSIBLE CAUSES
19	P0506	Idle air control system: rpm lower than expected	Engine at normal operating temperature; idle > 10 seconds	2	IACV disconnected IACV passages blocked IACV stepper motor jammed or mounted incorrectly MAFS signal fault (steady high voltage) Engine incorrect operation – open throttle / engine still idle
	P0507	Idle air control system: rpm higher than expected	Engine at normal operating temperature; idle > 10 seconds	2	IACV disconnected Air leak past throttle IACV passages blocked IACV stepper motor jammed or mounted incorrectly MAFS signal fault (steady low voltage)
	P1508	IACV circuit open circuit	Ignition ON > 15 seconds; ignition OFF	2	IACV disconnected IACV harness wiring open circuit IACV stepper motor failure (open circuit)
	P1509	IACV circuit short circuit	Ignition ON > 15 seconds; ignition OFF	2	IACV harness wiring short circuit IACV stepper motor failure (short circuit)
20	P1514	High load NEUTRAL / DRIVE malfunction	Drive at > 90% load	2	MAFS signal voltage high, but undetected NEUTRAL / PARK wiring (decoder to ECM) short circuit to ground BPM fault (NEUTRAL / PARK parallel circuit)
	P1516	Gear change NEUTRAL / DRIVE malfunction	Drive > 30 gear changes	2	NEUTRAL / PARK wiring (decoder to ECM) short circuit to ground BPM low resistance fault (NEUTRAL / PARK parallel circuit) TCM to ECM torque reduction request fault Vehicle speed signal fault, but undetected
	P1517	Engine cranking NEUTRAL / DRIVE malfunction	Start engine	2	BPM cranking inhibit fault BPM high resistance fault (NEUTRAL / PARK parallel circuit) NEUTRAL / PARK wiring (decoder to ECM) open circuit NEUTRAL / PARK wiring (decoder to ECM) short circuit to B+ voltage
22	P0605	ECM data corrupted	Ignition ON	1	ECM failure
21	P1607	CHECK ENGINE MIL circuit malfunction	Ignition ON	2	ECM to instrument pack / BPM wiring open circuit, short circuit or high resistance BPM fault (CHECK ENGINE) Instrument pack fault (CHECK ENGINE)
23	P1775	TCM CHECK ENGINE MIL request	Ignition ON	1	Possible transmission fault – check for flagged TCM DTCs
	P1776	Torque reduction request signal duration fault	Drive vehicle to initiate automatic gear changes	1	Driver placing rapid repeated shift demands on the transmission requiring torque reduction – torque reduction may not be possible Possible TCM fault (request too long)
	P1777	Torque reduction circuit malfunction	Engine running; normal operating temperature	2	Torque reduction signal wire open circuit Torque reduction signal wire short circuit to ground Torque reduction signal wire short circuit to B+ voltage Possible TCM fault (invalid signal)

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC Summary

AJ16 Engine Management – 1996/97

OBD II MONITORING CONDITIONS:

When testing for DTC reoccurrence, it can be determined if the Service Drive Cycle was of sufficient length by performing a PDU "Systems Readiness Test".

Use the PDU "Scantool Application" disc to communicate with the EMS ECM.

The Systems Readiness Test occurs automatically when PDU establishes communication with the ECM. PDU will report if any portion of the Systems Readiness Test has not been completed in the following format:

The following tests have been identified as incomplete:

- Module $51 (identifies EMS ECM)
  - Catalyst
  - Evaporative purge system
  - Secondary air system
  - O_2 sensor
  - EGR system

PDU DATALOGGER ACRONYMS

ACLOAD	Air conditioning request
ADAPT	Adaptive rate
AMFR	Adaptive air mass flow rate
BATT	Battery voltage
CRANK	Engine cranking signal
DTCS	Number of DTCs flagged
ECT	Engine coolant temperature
EGRT	Exhaust gas temperature sensor
EVP	Exhaust gas recirculation valve position
FMFR	Adaptive fuel mass flow rate
FUEL	Fuel level
GEAR	Drive / Neutral
HO2S1B1	Heated oxygen sensor cyl 1 3 upstream
HO2S1B2	Heated oxygen sensor cyl 4 6 upstream
HO2S2B1	Heated oxygen sensor cyl 1 3 downstream
HO2S2B2	Heated oxygen sensor cyl 4 6 downstream
HO2S1HM	Oxygen sensor heaters upstream
HO2S2HM	Oxygen sensor heaters downstream
IAT	Intake air temperature
ISCPOS	Idle air control valve (IAC)
MAFS	Mass airflow sensor
MIL	CHECK ENGINE MIL
REFIDLE	Idle reference speed
RPM	Engine speed
TCMRET	Torque reduction request
TMS-MAFS	Mass airflow
TPS	Throttle position sensor
TPS-INT	Closed throttle adaptive position Intel processor
TPS-TMS	Closed throttle adaptive position TMS processor
VSS	Vehicle speed

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P0101	MAFS range / performance	Drive > 1500 rpm > 4 seconds	2	TPS signal voltage high, but undetected Blocked air filter Blocked exhaust system Air intake leak MAPS to ECM sensing circuit high resistance MAPS to ECM sensing circuit intermittent short circuit to ground MAFS supply circuit high resistance MAFS failure
P0102	MAFS sense circuit low voltage	Engine run > 4 seconds	2	Blocked air filter Blocked exhaust system MAPS to ECM sensing circuit high resistance or open circuit MAPS to ECM sensing circuit intermittent short circuit to ground MAFS supply circuit open circuit or short circuit to ground MAFS failure
P0103	MAFS sense circuit high voltage	Engine idle < 1000 rpm > 4 seconds	2	MAPS to ECM signal ground wire open circuit MAPS to ECM sensing circuit short circuit to B+ voltage MAFS failure
P0111	IATS range / performance	Engine at normal operating temperature, drive; idle; drive	2	IATS disconnected Engine compartment hot air leak into intake tract IATS to ECM wiring open circuit or high resistance IATS to ECM sensing circuit short circuit to B+ voltage IATS failure
P0112	IATS sense circuit high voltage (low air temperature)	Ignition ON > 20 seconds	2	IATS disconnected IATS to ECM wiring open circuit or high resistance IATS to ECM sensing circuit short circuit to B+ voltage IATS failure
P0113	IATS sense circuit low voltage (high air temperature)	Ignition ON > 20 seconds	2	IATS to ECM wiring short circuit to ground IATS failure
P0116	ECTS range / performance	Engine at normal operating temperature; drive at highway speed	2	Low coolant level Engine thermostat stuck open ECTS to ECM sensing circuit high resistance when hot ECTS to ECM sensing circuit intermittent high resistance ECTS failure
P0117	ECTS sense circuit high voltage (low coolant temperature)	Engine run > 4 seconds	2	ECTS disconnected ECTS to ECM sensing circuit high resistance, open circuit or short circuit to B+ voltage ECTS failure
P0118	ECTS sense circuit low voltage (high coolant temperature)	Engine run > 4 seconds	2	Engine overheat condition ECTS to ECM wiring short circuit to ground ECTS failure
P0121	TPS performance	Drive at highway speed	2	Intake air or exhaust restricted Extreme high altitude operation Intermittent / incorrect , but undetected; TPS, engine speed, IATS, MAFS or IACV signals
P0123	TPS sense circuit high voltage	Drive steadily < 35% load > 25 seconds	2	TPS to ECM signal ground circuit open circuit TPS to ECM wiring (supply, sense) short circuit to each other TPS position sense circuit short circuit to B+ voltage MAFS signal voltage low, but undetected TPS failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P0125	ECTS response	Engine coolant temperature > 68º F (20º C) Run engine to coolant temperature < 68º F (20º C) < 5 seconds	2	ECTS disconnected Low coolant level Engine thermostat stuck open ECTS to ECM sensing circuit high resistance, open circuit or short circuit to B+ voltage ECTS failure
P0131	HO2S sense circuit low voltage – cylinders 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	HO2S sense wire short circuit to ground HO2S failure HO2S heater malfunction (tip temperature too hot)
P0132	HO2S sense circuit high voltage – cylinders 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	HO2S disconnected HO2S signal ground wire open circuit HO2S sense wire open circuit or short circuit to B+ voltage HO2S failure HO2S heater malfunction (tip temperature too cold)
P0133	HO2S sense circuit slow response – cylinders 1, 2, 3 (A bank), upstream (1)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	HO2S contaminated HO2S wiring harness high resistance fault HO2S failure
P0137	HO2S sense circuit low voltage – cylinders 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
P0138	HO2S sense circuit high voltage – cylinders 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
P0139	HO2S sense circuit slow response – cylinders 1, 2, 3 (A bank), downstream (2)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Refer to P0133 possible causes
P0151	HO2S sense circuit low voltage – cylinders 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
P0152	HO2S sense circuit high voltage – cylinders 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
P0153	HO2S sense circuit slow response – cylinders 4, 5, 6 (B bank), upstream (1)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Refer to P0133 possible causes
P0157	HO2S sense circuit low voltage – cylinders 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0131 possible causes
P0158	HO2S sense circuit high voltage: cylinders 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; idle > 25 seconds	2	Refer to P0132 possible causes
P0159	HO2S sense circuit slow response – cylinders 4, 5, 6 (B bank), downstream (2)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Refer to P0133 possible causes
P0171	Cylinders 1, 2, 3 (A bank) combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Fuel injector blockage Fuel injector wiring open circuit Engine misfire Intake manifold air leak Exhaust air leak (before catalyst)
P0172	Cylinders 1, 2, 3 (A bank) combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Exhaust air leak (before catalyst) Fuel injector blockage Engine misfire
P0174	Cylinders 4, 5, 6 (B bank) combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Refer to P0171 possible causes
P0175	Cylinders 4, 5, 6 (B bank) combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Refer to P0172 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P0201	Fuel injector circuit malfunction – cylinder 1	Engine running > 2 seconds	2	Injector disconnected Injector harness wiring open or short circuit Injector failure
P0202	Fuel injector circuit malfunction – cylinder 2	Engine running > 2 seconds	2	Refer to P0201 possible causes
P0203	Fuel injector circuit malfunction – cylinder 3	Engine running > 2 seconds	2	Refer to P0201 possible causes
P0204	Fuel injector circuit malfunction – cylinder 4	Engine running > 2 seconds	2	Refer to P0201 possible causes
P0205	Fuel injector circuit malfunction – cylinder 5	Engine running > 2 seconds	2	Refer to P0201 possible causes
P0206	Fuel injector circuit malfunction – cylinder 6	Engine running > 2 seconds	2	Refer to P0201 possible causes
P0300	Random misfire detected	Run engine steady > 2 minutes	2	Fuel contaminated Fuel injector(s) blocked or leaking Ignition secondary circuit breakdown (coils, spark plugs) Fuel pressure low Cylinder compression low Broken valve spring(s) CKPS circuit fault (CKPS DTCs also flagged) Fuel injector(s) circuit fault(s) (Injector DTCs also flagged) Ignition coil primary circuit fault(s) (Ignition coil DTCs also flagged)
P0301	Misfire detected – cylinder 1	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0302	Misfire detected – cylinder 2	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0303	Misfire detected – cylinder 3	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0304	Misfire detected – cylinder 4	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0305	Misfire detected – cylinder 5	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0306	Misfire detected – cylinder 6	Run engine steady > 2 minutes	2	Refer to P0300 possible causes
P0326	Knock sensing circuit 1 (cylinders 1, 2, 3) at maximum correction	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Low coolant level Poor quality fuel Knock sensor harness wiring shield condition (RFI interference) Combustion chamber deposits (pre ignition) Mechanical or background noise ECM failure
P0327	Knock sensing circuit 1 (cylinders 1, 2, 3) out of range (low voltage)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	One or both knock sensors loose in block ECM to knock sensors wiring high resistance, open circuit or short circuit to ground Knock sensor(s) failure
P0328	Knock sensing circuit 1 (cylinders 1, 2, 3)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Knock sensor harness wiring shield condition (RFI interference) Knock sensor(s) failure
P0331	Knock sensing circuit 2 (cylinders 4, 5, 6) at maximum correction	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Low coolant level Poor quality fuel Knock sensor harness wiring shield condition (RFI interference) Combustion chamber deposits (pre ignition) Mechanical or background noise ECM failure
P0332	Knock sensing circuit 2 (cylinders 4, 5, 6) out of range (low voltage)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Refer to P0327 possible causes
P0333	Knock sensing circuit 2 (cylinders 4, 5, 6) out of range (high voltage)	Drive steadily @ 2000 rpm, 50% load > 15 seconds	2	Refer to P0328 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P0335	CKPS circuit malfunction	Engine idle > 10 seconds	2	CKPS mounting bracket loose CKPS / reluctor ring alignment CKPS to ECM sensing circuit; open circuit, short circuit to ground or B+ voltage CKPS failure
P0336	CKPS range / performance	Engine idle > 10 seconds	2	Foreign material on CKPS face Reluctor ring damaged CKPS harness wiring shield condition (RFI interference) CKPS failure
P0340	CMPS circuit malfunction	Engine idle > 10 seconds	2	CMPS alignment CMPS tooth damage CMPS harness wiring shield condition (RFI interference) CMPS failure
P0400	EGR temperature sensor circuit malfunction	Engine at normal operating temperature; drive at 35% load > 1 minutes	2	ECM to EGR temperature sensor sense wire open circuit EGR temperature sensor "coked up" EGR valve, pipework blocked (insufficient EGR flow) EGR pipework leak (insufficient EGR flow) EGR temperature sensor failure
P0411	AIR system insufficient air flow to exhaust	Engine at normal operating temperature; start; idle 30 seconds	2	AIR system pipework blocked or leaking AIR pump stuck ON or OFF AIR pump control circuit fault AIR pump supply circuit fault AIR pump failure
P0413	AIR pump relay drive (coil) circuit open circuit	Ignition ON > 1 second	2	Air injection relay removed Air injection relay (coil circuit) open circuit ECM to air injection relay (coil) wiring open circuit or short circuit to B+ voltage
P0414	AIR pump relay drive (coil) circuit short circuit	Ignition ON > 1 second	2	Air injection relay (coil circuit) short circuit ECM to air injection relay (coil) wiring short circuit to ground
P0420	Catalyst efficiency below threshold – cylinders 1, 2, 3 (A bank)	Engine at normal operating temperature; drive steadily > 20 mph (32 km/h) > 1 minute, 10 seconds	***	Exhaust leak Upstream HO2S slow response Upstream HO2S sense wire open or short circuit Intake air leak MAFS fault
P0430	Catalyst efficiency below threshold – cylinders 4, 5, 6 (B bank)	Engine at normal operating temperature; drive steadily > 20 mph (32 km/h) > 1 minute, 10 seconds	***	Refer to P0420 possible causes
P0441	EVAP system incorrect purge flow	Engine at normal operating temperature; varied driving for 15 minutes; hot idle > 1 minute	2	EVAP valve sticking EVAP valve blocked EVAP purge hose blocked or disconnected EVAP canister atmosphere vent blocked EVAP valve failure AIR pump stuck ON

* Number of consecutive trips required to activate CHECK ENGINE MIL.

*** Three successive fail judgements. Diagnostic tests are performed continuously. Use the PDU "Scantool" Systems Readiness Test to determine if tests are complete.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P0442	EVAP system pressure leak (enhanced evaporative emissions vehicles)	Engine at normal operating temperature; fuel level between 1/4 and 3/4 full; varied driving for > 22 minutes; drive > 30 mph (48 km/h) > 10 seconds	2 **	Fuel tank, fuel filler cap or pipework pressure leak EVAP hoses / lines pressure leak EVAP valve pressure leak to engine Fuel tank pressure sensor signal high
P0443	EVAP valve circuit malfunction	Ignition ON > 1 second	2	EVAP valve disconnected ECM to EVAP valve "drive" circuit; open circuit, short circuit to ground or B+ voltage EVAP valve failure
P0446	Canister close valve circuit malfunction	Engine at normal operating temperature; varied driving for > 22 minutes; drive > 30 mph (48 km/h) > 10 seconds	2	ECM to canister close valve open circuit, short circuit to ground or B+ voltage Canister close valve electrical failure
P0447	Canister close valve low flow (enhanced evaporative emissions vehicles)	Engine at normal operating temperature; varied driving for 15 minutes; hot idle > 1 minute	2 **	Canister close valve blocked or stuck closed
P0452	Fuel tank pressure sensor signal low (enhanced evaporative emissions vehicles)	Engine run	2	ECM to fuel tank pressure sensor circuit; open circuit or short circuit to ground Fuel tank pressure sensor failure
P0453	Fuel tank pressure sensor signal high (enhanced evaporative emissions vehicles)	Engine run	2	ECM to fuel tank pressure sensor circuit; open circuit, short circuit to 5V supply or B+ voltage Fuel tank pressure sensor failure
P0460	Fuel level sense circuit malfunction	Engine idle< 2 minutes	2	Instrument pack to ECM fuel level signal circuit; open circuit, short circuit to ground or B+ voltage Instrument pack fault (incorrect fuel level signal) Fuel level sensor failure
P0461	Fuel level sense signal performance	Drive > 10 mph (16 km/h) > 50 minutes	2	Instrument pack to ECM fuel level signal circuit; open circuit, short circuit to ground or B+ voltage Instrument pack fault (incorrect fuel level signal) Fuel level sensor failure
P0500	Vehicle speed sensor malfunction (signal from instrument pack)	Drive > 1900 rpm; high load > 40 seconds; 40 gear changes	2	ECM to instrument pack wiring: open circuit, short circuit or high resistance Vehicle speed signal from instrument pack incorrect TCM fault – requests torque reduction while vehicle stopped ABS / TC CM vehicle speed signal incorrect ABS wheel speed sensor fault
P0506	Idle air control system: rpm lower than expected	Engine at normal operating temperature; idle > 10 seconds	2	IACV disconnected IACV passages blocked IACV stepper motor jammed or mounted incorrectly MAFS signal fault (steady high voltage) Engine incorrect operation – open throttle / engine still idle
P0507	Idle air control system: rpm higher than expected	Engine at normal operating temperature; idle > 10 seconds	2	IACV disconnected IACV passages blocked IACV stepper motor jammed or mounted incorrectly MAFS signal fault (steady low voltage)
P0508	IACV circuit: open circuit	Run engine; switch ignition OFF	2	IACV circuit open circuit IACV malfunction
P0509	IACV circuit: short circuit	Run engine; switch ignition OFF	2	IACV circuit short circuit to ground or B+ voltage IACV malfunction
P0605	ECM data corrupted	Ignition ON	1	ECM failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

** Through 1996 MY: DTC does not activate the CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P1137	HO2S sense circuit lack of "swing" – cylinders 1, 2, 3 (A bank), downstream (2) Sense circuit indicates lean combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 30 seconds	2	Downstream HO2S harness connectors (cylinders 1, 2, 3 / cylinders 4, 5, 6) reversed (Perform HO2S orientation) HO2S loose in exhaust pipe screw threads HO2S sense wire open circuit Exhaust leak before catalyst HO2S heater malfunction (tip temperature too cold) HO2S failure
P1138	HO2S sense circuit lack of "swing" – cylinders 1, 2, 3 (A bank), downstream (2) Sense circuit indicates lean combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 30 seconds	2	Downstream HO2S harness connectors (cylinders 1, 2, 3 / cylinders 4, 5, 6) reversed (Perform HO2S orientation) HO2S sense wire short circuit to ground HO2S heater malfunction (tip temperature too hot) HO2S failure
P1157	HO2S sense circuit lack of "swing" – cylinders 4, 5, 6 (B bank), downstream (2) Sense circuit indicates lean combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 30 seconds	2	Refer to P1137 possible causes
P1158	HO2S sense circuit lack of "swing" – cylinders 4, 5, 6 (B bank), downstream (2) Sense circuit indicates rich combustion (No HO2S response)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 30 seconds	2	Refer to P1138 possible causes
P1171	All cylinders combustion too lean	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Fuel filter, system blockage Fuel system leak Fuel pressure regulator failure (low fuel pressure) Low fuel pump output Fuel injectors blocked MAFS signal fault (low voltage) SC engine – Incorrect MAFS installed
P1172	All cylinders combustion too rich	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Fuel return pipe blocked Fuel pressure regulator failure (high fuel pressure) Fuel injectors leaking MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed
P1176	Adaptive fuel metering trim too lean (fuel flow rate)	Engine at normal operating temperature; drive steadily at > 20 (32 km/h) mph for > 25 seconds	2	Fuel injector supply wiring short circuit to ground Fuel filter, system blockage Fuel system leak Fuel pressure regulator failure (low fuel pressure) Low fuel pump output Fuel injectors blocked MAFS signal fault (low voltage) SC engine – Incorrect MAFS installed
P1177	Adaptive fuel metering trim too rich (fuel flow rate)	Engine at normal operating temperature; drive steadily at > 20 mph (32 km/h) for > 25 seconds	2	Fuel return pipe blocked Fuel pressure regulator failure (high fuel pressure) Fuel injectors leaking MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed SC engine – Intake air leak
P1178	Adaptive fuel metering trim too lean (air flow rate)	Engine at normal operating temperature; idle > 3 minutes; drive steadily at > 20 mph (32 km/h) for > 3 minutes; idle > 3 minutes	2	Air intake leak Low fuel pressure at idle Blocked injector MAFS signal fault (low voltage)

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P1179	Adaptive fuel metering trim too rich (air flow rate)	Engine at normal operating temperature; idle > 3 minutes; drive steadily at > 20 mph (32 km/h) for > 3 minutes; idle > 3 minutes	2	High fuel pressure at idle MAFS signal fault (high voltage) NA engine – Incorrect MAFS installed
P1185	HO2S heater circuit open circuit – both upstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	HO2S heater circuits high resistance HO2S heater harness wiring high resistance, open circuit or short circuit to ground
P1186	HO2S heater circuit short circuit – both upstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	HO2S heater circuits short circuit to sensor HO2S heater harness wiring short circuit to B+ voltage
P1187	HO2S heater circuit open circuit – both upstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	HO2S heater circuits high resistance HO2S heater harness wiring high resistance HO2S heater harness wiring open circuit MAFS signal fault Ignition fault (ignition retard causing high exhaust gas temperature)
P1188	HO2S heater circuit high resistance – both upstream sensors	Engine idle > 25 seconds	2	ECM to HO2S heater wiring open circuit (or intermittent open circuit) ECM to HO2S heater wiring short circuit to ground HO2S heater circuits high resistance or open circuit HO2S heaters failure
P1189	HO2S heater circuit low resistance – both upstream sensors	Engine idle > 25 seconds	2	HO2S loose HO2S heater circuit; short circuit to ground or B+ voltage HO2S heater circuits; high resistance or open circuit HO2S heaters failure
P1190	HO2S heater circuit low resistance – both upstream sensors	Engine idle > 25 seconds	2	High battery voltage (>17v) producing excess heater current ECM to HO2S heater wiring; short circuit to B+ voltage HO2S heater circuits; short circuit to ground Both HO2S heaters failure
P1191	HO2S heater circuit open circuit – both downstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	Refer to P1185 possible causes
P1192	HO2S heater circuit short circuit – both downstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	Refer to P1186 possible causes
P1193	HO2S heater circuit open circuit – both downstream sensors	Engine idle < 1000 rpm > 3 minutes, 20 seconds	2	Refer to P1187 possible causes
P1194	HO2S heater circuit high resistance – both downstream sensors	Engine idle > 25 seconds	2	Refer to P1188 possible causes
P1195	HO2S heater circuit low resistance – both downstream sensors	Engine idle > 25 seconds	2	Refer to P1189 possible causes
P1196	HO2S heater circuit low resistance – both downstream sensors	Engine idle > 25 seconds	2	Refer to P1190 possible causes
P1201	Fuel injector circuit open or short circuit – cylinder 1	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
P1202	Fuel injector circuit open or short circuit – cylinder 2	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
P1203	Fuel injector circuit open or short circuit – cylinder 3	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
P1204	Fuel injector circuit open or short circuit – cylinder 4	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P1205	Fuel injector circuit open or short circuit – cylinder 5	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
P1206	Fuel injector circuit open or short circuit – cylinder 6	Run engine; ignition OFF > 2 seconds	2	Refer to P0201 possible causes
P1313	Catalyst damage misfire detected – cylinders 1, 2, 3 (A bank)	Run engine steady > 2 minutes	1 **	Refer to P0300 possible causes
P1314	Catalyst damage misfire detected – cylinders 4, 5, 6 (B bank)	Run engine steady > 2 minutes	1 **	Refer to P0300 possible causes
P1315	Persistent misfire (one cylinder identified and injector switched off)	Run engine steady > 2 minutes	1	Refer to P0300 possible causes
P1316	Misfire excess emission	Run engine steady > 2 minutes	2 **	Refer to P0300 possible causes
P1361	Ignition coil primary circuit malfunction – cylinder 1	Engine running > 1 second	2	ECM to ignition coil primary circuit high resistance, open circuit or short circuit to ground CKPS malfunction (refer to P0335, P0336) Ignition coil failure
P1362	Ignition coil primary circuit malfunction – cylinder 2	Engine running > 1 second	2	Refer to P1361 possible causes
P1363	Ignition coil primary circuit malfunction – cylinder 3	Engine running > 1 second	2	Refer to P1361 possible causes
P1364	Ignition coil primary circuit malfunction – cylinder 4	Engine running > 1 second	2	Refer to P1361 possible causes
P1365	Ignition coil primary circuit malfunction – cylinder 5	Engine running > 1 second	2	Refer to P1361 possible causes
P1366	Ignition coil primary circuit malfunction – cylinder 6	Engine running > 1 second	2	Refer to P1361 possible causes
P1371	Ignition coil primary circuit: incorrect spark timing – cylinder 1	Engine running > 1 second	2	ECM to ignition coil primary circuit short circuit Ignition coil failure
P1372	Ignition coil primary circuit: incorrect spark timing – cylinder 2	Engine running > 1 second	2	Refer to P1371 possible causes
P1373	Ignition coil primary circuit: incorrect spark timing – cylinder 3	Engine running > 1 second	2	Refer to P1371 possible causes
P1374	Ignition coil primary circuit: incorrect spark timing – cylinder 4	Engine running > 1 second	2	Refer to P1371 possible causes
P1375	Ignition coil primary circuit: incorrect spark timing – cylinder 5	Engine running > 1 second	2	Refer to P1371 possible causes
P1376	Ignition coil primary circuit: incorrect spark timing – cylinder 6	Engine running > 1 second	2	Refer to P1371 possible causes
P1400	EGR valve position malfunction	Ignition ON > 1 second	2	EGR valve sticky, dirty or seized ECM to EGR valve position signal wire short or open circuit
P1401	EGR position circuit out of range (low or high voltage)	Ignition ON > 1 second	2	ECM to EGR valve position signal wire open circuit, short circuit to ground or B+ voltage EGR valve position sensor supply wire short or open circuit EGR valve position sensor ground wire short circuit to supply wire or open circuit EGR valve position sensor failure (EGR valve assembly)

* Number of consecutive trips required to activate CHECK ENGINE MIL.

** Through 1996 MY: DTC does not activate CHECK ENGINE MIL. If DTCs P1313, P1314 or P1316 are flagged, one or more of the cylinder identification DTCs will also be flagged (random misfire P0300 or individual cylinder P0301 – P0306). If DTC P1315 is flagged, one or more of the individual cylinder identification DTCs (P0301 – P0306) will also be flagged.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P1408	EGR temperature sensor circuit out of range (high voltage)	Ignition ON > 1 second	2	ECM to EGR temperature sensor sense wire short circuit to ground ECM to EGR temperature sensor sense wire short circuit to supply wire EGR temperature sensor failure
P1409	EGR valve drive circuit malfunction	Ignition ON > 1 second	2	ECM to EGR valve drive wire open circuit ECM to EGR valve drive wire short circuit to ground EGR valve failure
P1440	EVAP valve incorrect flow (enhanced evaporative emissions vehicles)	Engine at normal operating temperature; fuel level between 1/4 and 3/4 full; varied driving for > 22 minutes; drive > 30 mph (48 km/h) > 10 seconds	2	EVAP valve stuck open Fuel tank pressure sensor low output (but in range) Fuel tank filled with engine running
P1448	Enhanced evaporative emissions system performance fault 2 (vacuum test OK but no feedback change)	Engine at normal operating temperature; fuel level between 1/4 and 3/4 full; varied driving for > 22 minutes; drive > 30 mph (48 km/h) > 10 seconds	2 **	Fuel tank, fuel filler cap or pipework pressure leak EVAP hoses / lines pressure leak EVAP valve leaking pressure to engine Canister close valve stuck open
P1496	Enhanced evaporative emissions system performance fault 1 (vacuum test OK but no feedback change)	Engine at normal operating temperature; fuel level between 1/4 and 3/4 full; varied driving for > 22 minutes; drive > 30 mph (48 km/h) > 10 seconds	2 **	Fuel tank filled with engine running Fuel tank, fuel filler cap or pipework pressure leak EVAP hoses / lines pressure leak EVAP valve stuck closed Canister close valve stuck open Fuel tank pressure sensor signal circuit resistance Fuel tank pressure sensor malfunction
P1508	IACV circuit open circuit	Ignition ON > 15 seconds; ignition OFF	2	IACV disconnected IACV harness wiring open circuit IACV stepper motor failure (open circuit)
P1509	IACV circuit short circuit	Ignition ON > 15 seconds; ignition OFF	2	IACV harness wiring short circuit IACV stepper motor failure (short circuit)
P1514	High load NEUTRAL / DRIVE malfunction	Drive at > 90% load	2	MAFS signal voltage high, but undetected NEUTRAL / PARK wiring (decoder to ECM) short circuit to ground BPM fault (NEUTRAL / PARK parallel circuit)
P1516	Gear change NEUTRAL / DRIVE malfunction	Drive > 30 gear changes	2	NEUTRAL / PARK wiring (decoder to ECM) short circuit to ground BPM low resistance fault (NEUTRAL / PARK parallel circuit) TCM to ECM torque reduction request fault Vehicle speed signal fault, but undetected
P1517	Engine cranking NEUTRAL / DRIVE malfunction	Start engine	2	BPM cranking inhibit fault BPM high resistance fault (NEUTRAL / PARK parallel circuit) NEUTRAL / PARK wiring (decoder to ECM) open circuit or short circuit to B+ voltage
P1607	CHECK ENGINE MIL circuit malfunction	Ignition ON	2	ECM to instrument pack / BPM wiring open circuit, short circuit or high resistance BPM fault (CHECK ENGINE) Instrument pack fault (CHECK ENGINE)
P1775	TCM CHECK ENGINE MIL request	Ignition ON	1	Possible transmission fault – check for flagged TCM DTCs

* Number of consecutive trips required to activate CHECK ENGINE MIL.

** Through 1996 MY: DTC does not activate the CHECK ENGINE MIL.

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 69)	TRIPS*	POSSIBLE CAUSES
P1776	Torque reduction request signal duration fault	Drive vehicle to initiate automatic gear changes	1	Driver placing rapid repeated shift demands on the transmission requiring torque reduction – torque reduction may not be possible Possible TCM fault (request too long)
P1777	Torque reduction circuit malfunction	Engine running; normal operating temperature	2	Torque reduction signal wire open circuit, short circuit to ground or B+ voltage Possible TCM fault (invalid signal)
P1794	ECM B+ supply voltage low (below 10.5 V)	Run engine > 1600 rpm	2	Generator drive belt loose ECM B+ supply circuit; high resistance, open circuit or short circuit to ground Battery malfunction Charging system malfunction

* Number of consecutive trips required to activate CHECK ENGINE MIL.

The following Figures and Data pages are extracted from select Electrical Guides and are included here as an aid to understanding the Engine Management system. Do not use this information to diagnose vehicle faults.

Always refer to the Model and Model Year specific Electrical Guide for accurate information.

Contents

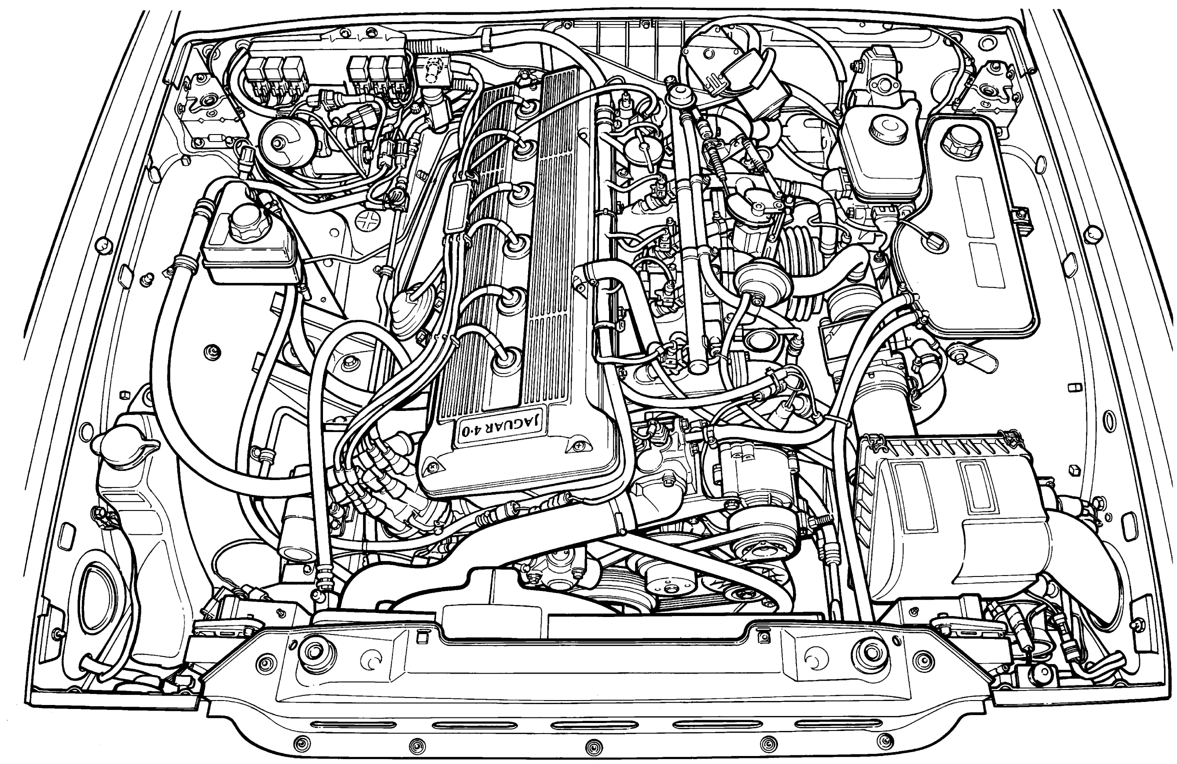
System Description

Component Location

Component Description

The AJ6 4.0 Litre Engine Management System (EMS) is used in 1990 – 1994 model year Sedan Range vehicles and 1993 – 1994 model year XJS Range vehicles. This system combines the control of all engine operating and emission related components through a single microprocessor based Engine Control Module (ECM). The ECM incorporates an On-Board Diagnostics (OBD) system that monitors certain ECM control and drive functions for faults. The OBD system is known as "OBD level one specification". OBD I is the common abbreviation.

AJ6 4.0 LITRE ENGINE



T800/F.01

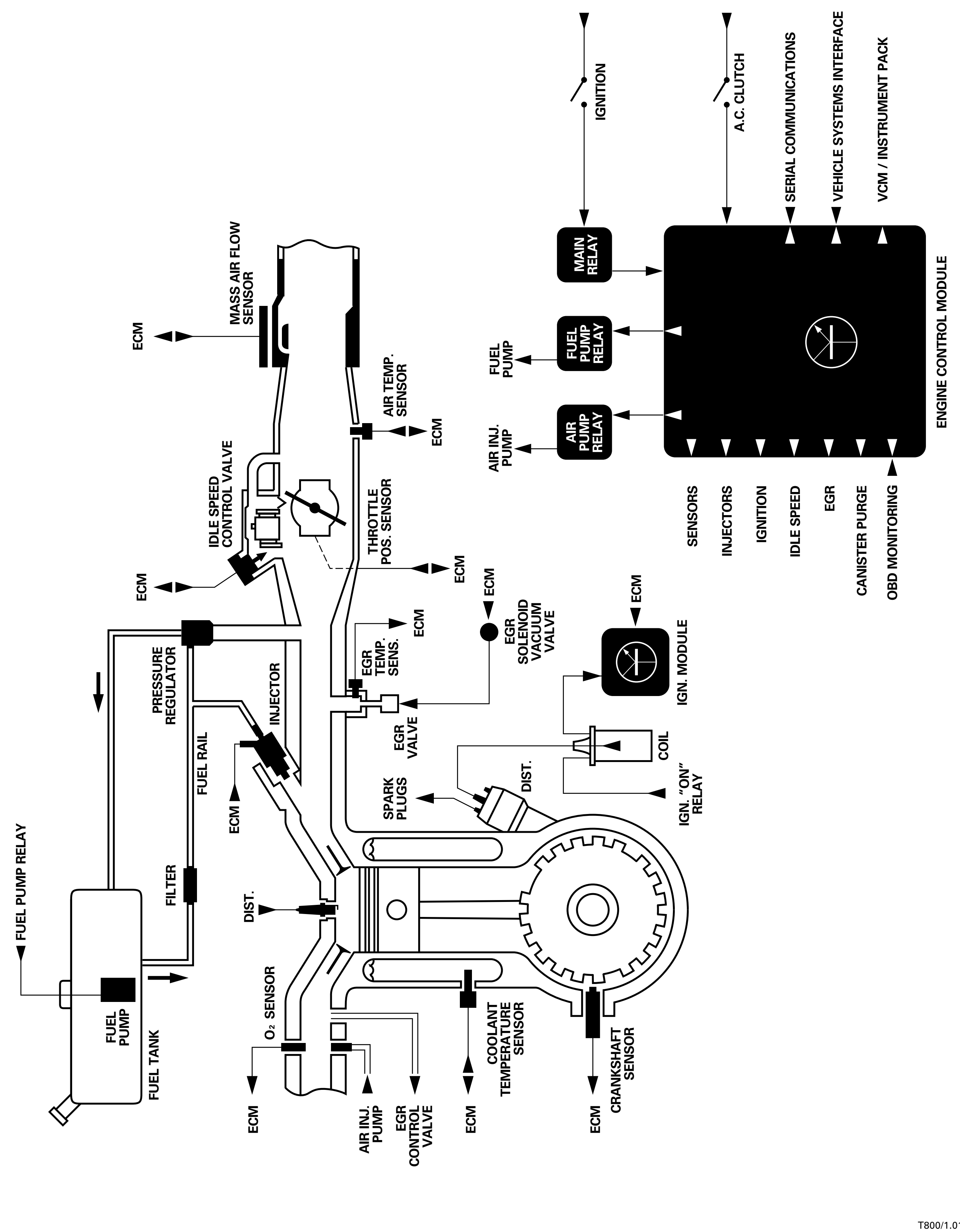
Overview

The AJ6 4.0 Litre Engine Management System (EMS) is an integrated engine management system, controlled through a digital Electronic Control Module (ECM) containing a microprocessor. The system maintains optimum performance over the engine operating range by precisely controlling fuel injection, ignition timing and emission control functions. In addition, the ECM provides various interface outputs and incorporates an on-board diagnostic function.

A summary of EMS function and control includes:

- Fuel delivery (fuel pump)
- Evaporative emission control (canister purge)
- Fuel injection
- Cold start
- Warm-up
- Exhaust emission
- Oxygen sensor feedback
- Overrun fuel cut-off
- RPM limitation (engine overspeed)
- Wide-open-throttle fuel cut-off
- Ignition timing
- Idle speed control
- Air injection
- Exhaust gas recirculation
- Adaptive idle fuel metering (1993 MY ON)
- On-Board Diagnostics (OBD)
- "Limp home" capability
- Vehicle systems interfaces
- Serial communication (ISO)

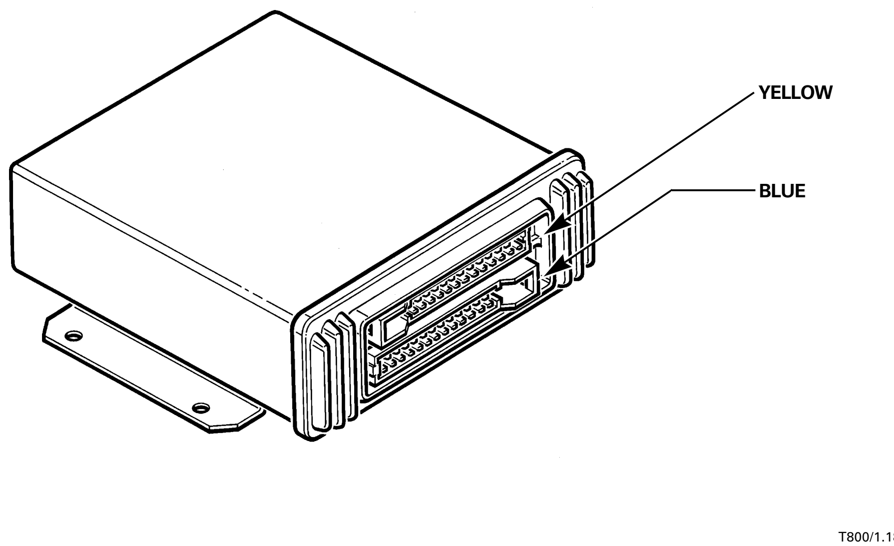
TYPICAL AJ6 4.0 LITRE ENGINE MANAGEMENT SYSTEM



Engine Control Module (ECM)

The AJ6 4.0L EMS is microprocessor based using the Lucas 15 CU ECM as the heart of the system. The 15 CU ECM microprocessor runs at 2.0 MHz. The ECM uses discrete components plus analog-to-digital circuits to interface between the microprocessor and the input sensors and output devices. Software, programmed into an EPROM, is divided into “control code” and “data” (engine calibration). Control code is common to all engine specifications; data is written for specific market specifications such as US EPA emission regulations.

15 CU ENGINE CONTROL MODULE



The ECM contains two double sided printed circuit boards. One is a low power board and the other is a high power board. The yellow and blue 25-way connectors are therefore referred to as the low and high power connectors respectively. Most of the input signals from engine mounted sensors, and interfaces with other systems are located on the low power (Yellow) connector. The high power connector (Blue), mainly serves outputs such as fuel injector drive and relay activation.

The ECM receives sensor inputs and feedbacks, which are used to determine the optimum strategy for the prevailing conditions. The ECM’s strategy has 256 memory locations containing injector pulse durations and ignition timing angles for 16 different engine loads (engine load sites) and 16 different engine speeds (engine speed sites). Canister purge, idle speed, air injection and exhaust gas recirculation are controlled by the ECM from stored strategies.

Crankcase Emission Control

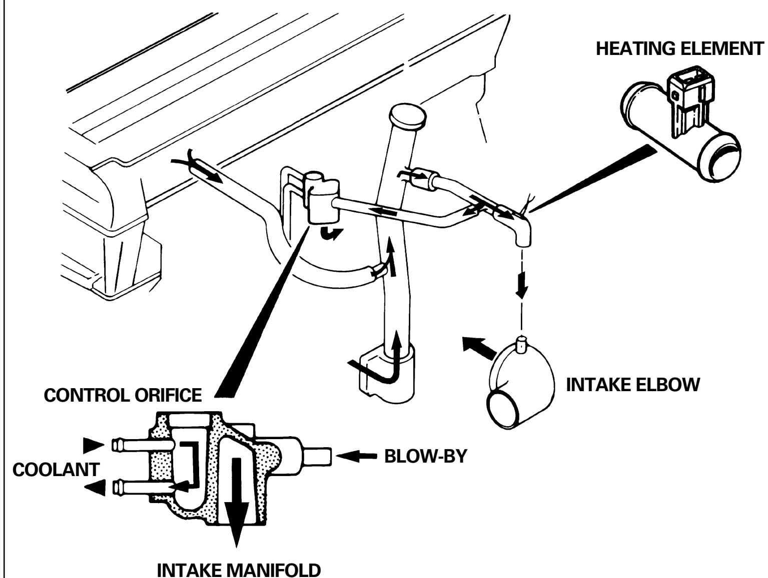
In order to prevent crankcase vapor from escaping to the atmosphere, a closed crankcase emission control system is employed that maintains a slight vacuum in the crankcase under all engine operating conditions.

Crankcase vapor is collected from the camshaft cover and from the oil filler tube. At part throttle, the gases are fed into the intake manifold through a coolant heated restrictor. During full load operation the gases are fed into the engine through both the coolant heated restrictor and air intake elbow connection.

The necessary crankcase vacuum is balanced by the part throttle restrictor and the full throttle orifice in the inlet elbow. The restrictor and orifice sizes have been carefully chosen to control the crankcase vacuum while not flowing so much gas that idle speed is affected.

The part throttle restrictor is coolant heated to prevent icing during cold weather operation. An additional electrical breather heater element is located in the full throttle breather hose. The electrical heater provides heat to the gases passing through the hose, preventing ice formation in the inlet elbow orifice. The electrical heater element is controlled independently of the EMS ECM by an ambient temperature sensor, thermal switch and relay. Starting in the 1994 model year, a throttle housing heated by engine coolant was introduced.

CRANKCASE EMISSION CONTROL

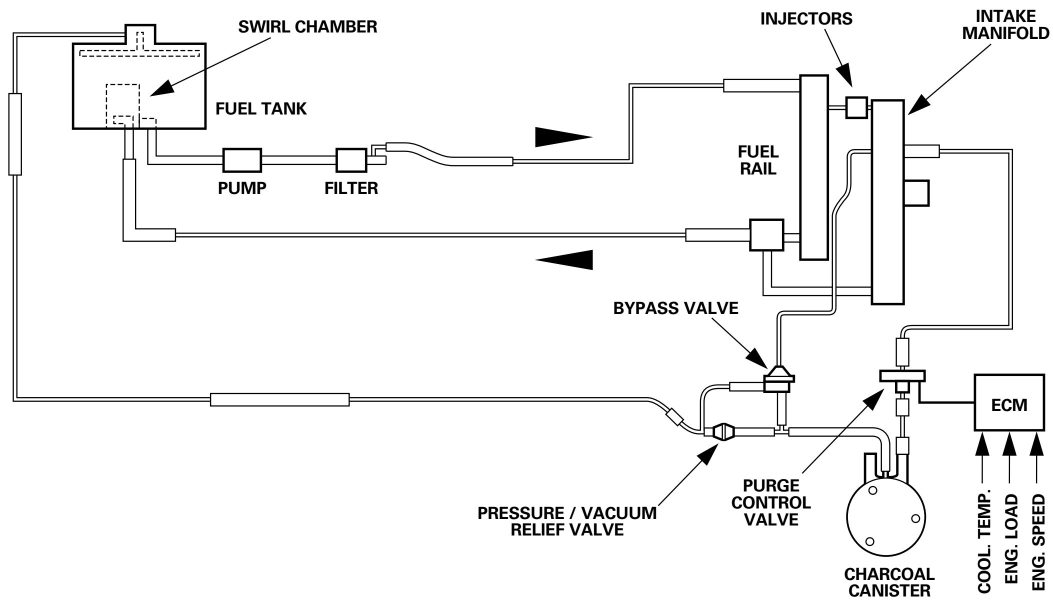


PART LOAD RESTRICTOR: 2.5mm; FULL LOAD ORIFICE: 8.0mm T800/1.02

Fuel Delivery and Evaporative Emission Control

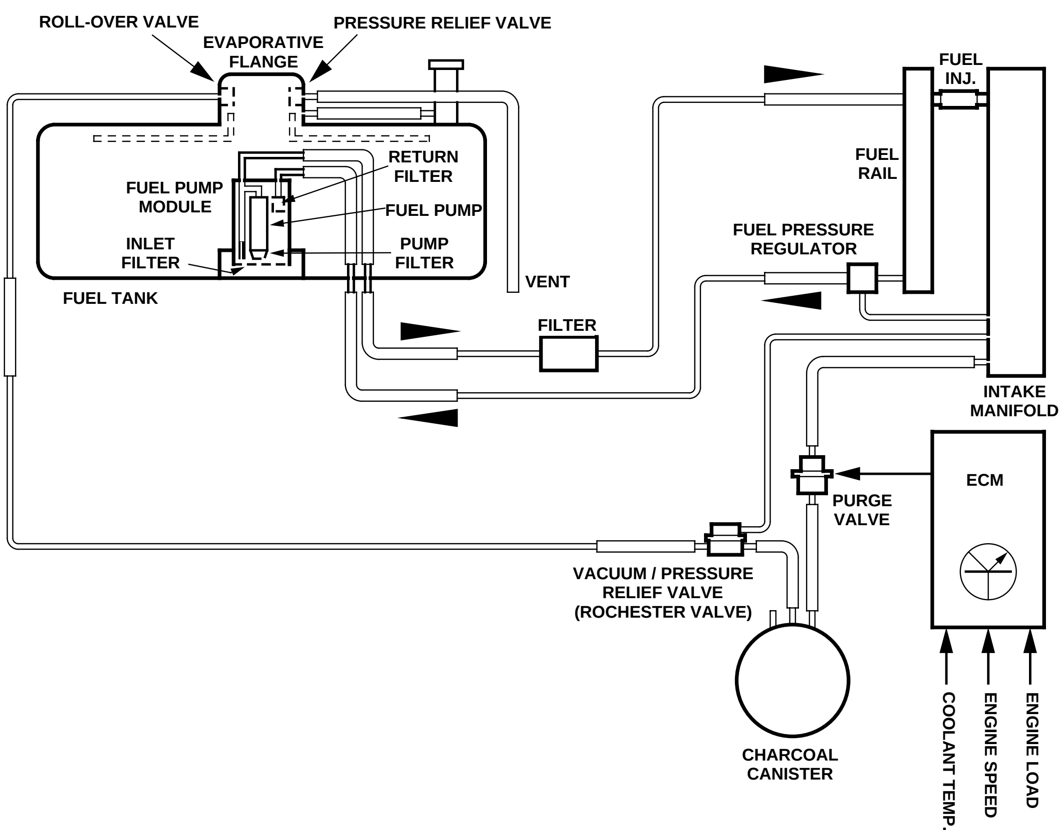
Since the 1990 model year, two fuel delivery and evaporative emission control systems have been used for all AJ6 4.0 litre installations. The two systems are illustrated below.

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL: XJ6 SEDAN RANGE 1990 MY



T800/1.04

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL: XJ6 SEDAN RANGE 1991 – 94 MY; XJS RANGE 1993 – 94 MY



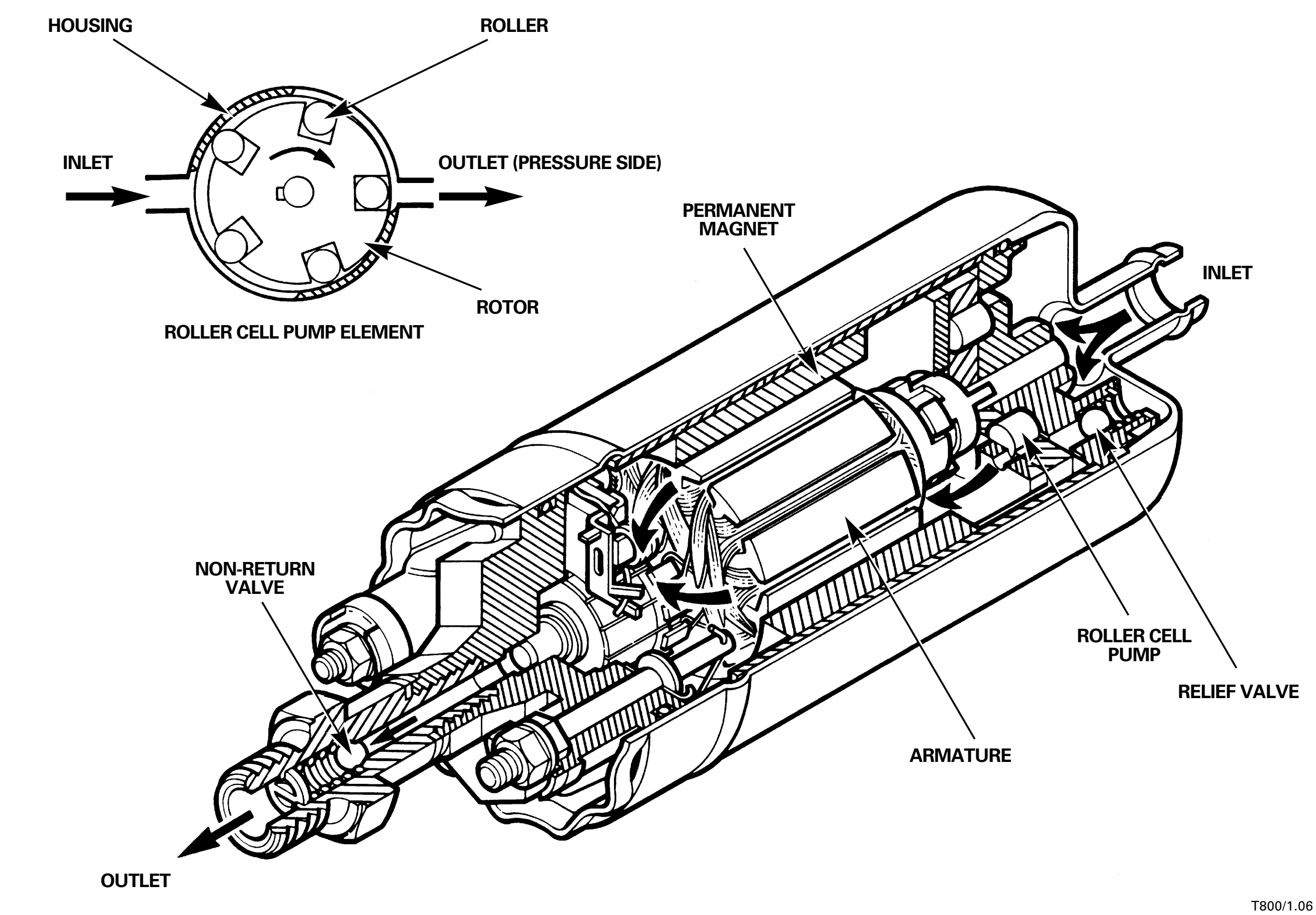
T800/1.05

Fuel Delivery

A recirculating fuel system provides a continuous supply of pressurized, cooled fuel to the fuel rail. There is sufficient fuel flow to allow full load engine operation at all times.

Fuel pump: XJ6 Sedan 1990 MY
Fuel is drawn from the fuel tank by an electric pump located on the rear subframe and is delivered to the fuel rail through a renewable filter mounted to the underbody. Unused fuel is returned to the tank swirl chamber where it passes through a venturi before mixing with the remaining fuel in the tank. This action cools the returning fuel.

FUEL PUMP: XJ6 SEDAN RANGE 1990 MY



The in-line fuel pump is a roller type pump driven by a permanent magnet electric motor. An eccentric rotor mounted on the armature shaft has metal rollers housed in pockets around the circumference. When the motor is energized, centrifugal force acting on the rollers forces them outward so that they act as seals. The fuel between the rollers is then forced to the outlet side of the pump.

Fuel Delivery and Evaporative Emission Control (continued)

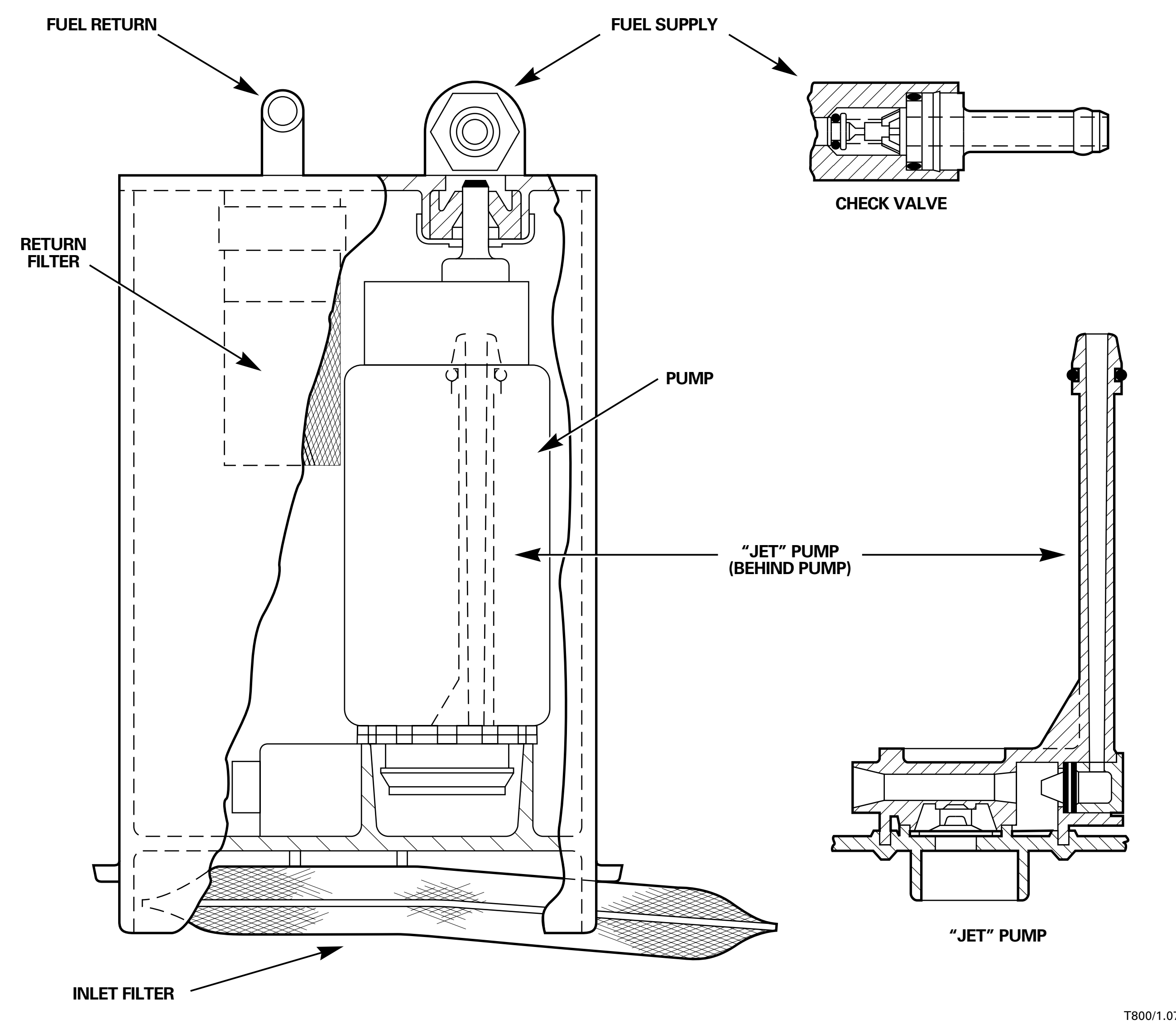
Fuel Delivery (continued)

Fuel pump module: 1991 MY ON vehicles
The fuel pump is an integral component of an in-tank fuel pump module. The fuel pump module mounts in a rubber holder attached to the bottom of the fuel tank on brackets. The fuel pump module and the rubber holder are indexed to ensure correct alignment in the tank.

Fuel is drawn from the fuel tank through a 70 micron filter at the base of the module, then through a 400 micron filter at the pump inlet. The pump delivers the fuel to the fuel rail through a renewable in-line filter mounted to the underbody. Unused fuel is returned to the fuel pump module where it passes through another 70 micron filter. A small portion of the pressurized fuel flows through a venturi “teed” into the supply side inside the module. This flow enables a “jet pump” to pick up fuel so that the module remains full at all times.

Both the outlet and return ports through the pump module have check valves. The outlet check valve reduces back flow from the fuel rail when the pump is off. The return check valve holds fuel pressure in the return line from the fuel rail and prevents siphoning if a fuel line is disconnected.

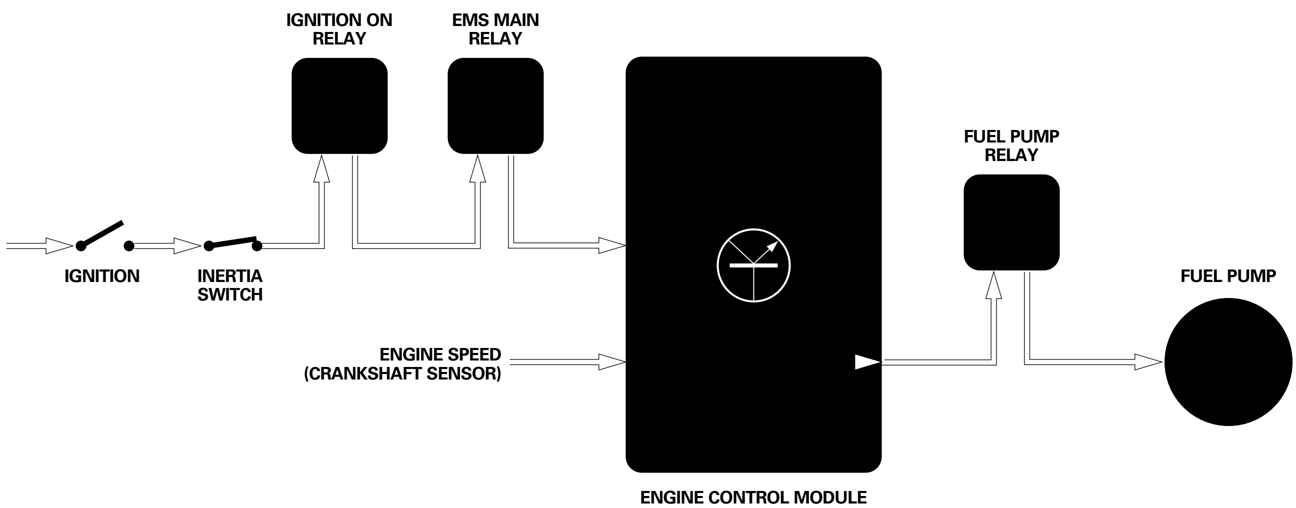
FUEL PUMP MODULE: 1991 MY ON VEHICLES



Fuel pump control

The electrically powered fuel pump is controlled by the ECM via the fuel pump relay. After the ignition is turned on (position II), the pump runs for about 1 second to build fuel pressure for starting. When the ECM receives an engine speed signal from the crankshaft position sensor, it activates the fuel pump relay, which in turn switches on the fuel pump. The fuel pump will continue to run either until the ignition is turned off or until approximately 1 second after there is no speed signal. The ECM monitors the output to the fuel pump relay for on-board diagnostics.

FUEL PUMP CONTROL



NOTE: THIS DIAGRAM ILLUSTRATES CONTROL LOGIC FLOW ONLY;
REFER TO THE APPLICABLE WIRING DIAGRAM FOR POWER AND CIRCUIT INFORMATION.

T800/1.08

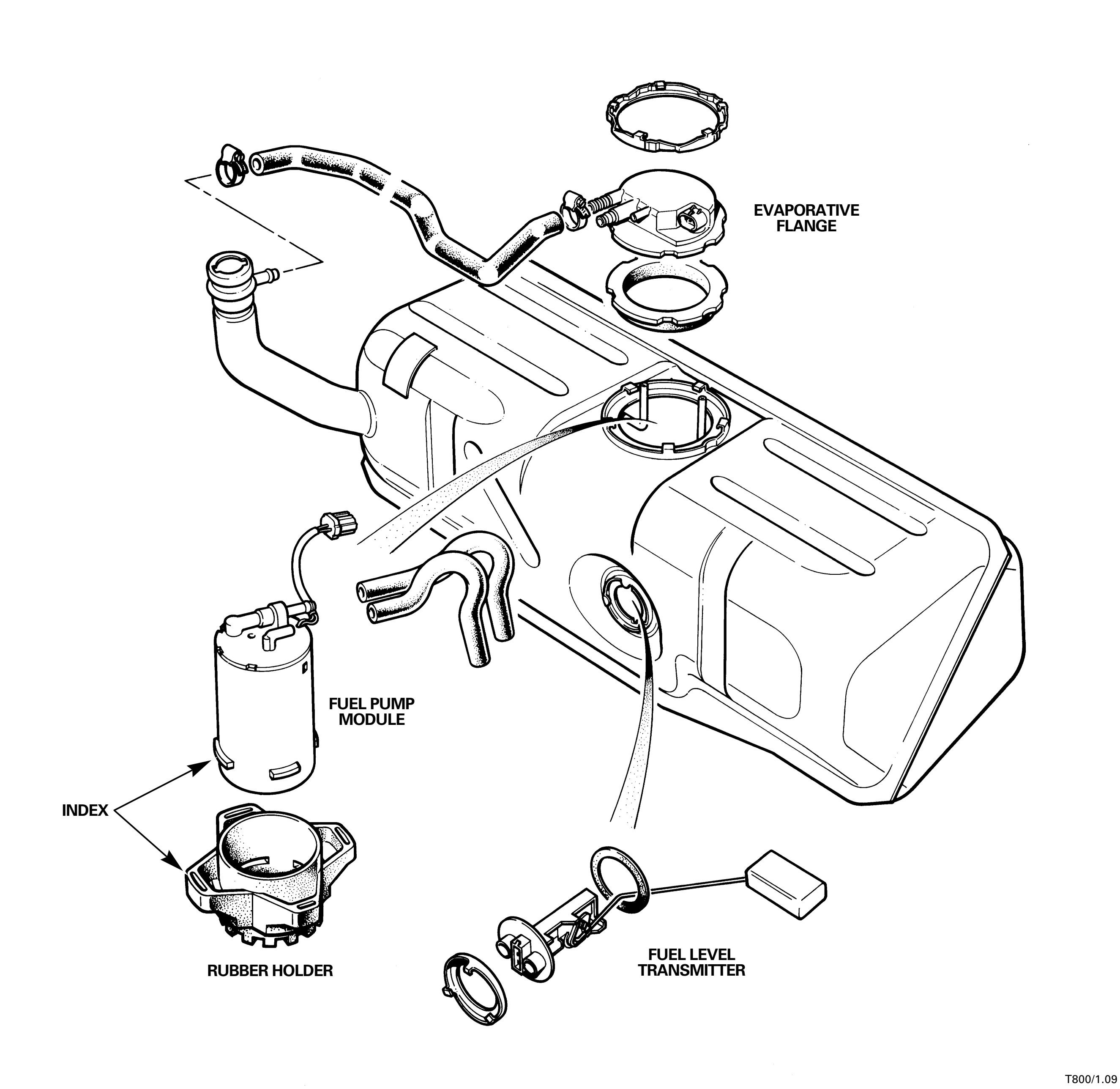
NOTE: In the event of a vehicle collision, the inertia switch will switch off all ignition powered circuits, including the EMS main relay. This action will remove power from the ECM and cause the fuel pump relay to de-energize, switching off the fuel pump.

Fuel Delivery and Evaporative Emission Control (continued)

Fuel Delivery (continued)

Fuel tank assembly: 1991 MY ON vehicles
The fuel pump module connects to the tank outlet and return ports via flexible hoses. Electrical connection to the wiring harness is made through the evaporative flange.

FUEL TANK ASSEMBLY: 1991 MY ON VEHICLES

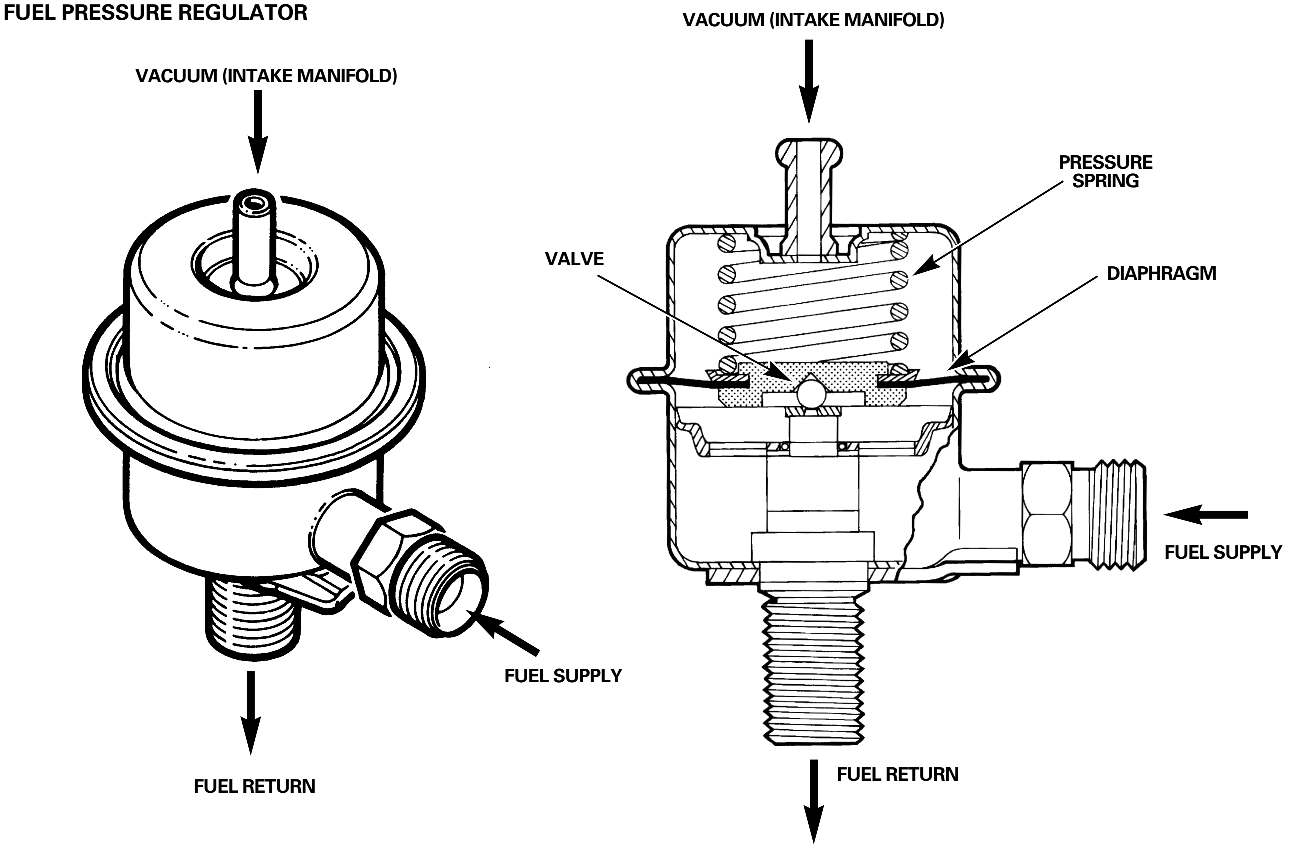


Fuel rail and pressure regulator

Fuel is pumped to the fuel rail and injectors, where fuel pressure is controlled by the fuel pressure regulator. Excess fuel, above the engine requirement, is returned to the fuel tank. The pressure regulator spring chamber above the diaphragm is referenced to intake manifold vacuum. The differential pressure across the fuel injector nozzles is therefore maintained constant at 44 psi (3.0 bar) and the quantity of fuel injected for a given injector pulse duration is also constant. Fuel pressure measured on a test gauge will vary between 32 psi (2.3 bar) at overrun to 44 psi (3.0 bar) at full load.

The fuel pressure regulator is located as close as possible to the fuel rail so that good dynamic control of fuel pressure is achieved. This design provides the same pressure across each injector, and delivers an equal quantity of fuel to each of the six cylinders.

FUEL PRESSURE REGULATOR



Fuel Delivery and Evaporative Emission Control (continued)

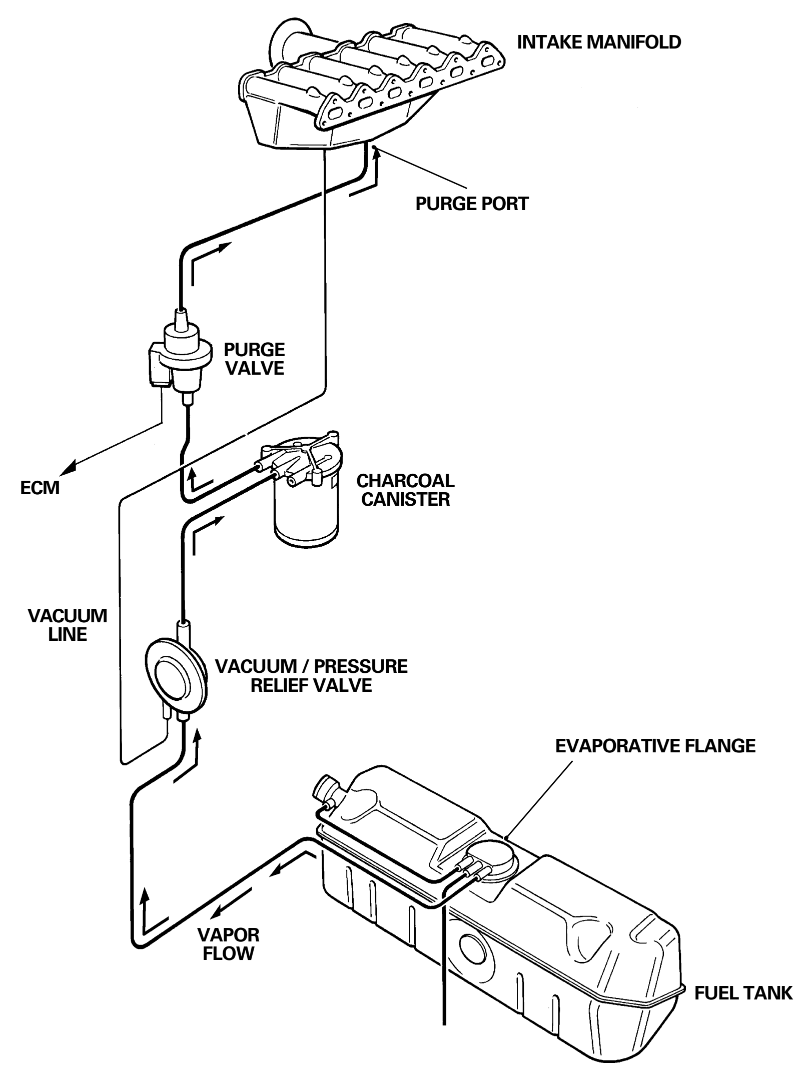
Evaporative Emission Control: XJ6 Sedan 1990 MY

The fuel tank incorporates a plastic vessel that limits the fill level and allows for 10% fuel expansion. Tank venting is via a system of vapor tubes and a liquid / vapor separator in the tank to the charcoal canister, located in the left front wheel well. Vapor flow to the canister is controlled by an engine vacuum-operated bypass valve which allows vapor flow to the canister when the engine is operating. A pressure / vacuum relief valve prevents excessive pressure or vacuum from building in the fuel tank. Canister purging to the intake manifold is controlled by the ECM through an electric purge valve located at the canister.

Evaporative Emission Control: All models 1991 MY ON

The fuel tank is designed with a limited fill feature which allows about 10% fuel expansion. The vapor pipe connected to the filler neck is connected into the tank at the maximum fuel level. When the fuel covers the bottom of the vapor tube, fuel rises in the filler neck shutting off the fuel delivery nozzle. Purging and control of vapor flow to the canister are identical to the 1990 model year system.

AJ6 4.0L EMS EVAPORATIVE EMISSION CONTROL (TYPICAL)

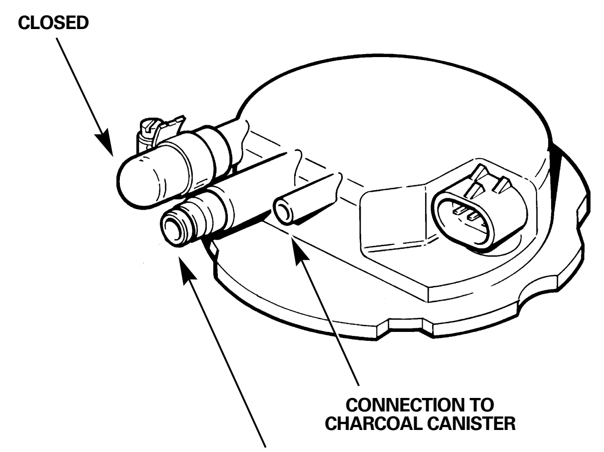


T800/1.11

Evaporative flange

The top of the fuel tank incorporates a removable evaporative flange with three outlets. One outlet is used for the filler neck vent hose on 1991 model year vehicles and is capped-off on later vehicles. The center outlet incorporates a 2.5 – 3 psi pressure relief valve and is connected to a relief tube that vents to under the vehicle. The third outlet incorporates a roll-over valve and connects to the charcoal canister. Electrical connection to the fuel pump module is made through the evaporative flange.

EVAPORATIVE FLANGE



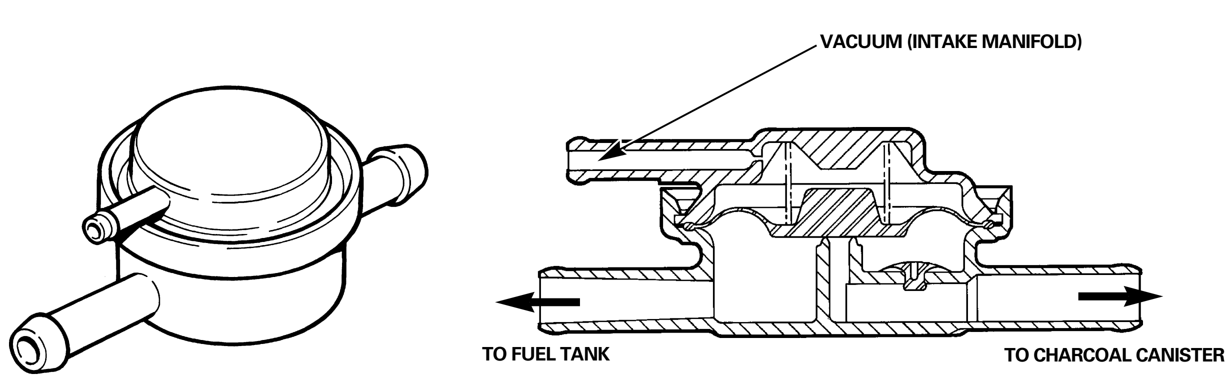
T800/1.12

Vacuum / pressure relief valve

The flow of vapor to the canister is controlled by the vacuum / pressure relief valve (Rochester valve). The valve has three functions: fuel tank pressure relief, fuel tank vacuum relief, and vapor flow control.

When the vehicle is not operating and fuel temperature in the tank is increasing, vapor is released, limiting the tank pressure to approximately 1 to 1.25 psi. When the vehicle is not operating and fuel temperature in the tank is decreasing, a negative pressure is created. The umbrella check valve in the vacuum / pressure relief valve allows vapor to flow back into the tank from the charcoal canister, preventing the tank from collapsing. When the engine is operating, a manifold vacuum signal, from the intake manifold, opens the valve allowing vapor flow to the canister and reducing the fuel tank pressure to near zero. An additional fuel tank overpressure safeguard is provided by a 4 psi relief valve in the fuel cap.

VACUUM / PRESSURE RELIEF VALVE

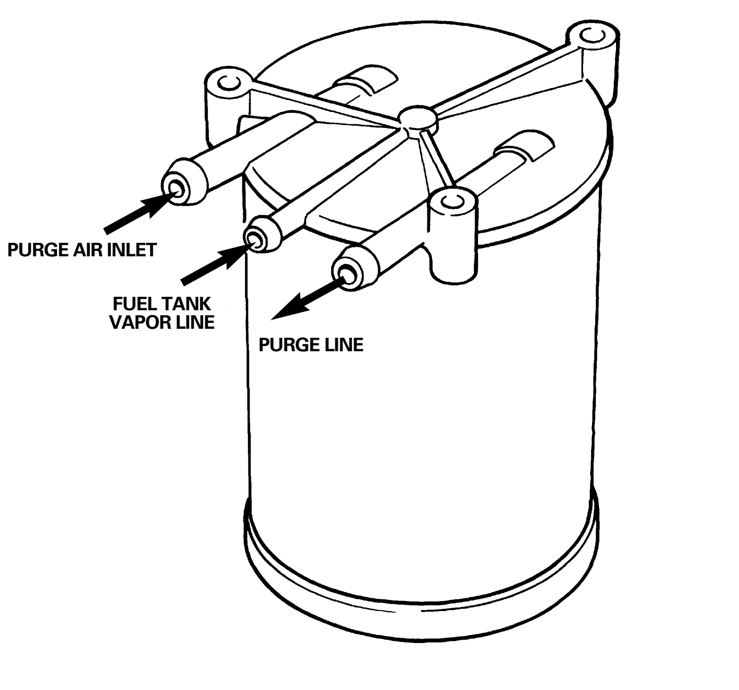


T800/1.13A, B

Fuel Delivery and Evaporative Emission Control (continued)

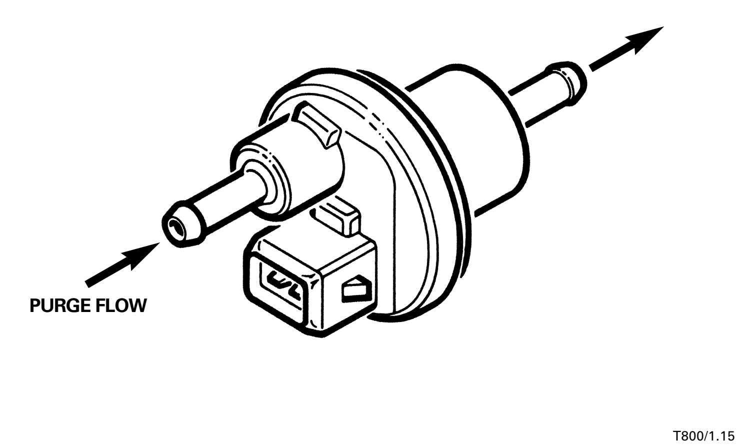
Evaporative Emission Control: All models

CHARCOAL CANISTER



Charcoal canister
The charcoal canister contains activated charcoal that absorbs the fuel tank vapors. As the charcoal can become saturated, the canister is purged of the collected vapors during engine operation. Three ports are provided on the canister: one for vapor flow in, one for purge flow to the intake manifold, and one to allow air to enter the canister during purging.

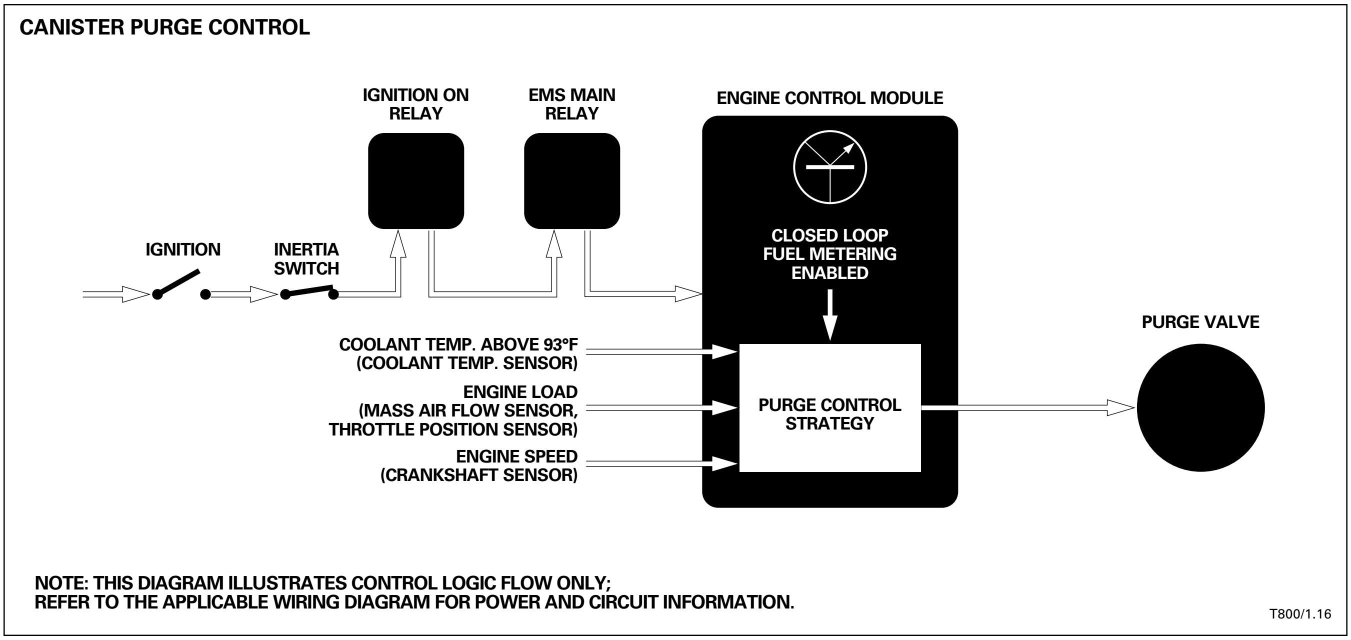
PURGE VALVE



Purge valve
The engine management ECM operates the purge control valve to allow a regulated vapor flow to the intake manifold dependent on engine operating conditions. The purge valve is a solenoid operated valve that is normally open. The valve closing and subsequent rate of vapor flow (opening) is varied by the "length" of a pulsed electrical signal provided from the ECM.

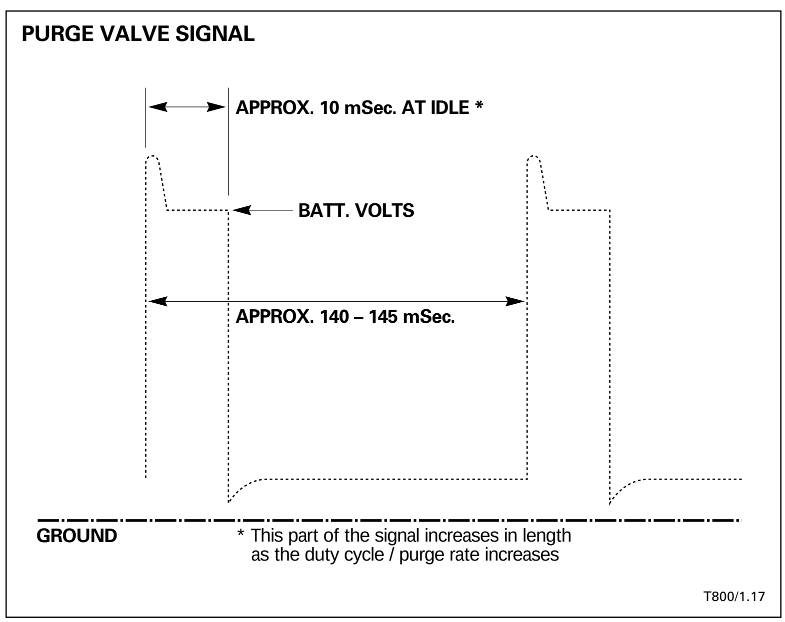
Canister purging

The vapor adsorbed by the activated charcoal in the canister is purged by using engine vacuum to draw air through the charcoal and into the intake manifold. The conditions during which vapor is purged and the quantity purged is programmed into the ECM. The purge rate has to be sufficient to prevent the charcoal canister from venting vapor to the atmosphere. On the other hand, purge rates that are too high would cause driveability problems.



Canister purge is enabled by the ECM when the engine coolant temperature exceeds 93°F (34°C) and closed loop fuel metering control is operational. The rate of purge is determined from an 8 x 16 load versus engine speed strategy.

When the ignition is turned ON (engine inoperative), the valve is fully energized and closed to prevent vapor flow to the engine. When the engine is operating at idle and purge flow is enabled, the purge flow will be small. As engine load and speed increases, the purge rate will increase proportionally. When the ignition is turned off the valve is fully energized and held closed for a short period to prevent vapor from being drawn into the engine as it slows to stop to prevent run-on. Purge valve operation at idle can be detected by holding the valve in the palm of the hand. The ECM monitors the output signal to the purge valve for on-board diagnostics.



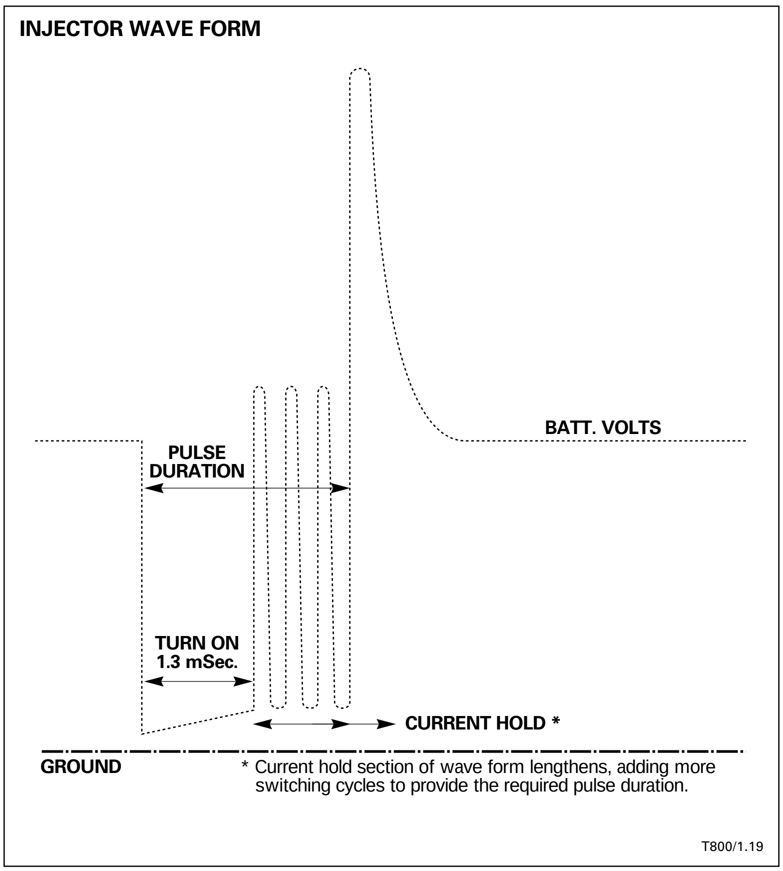
Fuel Injection; Idle Speed Control

Fuel Injection

Fuel metering is obtained by controlling the injector pulse duration during each engine revolution. The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups – primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, cranking signal, throttle movement and position and exhaust oxygen content. The injector pulse is then trimmed for battery voltage. Except during "cranking" and rapid throttle application, all six injectors are pulsed once per engine revolution (twice per engine cycle). Half of the fuel requirement is delivered at each pulse and the pulse duration is recalculated before each succeeding injection.

Fuel metering strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing injector pulse duration in milliseconds fill each site and cover the entire engine load and speed range.

NOTE: The sites are numbered 0 to 15 (16 total). Site 0 is less than overrun load, and low engine speed. Site 15 is higher than full load and high engine speed. The load and speed sites are purposely chosen to extend beyond the operational envelope of the engine.



All fuel injectors are pulsed simultaneously by the ECM "output stage". To reduce power consumption, the current drawn by the injectors is controlled by the ECM. The injectors are opened by a relatively large "turn on" pulse and are held open for the required duration by a series of smaller "hold on" pulses.

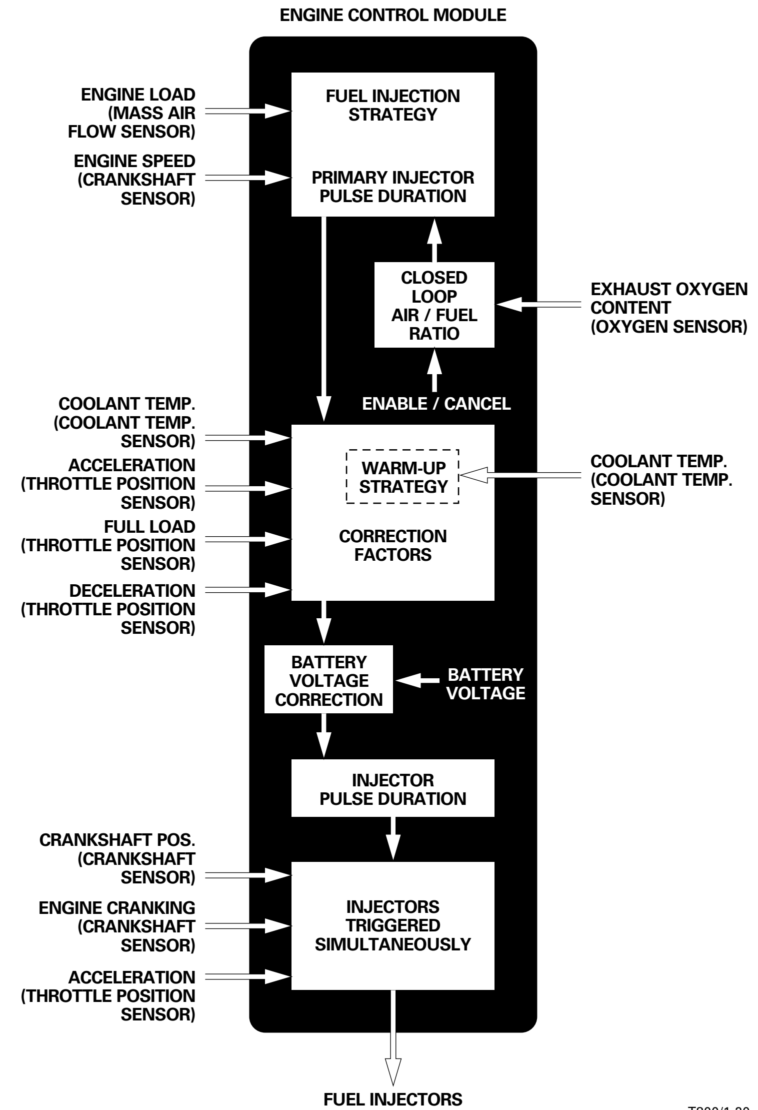
Additional fuel injection controls are used for overrun fuel cut-off, engine overspeed prevention and wide-open-throttle during cranking fuel cut-off.

The ECM monitors its output signals to the fuel injectors and its input signals from sensors for on-board diagnostics.

Fuel Injection Primary Control

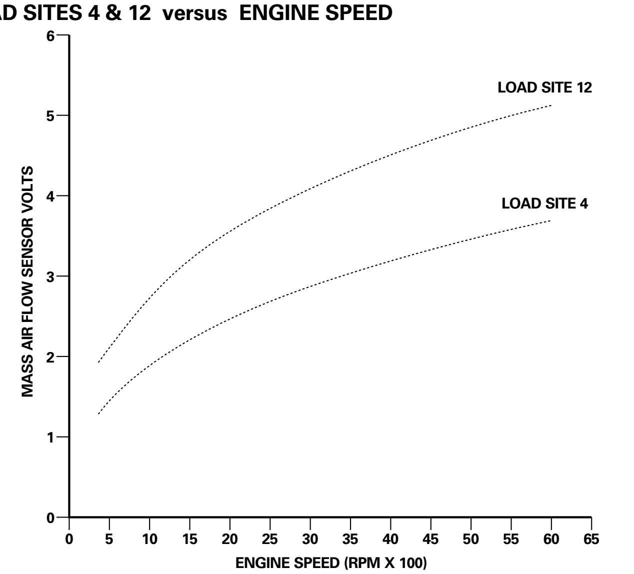
Fuel metering is controlled primarily as a function of engine load and speed. Engine load is sensed by a mass air flow sensor located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft sensor located behind the engine damper. In addition to engine speed, the sensor supplies crankshaft position inputs to the ECM for ignition timing. The ECM processes the input from the mass air flow meter and the crankshaft sensor to access pulse duration from the fuel metering strategy. Usually, the load and speed at which the engine is running will be between sites. A function known as two dimensional interpolation is used to calculate the correct pulse duration for the between-sites engine condition.

FUEL INJECTION PRIMARY AND SECONDARY CONTROL



T800/1.20

LOAD SITES 4 & 12 versus ENGINE SPEED



T800/1.21

Fuel injection; Idle Speed Control (continued)

Fuel Injection Secondary control

Secondary fuel metering control adjusts for engine coolant temperature, cranking signal, throttle movement and position and exhaust oxygen content.

Cranking and after-start enrichment
The ECM provides fuel metering enrichment for cranking and after-start conditions.

The ECM recognizes engine cranking from the engine speed input (less than 200 rpm) and increases the injector pulse frequency to three injection pulses per engine revolution. The pulse duration is determined by engine coolant temperature. Cranking fuel metering is canceled at 250 rpm above a coolant temperature of 107°F (42°C) and at 500 rpm below the same temperature. At that point, injection reverts to one pulse per revolution and after-start enrichment is then applied. The pulse duration, and the rate at which the enrichment is decreased back to the warm-up phase is dependent upon engine coolant temperature.

Warm-up
The programmed warm-up enrichment provides extra fuel during engine warm-up based on the engine temperature measured by the coolant temperature sensor. The injector pulse duration is increased above the fully warm requirement when the coolant temperature is less than 186°F (85°C).

Acceleration enrichment
When the ECM senses that the throttle is opening (throttle position sensor input), the injector pulse duration is lengthened by an amount dependent upon the rate at which the throttle is opened and on engine coolant temperature. This acceleration enrichment prevents a momentary lean condition that can cause driveability or exhaust emission problems. If the throttle is opened rapidly, a single "extra" injector pulse of about 5 milliseconds is generated to improve engine response.

Full load enrichment
If the ECM senses a full throttle input from the throttle position sensor, full load enrichment is applied and closed loop operation is temporarily canceled.

Deceleration leaning
When the ECM senses that the throttle is closing (throttle position sensor input), the injector pulse duration is shortened dependent on the rate at which the throttle closed. This action prevents a momentary rich condition that can cause exhaust emission problems.

Summary of ECM functions based on throttle position sensor input:

Throttle Position	ECM Function
Throttle closed (signal 0.25 – 0.75 volts)	Idle speed control function Ignition idle strategy Overrun fuel cut-off Idle fuel trim (adjustable mass air flow sensor potentiometer only) Adaptive idle fueling trim
Part throttle (signal above closed throttle voltage and below full throttle voltage)	Main fuel metering strategy Main ignition strategy EGR enabled
Opening throttle (signal voltage increasing)	Acceleration enrichment
Closing throttle (signal voltage decreasing)	Deceleration leaning
Full throttle (signal greater than 3 volts)	Full load enrichment (load dependent)

NOTE: Other sensor inputs are required for the initiation of most of the above listed ECM functions as described in Fuel Injection, Idle Speed Control, Ignition, EGR and Adaptive Idle Fuel Metering.

Closed loop operation
In order to significantly reduce exhaust emission, the exhaust system incorporates 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible. It is generally accepted that optimum combustion occurs with an air / fuel ratio of 14.7 : 1 (Lambda = 1). A closed loop system between fuel injection, ECM control and exhaust oxygen content feedback is used to maintain the air / fuel ratio as close to 14.7 : 1 as possible.

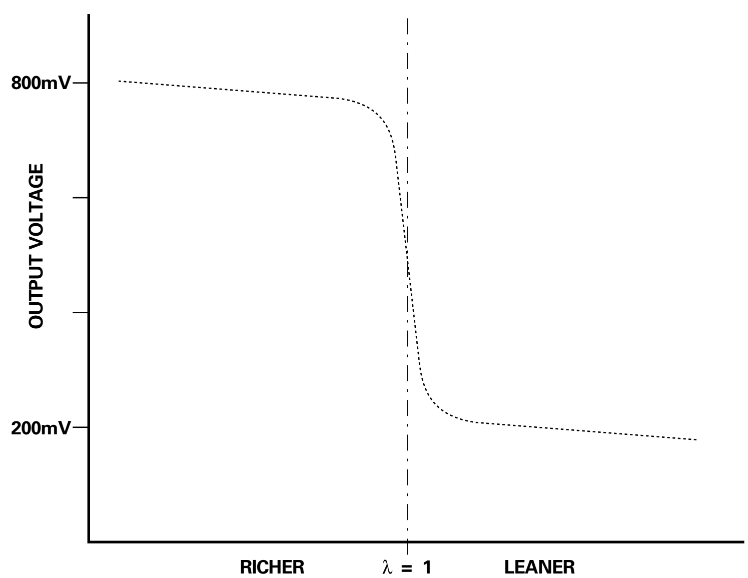
In response to the oxygen sensor voltage, the ECM continuously drives the air / fuel ratio rich-lean-rich by adding to, or subtracting from, the injector pulse duration determined from the main fuel metering strategy.

Note that the oxygen sensor voltage switches abruptly at an air / fuel ratio of 14.7 : 1 (Lambda = 1).

Closed loop operation is canceled by the ECM during the following functions:

- full load enrichment
- after-start enrichment
- warm-up (below 95°F [35°C])
- deceleration fuel cut-off

OXYGEN SENSOR CHARACTERISTIC (HO2SRAW)



Fuel injection; Idle Speed Control (continued)

Fuel Injection Secondary Control (continued)

Oxygen sensor feedback

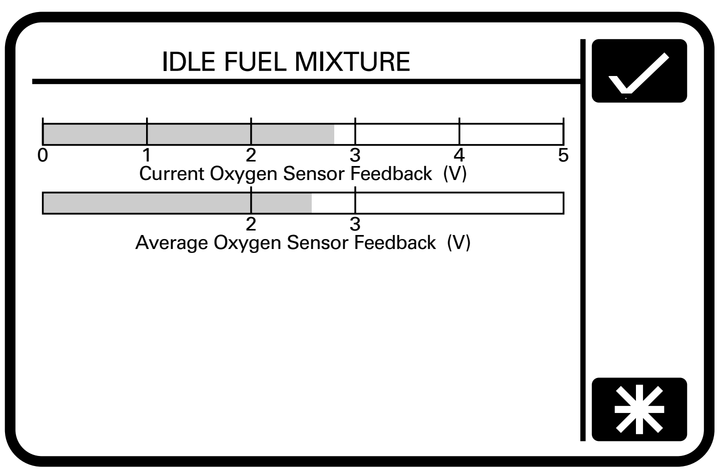
Oxygen sensor feedback is an ECM output voltage that is used for technician monitoring of closed loop operation. Oxygen sensor feedback can only be accessed through serial communications using JDS or PDU. The dampened or "average" feedback voltage is used to measure the amount of "dynamic" correction applied by the ECM to the fuel metering strategy in response to exhaust gas oxygen content.

NOTE: Oxygen sensor feedback may also be called Lambda feedback or integrator voltage.

The range for oxygen sensor feedback is 0 – 5 volts, representing a fuel metering strategy correction of -22% to +22%. The normal "average" feedback voltage is 2 – 3 volts.

Average oxygen sensor feedback voltage	Correction (dynamic) applied by ECM
2.5 volts	No correction is being applied. When closed loop operation is canceled, the ECM holds feedback at 2.5 volts.
Less than 2.5 volts	The ECM is correcting for a rich condition by subtracting from the injector pulse duration held in the engine load / speed site.
Greater than 2.5 volts	The ECM is correcting for a lean condition by adding to the injector pulse duration held in the engine load / speed site.

OXYGEN SENSOR FEEDBACK



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Battery voltage correction

Because the time to achieve full lift of the injector pintle decreases as voltage increases, the amount of fuel delivered by the injector for a given pulse duration is dependent upon the injector operating voltage.

The ECM is programmed with a voltage correction strategy. The supply voltage is monitored by a software routine and the correction applied to the pulse duration.

Additional Fuel Injection Controls

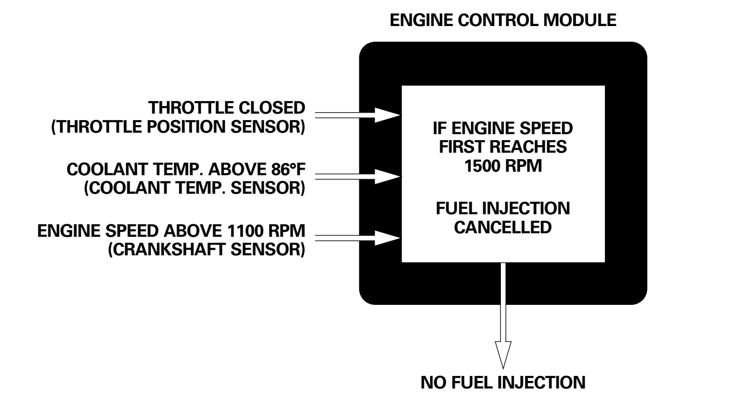
Overrun fuel cut-off
In order to improve fuel economy and aid in controlling exhaust emission, the ECM cancels fuel injection during engine overrun conditions. The ECM determines overrun conditions from inputs received from the throttle position sensor, crankshaft sensor and coolant temperature sensor.

With the throttle closed and the engine speed above 1100 rpm, the ECM cancels fuel injection, provided that the coolant temperature is above 86°F (30°C). The engine speed must always reach 1500 rpm first for overrun fuel cut-off to occur. In order to smooth the transition back to power, the ECM retards the ignition timing and shortens the injector pulse duration as the throttle opens and fuel injection is reinstated.

Engine overspeed control
An engine overspeed control function limits the maximum engine speed to 6300 rpm by canceling fuel injection. Fuel injection is reinstated at a slightly lower engine speed.

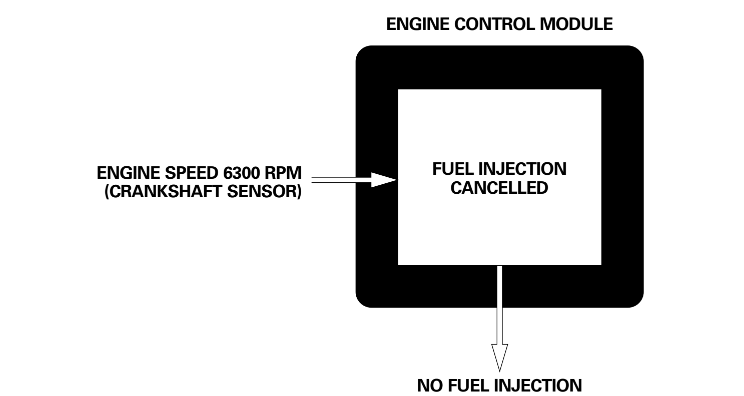
Wide-open-throttle during cranking
If the ECM senses that the throttle is wide open (throttle position sensor input) during cranking (less than 200 rpm), fuel injection is canceled to help clear a flooded engine.

OVERRUN FUEL CUT-OFF



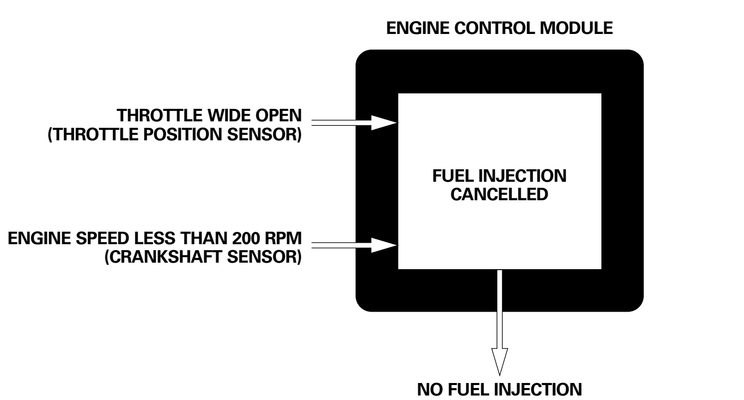
T800/1.24

ENGINE OVERSPEED CONTROL



T800/1.25

WIDE-OPEN-THROTTLE DURING CRANKING



T800/1.26

Fuel Injection; Idle Speed Control (continued)

Idle Speed Control

Idle speed is regulated by the motorized idle speed control valve that controls throttle bypass air. The control valve is driven by the ECM. The ECM uses inputs received from ignition ON, the crankshaft sensor, coolant temperature sensor and throttle position sensor as well as inputs for gear position, air conditioning compressor operation and road speed to control idle speed.

ECM idle speed control occurs at closed throttle when road speed is less than 3 mph. The programmed idle speed accounts for engine temperature and the loads placed on the engine by the transmission (gear position N, D, etc.), and air conditioning compressor clutch operation.

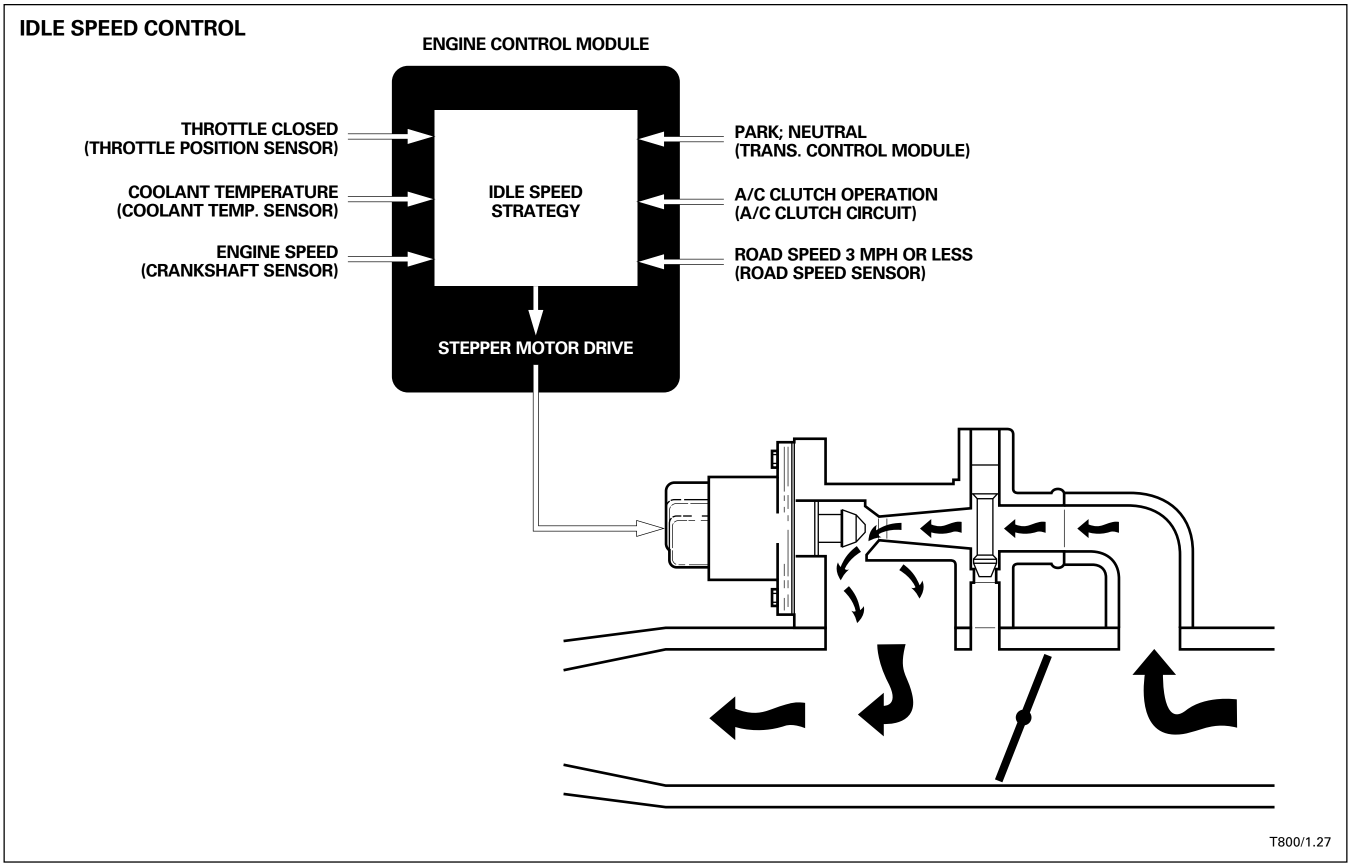
Typical controlled engine idle speeds

Cold engine (68°F [20°C]) / Neutral	800 rpm
Cold engine (68°F [20°C]) / Drive	650 rpm
Warm engine (193°F [90°C]) / Neutral	700 rpm
Warm engine (193°F [90°C]) / Drive	580 rpm

An ECM software function allows for a correction to the idle speed “base line” as the engine base idle changes with age. The automatic adjustment values are held in RAM within the ECM and will be retained or updated as long as the ECM is connected to battery voltage. If battery voltage is removed for any reason, the stored correction values will be lost. The values will be relearned only after the battery is reconnected, the engine operated from cold to normal operating coolant temperature at idle, and the vehicle driven for approximately 50 yards above 3 mph.

NOTE: At road speeds above 3 mph, the idle speed control valve is opened to limit overrun intake manifold pressure. The amount that the valve is opened is based on engine speed and throttle opening.

The ECM monitors its output signal to the idle speed control valve for on-board diagnostics.



Engine start-up
ECM idle speed control begins shortly after the engine is started, provided the throttle is closed (throttle position sensor at idle) and the road speed is less than 3 mph. The stepper motor in the control valve is closed in stages until the target idle speed is reached.

Gear position
When the gear selector is moved to Park or Neutral from drive, the engine management ECM receives a ground signal from the transmission rotary switch (XJS) or transmission decoder (XJ6 Sedan). The ECM then closes the idle speed control valve a predetermined number of steps in anticipation of the reduced engine load. When the engine is at normal operating temperature, the ECM maintains idle speed at 700 rpm in P or N and at 580 rpm in R, D, 2 or 3.

Air conditioning compressor clutch operation
When the air conditioning compressor clutch is energized, a parallel circuit inputs battery voltage to the engine management ECM. The ECM opens the idle speed control valve a predetermined number of steps to anticipate the change in engine load.

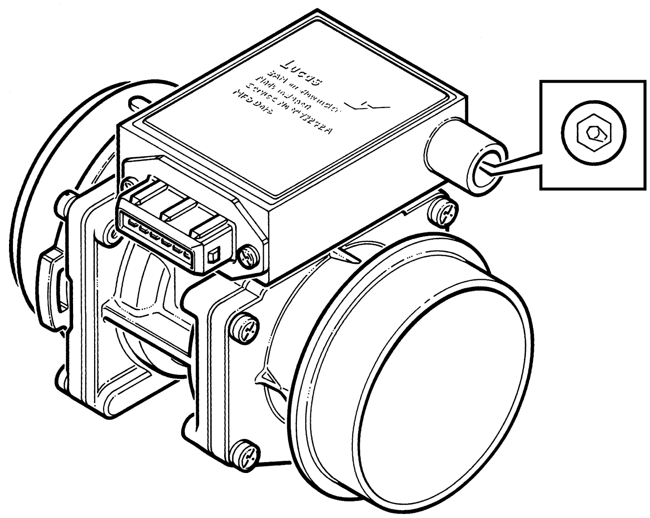
Ignition switched OFF
When the ignition is switched OFF, the control valve indexes to a known parked position. On 1990 model year vehicles, the reference is from the fully opened position. On later vehicles, the reference is from the fully closed position, 7 seconds after the ignition is switched OFF.

Fuel Injection; Idle Speed Control (continued)

Idle Trim (1990 – 1992 MY)

In order to compensate for slight differences from one vehicle to another, the ECM baseline to the *idle fuel metering strategy* can be properly set with the mass air flow sensor idle trim potentiometer.

IDLE TRIM POTENTIOMETER



T800/1.28

Adaptive Idle Fuel Metering (1993 MY ON Systems)

In order to ensure optimum performance, the ECM contains an adaptive idle fuel metering software function that automatically makes a baseline correction to the *idle fuel metering strategy*, throughout the life of the vehicle. The total available trim to the nominal injector pulse duration is ± 10%. Adaptive idle fuel metering is performed by the ECM at idle, only when diagnostic trouble codes (DTC) are cleared, and certain preconditions are met. If the DTCs are cleared and the preconditions are met, the ECM cancels purge flow and adapts the fuel metering strategy. Between adaptations, there is a delay of approximately eight minutes. The correction is applied across the entire engine speed and load range.

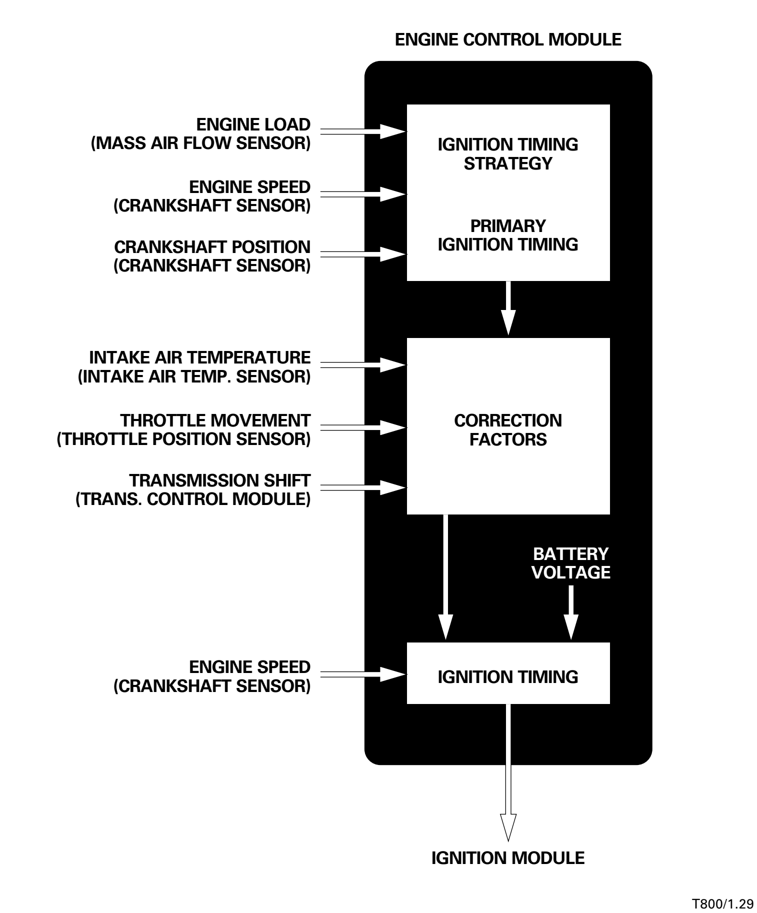
NOTE: With the incorporation of adaptive idle fuel metering, the idle trim potentiometer was removed from the mass air flow sensor.

Adaptive idle fuel metering preconditions:

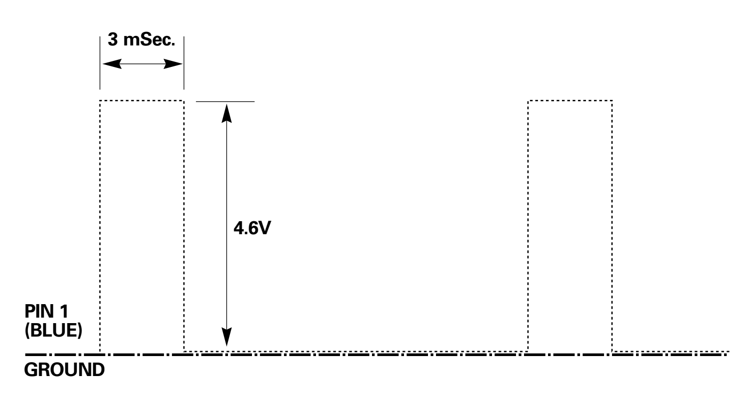
- throttle is closed
- engine speed is below 1000 rpm
- road speed is below 3 mph (6 kph)
- engine coolant temperature is above 170°F (76°C)
- idle speed adaptive delay is complete (vehicle speed reached 3 mph for approximately 100 yards traveled)
- closed loop air / fuel ratio control is operating and in control
- oxygen sensor feedback (HO2SFB) voltage outside of the normal range (2 – 3 volts)

If the ECM loses its battery voltage supply for any reason, the stored correction will be lost and fueling will revert to the programmed values.

IGNITION TIMING PRIMARY AND SECONDARY CONTROL



ECM IGNITION OUTPUT SIGNAL TO IGNITION MODULE



Ignition Timing Control

Ignition Timing

Ignition timing is controlled by the engine control module (ECM) according to sensor inputs. As with fuel injection, the sensed control inputs form two groups: primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine intake air temperature, throttle movement and position and transmission upshift (automatic transmission).

Ignition timing strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing ignition timing values fill each site. The resulting 256 ignition timing values cover the entire engine load and speed range. Ignition timing is then calculated from the ignition timing strategy according to secondary input correction factors.

The ECM drives the ignition module to switch the ignition coil low tension circuit and monitors the output signal for on-board diagnostics.

Ignition Timing Primary Control

Ignition timing is controlled primarily as a function of engine load and speed. Engine load is sensed by a mass air flow sensor located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft sensor located behind the engine damper. In addition to engine speed, the sensor supplies crankshaft position inputs to the ECM for ignition timing. The ECM processes the inputs from the mass air flow meter and the crankshaft sensor and accesses ignition timing from the ignition timing strategy. Usually, the load and speed at which the engine is running will be between load and speed sites. Two dimensional interpolation is used to calculate the correct ignition timing for the between-sites engine condition.

Ignition Timing Secondary Control

Secondary ignition timing control inputs consist of engine intake air temperature, throttle movement and position, battery voltage and transmission upshift (automatic transmission).

Intake air temperature
Ignition timing is corrected by the ECM for engine intake air temperature measured by the air temperature sensor mounted in the air inlet elbow. A portion of the ignition strategy (load sites 6 through 15; speed sites 4 through 15) is programmed with the temperature at which ignition retard commences for each load / speed site. In general, light loads / low speeds have retard thresholds set to a high temperature (approximately 212°F [100°C]) while high loads / high speeds have retard thresholds set about 86°F (30°C). Above the threshold temperature, ignition timing is retarded at the rate of 2.25° per 10°C.

Dwell angle
The dwell angle and peak coil current are controlled by the ignition module, located in the engine compartment near the ignition coil. A feature called "stall turn-off" is used to prevent coil overheating and battery discharge. If the ignition switch is left on without the engine running, the ignition module switches the coil current off.

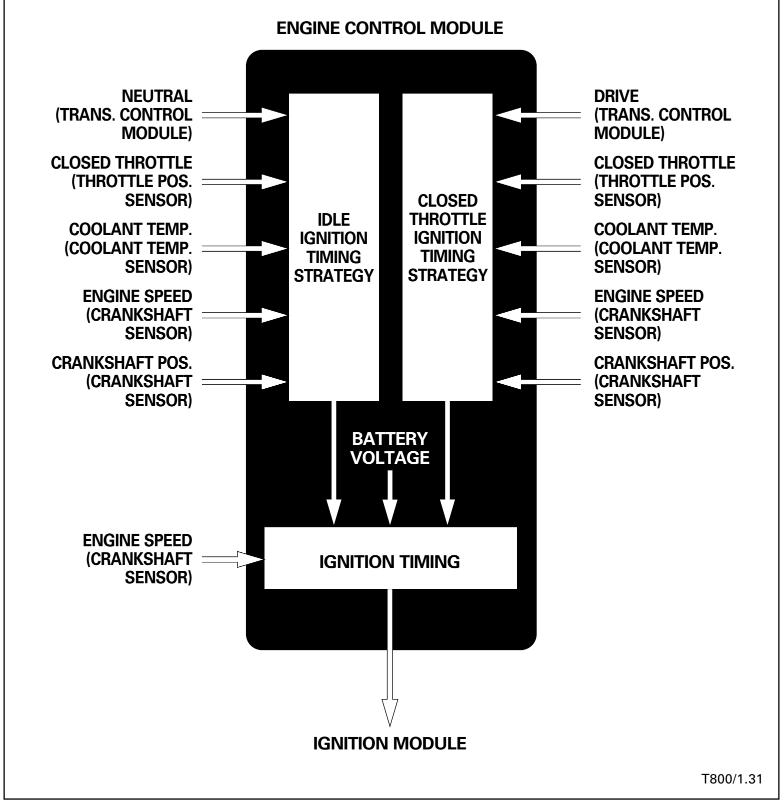
Closed Throttle / Idle

There are separate closed throttle ignition strategies for gear positions Neutral and Drive, each with 8 speed break points for engine speed versus timing. With the engine at normal operating temperature, the Ignition timing at idle will be 10° BTDC in N (700 rpm) and 16° BTDC in D (580 rpm).

Ignition Secondary Circuit

The ignition secondary circuit consists of a distributor and a standard ignition coil. The distributor contains only a rotor arm and a cap. The distributor must be correctly positioned to index the rotor to the cap; however, it has no affect on ignition timing.

CLOSED THROTTLE / IDLE IGNITION TIMING CONTROL



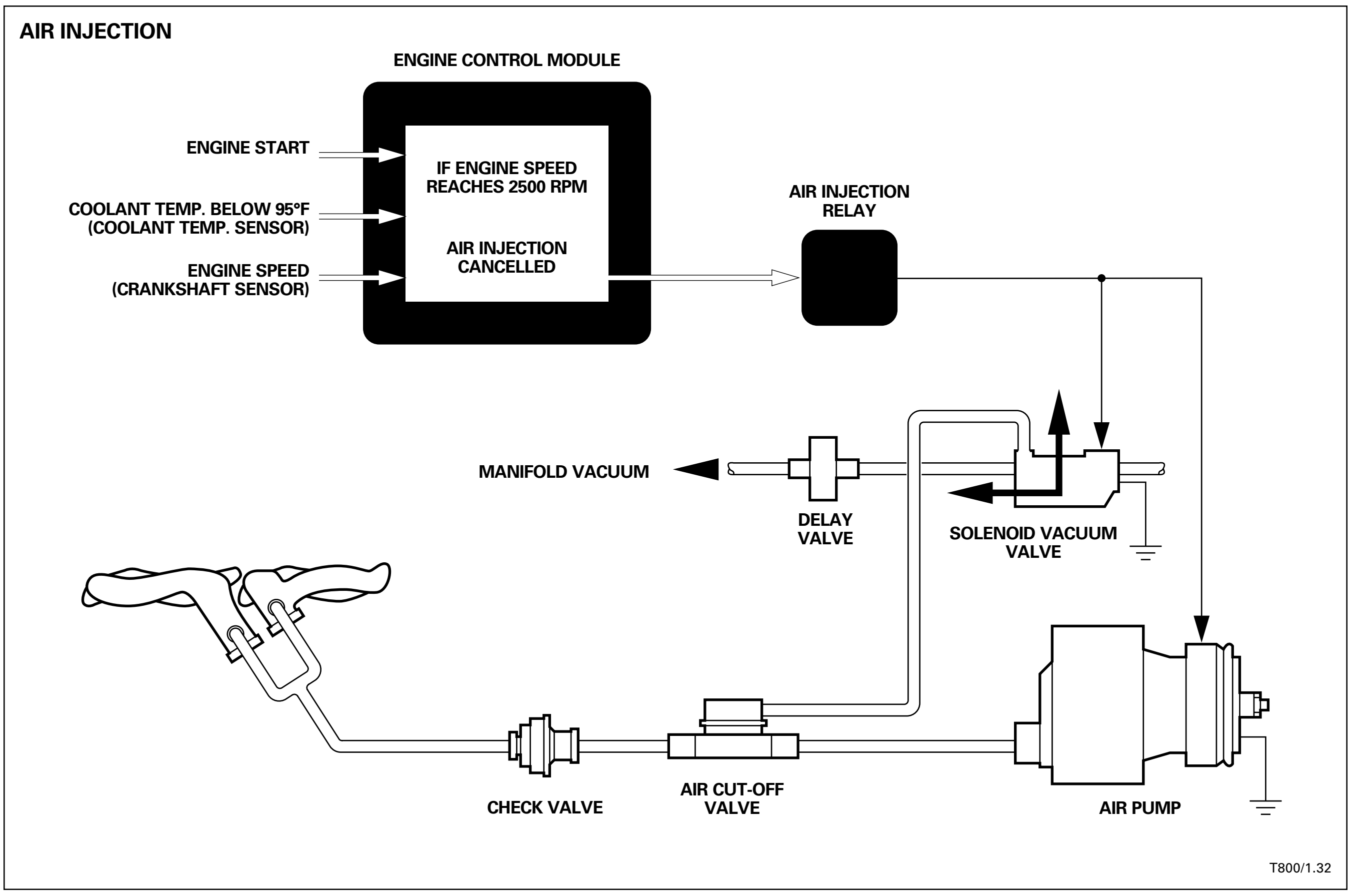
Air Injection

Air Injection Operation

Air injection is used to promote reaction in the exhaust down pipe catalyst, reducing the time required for the catalyst to reach working temperature. The air pumped into the exhaust manifolds mixes with exhaust gas and oxidation takes place. The heat generated in this process reduces the time required for the catalyst to reach operating temperature.

Air injection is enabled by the ECM following each cold start and remains on until the engine coolant temperature reaches 95°F (34°C). At 95°F the air injection circuit is switched off and closed loop air / fuel ratio control is enabled. If the engine speed exceeds 2500 rpm while air injection is enabled, the ECM will switch off the circuit.

On 1993 – 94 MY vehicles, air injection is also enabled for approximately 30 seconds after each hot start.



The ECM switches the air injection relay, which in turn switches both the air pump clutch and the air injection solenoid vacuum valve. The solenoid vacuum valve controls the vacuum signal to the air switching valve. The air switching valve performs two functions. It backs-up the air injection check valve and it prevents air from being sucked through the pump and check valve into the exhaust. Such leakage would cause an air / fuel ratio error at the oxygen sensor. The vacuum supply to the air switching valve is sourced from the intake manifold through a delay valve. The delay valve is used to ensure that the air switching valve is held open during short periods of high engine load.

The ECM monitors its output to the air injection relay for on-board diagnostics.

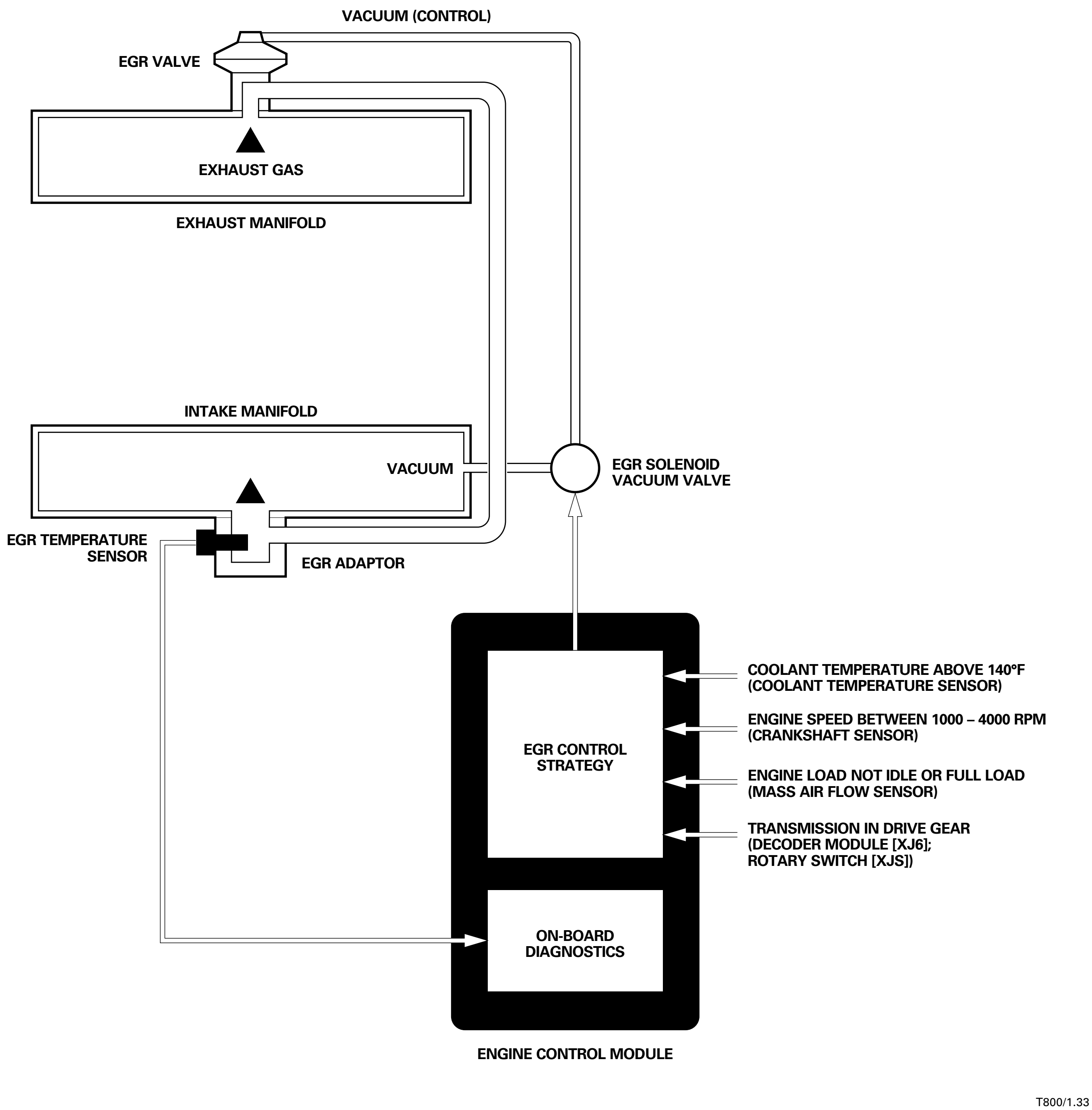
Exhaust Gas Recirculation

EGR Operation

Exhaust gas recirculation (EGR) is used to reduce the "oxides of nitrogen" (NOx) in the exhaust during periods of high engine combustion temperatures (high loads and engine speeds). The introduction of exhaust gas into the combustion chambers lowers the peak combustion temperature by reducing the volume of air / fuel mixture to be combusted.

The ECM both controls and monitors the operation of the system.

EXHAUST GAS RECIRCULATION



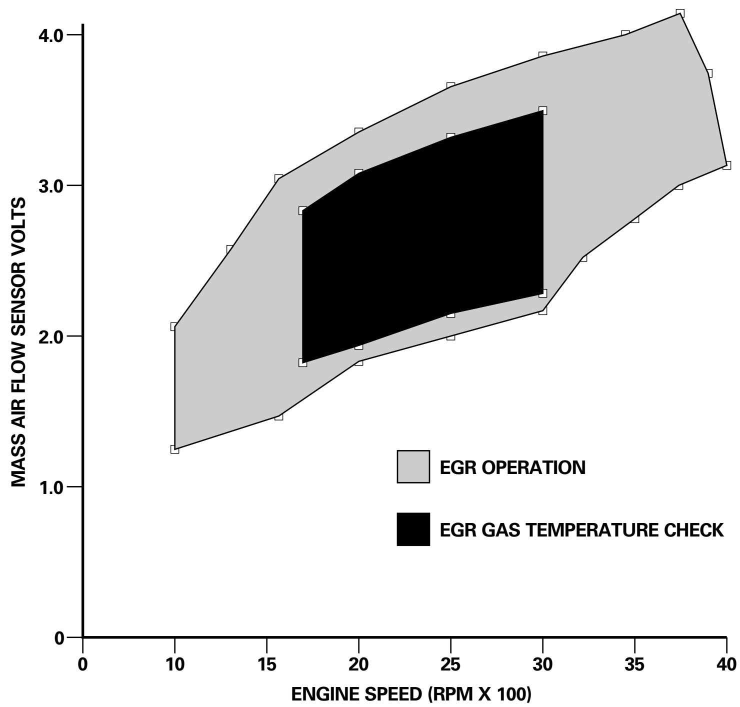
Exhaust Gas Recirculation (continued)

EGR Operation (continued)

EGR is enabled by the ECM when the following conditions exist:

- The engine coolant temperature exceeds 140°F (60°C)
- The engine is within a load / speed envelope that excludes idle and full load in the engine speed range 1000 – 4000 rpm
- The transmission is in a driving gear (not P or N)

EGR OPERATING ENVELOPE



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The ECM controls EGR by switching the EGR solenoid vacuum valve, which in turn, controls vacuum application to the EGR valve. The vacuum operated EGR valve controls the flow of exhaust gases between the exhaust and intake manifolds. Flow through the valve is proportional to exhaust back pressure, which is itself proportional to engine load. Vacuum is applied to the EGR valve via the ECM switched solenoid vacuum valve.

The ECM monitors its output to the EGR solenoid vacuum valve for on-board diagnostics.

The temperature of the exhaust gas flow to the intake manifold is also monitored by the ECM for on-board diagnostics. Monitoring takes place over a load / speed range within the EGR operational envelope.

On-Board Diagnostics (OBD)

On-Board Diagnostic Facility (OBD I)

The ECM includes a fault diagnosis facility that continuously monitors the operation of the engine management sensors and components. If a fault is detected, the OBD system will activate the Malfunction Indicator Lamp (MIL) (CHECK ENGINE) warning in the instrument pack and flag a diagnostic trouble code (DTC) in the ECM memory. The ECM can be interrogated through the instrument pack LCD display (XJ6 Sedan Range) or center console LCD display (XJS Range). To display the code, switch the ignition OFF; wait 5 seconds, then switch the ignition ON (do not crank the engine). On Sedan Range vehicles, press the VCM button. On XJS Range vehicles, a code is automatically displayed 5 seconds after the ignition is switched ON. The CHECK ENGINE warning will display and the DTC will appear 5 seconds later. If two or more DTCs are flagged in memory, only the highest priority code will be displayed. If the vehicle battery is disconnected, all stored codes will be cleared from the ECM's memory. DTCs can also be accessed via serial communication.

Limp Home Default

In order to allow vehicle operation if a malfunction occurs, "limp home" default values are incorporated as an ECM facility. If a sensor fault is detected by the OBD system, the ECM will substitute a nominal value for the missing input(s) as follows:

Missing Sensor Input	Default value
Engine coolant temperature	78° F (25° C)
Intake air temperature	86° F (30° C)
Mass air flow	Throttle position (voltage) Vs. pulse duration matrix; ignition timing = 8° BTDC @ idle, 20° BTDC above idle
Throttle position	1.5 volts
EGR temperature	Switches off EGR
Oxygen sensor voltage	Closed loop operation canceled (feedback = 2.5 volts)
Idle trim adjustment (1990 – 1992 MY only)	2.5 volts

On-Board Diagnostics (OBD) (continued)

Diagnostic Trouble Code Summary (listed in order of priority)

DTC	Limp Home Default	Fault Area	JDS / PDU Description
29		ECM self test	Lucas injection ECM
44	X	Oxygen sensor circuit	HO2S / circuit
24		Ignition drive circuit	IA drive circuit
12	X	Mass air flow sensor circuit	Mass air flow sensor / circuit
33		Injector drive circuit	Fuel injector / circuit
34		Rich condition during overrun fuel cut-off	Fuel injector leakage
14	X	Coolant temperature sensor circuit	ETC Sensor / Circuit
17	X	Throttle position sensor circuit	TP potentiometer / circuit
18		Throttle position sensor and mass air flow sensor (high throttle pos. voltage; low air flow voltage)	TP / potentiometer / calibration 1
19		Throttle position sensor and mass air flow sensor (low throttle pos. voltage; high air flow voltage)	TP / potentiometer / calibration 2
89		Purge valve drive circuit	EVAP valve / circuit
26		Oxygen sensor feedback (lean)	Air leak
37		EGR drive circuit	EGR valve / circuit
39	X	EGR temperature sensor circuit	Exhaust gas temperature sensor
22		Fuel pump drive circuit	Fuel pump / HO2S relay / circuit
23		Oxygen sensor feedback (rich)	Fuel supply
46		Idle speed control valve (coil 1 drive circuit)	IACV circuit, coil 1
47		Idle speed control valve (coil 2 drive circuit)	IACV circuit, coil 2
48		Idle speed control valve	IACV position error
11	X	Idle fuel trim (1990 – 92 MY XJ6)	
68		Road speed sensor circuit	Vehicle speed sensor / wiring
69		Drive / Neutral input circuit	PNPS / circuit
16	X	Intake air temperature circuit	IAT Sensor / Circuit
66		Air injection pump drive circuit	AIR relay / circuit

NOTE: 1992 MY ON systems (ECM part no. DBC 9622 ON): In order to prevent incorrect flagging of DTCs related to low fuel supply, fuel metering diagnostics are canceled when the fuel tank level falls below approximately 2.5 gallons (11 litres).

Vehicle Systems Interfaces

The engine management system interfaces with the transmission control module, the instrument pack and the air conditioning compressor clutch circuit to provide operational control, sensor input and data input.

Transmission Control Module Interface

Engine torque reduction
The ECM receives two ignition timing retard inputs from the TCM: transmission shift "up / down" signal (IGNITION SELECT) (pulsed signal), and transmission "shift in progress" signal (IGNITION RETARD) (pulsed signal). Refer to Ignition Timing, page 29, for a detailed explanation.

Engine speed and load
The ECM outputs engine load and speed signals (PULSED SIGNALS) to the TCM. The TCM uses the engine load and speed data to determine shift patterns and torque converter clutch apply and release.

Engine idle speed
The transmission decoder module (XJ6), rotary switch (XJS) outputs gear position signals to the ECM. When the gear selector is in R, D, 2 or 3, the signal is 5 volts; when the gear selector is in P or N, the signal is ground or 0 volts. The ECM uses the gear position inputs to control idle speed and for DTC 69. Refer to Ignition Timing, page 29, and Idle Speed Control, pages 26 – 27, for a detailed explanation.

Instrument Pack Interface

Vehicle road speed
The instrument pack outputs a road speed signal (pulsed signal) to the ECM. The ECM uses the signal to determine idle speed control functions.

Low fuel level (1992 MY ON [ECM part no. DBC 9622 ON])
The instrument pack outputs a fuel level voltage signal to the ECM. When the voltage drops below 5.7 volts (2.5 gallons [11 litres] fuel remaining), fuel metering diagnostics (OBD) are canceled. Cancelling the fuel metering diagnostics prevents the ECM from flagging DTCs caused by the vehicle running out of fuel.

Engine speed
Engine speed is output to the instrument pack for operation of the tachometer. Engine speed is sensed from the ignition coil primary circuit (1990 – 92 MY Sedan and XJS). The ECM outputs an engine speed signal (pulsed signal) to the instrument pack (1993 MY ON Sedan).

Fuel metering pulse
The ECM outputs a fuel metering pulse to the instrument pack for use by the trip computer (average fuel consumption, instantaneous fuel consumption).

Fuel fail warning
If the OBD system detects a fault, the ECM outputs a fuel fail warning signal (ground) to the instrument pack. Refer to On-Board Diagnostics, page 35.

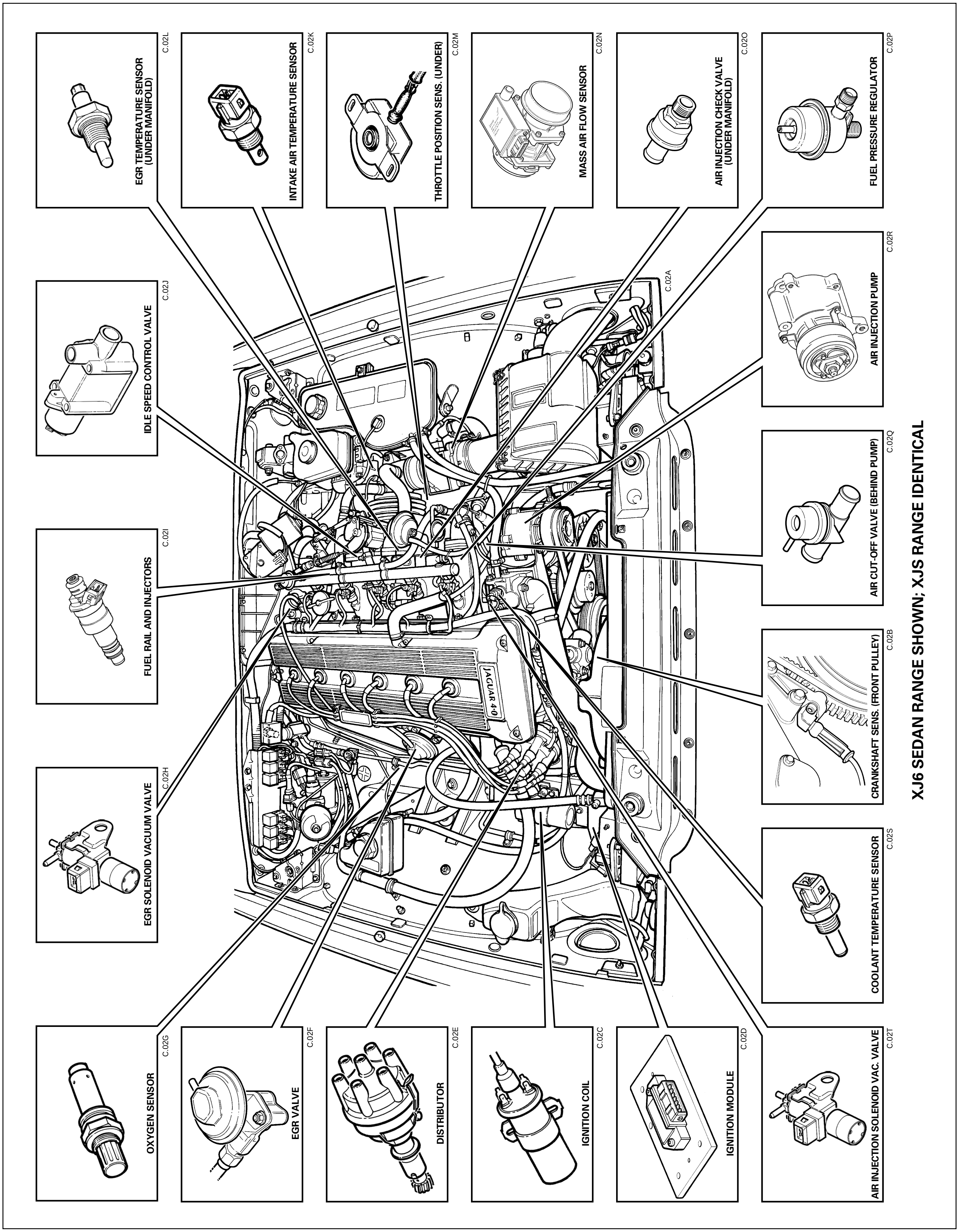
Air Conditioning Compressor Clutch Interface

When the air conditioning compressor clutch is operating, a parallel circuit applies battery voltage to the ECM. The ECM uses this signal to determine the need for idle speed control compensation.

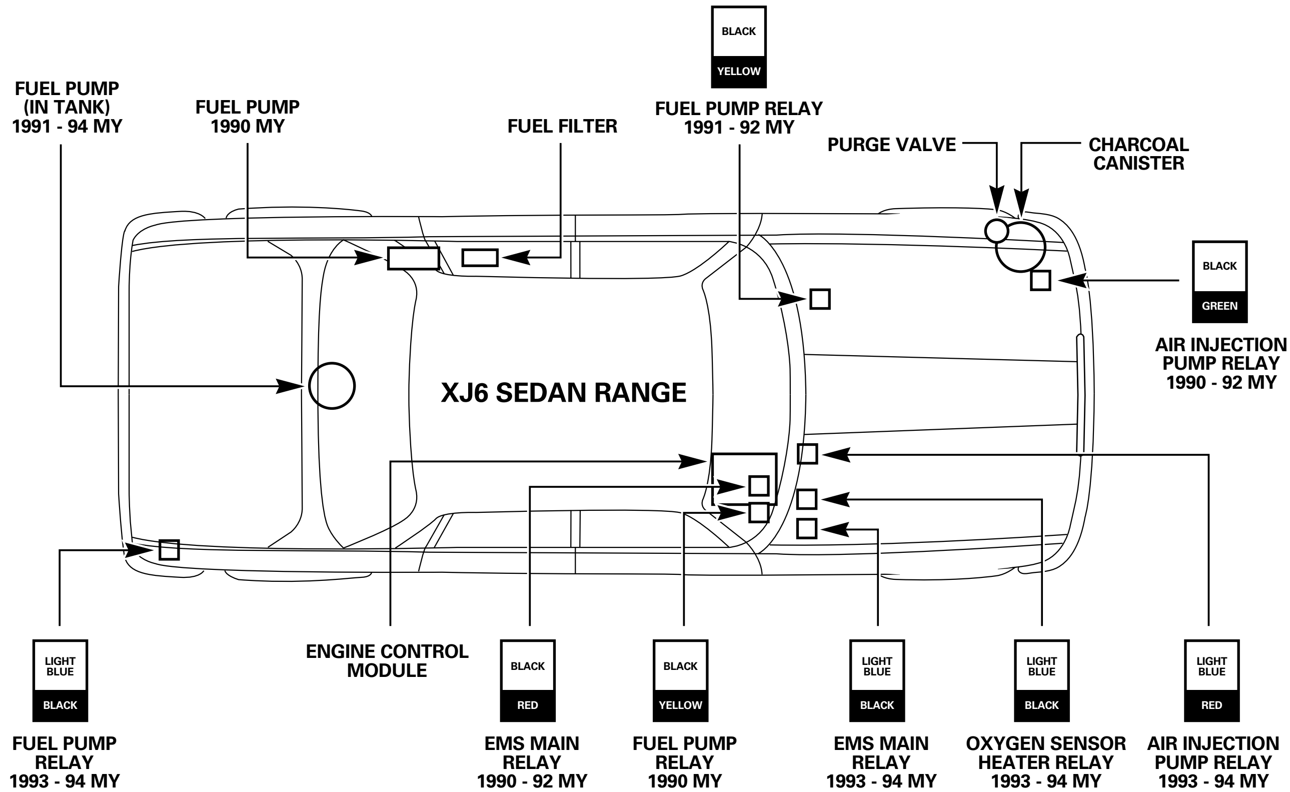
Serial Communication

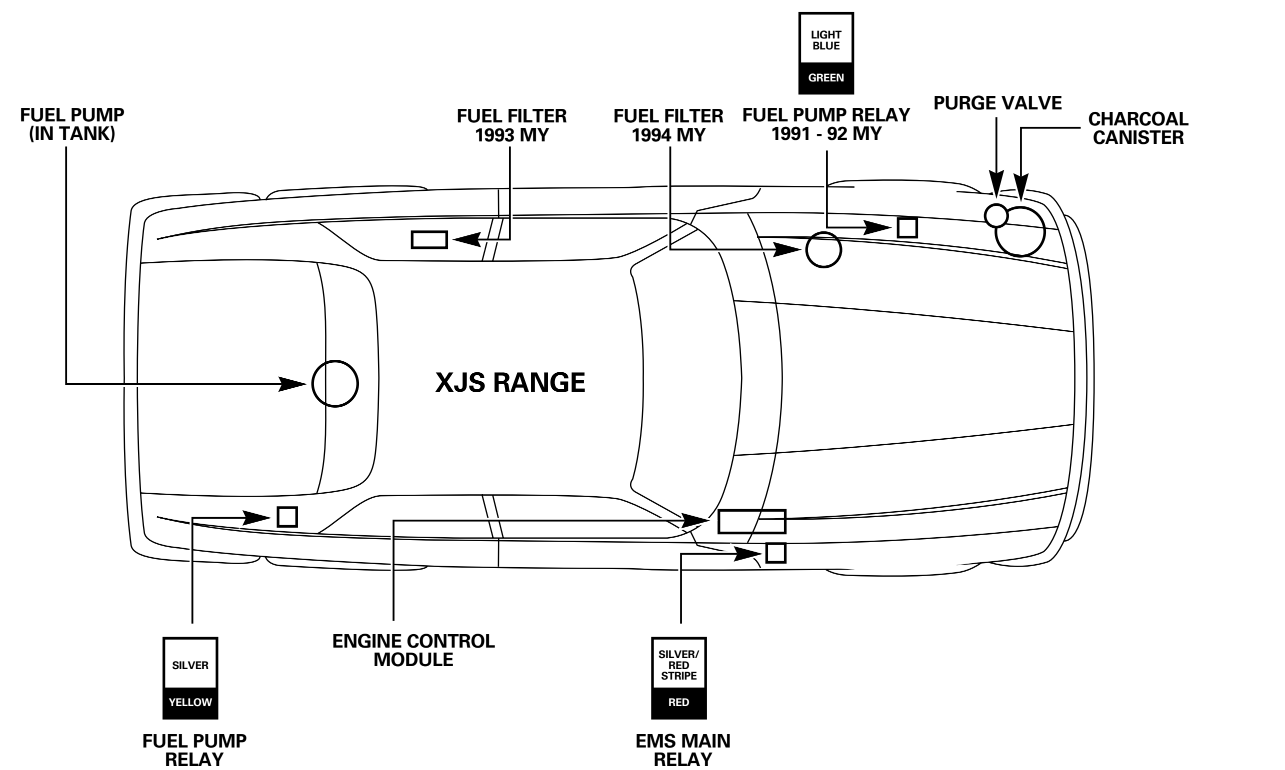
Serial communication between the engine management system and JDS or PDU is available. Serial communication is used for engine setup, accessing stored DTCs, fault diagnosis and erasing DTCs.

EMS Components Installed on Engine



EMS Components Installed on Vehicle

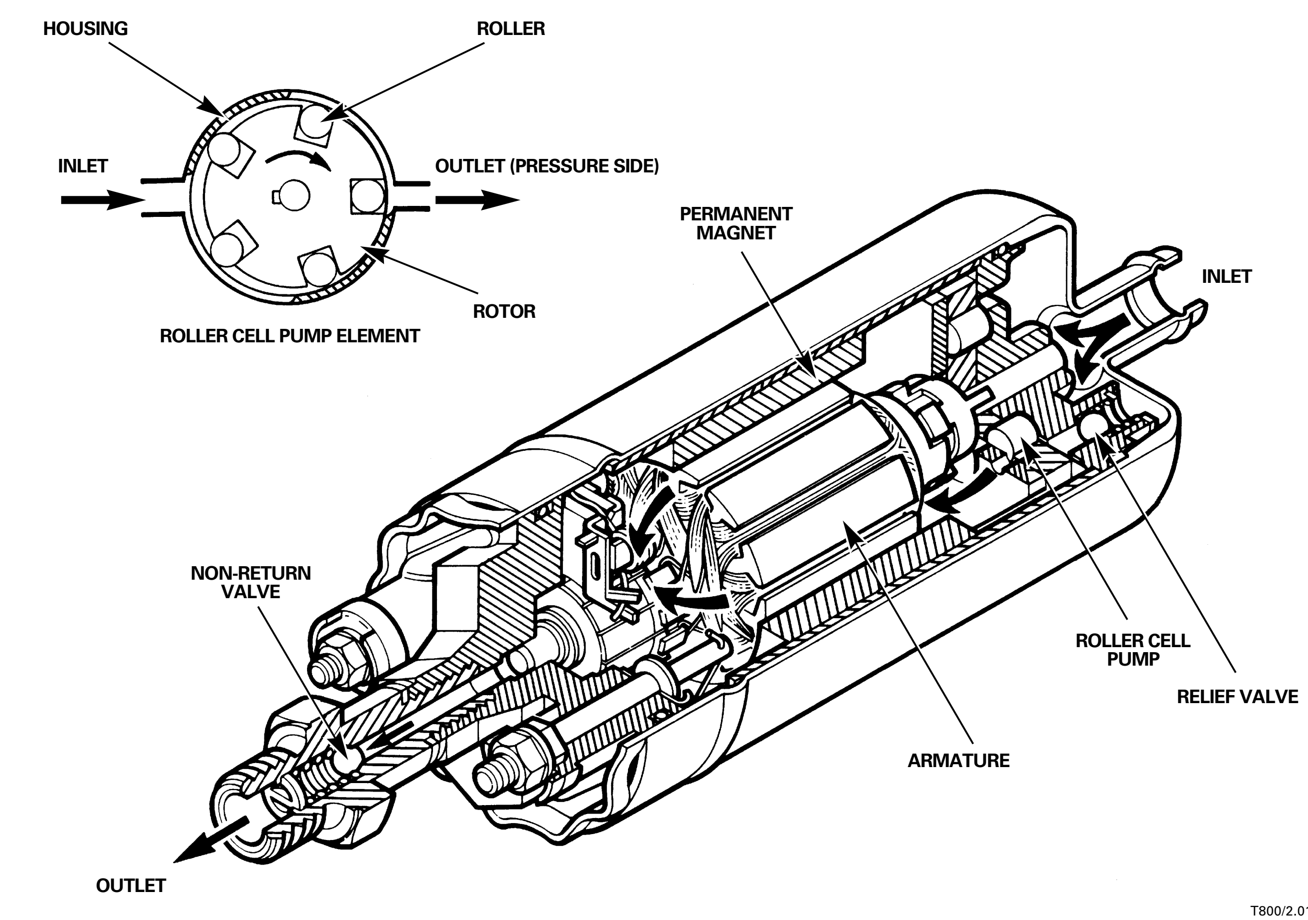




Fuel Pump (XJ6 Sedan 1990 MY)

The in-line fuel pump is a roller type pump driven by a permanent magnet electric motor. An eccentric rotor mounted on the armature shaft has metal rollers housed in pockets around the circumference. When the motor is energized, centrifugal force acting on the rollers forces them outward so that they act as seals. The fuel between the rollers is then forced to the outlet side of the pump. A replaceable non-return valve is threaded into the pump outlet. The non-return valve prevents fuel pressure loss when the pump is not running. The pump is located on the rear suspension subframe.

FUEL PUMP: XJ6 SEDAN RANGE 1990 MY



Fuel Pump Module (1991 MY ON vehicles)

The fuel pump is an integral component of an in-tank fuel pump module. The fuel pump module mounts in a rubber holder attached to the bottom of the fuel tank on brackets. The fuel pump module and the rubber holder are indexed to ensure correct alignment in the tank.

Fuel is drawn from the fuel tank through a 70 micron filter at the base of the module, then through a 400 micron filter at the pump inlet. The pump delivers the fuel to the fuel rail through a renewable in-line filter mounted to the underbody. Unused fuel is returned to the fuel pump module where it passes through another 70 micron filter. A small portion of the pressurized fuel flows through a venturi “teed” into the supply side inside the module. This flow enables a “jet pump” to pick up fuel so that the module remains full at all times.

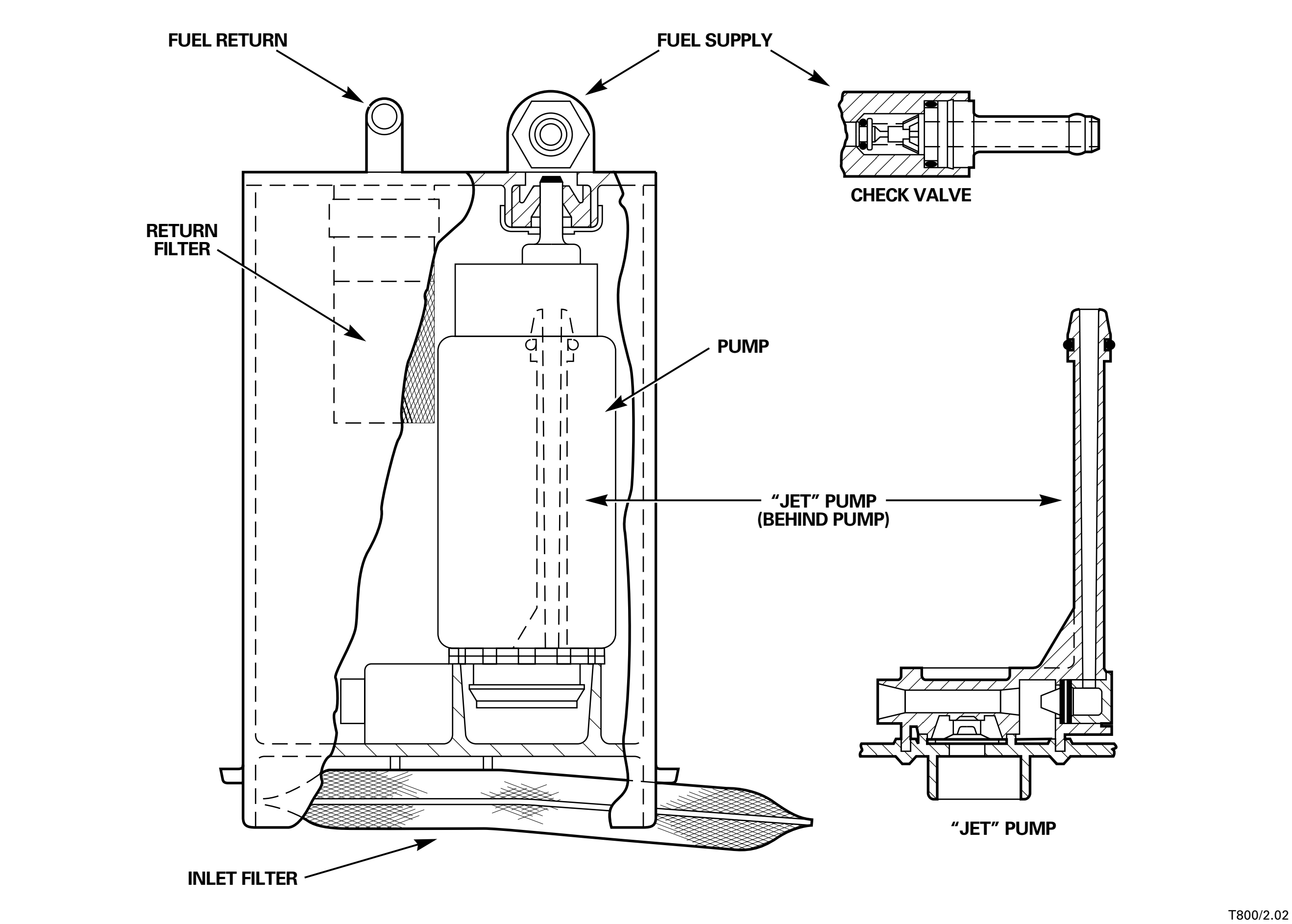
Both the outlet and return ports through the pump module have check valves. The outlet check valve reduces back flow from the fuel rail when the pump is off. The return check valve holds fuel pressure in the return line from the fuel rail and prevents siphoning if a fuel line is disconnected.

The inlet filter must not be folded or damaged and must be squarely mounted on its neck. If the filter is damaged in any way, the fuel pump module must be replaced.

Fuel Pump Specifications

Speed	7000 rpm
Flow rate	640 ml / 20 sec. @ 36 psi
Current	8 – 9 A @ 13.2 volts and 36 psi

FUEL PUMP MODULE: 1991 MY ON VEHICLES

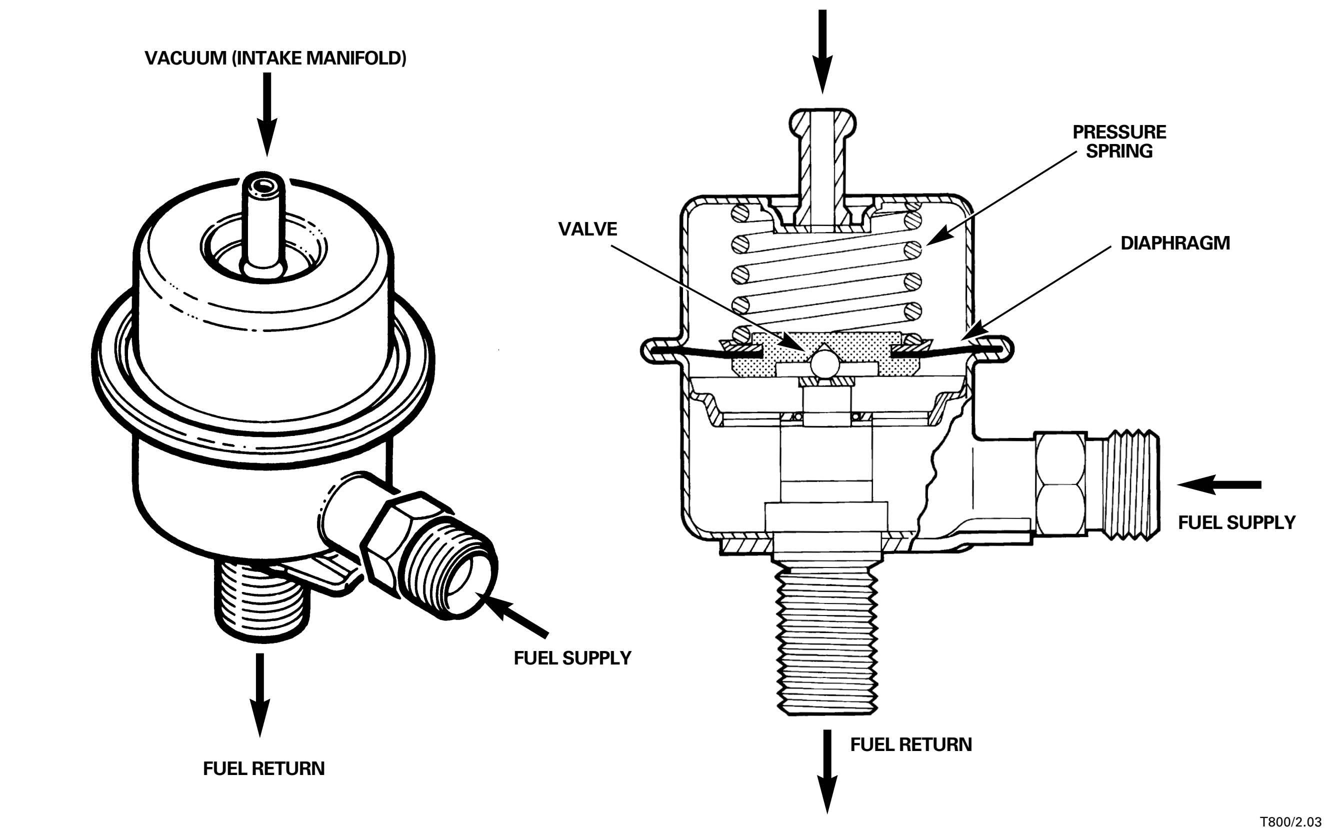


Fuel Pressure Regulator

Fuel is pumped to the fuel rail and injectors, where fuel pressure is controlled by the fuel pressure regulator. Excess fuel, above the engine requirement, is returned to the fuel tank. The pressure regulator spring chamber above the diaphragm is referenced to intake manifold vacuum. The differential pressure across the fuel injector nozzles is therefore maintained constant at 44 psi (3.0 bar) and the quantity of fuel injected for a given injector pulse duration is also constant. Fuel pressure measured on a test gauge will vary between 32 psi (2.3 bar) at overrun to 44 psi (3.0 bar) at full load.

The fuel pressure regulator is located as close as possible to the fuel rail so that good dynamic control of fuel pressure is achieved. This design provides the same pressure across each injector, and delivers an equal quantity of fuel to each of the six cylinders.

FUEL PRESSURE REGULATOR



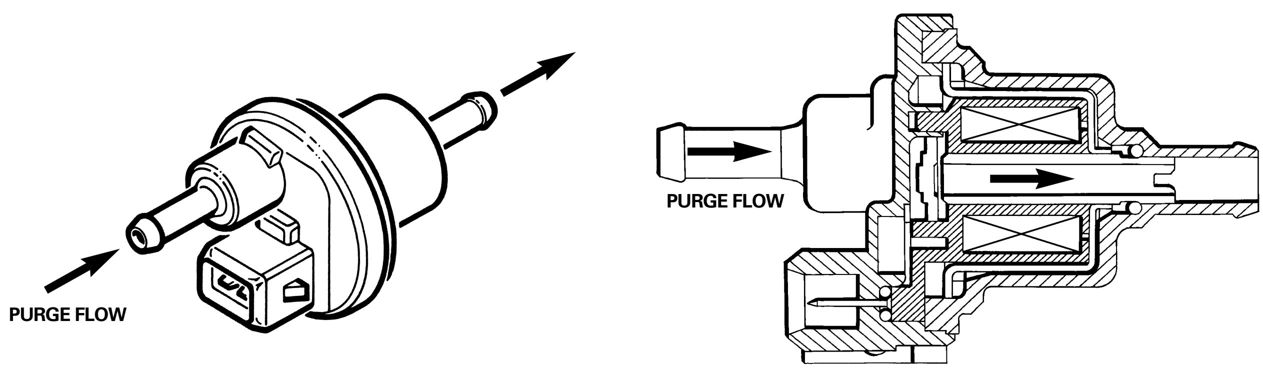
The main component of the pressure regulator is the diaphragm, below which a steel ball valve is mounted on a disc. The upper side of the diaphragm incorporates a spring retaining cup. Spring length is set during manufacturing by deforming the top cover until the fuel pressure at which the diaphragm lifts at atmospheric pressure is set at 44 psi (3.0 bar). A filter screen prevents any small pieces of debris from the fuel rail becoming trapped under the disc.

The tube on the top of the upper case is connected to the intake manifold. During engine operation, intake manifold vacuum “assists” the pressurized fuel to lift the diaphragm against the spring. When fuel pressure exceeds the control value, the valve lifts off the seat allowing a portion of the fuel to be directed to the outlet port, thereby maintaining fuel pressure at the control value. The excess fuel is returned to the fuel tank.

Purge Valve

The engine management ECM operates the purge control valve to allow a regulated vapor flow to the intake manifold dependent on engine operating conditions. The purge valve is a solenoid operated “duty cycle” valve that is normally open. The valve closing and subsequent rate of vapor flow (opening) is varied by the “length” of a pulsed electrical signal provided from the ECM. The resistance of the purge valve coil is approximately 42 ohms. The purge valve is located in the left front fender arch, next to the charcoal canister.

PURGE VALVE

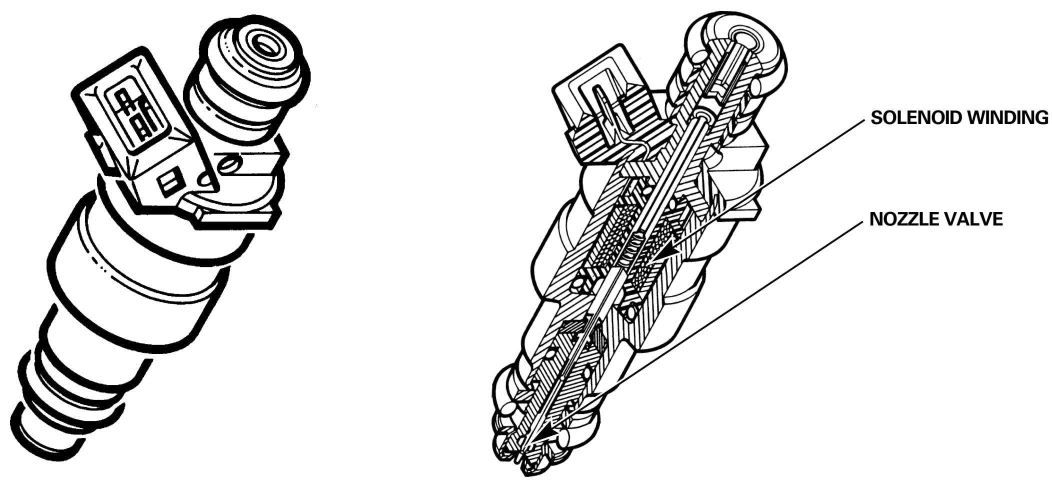


T800/2.04A, B

Fuel Injectors (1990 – 1992 MY)

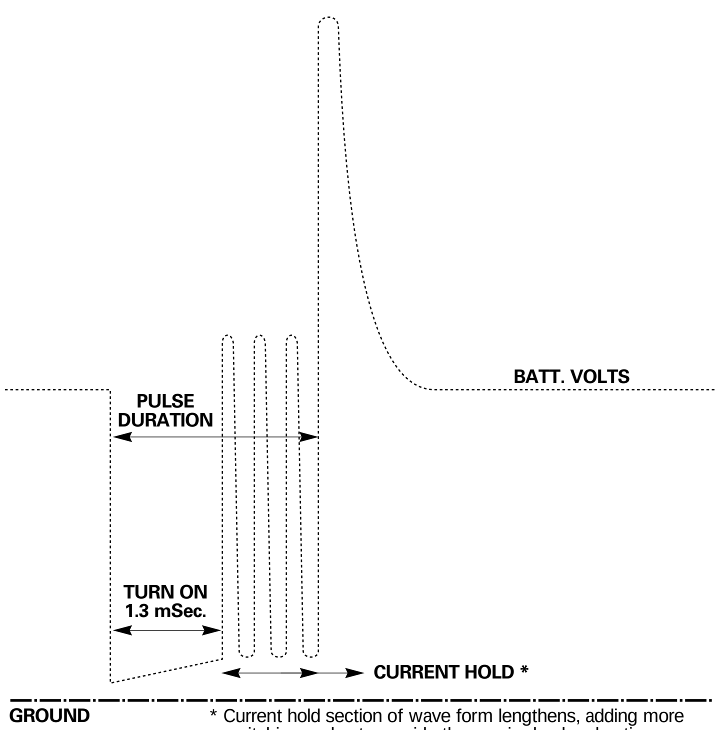
The fuel injectors are solenoid operated valves that are pulsed by the ECM. The mechanical design of the injectors incorporates a pintle valve with a waisted shape tip passing through the orifice at the bottom of the injector body. The waisted shape of the pintle tip and orifice cause the fuel flow to form a cone-shaped spray of small fuel particles. The fuel inlet at the top of the injector has a small filter to trap any debris that may be present in the fuel. "O" Rings are used to seal the injector between the fuel rail and intake manifold.

PINTLE-TYPE FUEL INJECTOR



T800/2.05A, B

INJECTOR WAVE FORM



* Current hold section of wave form lengthens, adding more switching cycles to provide the required pulse duration.

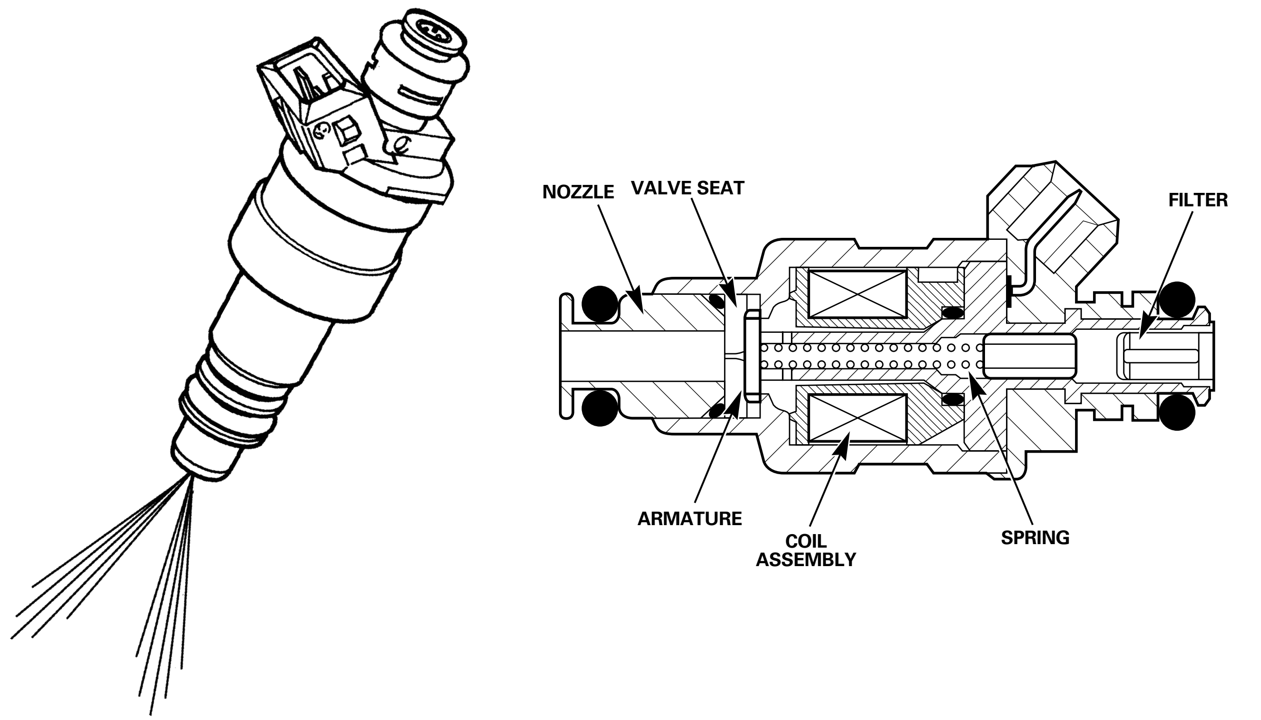
T800/2.06

The electrical pulses applied to the injector coil by the ECM attract the head of the pintle to the coil armature. This action overcomes spring pressure and allows fuel to flow through the annulus between the pintle tip and the orifice. Full valve lift (approximately 0.006 in) is reached in about 1 millisecond. The resistance of the fuel injector coil is approximately 2.5 ohms.

Fuel Injectors (1993 MY ON)

The basic design and operation of the fuel injectors is similar to the earlier type; however, the injector tips use a plate-type, twin-spray design. This design has several benefits: it aims a fuel spray a each intake valve throat, it is quieter in operation, and the tip is less prone to contamination. The injectors are secured to the fuel rail with custom clips that ensure the twin jets of fuel are directed to the intake valve throats. A green band is used to identify the plate-type, twin-spray injector.

TWIN-SPRAY FUEL INJECTOR

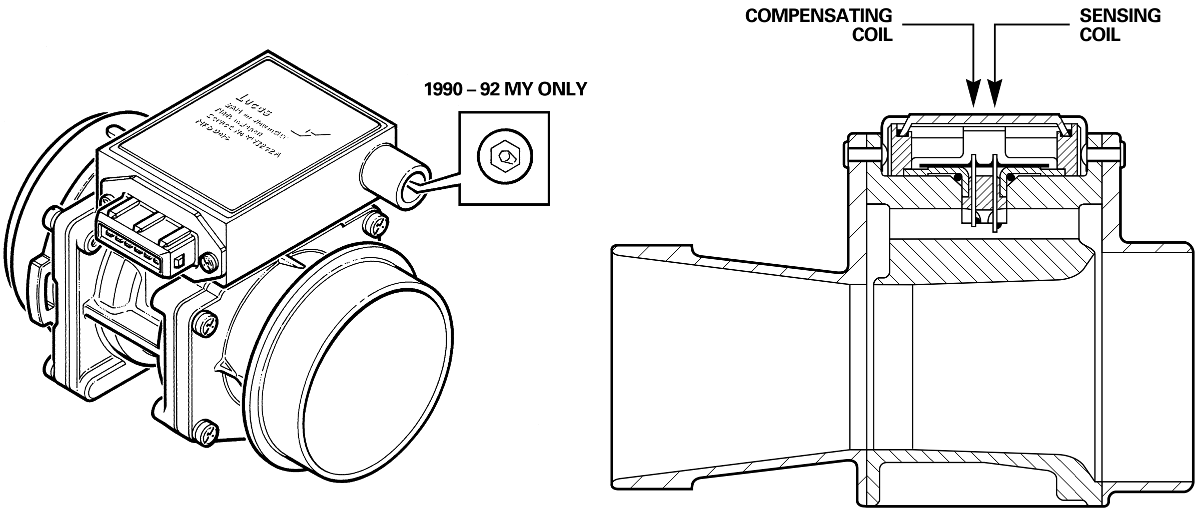


T800/2.07A, B

Mass Air Flow Sensor

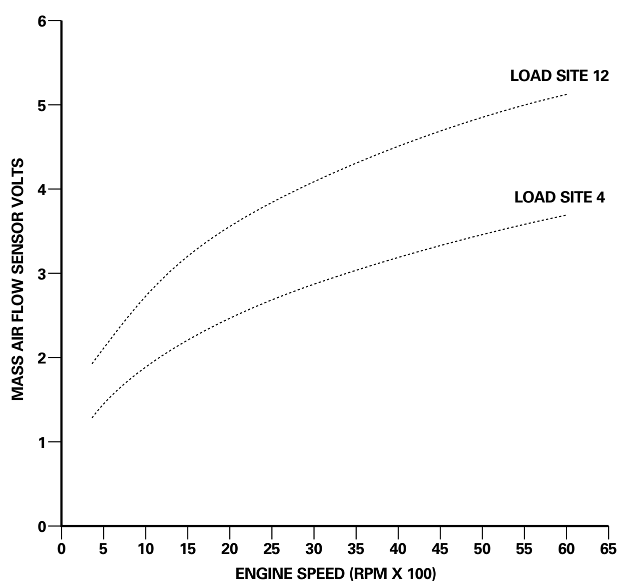
The mass air flow sensor, located in the intake tract downstream of the air cleaner, measures the volume of air flow into the engine intake. The sensor has a cast alloy body with an integral electronic module. Some of the air flows through a bypass channel containing two small wire coils: a sensing coil and a compensating coil. The sensing coil is electrically heated by the electronic module; the compensating coil remains unheated.

MASS AIR FLOW SENSOR



T800/2.08A, B

LOAD SITES 4 & 12 VERSUS ENGINE SPEED



T800/2.09

Intake air volume is determined by measuring the electrical current required to keep the temperature differential of the two coils constant. This measurement occurs in the circuitry of the sensor. The sensor then provides a voltage signal representing air flow to the ECM. The theoretical full range of the signal is 0 – 5 volts. Idle voltage is normally 1.10 – 1.40 volts and torque converter stall (full throttle; 1850 – 2150 rpm) voltage is normally 3.00 – 3.30.

On 1990 to 1992 MY vehicles, an adjustable potentiometer is incorporated into the mass air flow sensor to provide for idle fuel trim adjustment during initial engine setup. This potentiometer operates independently of the air flow elements and provides a constant voltage signal to the ECM. The idle trim potentiometer has an adjustment range of approximately 0 – 1000 ohms, measured between pins 1 and 6 of the mass air flow sensor connector. The ECM applies a 5 volt reference to pin 6 and a ground to pin 1. With the mass air flow sensor connected, the reference measured at pin 6 must be less than 4 volts or DTC 11 will be flagged. Typically, the voltage is between 2 and 3 volts.

During 1994 MY, gold-plated connector pins were introduced to prevent corrosion and resistance build-up. The gold-plated pins can be identified by their color.

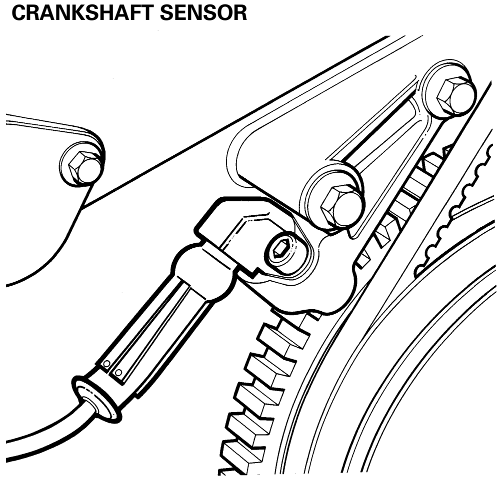
⚠ CAUTION! Tin-plated pins and gold-plated pins must not be matched; they are not compatible.

Crankshaft Sensor

The crankshaft sensor provides both engine speed and crankshaft position signals to the ECM. The sensor is a variable reluctance device, consisting of a bobbin coil with a magnetic core. The resistance of the coil is approximately 1.35 kilo ohms. The steel teeth on the crankshaft timing ring are used as a rotor. As the rotor teeth pass by the crankshaft sensor, pulses are generated.

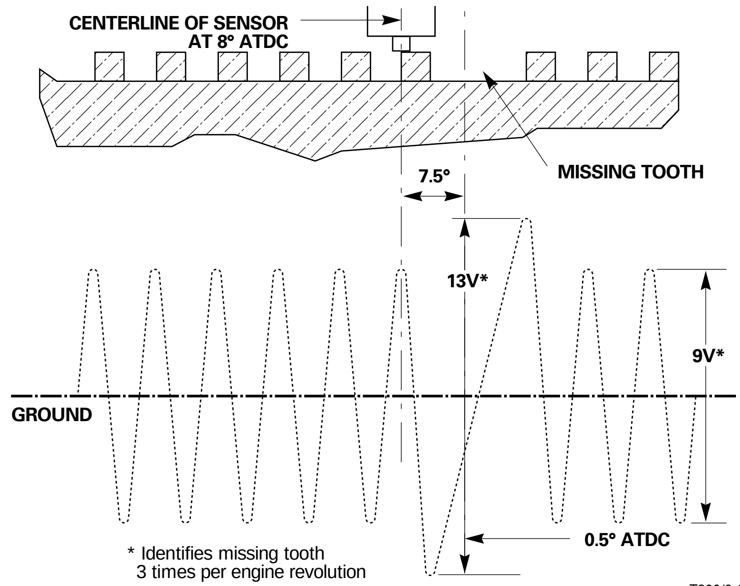
The rotor has 60 tooth positions set at 6° intervals with three teeth missing. The gaps identify the TDC position of the 6 cylinders during one complete engine cycle (two crankshaft revolutions). The rotor thus provides both engine speed and crankshaft position information to the ECM. The missing pulses identify crankshaft position. Each tooth pulse after the missing pulse represents 6° of crankshaft rotation. Thus the frequency of the toothed pulses are a measure of engine speed. The sensor is mounted to the timing cover on the front of the engine.

CRANKSHAFT SENSOR



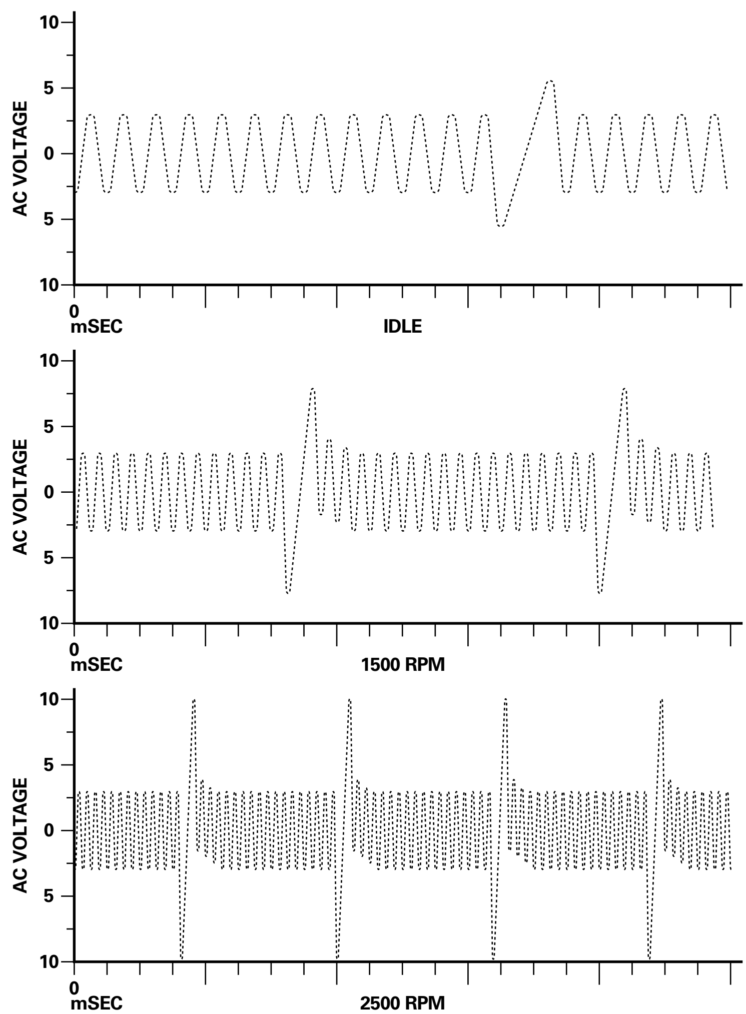
T800/2.10

CRANKSHAFT SENSOR SIGNAL



T800/2.11

CRANKSHAFT SENSOR SIGNAL AT VARIOUS ENGINE SPEEDS



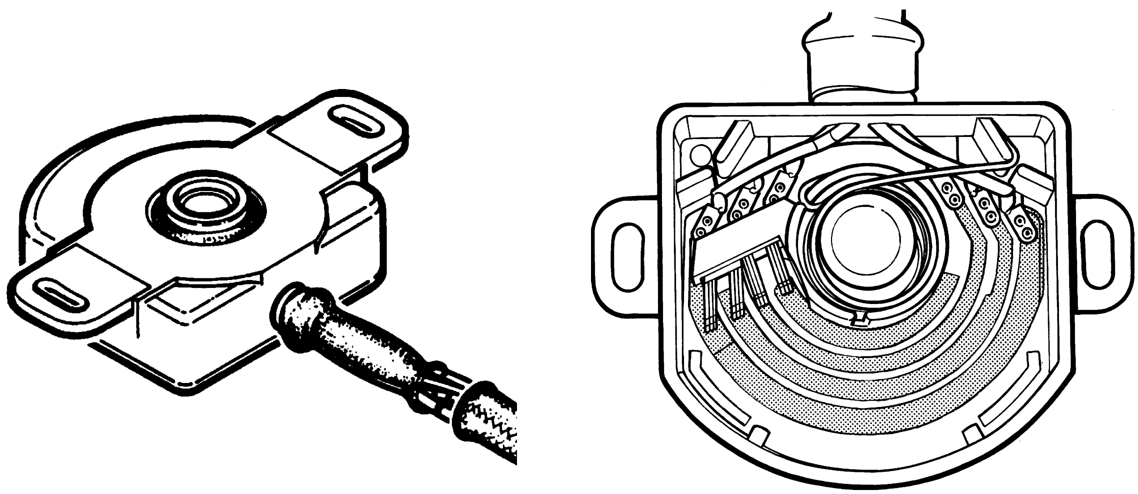
T800/2.12

Throttle Position Sensor

The throttle position sensor is a twin track design containing two separate potentiometer tracks with wipers driven by a common spindle. The sensor is mounted on the throttle housing with the spindle connected to the throttle shaft. One potentiometer track is used by the engine management system; the other track is used by the transmission control system. Both potentiometers have the same resistance, voltage and angle of rotation characteristics. The range of resistance is approximately 500 ohms to 5.5 kilo ohms. The throttle position sensor provides a voltage signal to the ECM that indicates throttle position and movement. The theoretical full range of the signal is 0 to 5 volts.

The throttle position sensor output relative to the throttle valve position is set at closed throttle using JDS or PDU. The ECM software function that recognizes closed throttle is "adaptive" and will "learn" that voltage in a range from 0.25 to 0.75 volts is the closed throttle position. However, to avoid the ECM having to relearn the idle setting each time the battery is disconnected, the idle voltage should be set very close to 0.6 volts.

THROTTLE POSITION SENSOR



T800/2.13

The ECM uses the voltage signal provided by the sensor for a number of ECM functions:

Throttle Position	ECM Function
Throttle closed (signal 0.25 – 0.75 volts)	Idle speed control function Ignition idle strategy Overrun fuel cut-off Idle fuel trim (adjustable mass air flow sensor potentiometer only) Adaptive idle fueling trim
Part throttle (signal above closed throttle voltage and below full throttle voltage)	Main fuel metering strategy Main ignition strategy EGR enabled
Opening throttle (signal voltage increasing)	Acceleration enrichment
Closing throttle (signal voltage decreasing)	Deceleration leaning
Full throttle (signal greater than 3 volts)	Full load enrichment (load dependent)

NOTE: Other sensor inputs are required for the initiation of most of the above listed ECM functions.

Coolant Temperature Sensor

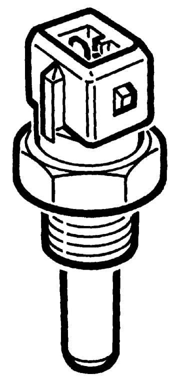
The coolant temperature sensor, located on the thermostat housing, is a negative temperature coefficient (NTC) thermistor. NTC means that the resistance of the thermistor decreases as the sensed temperature increases. Pin 1 of the sensor is connected to ground through the ECM. The ECM applies 5 volts to pin 2 of the sensor and monitors the voltage across the sensor pins. The theoretical full voltage range is from 5 to 0 volts representing maximum cold to maximum hot.

The ECM converts the monitored voltage into a digital number that relates to an engine coolant temperature. The temperature signal is then used for a number of functions:

- Cranking enrichment
- Warm-up enrichment
- Acceleration enrichment
- Air injection
- Idle speed control
- Enable EGR
- Evaporative canister purge

NOTE: Other sensor inputs are required for the initiation of most of the above listed ECM functions.

COOLANT TEMPERATURE SENSOR



T800/2.14

Coolant temperature sensor – temperature versus resistance:

Coolant temperature °F	°C	Resistance (kilo ohms)
14	-10	9.20
32	0	5.90
50	10	3.70
68	20	2.50
86	30	1.70
104	40	1.18
122	50	0.84
140	60	0.60
158	70	0.435
176	80	0.325
193	90	0.25
212	100	0.19

Coolant temperature sensor – temperature versus typical approximate voltage:

Coolant temperature °F	°C	Voltage (measured at ECM Yellow connector pin 2 or sensor pin 2)
14	-10	4.05
32	0	3.64
59	15	2.89
78	25	2.42
86	30	2.20
104	40	1.78
122	50	1.44
140	60	1.17
158	70	0.95
176	80	0.78
193	90	0.65
212	100	0.55

Intake Air Temperature Sensor

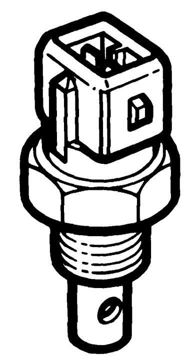
The air temperature sensor, located in the air intake elbow, is a negative temperature coefficient (NTC) thermistor. NTC means that the resistance of the thermistor decreases as the sensed temperature increases. The air temperature sensor construction differs from the coolant temperature sensor in that the thermistor element is exposed by holes in the tip of the housing. The holes are designed to allow fast response in measuring air temperature changes while at the same time providing the necessary mechanical protection. Pin 1 of the sensor is connected to ground through the ECM. The ECM applies 5 volts to pin 2 of the sensor and monitors the voltage across the sensor pins. The theoretical full voltage range is from 5 – 0 volts representing maximum cold to maximum hot.

The ECM converts the monitored voltage into a digital number that is used to control the ignition timing strategy. Refer to Ignition Timing Control on pages 29 – 31.

Intake air temperature sensor – temperature versus resistance:

Intake air temperature °F	°C	Resistance (kilo ohms)
14	-10	9.20
32	0	5.90
50	10	3.70
68	20	2.50
86	30	1.70
104	40	1.18
122	50	0.84
140	60	0.60
158	70	0.435
176	80	0.325
193	90	0.25
212	100	0.19

AIR TEMPERATURE SENSOR



T800/2.15

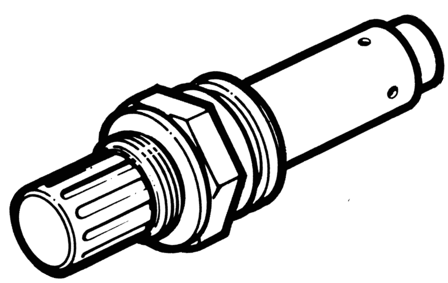
Intake air temperature sensor – temperature versus typical approximate voltage:

Intake air temperature °F	°C	Voltage (measured at ECM Yellow connector pin 20 or sensor pin 1)
14	-10	4.05
32	0	3.64
59	15	2.89
78	25	2.42
86	30	2.20
104	40	1.78
122	50	1.44
140	60	1.17
158	70	0.95
176	80	0.78
193	90	0.65
212	100	0.55

Oxygen Sensor

The oxygen sensor, located in the exhaust down pipe after the first catalyst, is a device that produces voltage by conducting oxygen ions at temperatures above 572°F (300°C). In order to reduce the amount of exhaust gas and resulting emission needed to bring the sensor up to working temperature, an internal electric heater is used. The tip portion of the sensor ceramic element is in contact with the exhaust gas. The remaining portion of the ceramic element is in contact with ambient air via capillary action through the heater electrical wires.

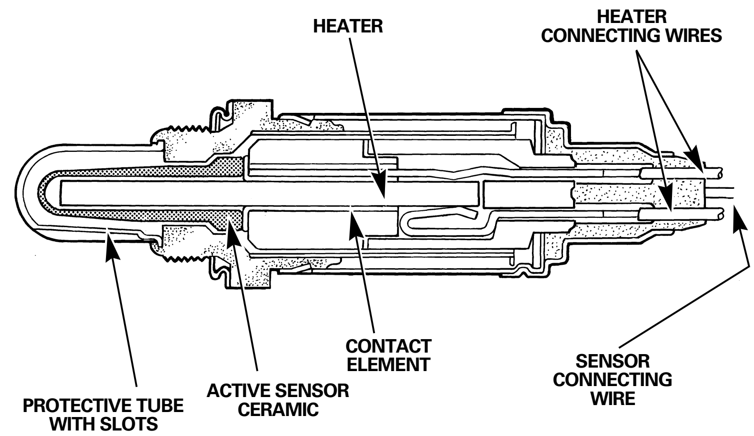
OXYGEN SENSOR



T800/2.16A

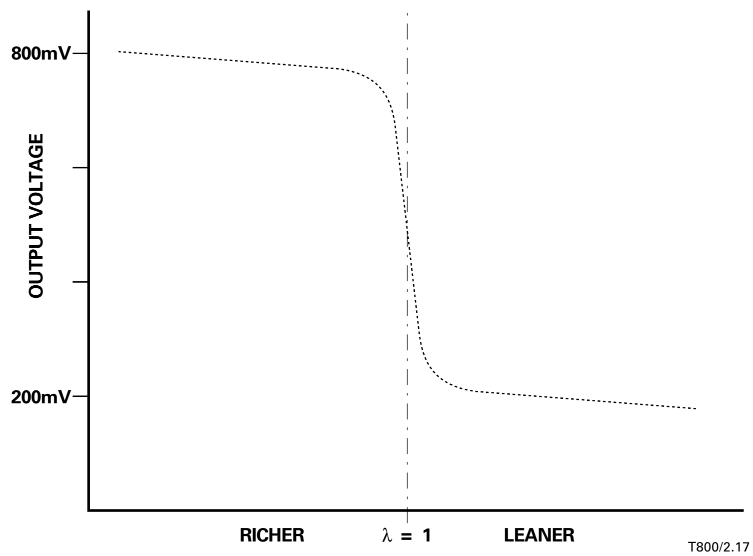
The sensor voltage output switches between approximately 800 millivolts and approximately 200 millivolts depending on the oxygen level differential between ambient air and exhaust gas on either side of the ceramic element. When the air / fuel ratio is richer than 14.7 : 1 (Lambda = 1.0), the voltage output is high; when the air / fuel ratio is leaner than 14.7 : 1 (Lambda = 1.0), the output voltage is low. Only a very small change in air / fuel ratio is required to switch the oxygen sensor.

OXYGEN SENSOR CROSS SECTION



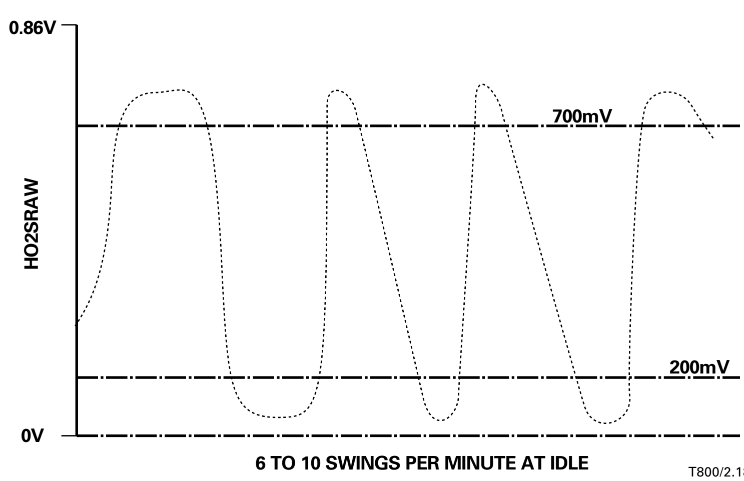
T800/2.16B

OXYGEN SENSOR CHARACTERISTIC



T800/2.17

OXYGEN SENSOR VOLTAGE TRACE: PDU HO2SRAW

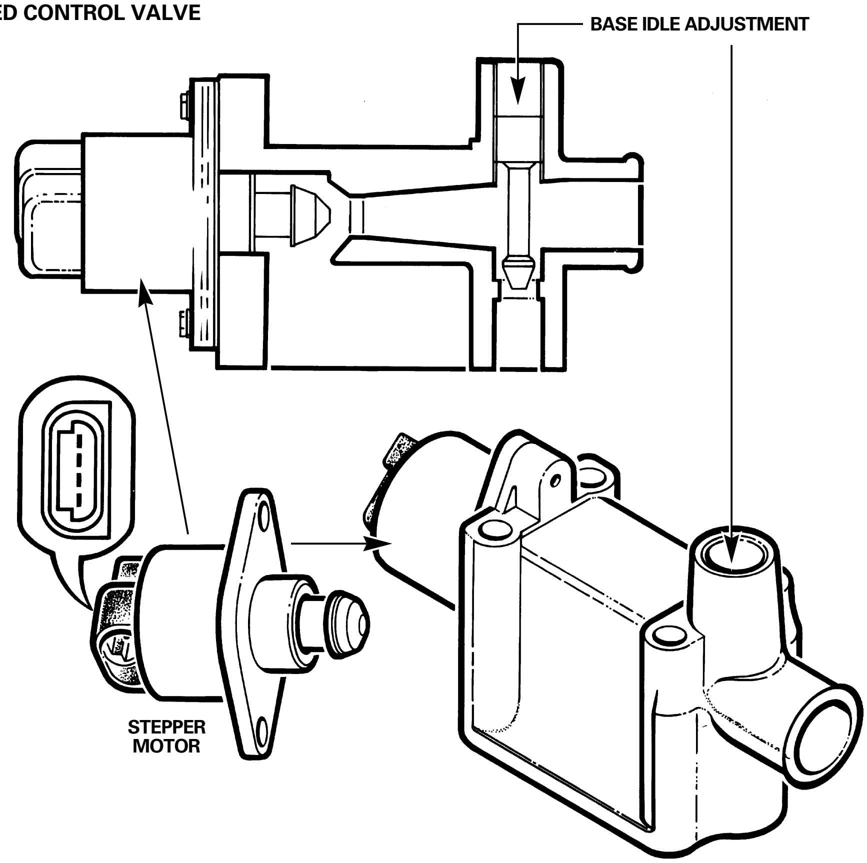


T800/2.18

Idle Speed Control Valve

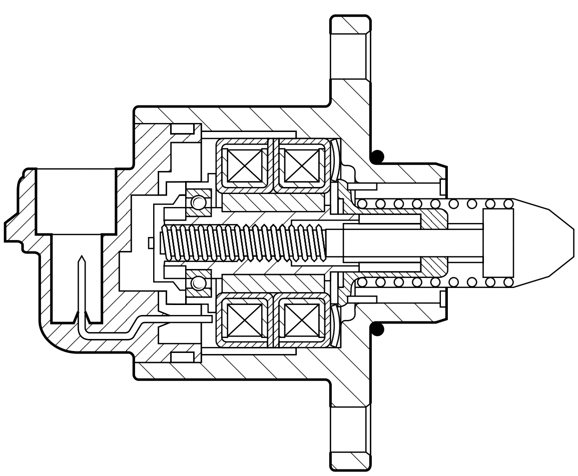
The idle speed control valve assembly, located on the top of the intake manifold, contains a manually adjusted base idle throttle bypass passage and an additional variable bypass passage. The flow of bypass air through the variable passage is regulated by a stepper motor driven by the ECM. The stepper motor has two coils that are pulsed by the ECM. The pulses are phased 90° apart. The order in which the coils are pulsed determines the direction of stepper motor travel. The coil resistance is approximately 50 ohms.

IDLE SPEED CONTROL VALVE



T800/2.19

STEPPER MOTOR CROSS SECTION



T800/2.20

The stepper motor has a total travel from fully opened to fully closed of approximately 230 steps.

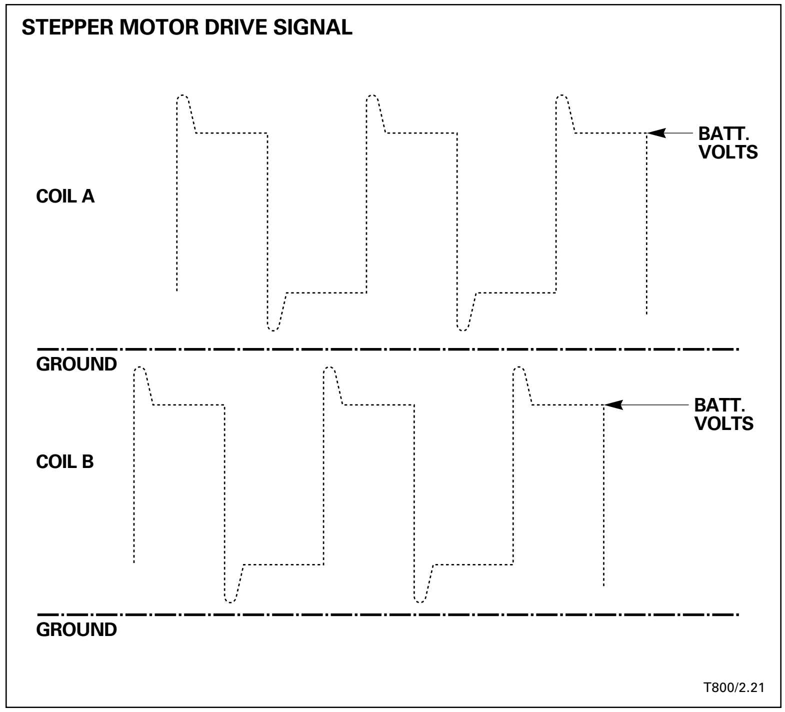
During engine setup (using JDS or PDU), the stepper motor is positioned at 200 steps from fully opened to allow the base idle speed to be set, using the manual air bypass screw. Once the base idle speed is set correctly, the stepper motor will hold the closed loop idle speed within a few rpm of the nominal idle speed (700 rpm in "N" and 580 rpm in "D"; normal operating coolant temperature).

When the ignition is switched off, the control valve indexes to a known "parked" position.

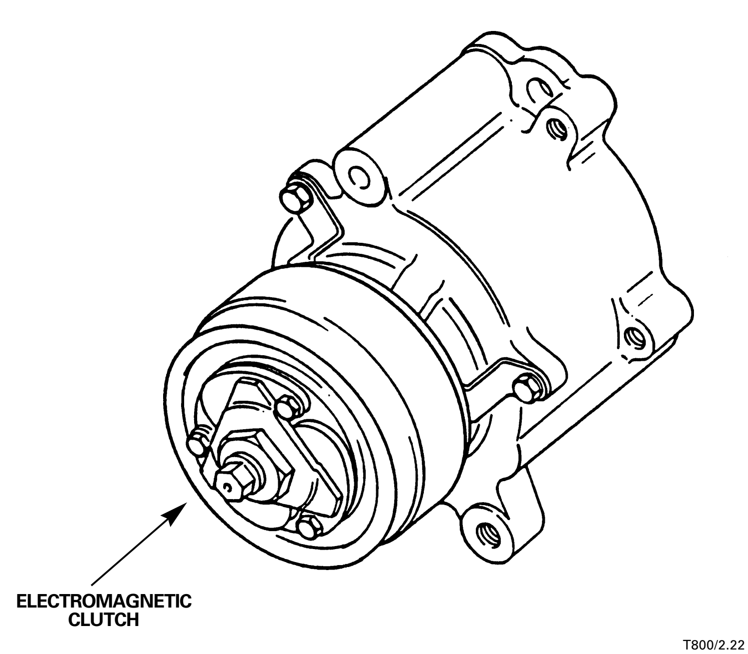
On 1990 model year vehicles, the reference is from the fully opened position. On later vehicles, the reference is from the fully closed position.

On 1993 and later model years, there is a 7-second delay after the ignition is switched off before the control valve closes.

To accurately maintain a correct idle speed, the ECM "learns" the idle stepper position. If the ECM is disconnected from battery power, the idle position must be relearned. The simple way to allow the ECM to relearn the position is to start the engine from cold and allow it to idle until fully warm, then drive the vehicle for a short distance.



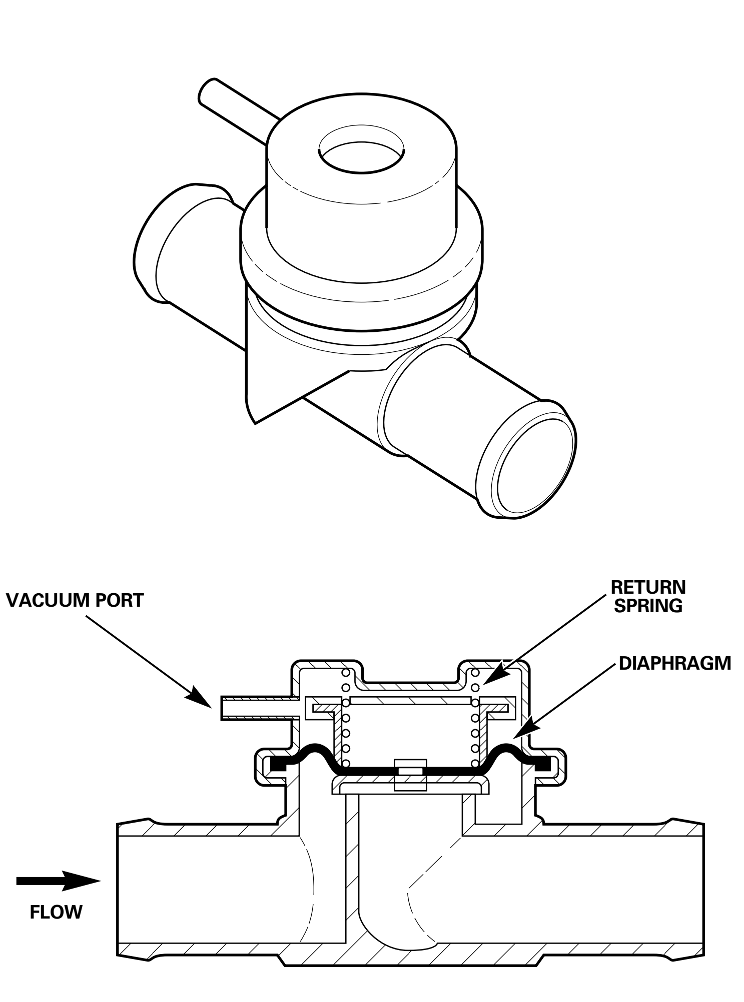
AIR PUMP



Air Pump

The mechanical rotary vane air pump is belt driven through an electromagnetic clutch. The clutch allows the pump to be engaged/disengaged by the ECM (via the air injection relay. If the engine speed exceeds 2500 rpm while air injection is enabled, the ECM will switch off the circuit to prevent over speeding the air pump. Excessive back pressure would damage the pump.

AIR SWITCHING VALVE



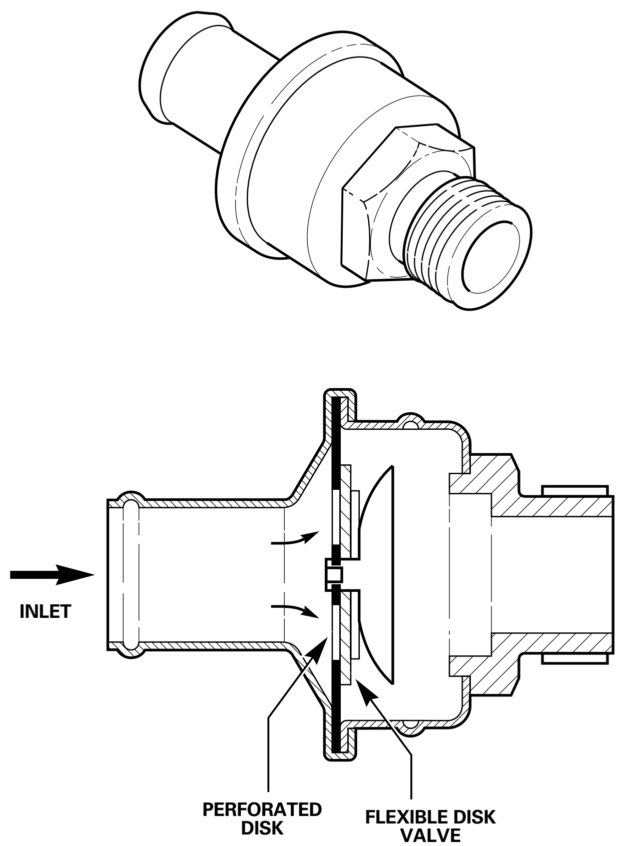
Air Switching Valve

The vacuum actuated air switching valve, located behind the air pump, contains a spring-loaded diaphragm valve resting on a seat. When vacuum is applied, the diaphragm lifts to allow air flow.

Air Injection Check Valve

The check valve, located in the delivery tube behind the air pump, prevents the back-flow of exhaust gas to the air pump.

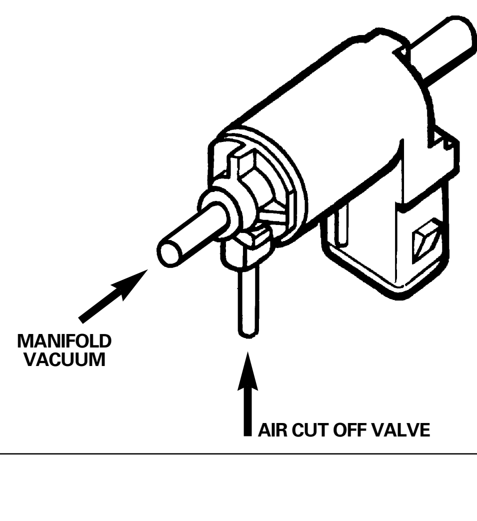
AIR INJECTION CHECK VALVE



Air Injection Solenoid Vacuum Valve

The air injection solenoid vacuum valve is located at the left front corner of the engine. When activated via the air injection relay, the normally closed solenoid valve opens to apply intake manifold vacuum to the air switching valve. The resistance of the solenoid coil is approximately 45 ohms.

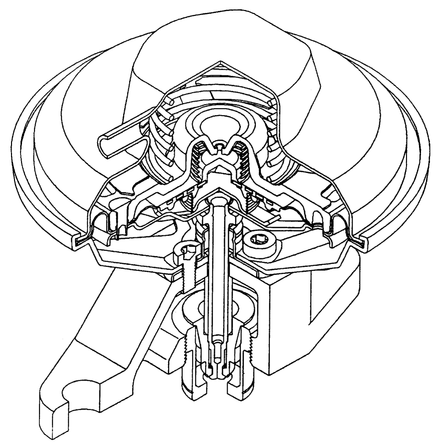
AIR INJECTION SOLENOID VACUUM VALVE



EGR Valve

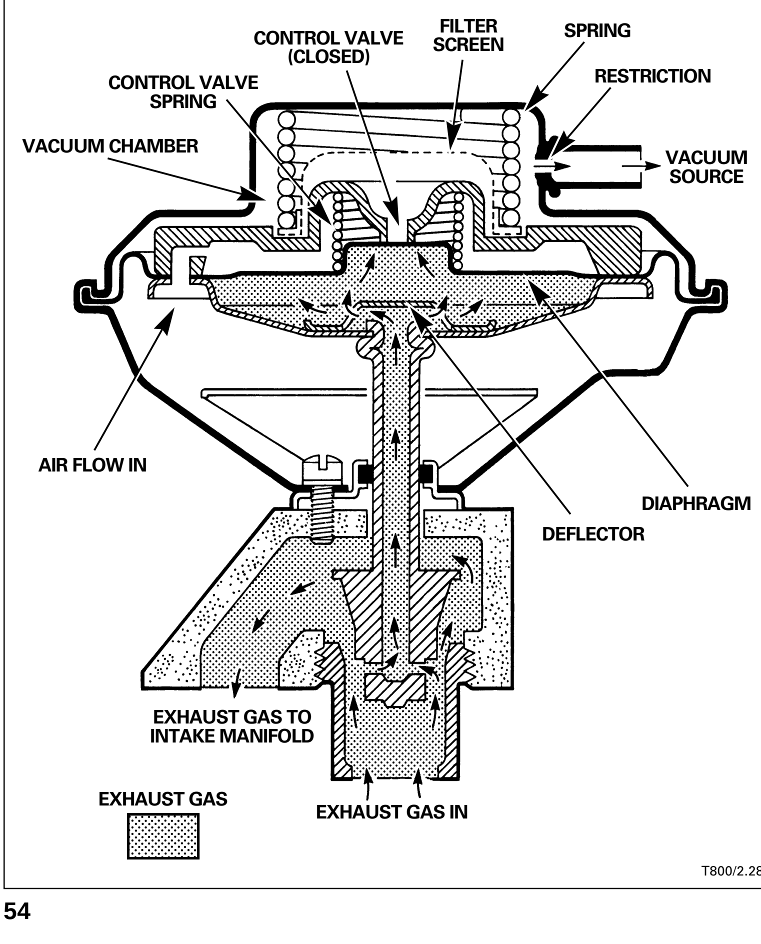
The EGR control valve is a “negative pressure” vacuum operated valve that compensates for exhaust back pressure. The amount of exhaust gas flow into the intake manifold varies depending on intake manifold vacuum and variations in exhaust back pressure. The valve diaphragm has an internal vacuum bleed hole that is held closed by a small spring when no exhaust back pressure exists. When vacuum is applied via the solenoid vacuum valve, the EGR valve opens against the pressure of the large spring. When intake manifold vacuum combines with negative exhaust back pressure, the vacuum bleed hole opens to close the valve.

EGR VALVE



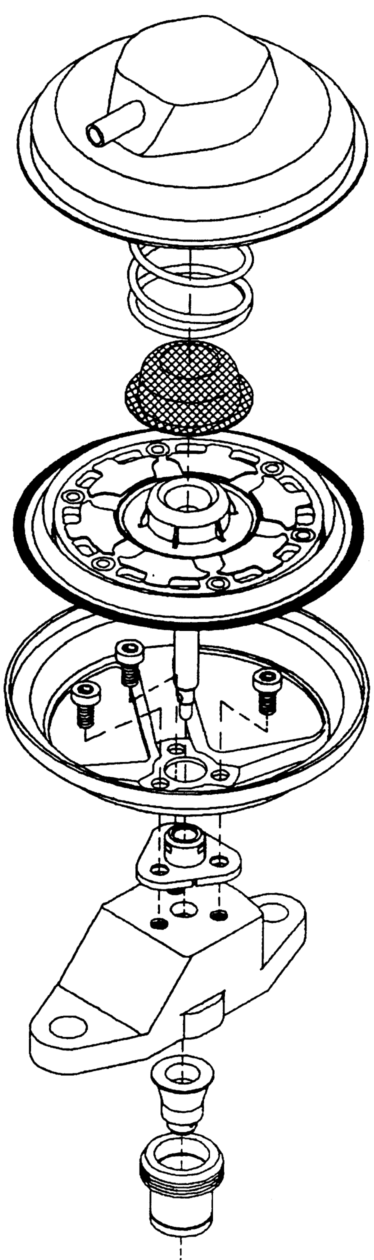
T800/2.27

EGR VALVE OPERATION



T800/2.28

EGR VALVE

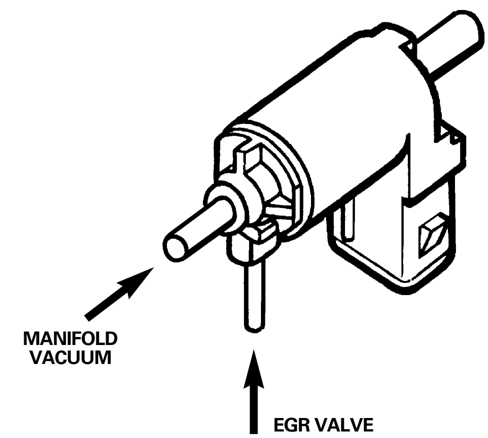


T800/2.26

EGR Solenoid Vacuum Valve

The EGR solenoid vacuum valve is located at the rear of the intake manifold. When activated by the ECM, the normally closed solenoid valve opens to apply intake manifold vacuum to the EGR valve. The resistance of the solenoid coil is approximately 45 ohms.

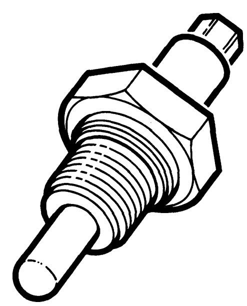
EGR SOLENOID VACUUM VALVE



EGR Temperature Sensor

The EGR sensor is a negative temperature coefficient (NTC) thermistor. NTC means that the resistance of the thermistor decreases as the sensed temperature increases. The ECM applies 5 volts to pin 1 of the sensor and monitors the voltage across the sensor pin to ground. The theoretical full voltage range is from 5 to 0 volts representing maximum cold to maximum hot. Typically, with the engine running at 2000 rpm, the sensor voltage will drop 0.1 volt when the EGR valve is opened.

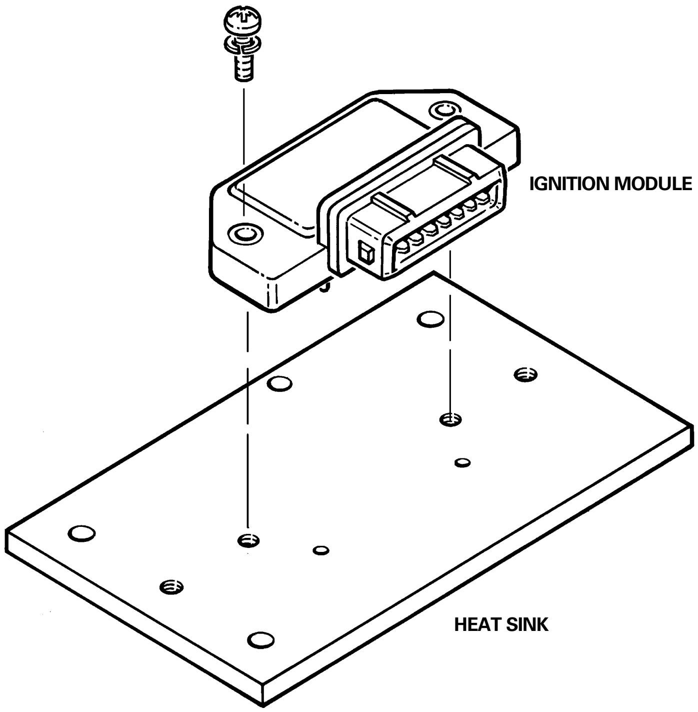
EGR TEMPERATURE SENSOR



EGR temperature sensor – temperature versus resistance :

Intake air temperature °F	°C	Resistance (kilo ohms)
122	50	600
212	100	90
302	150	11
392	200	5
482	250	2
572	300	0.8
662	350	0.3
752	400	0.1

IGNITION MODULE



T800/2.31

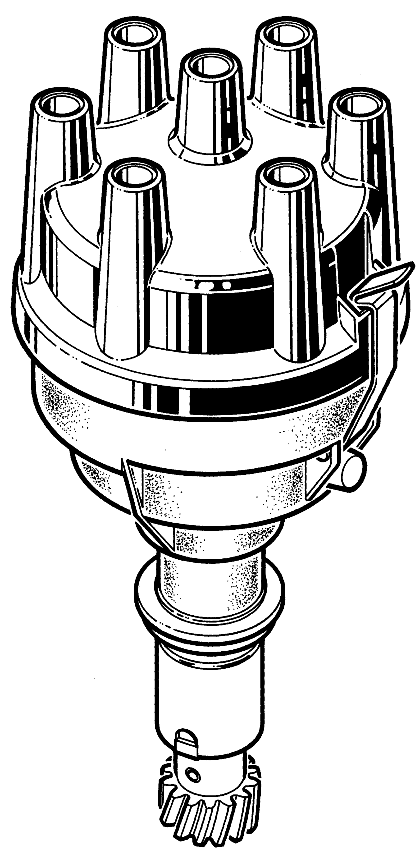
Ignition Module

The ignition module is controlled by the ECM output signal and switches the ignition coil primary circuit. The dwell angle and peak coil current is also controlled by the ignition module. A feature called “stall turn-off” is used to prevent coil overheating and battery discharge if the ignition is left on without the engine running.

NOTE: 1990 model year systems have a four-wire (plus ground) ignition module. 1991 ON model year systems have a three-wire (plus ground) ignition module. The modules are interchangeable.

The module is mounted to an aluminum heat sink plate. If the module and heat sink are separated, heat sink compound must be applied between the components upon reassembly.

IGNITION DISTRIBUTOR



T800/2.32

Ignition Distributor

The distributor is a standard unit containing only a rotor arm and cap to distribute high voltage to the spark plugs. The distributor has no effect on ignition timing and can be considered as a simple rotating switch. It is necessary only to position the distributor for correct rotor-to-cap alignment at TDC.

The following Figures and Data pages are extracted from select Electrical Guides and are included here as an aid to understanding the Engine Management system. Do not use this information to diagnose vehicle faults.

Always refer to the Model and Model Year specific Electrical Guide for accurate information.

Contents

Overview

The Jaguar 6.0 litre V12 / ND (Nippon Denso) Engine Management System (EMS), introduced in the 1995 Model Year XJ12 Sedan, is controlled through a digital Engine Control Module (ECM) containing a microprocessor. The system maintains optimum performance by precisely controlling all fuel injection, ignition and emission control functions. In addition, the ECM provides various interface outputs and incorporates an on-board diagnostic facility.

The V12 / ND EMS complies with OBD II (on-board diagnostics II), the second generation environmental legislative regulations that set the acceptable maximum level of motor vehicle exhaust emission and the engine control systems self diagnosis capabilities.

The V12 Lucas / Marelli EMS complies with OBD I. Generally, the operating standards for the two OBD systems are as follows:

OBD I (V12 Lucas / Marelli EMS)

- Regulated exhaust emission level
- Monitoring and diagnosis of electrical fuel system faults
- Monitoring of both open and closed circuit faults
- Visual warning to driver: MIL (CHECK ENGINE)
- Fault code available to technician: Diagnostic Trouble Code — DTC (Fuel Fail Code — FF)

OBD II (V12 / ND EMS)

- Reduced exhaust emission level
- Industry standardized DTCs
- Generic (after-market) scan tool capable of DTC retrieval
- Expanded self diagnostics to include monitoring and diagnosis of any power train system fault that will likely cause exhaust emission to exceed 1.5 times the standard level.
- Failure prediction of subsystems by performance observation over the life of the power train including: catalyst efficiency, engine misfire, and secondary air injection.

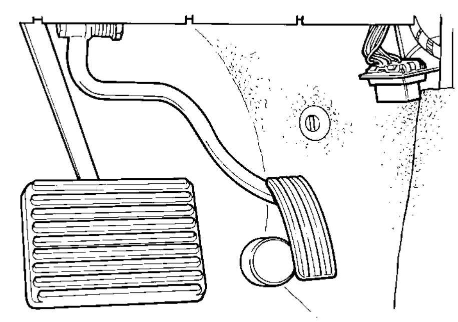
NOTES

On-Board Diagnostic Facility – OBD II

The OBD facility has expanded diagnostic capabilities to continuously monitor the operation of the engine management sensors and components. In addition, the facility predicts failure of subsystems by performance observation. If a fault is detected by OBD monitoring or testing, it is registered in the ECM internal software. The ECM decides whether to flag a DTC and activate the CHECK ENGINE MIL (Malfunction Indicator Light).

Faults stored in the ECM memory can only retrieved through serial communication via the data link. DTCs are held in memory (RAM) that requires vehicle battery power to remain activated. Disconnecting the vehicle battery will erase all stored codes.

DATA LINK CONNECTOR



T851 / 4.70

Engine Management Faults

Except in cases where vehicle operation would be seriously impaired, a fault must be detected on two consecutive trips before the CHECK ENGINE MIL will activate. After the MIL is activated, if three sequential trips are made with no recurrence of the fault(s) and no occurrence of additional fault(s), the MIL will extinguish on the next trip. The fault(s) will remain stored in memory. The ECM will erase any fault code that does not recur after 40 consecutive engine warm-up cycles.

Transmission Faults

Upon detection of a transmission fault, the TCM activates the TRANSMISSION MIL immediately, and signals the ECM to activate the CHECK ENGINE MIL and store an engine management DTC. If the transmission fault is "self corrected", the TRANSMISSION MIL will extinguish at the end of the drive cycle; however, the CHECK ENGINE MIL will remain activated for an additional three consecutive fault-free trips. The engine management DTC will be erased after 40 fault-free engine warm-up cycles.

Trips and Service Drive Cycle

"Trip" and "Service Drive Cycle" are terms used in conjunction with OBD II.

A "Trip" means vehicle operation, following an engine-off period, of duration and driving mode such that all EMS components and subsystems are checked at least once by the diagnostic system, with the exception of catalyst efficiency monitoring. Catalyst efficiency and evaporative system monitoring require a steady vehicle speed check.

NOTES

Trip Test
To test all of the EMS components and subsystems, the trip test procedure must be followed twice, with an engine stop between to allow the two-trip logic to operate and a DTC to be stored.

Trip test procedure:

1 Turn off the air conditioning system.

2 Start the engine and idle for 20 seconds.

3 Wait for the engine to warm up to a coolant temperature of greater than 80°C.

4 Idle the engine for two minutes without turning the steering wheel or operating electrical loads.

5 Drive the car as described below, with the gear selector in "D" unless otherwise stated. The specified speeds are targets. If the actual speed is not more than 2 mph different from the target, the test will be performed correctly. Hold a steady throttle position and drive on a level road.

- Accelerate to 34 mph and drive steadily at this speed for 1 minute.
- Accelerate to 44 mph and drive steadily at this speed for 10 seconds.
- Accelerate to 56 mph and drive steadily at this speed for 1 minute.
- Drive for over 10 seconds with the engine above 3000 rpm (select a lower gear to limit vehicle speed).
- Brake gently to a stop.
- Accelerate to 22 mph and then brake to a stop. Repeat this step four times.

6 Switch the engine off.

7 Interrogate the ECM for stored codes, first with the key on and the engine off, then with the engine idling.

Service Drive Cycle Test
To check for a reoccurrence of a particular DTC, a vehicle must be operated over a "Service Drive Cycle". A "Service Drive Cycle" is a planned routine of operating a vehicle so that the components and subsystems that are being monitored by a particular code will be tested. For certain DTCs, such as that for the engine coolant temperature sensor (ECTS), the Service Drive Cycle is simple and includes:

- ignition ON
- engine start
- engine run to normal operating temperature
- ignition OFF

More complex diagnostic routines require additional operating modes. For a full list of operating modes, required for each code, refer to the DTC Summary on pages 53 – 62.

NOTES

On-Board Diagnostic Facility – OBD II (continued)

Systems Readiness Test

It can be determined if the Service Drive Cycle was of sufficient length to test for DTC reoccurrence by performing a PDU "Systems Readiness Test".

The Systems Readiness Test occurs automatically when the PDU reads the DTCs from the ECM memory and reports if a full OBD check has or has not been completed since the memory was last cleared.

If code P1000 is stored in memory, the on-board diagnostic tests have not been completed.

If code P1111 is stored in memory, the on-board diagnostic tests have been completed.

OBD II Reports to Jaguar Cars

Whenever the CHECK ENGINE MIL is activated, a DTC and accompanying "freeze frame" data will be stored in the ECM memory. This information must be retrieved using the PDU "OBD II Report" and reported to Jaguar Cars on form S93.

Limp Home Default

In order to allow vehicle operation if a malfunction occurs, "limp home" default values are incorporated as an ECM facility. If a sensor fault is detected by OBD, the ECM will substitute a nominal value for the missing input(s). The ECM contains default strategies / values for the following:

- Manifold absolute pressure sensors (MAPS)
- Camshaft position sensor (CMPS)
- Throttle position sensor (TPS)
- Engine coolant temperature sensor (ECTS)
- Crankshaft position sensor (CKPS)
- Intake air temperature sensor (IATS)
- Heated oxygen sensors (HO2S)
- Ignition control modules
- Evaporative control valves (EVAPP valves)
- Fuel pump 1
- High altitude correction sensor (HACS)

Diagnostic Trouble Codes

The number of possible diagnostic trouble codes (DTCs) has been greatly increased. Each DTC is a five place standard SAE (Society of Automotive Engineers) code that describes a subsystem and the specific fault. Refer to the DTC Summary on pages 53 – 62 for a complete DTC listing including monitoring conditions and possible faults.

DTCs are arranged in seven major groups as follows:

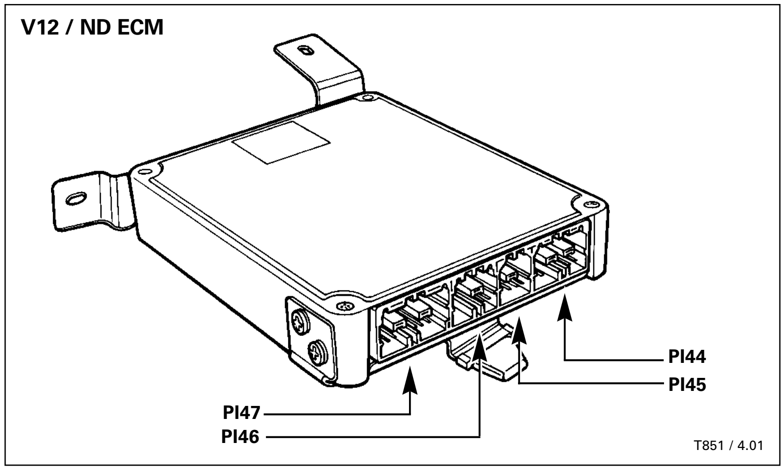
PX1XX	Fuel and air metering
PX2XX	Fuel and air metering
PX3XX	Ignition system or misfire
PX4XX	Auxiliary emission controls
PX5XX	Vehicle speed; idles control; auxiliary inputs
PX6XX	Computer and auxiliary inputs
PX7XX	Transmission control

NOTES

Engine Control Module

The V12 / ND EMS is microprocessor based using a unique Nippon Denso ECM as the heart of the system. The ECM has a 128 megabyte memory with a microprocessor running at a clock speed of 4 MHz. The ECM uses discrete components plus analog-to-digital circuits to interface between the microprocessor and the input sensors and output devices. Software is programmed into an EPROM used for control, data, On-Board Diagnostics and adaptive functions.

The ECM controls the engine management system as two separate systems (A bank, B bank) or as one twelve cylinder system depending on engine operating conditions and diagnostic functions.



A nonvolatile memory is used to store the vehicle identification number (VIN). Quiescent current is used to keep the ECM random access memory (RAM) active so that OBD generated DTCs and adaptive values are maintained. If the vehicle battery is disconnected, the ECM will “relearn” adaptive values during the next driving cycle

CAUTION: ECMs must not be switched from one vehicle to another because the VIN will be mismatched.

The ECM contains four connector sockets. A rough guide to the connector function grouping is as follows: the 28-way connector (PI44) carries the ECM to vehicle interfaces; the 16-way connector (PI45) carries the EMS sensor inputs; the 22-way connector (PI46) carries the EMS signal inputs and outputs; the 34-way connector (PI47) carries the EMS actuator outputs and most of the grounds.

Specific variants (Federal, ROW) are achieved through PECUS (programmable electronic control units) programming of the ECM EPROM during manufacturing.

If a replacement ECM flashes the CHECK ENGINE MIL when the ignition is switched to position II, PECUS programming has not been carried out.

ECM monitoring for OBD II

Each time the ignition is switched ON, the ECM checks its memory for corrupted data. If a fault is found, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. The CHECK ENGINE MIL will remain lit after the engine is started. Refer to DTC Summary: Groups 23 and 25, page 62.

High altitude correction

A high altitude correction sensor (HACS) that senses barometric pressure is incorporated into the ECM. The HACS input is used for high altitude fuel metering correction, OBD diagnostic information, and idle speed control correction. The HACS cannot be replaced separately.

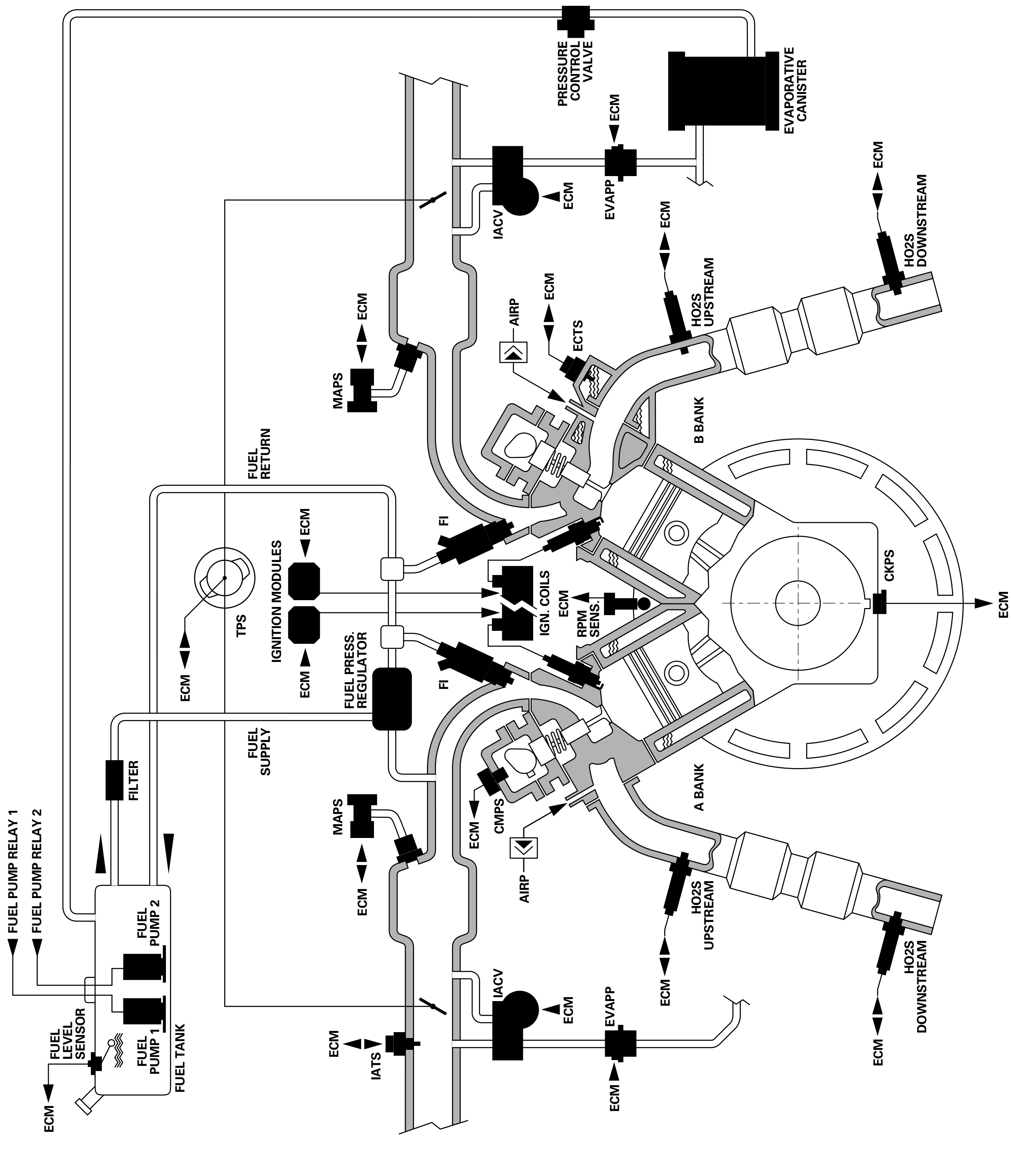
HACS monitoring for OBD II

The HACS is checked for a continuous high or low signal. If there is a fault, a DTC will be flagged and the CHECK ENGINE MIL will be activated immediately. The sensor is also monitored with the engine running by comparison with the MAP sensor signals. If the value is too high or too low compared to the MAPS signals, a DTC will be flagged. The fault must occur on two consecutive trips before the CHECK ENGINE MIL will be activated. Refer to DTC Summary: Group 7, pages 54 and 58.

NOTES

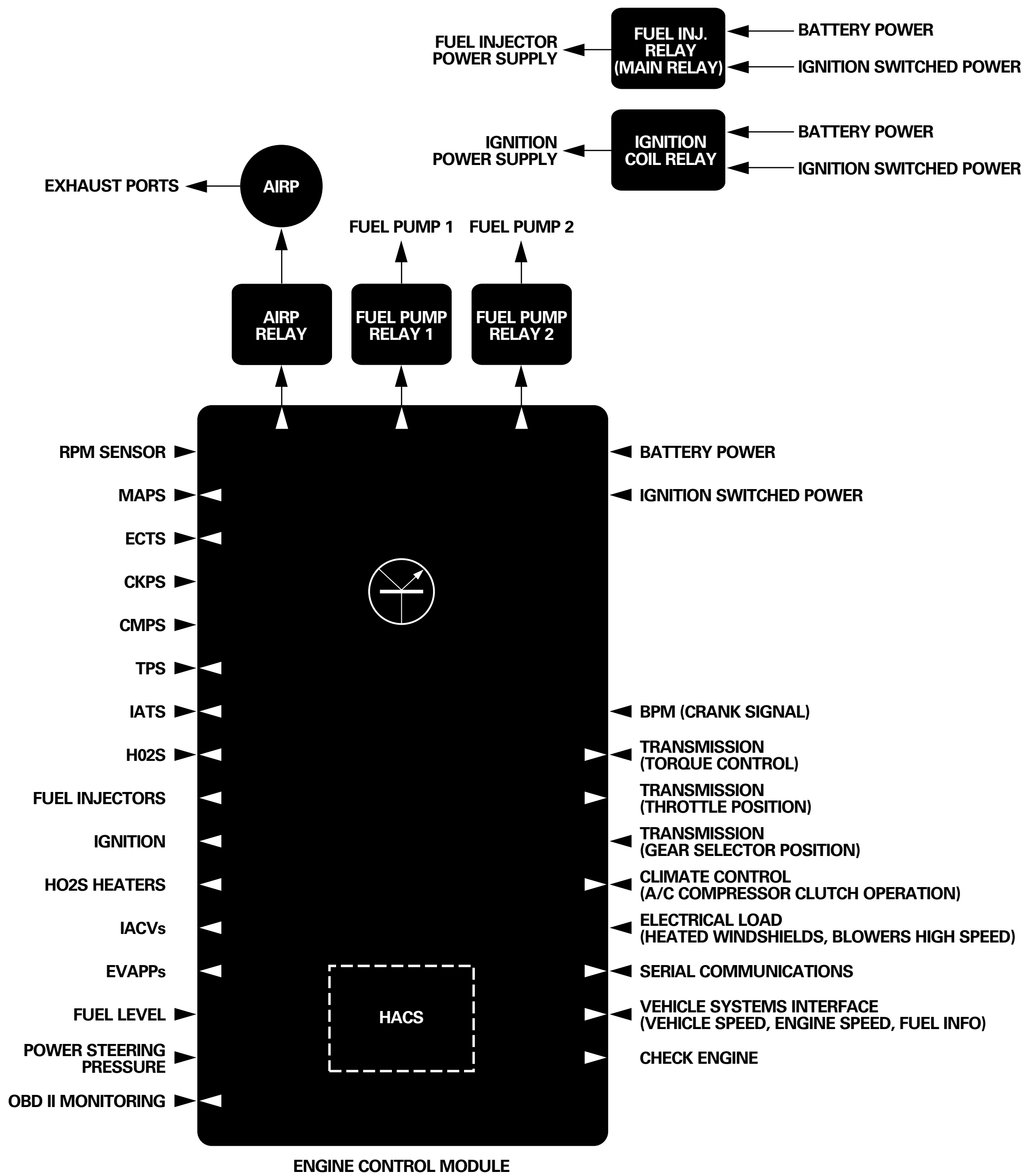
Engine Control Module (continued)

V12 / ND ENGINE MANAGEMENT LOGIC



T851 / 4.02A

V12 / ND ENGINE MANAGEMENT LOGIC

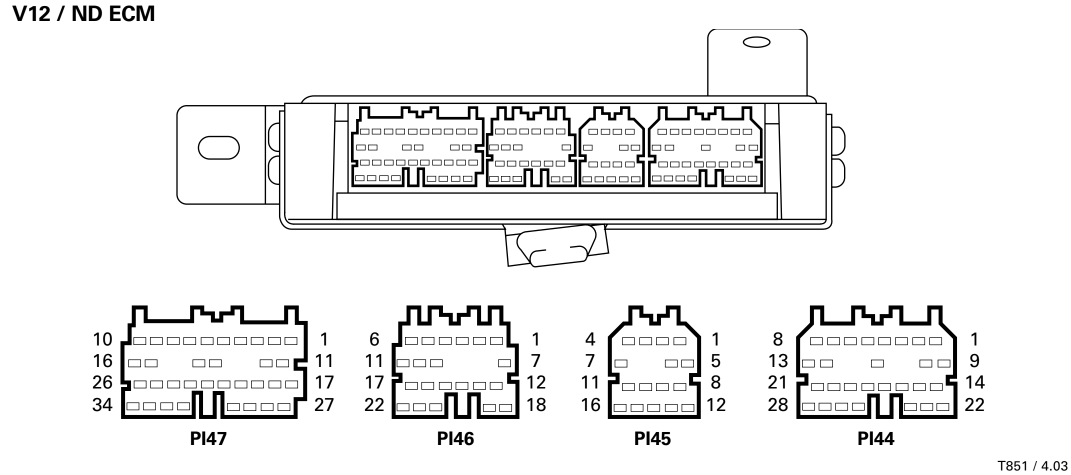


KEY TO ACRONYMS (THIS PAGE AND PAGE AT LEFT)

AIRP	SECONDARY AIR INJECTION PUMP	HO2S	HEATED OXYGEN SENSOR
CKPS	CRANKSHAFT POSITION SENSOR	IACV	IDLE AIR CONTROL VALVE
CMPS	CAMSHAFT POSITION SENSOR	IATS	INTAKE AIR TEMPERATURE SENSOR
ECM	ENGINE CONTROL MODULE	KS	KNOCK SENSOR
ECTS	ENGINE COOLANT TEMPERATURE SENSOR	MAPS	MANIFOLD ABSOLUTE PRESSURE SENSOR
EVAPP	EVAPORATIVE EMISSION CONTROL (PURGE) VALVE	RPM SENS.	ENGINE SPEED SENSOR
FI	FUEL INJECTOR	TPS	THROTTLE POSITION SENSOR
HACS	HIGH ALTITUDE CORRECTION SENSOR		

T851 / 4.02B

Engine Control Module (continued)



Engine Control Module Pin Out Information

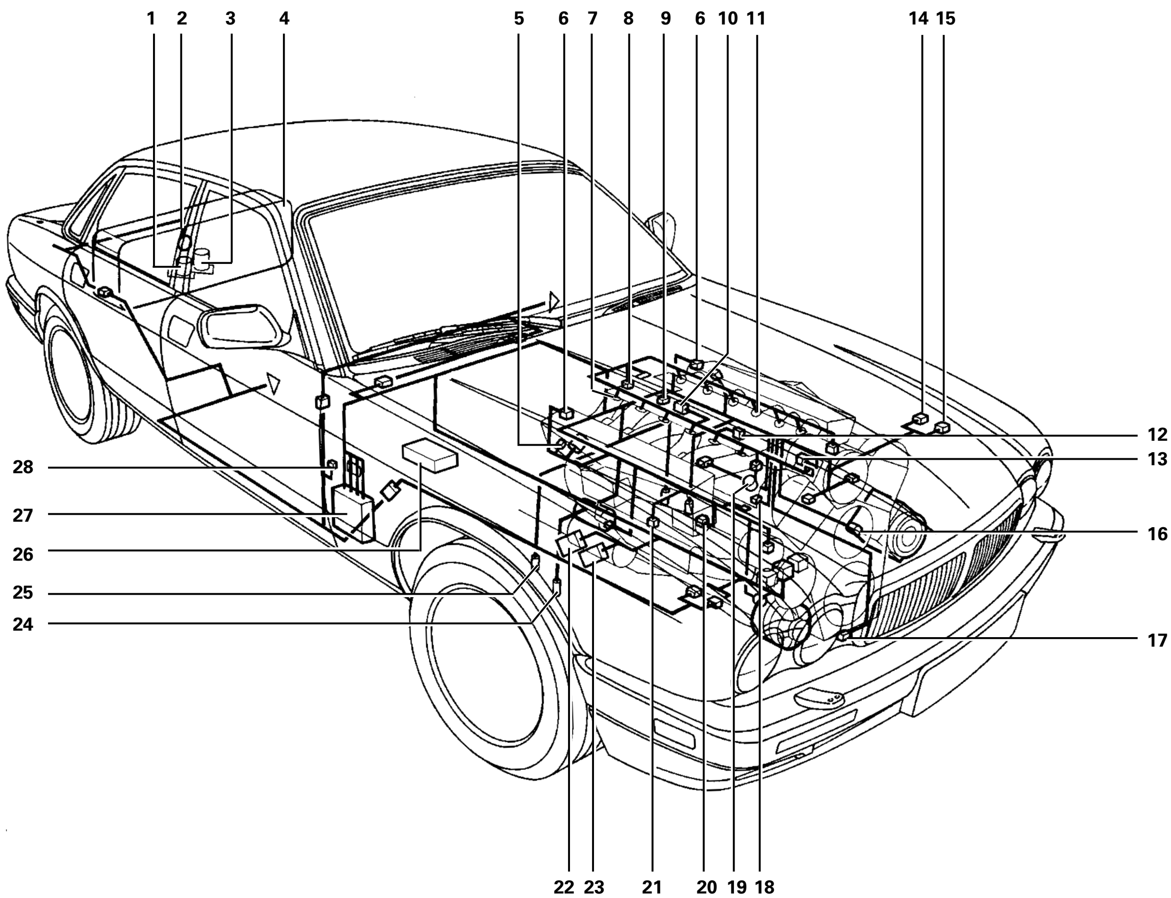
I = Input O = Output SG = Signal Ground D = Serial Communications

I/O	Pin	Description
O	PI44-1	Fuel used
O	PI44-2	Check engine MIL
O	PI44-3	Engine torque signal
O	PI44-4	Throttle position
O	PI44-5	Load inhibit signal
I	PI44-6	Torque reduction
I	PI44-7	Vehicle speed
O	PI44-10	Engine speed
I	PI44-12	Electrical load: Heated windshield, heated backlight or blowers on high speed
I	PI44-13	Air conditioning request
D	PI44-14	Not used
I	PI44-18	Park / neutral
I	PI44-21	Fuel level
D	PI44-22	Serial communication input
D	PI44-23	Serial communication output
	PI44-24	Battery power supply
	PI44-25	Ignition switched power supply
	PI44-26	Flexible fuel select link (dealer fit)
	PI44-28	Ground (signal)
I	PI45-1	MAP sensor feedback – B bank
I	PI45-2	MAP sensor feedback – A bank
I	PI45-3	Idle switch
I	PI45-4	Throttle position sensor feedback voltage
I	PI45-5	Coolant temperature sensor
I	PI45-6	Intake air temperature sensor
O	PI45-7	Common sensor reference voltage
I	PI45-8	Downstream HO2S feedback – B bank
I	PI45-9	Downstream HO2S feedback – A bank
I	PI45-10	Upstream HO2S feedback – B bank
I	PI45-11	Upstream HO2S feedback – A bank
	PI45-12	Ignition switched power supply

I/O	Pin	Description
I	PI45-13	Power steering pressure switch
	PI45-14	Ground (signal)
SG	PI45-15	Common sensor shield ground
SG	PI45-16	Common sensor reference ground
O	PI46-3	Downstream HO2S heater ground – B bank
O	PI46-4	Downstream HO2S heater ground – A bank
O	PI46-5	Upstream HO2S heater ground – B bank
O	PI46-6	Upstream HO2S heater ground – A bank
I	PI46-7	Crank signal
I	PI46-8	Camshaft position sensor
	PI46-10	Ground
	PI46-11	Ground
SG	PI46-12	Camshaft position sensor
I	PI46-13	Crankshaft position sensor
I	PI46-14	Engine speed sensor
O	PI46-16	A/C compressor clutch relay
O	PI46-17	Secondary air injection relay
SG	PI46-18	Crankshaft position sensor
SG	PI46-19	Engine speed sensor
I	PI46-20	Ignition failure – B bank
I	PI46-21	Ignition failure – A bank
	PI46-22	Ground
O	PI47-1	Idle air control valve close – B bank
O	PI47-2	Idle air control valve open – B bank
O	PI47-3	Idle air control valve close – A bank
O	PI47-4	Idle air control valve open – A bank
O	PI47-5	Fuel injectors 3 & 5 – B bank
O	PI47-6	Fuel injectors 2 & 4 – A bank
O	PI47-7	Fuel injectors 1 & 4 – B bank
O	PI47-8	Fuel injectors 3 & 6 – A bank
O	PI47-9	Fuel injectors 2 & 6 – B bank
O	PI47-10	Fuel injectors 1 & 5 – A bank
O	PI47-11	Secondary air vacuum solenoid valve
O	PI47-12	Fuel pump relay 2
	PI47-13	Ground
	PI47-14	Ground
	PI47-15	Ground
	PI47-16	Ground
O	PI47-17	Ignition module negative – 3B
O	PI47-18	Ignition module negative – 2B
O	PI47-19	Ignition module negative – 1B
O	PI47-20	Ignition module negative – 3A
O	PI47-21	Ignition module negative – 2A
O	PI47-22	Ignition module negative – 1A
	PI47-23	Ground
	PI47-26	Ground
	PI47-27	Ground
	PI47-28	Ground
O	PI47-29	Fuel pump relay 1
O	PI47-33	EVAP valve – B bank
O	PI47-34	EVAP valve – A bank

EMS Component Location

EMS COMPONENT CONNECTOR LOCATIONS

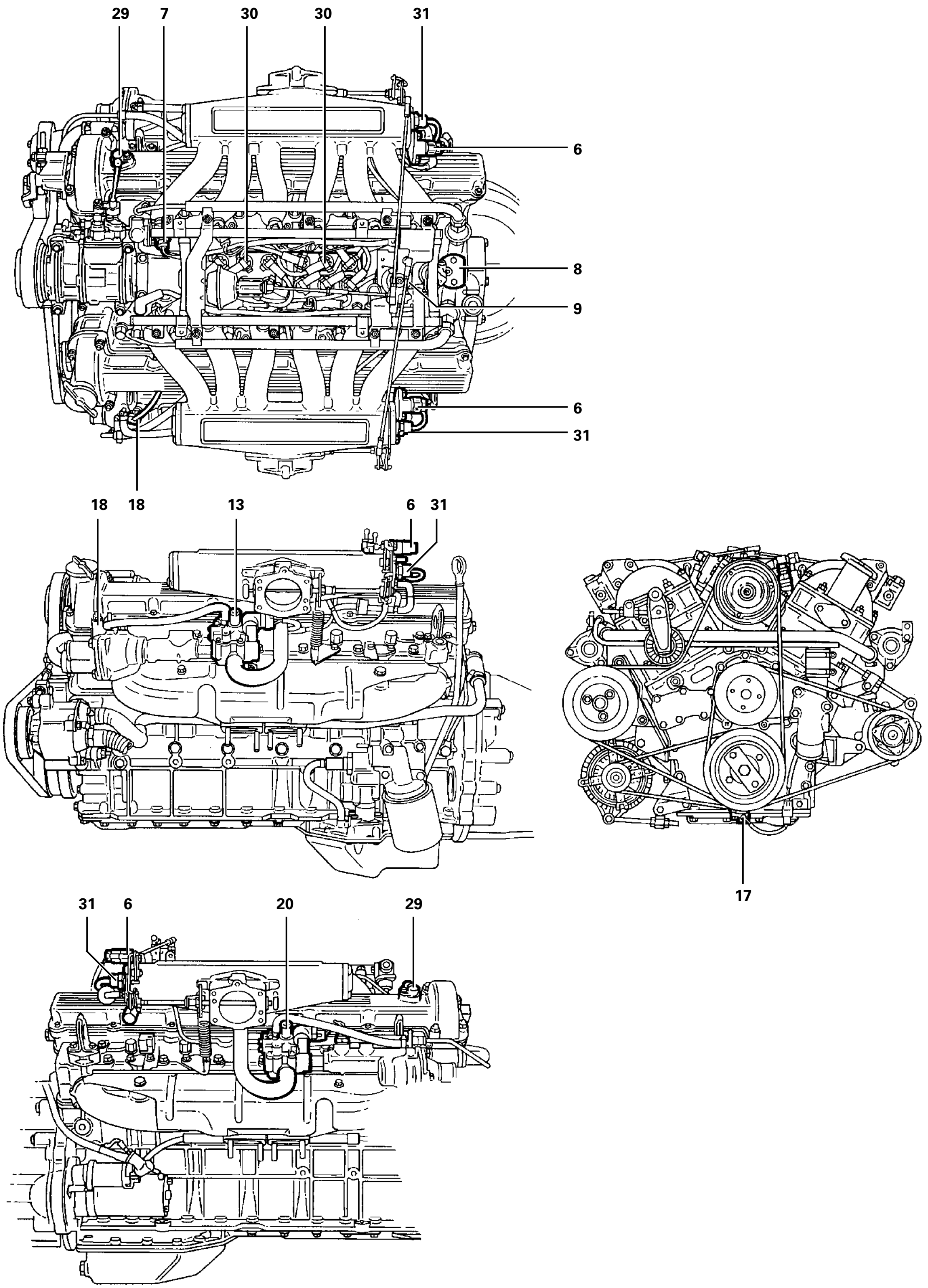


KEY TO ILLUSTRATION
(ALSO APPLIES TO ILLUSTRATION AT RIGHT)

1 FUEL PUMP 1
2 FUEL LEVEL SENSOR
3 FUEL PUMP 2
4 FUEL TANK
5 VACUUM SOLENOID VALVE
6 ABSOLUTE PRESSURE SENSOR(S)
7 A BANK FUEL INJECTORS (FI)
8 ENGINE SPEED SENSOR
9 THROTTLE POSITION SENSOR (TPS)
10 IGNITION COIL PACK
11 B BANK FUEL INJECTORS (FI)
12 IGNITION COIL PACK
13 B BANK IDLE AIR CONTROL VALVE (IACV)
14 A BANK EVAPORATIVE EMISSION CONTROL VALVE (EVAPP)
15 B BANK EVAPORATIVE EMISSION CONTROL VALVE (EVAPP)
16 SECONDARY AIR INJECTION PUMP (AIR PUMP)
17 CRANKSHAFT POSITION SENSOR (CKPS)
18 ENGINE COOLANT TEMPERATURE SENSOR (ECTS)
19 FUEL PRESSURE REGULATOR
20 A BANK IDLE AIR CONTROL VALVE (IACV)
21 INTAKE AIR TEMPERATURE SENSOR (IATS)
22 B BANK IGNITION MODULE
23 A BANK IGNITION MODULE
24 A BANK DOWNSTREAM HEATED OXYGEN SENSOR (HO2S)
25 A BANK UPSTREAM HEATED OXYGEN SENSOR (HO2S)
26 TRANSMISSION CONTROL MODULE (TCM)
27 ENGINE CONTROL MODULE (ECM)
28 INERTIA SWITCH
29 CAMSHAFT POSITION SENSOR (CMPS)
30 IGNITION COIL PACKS
31 GAS FILTER(S) (FOR MAFS)
32 B BANK MANIFOLD ABSOLUTE PRESSURE SENSOR

T851 / 4.04

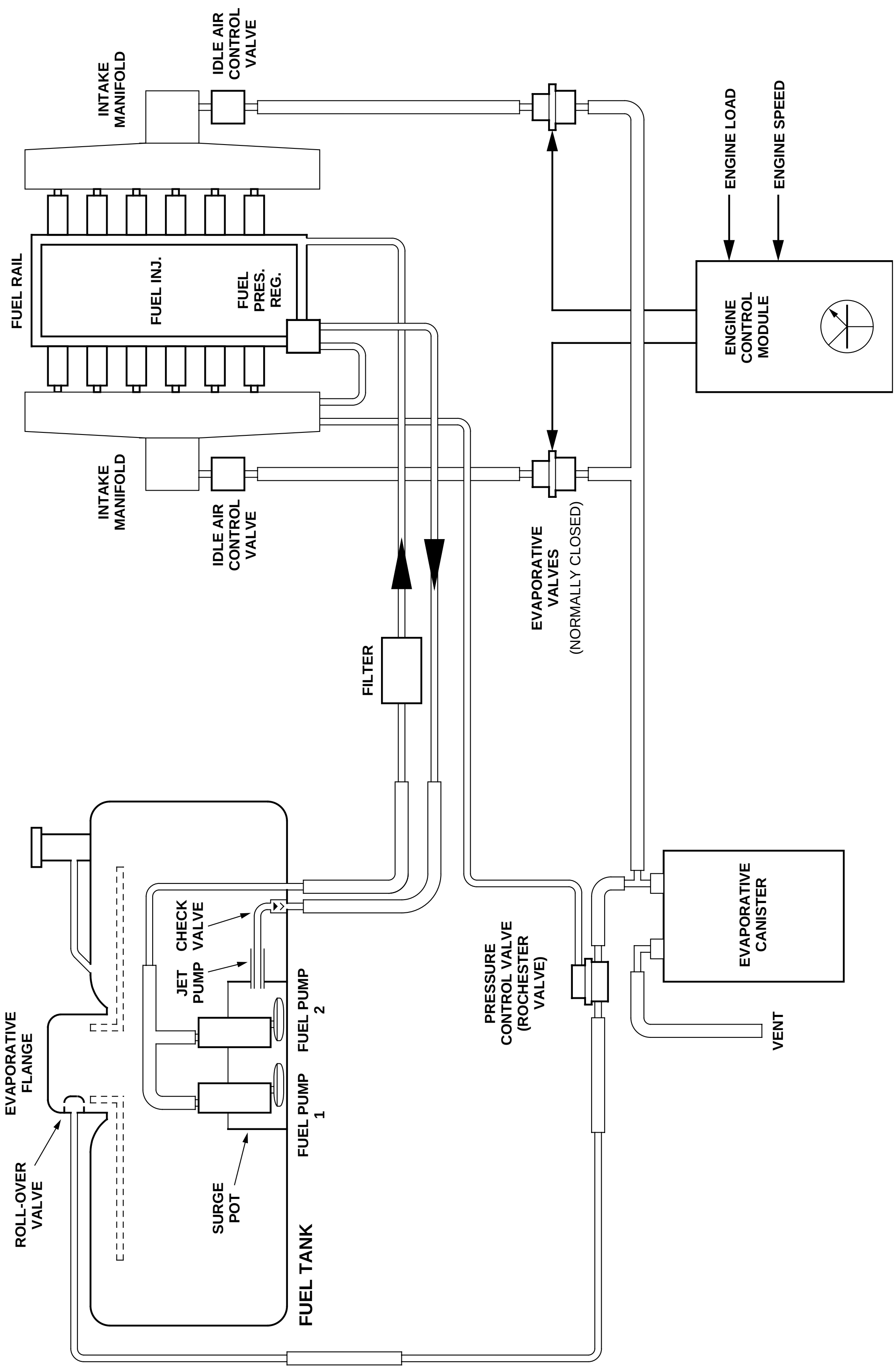
EMS COMPONENT LOCATIONS



T851 / 4.05

Fuel Delivery and Evaporative Emission Control

V12 / ND EVAPORATIVE EMISSION CONTROL SYSTEM



T851 / 4.06

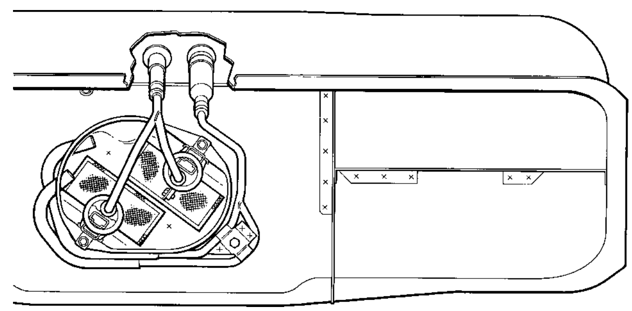
Fuel Delivery

Fuel Tank

The fuel tank incorporates two fuel pumps and the necessary plumbing for fuel supply and return. The tank uses baffle plates to reduce fuel surge and a surge pot to ensure that a constant supply of fuel is available for the pumps. Each pump is located by a rubber mount and clamp attached to the surge pot. The tank interior piping incorporates a jet pump and a check valve in the fuel return line. Returning fuel flows through the jet pump, which draws additional cool fuel from the tank for supply to the surge pot. This supplemented return flow ensures that the surge pot remains full of fuel. The return check valve prevents reverse flow through the fuel return line.

Access to the tank interior is through the evaporative flange at the top of the tank.

FUEL TANK ARRANGEMENT



T851/4.07

Fuel Pumps

Two fuel pump assemblies are used for two-stage fuel delivery. The pump units consist of a turbine driven by a DC motor, a check valve and an inlet filter. The fuel output from the turbine pump provides a cooling flow around the motor before being discharged through the outlet check valve. The check valve prevents reverse flow when the engine is switched off.

Fuel pump specifications

Nominal pump delivery:
26.45 gallons per hour at 43.5 psi (3 bar)

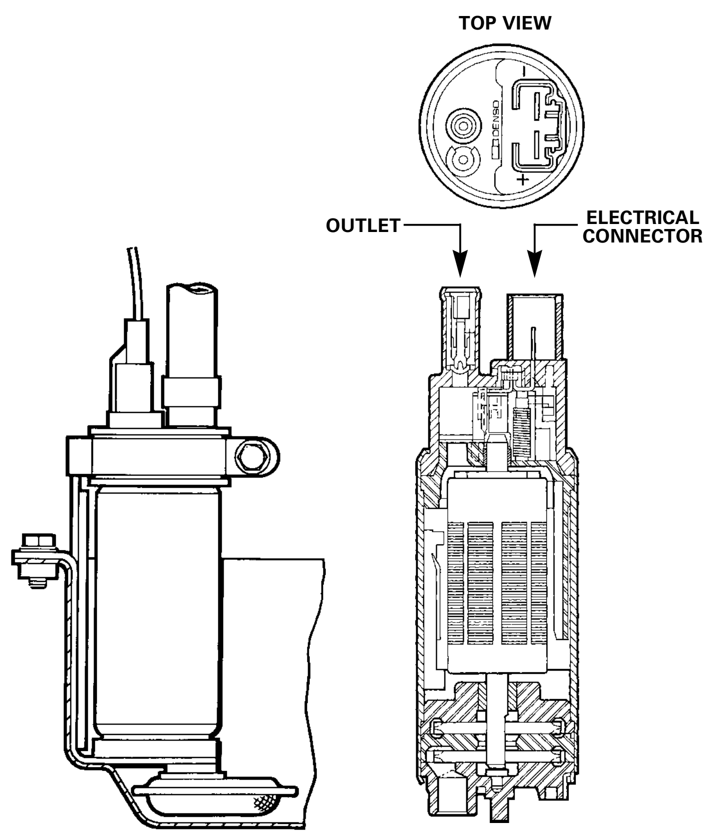
Current draw:
7 amps at 13.2V (3 bar)

In-line Fuel Filter

A replaceable in-line fuel filter is located in the supply line above the rear axle on the left side.

NOTES

FUEL PUMP WITH CROSS-SECTION



T851 / 4.08, 4.09

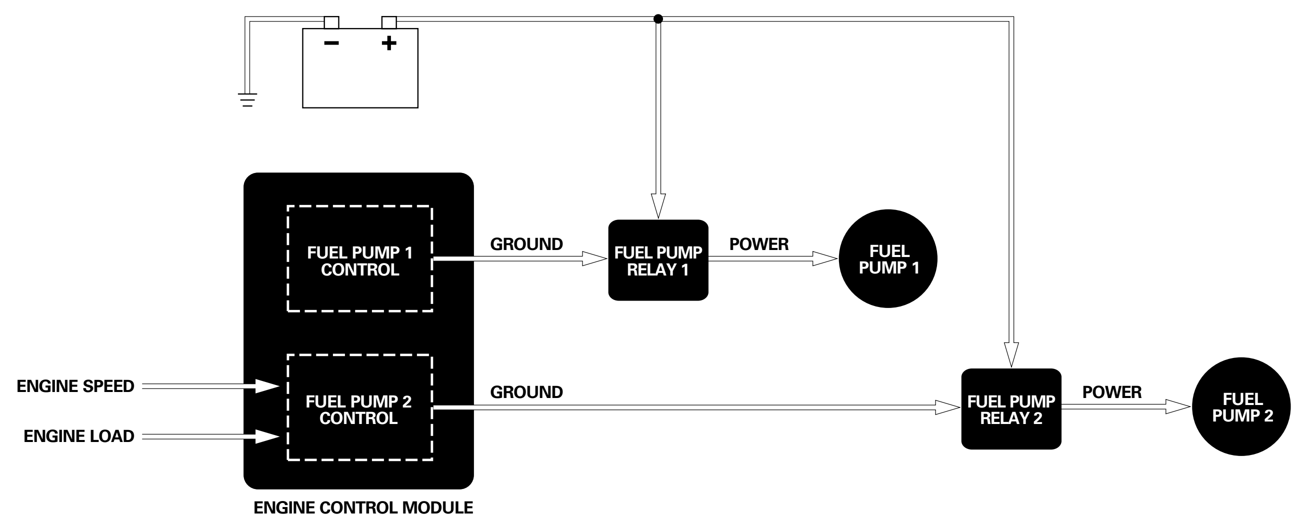
Fuel Delivery (continued)

Twin Fuel Pump Control

When the ignition is switched on (position II), the ECM initially switches on fuel pump 2, after a delay of 0.1 second. If the ignition switch remains in position II without moving the key to crank (position III), the ECM will switch off pump 2 after a maximum of 3 seconds (1995 MY) or 0.8 seconds (1996 MY). When the ignition switch is moved to crank (position III), fuel pump 2 is switched off and fuel pump 1 is activated. Fuel pump 1 operates continuously while the engine is running. The ECM activates pump 2 at higher engine speeds to provide increased fuel flow during high engine demand. Fuel pump 2 is controlled from a predetermined engine speed and load strategy.

Both fuel pumps are switched directly by the ECM via fuel pump relays.

TWIN FUEL PUMP CONTROL



T851 / 4.10

NOTE: In the event of a vehicle collision, the inertia switch will switch off all ignition powered circuits, including EMS power and fuel pump relay power. This action will switch off the fuel pumps and prevent fuel flow.

Fuel pump monitoring for OBD II

The drive voltage to the fuel pump relays is continuously monitored. If the voltage is not within the expected limits, a DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 10, page 62.

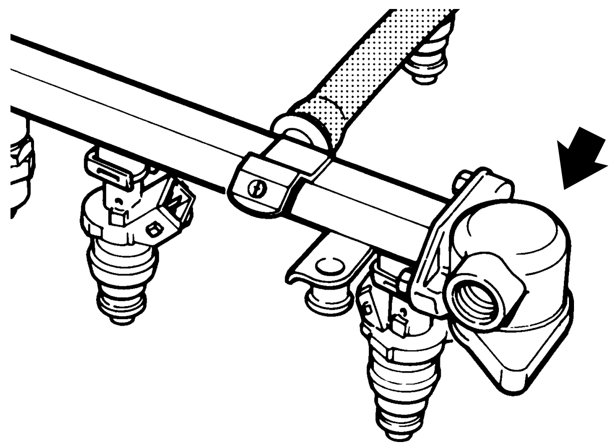
NOTES

Fuel Pressure Regulator

Fuel is pumped to the fuel rail and injectors, where fuel pressure is controlled by the fuel pressure regulator. The pressure regulator is a carry-over component from the Lucas / Marelli 6.0L V12 system. Excess fuel, above the engine requirement, is returned to the fuel tank. The pressure regulator spring chamber above the diaphragm is referenced to intake manifold vacuum. The differential pressure across the fuel injector nozzles is therefore maintained constant at 44 psi (3.0 bar) and the quantity of fuel injected for a given injector pulse duration is also constant. Fuel pressure measured on a test gauge will vary between 32 psi (2.3 bar) at overrun to 44 psi (3.0 bar) at full load to compensate for intake manifold absolute pressure.

The fuel pressure regulator is located as close as possible to the fuel rail so that good dynamic control of fuel pressure is achieved. This design provides the same pressure across each injector, and delivers an equal quantity of fuel to each of the twelve cylinders.

FUEL PRESSURE REGULATOR



T851 / 4.11

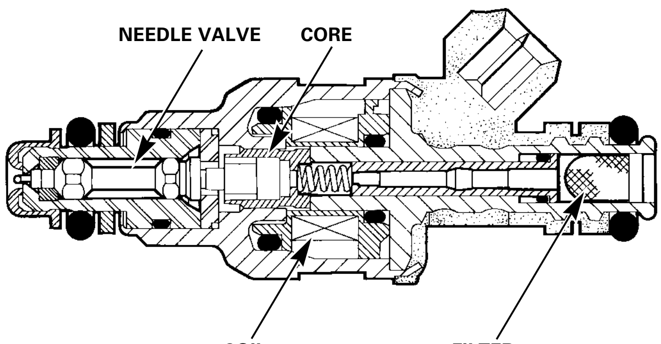
NOTES

Fuel Delivery (continued)

Fuel Injectors

The fuel injectors are needle valve type injectors that are unique to the V12 / ND system. The injectors are connected directly to the fuel rail and retained by clips and 'O' ring seals.

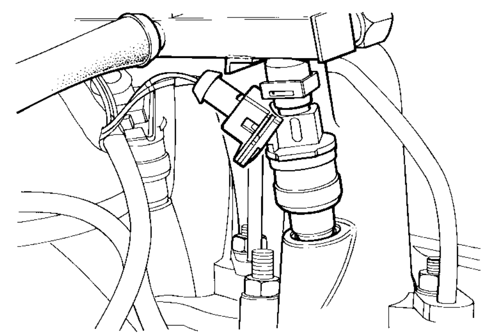
FUEL INJECTOR CROSS SECTION



INJECTOR COIL RESISTANCE (NOMINAL): 14.5 OHMS

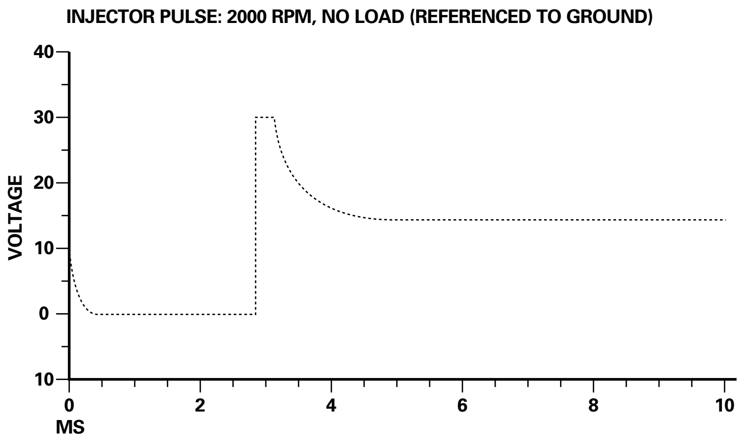
T851 / 4.13

FUEL INJECTOR LOCATION



T851 / 4.12

FUEL INJECTOR CHARACTERISTIC



T851 / 4.14

The injector drive signal is a single pulse. The pulse width is modulated to control the injector pulse duration.

Fuel injector monitoring for OBD II
The drive signal to each pair of injectors is compared to an expected voltage value. If the drive value is not correct for a specific number of injector pulses, an injector fault DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 11, page 58.

NOTES

Evaporative Emission Control

The fuel tank can be filled to approximately 90% of its capacity. The additional 10% of volume allows for expansion of the fuel without escape to the atmosphere.

When the engine is switched off, the fuel tank pressure is maintained at a positive pressure of 1.0 – 1.33 psi by the pressure control valve. Pressure above 1.33 psi is released by the valve to the evaporative canister.

When the engine is running, manifold vacuum acts on the pressure control valve, which opens the vent line from the fuel tank to the evaporative canister. Air enters the canister and flows to the tank to replace the fuel delivered to the engine and maintain atmospheric pressure in the tank.

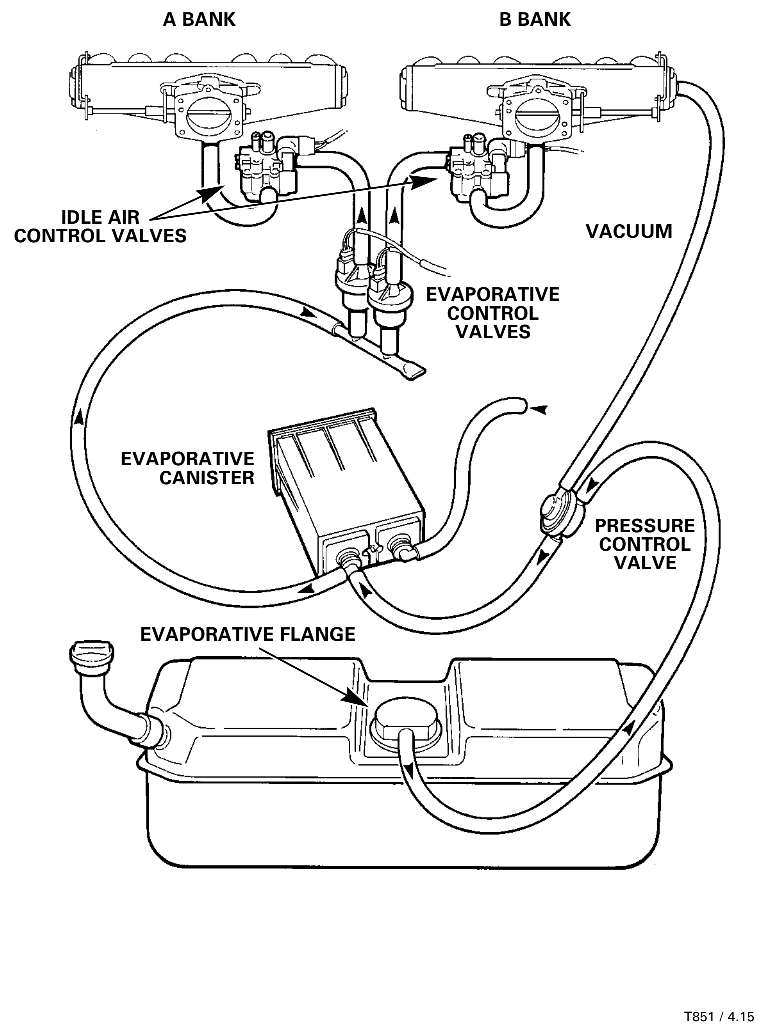
If the pressure control valve fails, the fuel tank cap will vent the fuel tank pressure at 2.0 – 2.5 psi.

Canister Purge

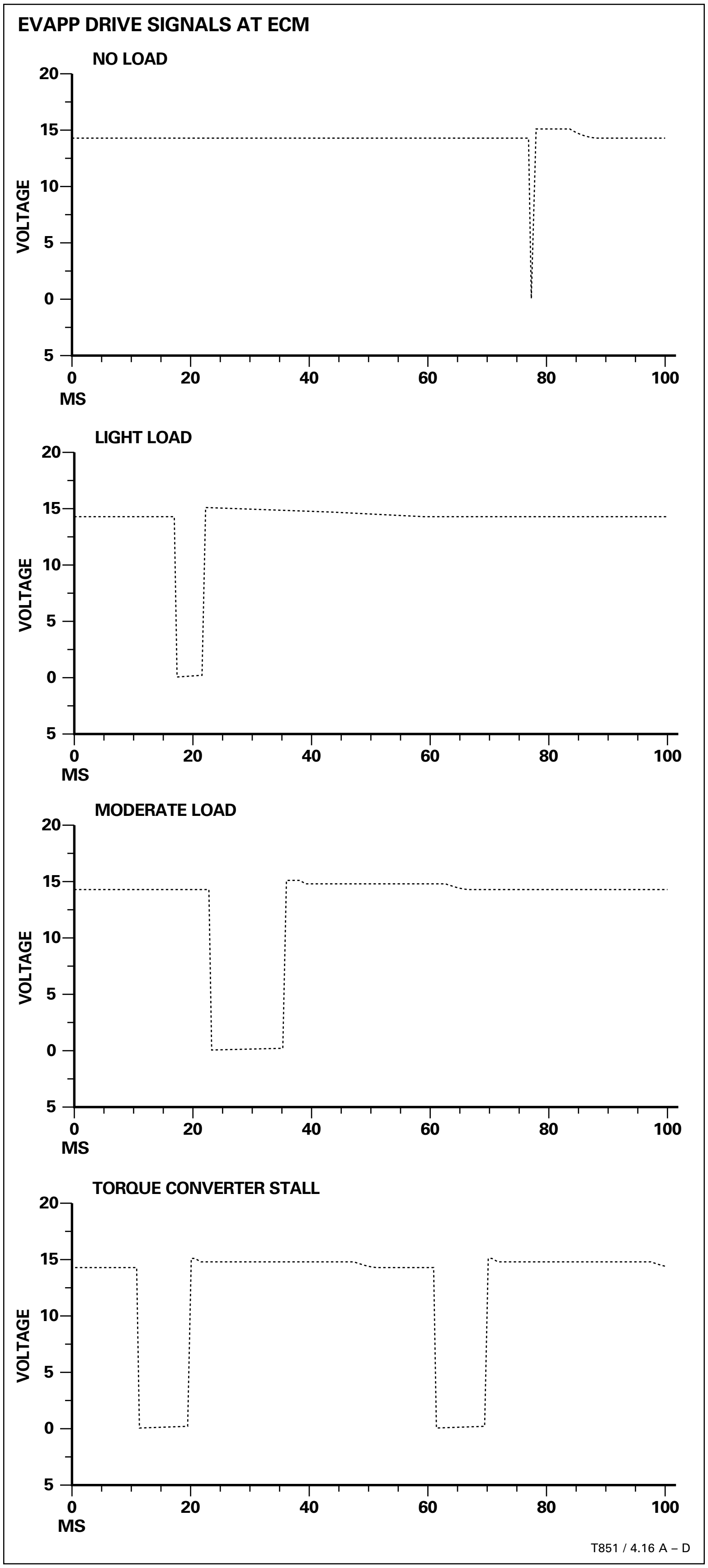
When canister purge is enabled by the ECM, the ECM meters purge flow to the idle air control valves through the normally closed evaporative emission control (purge) valves (EVAPP). Purge flow depends on engine speed and load, idle switch status (open / closed), and the status of certain diagnostic functions.

NOTES

EVAPORATIVE EMISSION CONTROL SYSTEM



Evaporative Emission Control (continued)



Canister Purge (continued)

The EVAPP drive signal is a square wave that is both pulse width an frequency modulated.

EVAP monitoring for OBD II

The EVAP system is tested during the first long hot idle period after each engine start. The ECM activates each EVAPP (purge valve) individually and checks for changes in short term fuel adaptation in each bank as well as idle air control valve feedback and engine speed. If the monitored values do not change a predetermined amount, a DTC is flagged. The EVAPP drive signals are also monitored during purge flow. If the drive signal state does not match the ECM command for a preset number of ON / OFF cycles, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 17, page 61.

NOTE: A and B bank EVAPP electrical connections and hose routing must be correct or rough idle will occur and / or a DTC will be flagged.

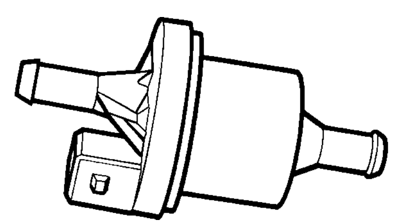
NOTES

Evaporative Emission Control Valves (EVAPP)

The evaporative emission control (purge) valves are normally closed. These valves are visually similar to the normally open valves used in the V12 Lucas / Marelli EMS. The amount of valve opening (and canister purge flow) is determined by the ECM drive signals allowing the ECM to accurately control purge flow for the prevailing engine operating conditions. The EVAPP valves are mounted below the left headlight module.

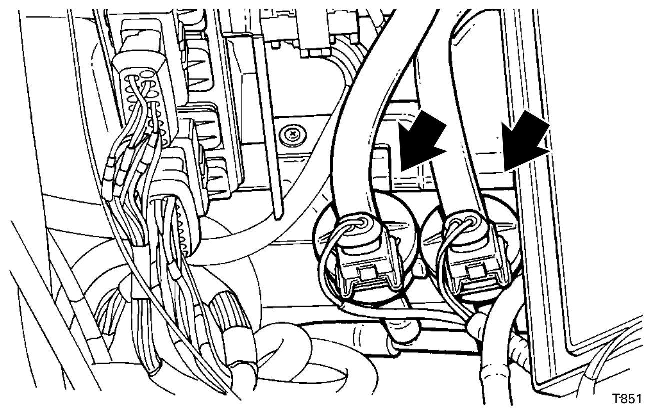
⚠ CAUTION: Do not interchange the EVAPP valves between the V12 / ND EMS and the V12 Lucas / Marelli EMS. Before installation, verify that the correct part number is stamped on the valve.

EVAPORATIVE EMISSION CONTROL VALVE



T851 / 4.17

EVAPORATIVE EMISSION CONTROL VALVES LOCATION

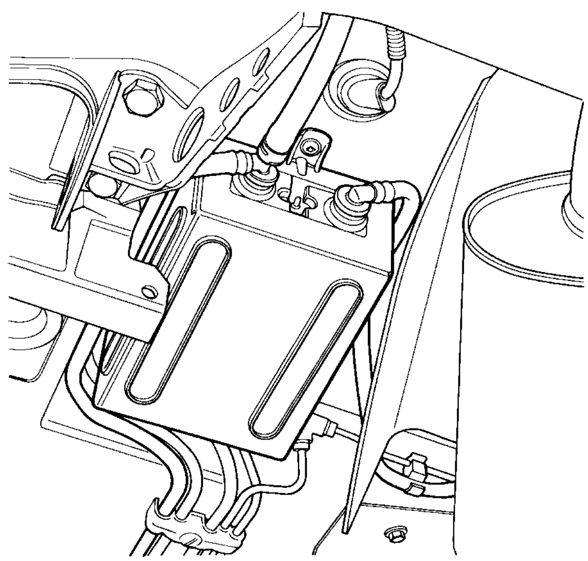


T851 / 4.18

Evaporative Canister

The new reshaped evaporative canister (charcoal canister) is identical in operation to previous canisters. The new canister contains filters to prevent charcoal particle leakage. The canister is located under the vehicle near the intermediate mufflers.

EVAPORATIVE CANISTER



T851 / 4.19

NOTES

Fuel Injection

Fuel metering is obtained by controlling the injector pulse during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups — primary and secondary. Primary control inputs are manifold absolute pressure (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, cranking signal, throttle movement and position, exhaust oxygen content and vehicle elevation. The injector pulse is then corrected for actual battery voltage. Depending on engine operating conditions, fuel injectors are pulsed semisequentially in pairs, in a group (A bank, B bank), or all 12 simultaneously. Semisequentially means twice per engine cycle (once per engine revolution) in the engine firing order.

Fuel injector pairing is as follows: 1A / 5A; 2A / 4A; 3A / 6A; 1B / 4B; 2B / 6B; 3B / 5B.

Fuel metering strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. Digital numbers representing injector pulse duration in milliseconds fill each site and cover the entire engine load and speed range. During most engine operating conditions, fuel metering correction is applied to A bank and B bank independently. In some instances, fuel metering correction is applied to all twelve cylinders simultaneously.

The ECM times the injection pulse using the crankshaft position sensor (CKPS) input that occurs once per engine revolution, and the engine speed (RPM) sensor input that occurs 12 times per engine revolution. The ECM distributes (sequences) the paired injection pulses in the engine firing order using the camshaft position sensor (CMPS) input that occurs once per engine cycle as cylinder A1 approaches TDC on the compression stroke. Refer to the RPM Sensor, CKPS and CMPS descriptions on pages 26 – 29.

Additional fuel injection controls are used for overrun fuel cutoff, engine overspeed prevention, and fuel cutoff during wide-open-throttle cranking.

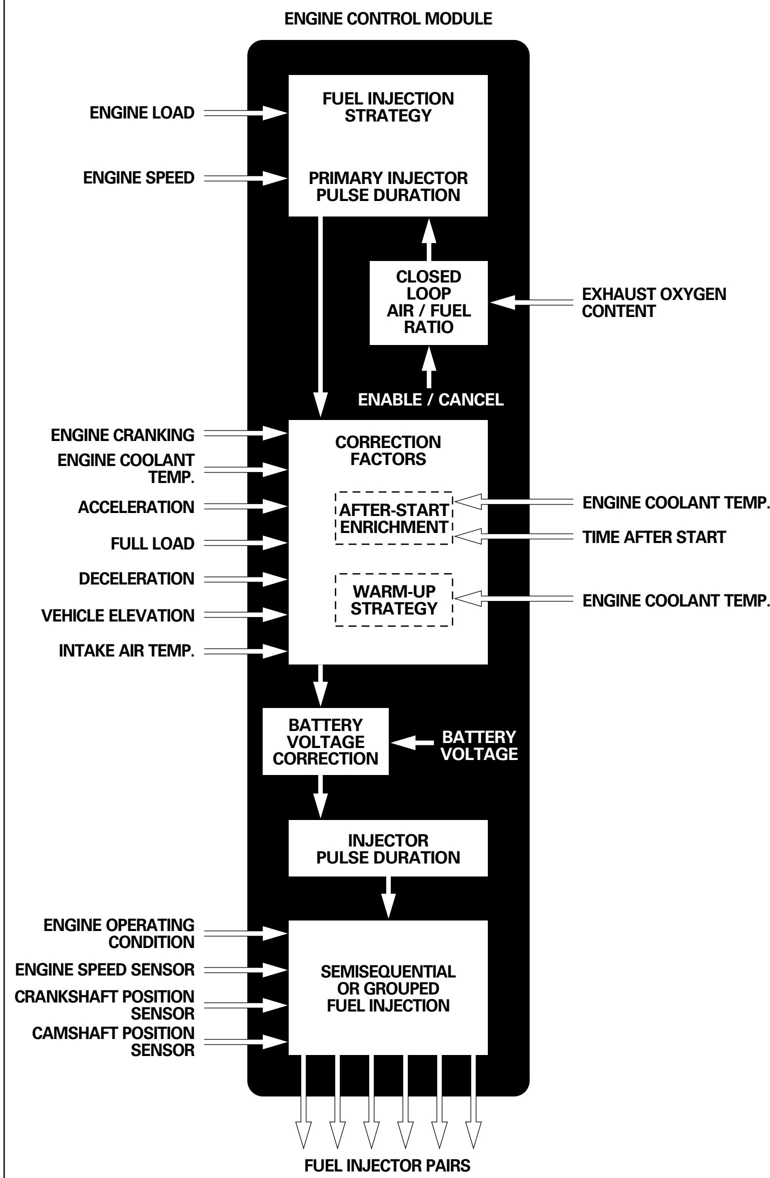
NOTES

Fuel Injection Primary Control

Fuel metering is controlled primarily as a function of engine load and speed. Engine load is sensed by the intake manifold absolute pressure sensors (MAPS) (one A bank, one B bank) connected to the rear of the engine air intake manifolds. Engine speed is sensed by the engine speed sensor (RPM Sensor) located at the rear of the engine vee. The ECM processes the input from the two MAPS and the RPM Sensor to access pulse duration from the fuel metering strategy.

NOTES

FUEL INJECTION PRIMARY AND SECONDARY CONTROL



T851 / 4.20

Fuel Injection (continued)

Fuel Injection Secondary Control

Secondary fuel metering control adjusts for engine coolant temperature, cranking signal, throttle movement and position, exhaust oxygen content, vehicle elevation, intake air temperature, battery voltage and the number of engine revolutions after engine starting.

Cranking and engine start enrichment
The ECM provides fuel metering enrichment for engine starts by increasing the injector pulse duration and "grouping" fuel injection. When the ECM receives a "crank" signal (parallel circuit from the body processor module output to the starter relay coil) plus an engine speed signal, injector pulse duration is increased and grouped injection takes place four times per engine cycle until the engine starts. In addition, there is a single simultaneous pulse of all 12 injectors upon initial cranking.

Crank signal monitoring for OBD II
If the engine is running with a continuous crank signal or started without a crank signal, a DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 8, page 59.

After-start enrichment
After engine start, injector pulsing occurs in pairs semisequentially. The injector pulse duration, and the rate at which the enrichment is decreased back to the warm-up phase, are dependent upon engine coolant temperature, measured by the engine coolant temperature sensor (ECTS), and the time after engine starting.

Warm-up
The programmed warm-up enrichment provides extra fuel during engine warm-up based on the engine temperature, measured by the coolant temperature sensor (ECTS). The warm-up phase is applied when the coolant temperature is below normal operating temperature.

Acceleration enrichment
When the ECM senses that the throttle is opening (throttle position sensor (TPS) input), the injector pulse duration is lengthened by an amount dependent upon the rate at which the throttle is opened, and on engine coolant temperature.

Full load enrichment
If the ECM senses a full throttle input from the throttle position sensor (TPS) and the manifold absolute pressure sensors (MAPS), full load enrichment is applied and momentary simultaneous (all 12 injectors) injection occurs. Closed loop operation is temporarily canceled.

Deceleration leaning
When the ECM senses that the throttle is closing (TPS input), the injector pulse duration is shortened dependent on the rate at which the throttle closed, preventing a momentary rich condition.

Closed loop fuel metering (Short term fuel trim)
In order to significantly reduce exhaust emission, the exhaust system incorporates two primary and two secondary 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible. A closed loop system between fuel injection, ECM control, and exhaust oxygen content feedback is used to maintain an air / fuel ratio as close to optimum (stoichiometric) as possible. In response to oxygen sensor voltage, the ECM continuously drives the air / fuel ratio rich-lean-rich by adding to, or subtracting from the baseline injector pulse duration. Refer to Heated Oxygen Sensors, pages 34 – 35.

NOTES

Closed loop fuel metering is canceled during the following engine operation conditions:

- engine starting
- air injection operation
- full load
- fuel metering cutoff
- certain fault conditions

Vehicle elevation
At high elevations, the fuel metering pulse is corrected using the input from the high altitude correction sensor (HACS) within the ECM. Refer to High Altitude Correction, page 5.

Intake air temperature
At low intake air temperature, the fuel metering pulse is increased to compensate for the increased intake air density.

Battery voltage correction
Because the time to achieve full lift of the injector pintle decreases as voltage increases, the amount of fuel delivered by the injector for a given pulse duration is dependent upon the injector operating voltage. The ECM is programmed with a voltage correction strategy. The supply voltage is monitored by a software routine and the correction applied to the pulse duration.

Additional Fuel Injection Controls

Overrun fuel cutoff
In order to improve fuel economy and aid in controlling exhaust emission, the ECM cancels fuel injection during engine overrun conditions. The ECM determines overrun conditions from inputs received from the throttle position sensor (TPS), engine speed (RPM) sensor and engine coolant temperature sensor (ECTS).

Engine overspeed control
An engine overspeed control function limits the maximum engine speed by canceling fuel injection, initially at 6100 rpm. If maximum engine speed is maintained, fuel injection cancellation is reduced to 6000 rpm.

Wide-open-throttle during cranking
If the ECM senses that the throttle is wide open (throttle position sensor (TPS) input) during cranking, fuel injection is canceled to help clear a flooded engine.

Fuel metering adaption (Long term fuel trim)
Long term fuel trim allows for minor engine mechanical variability and engine aging. The ECM contains adaptive idle fuel metering software that automatically makes a baseline correction to the idle fuel metering strategy using long term information from the oxygen sensors. The adaptive values are held in memory and will be retained as long as the vehicle battery is connected. If the battery is disconnected, the adaptive values will be lost. The ECM will relearn the values during the next driving cycle (if conditions permit).

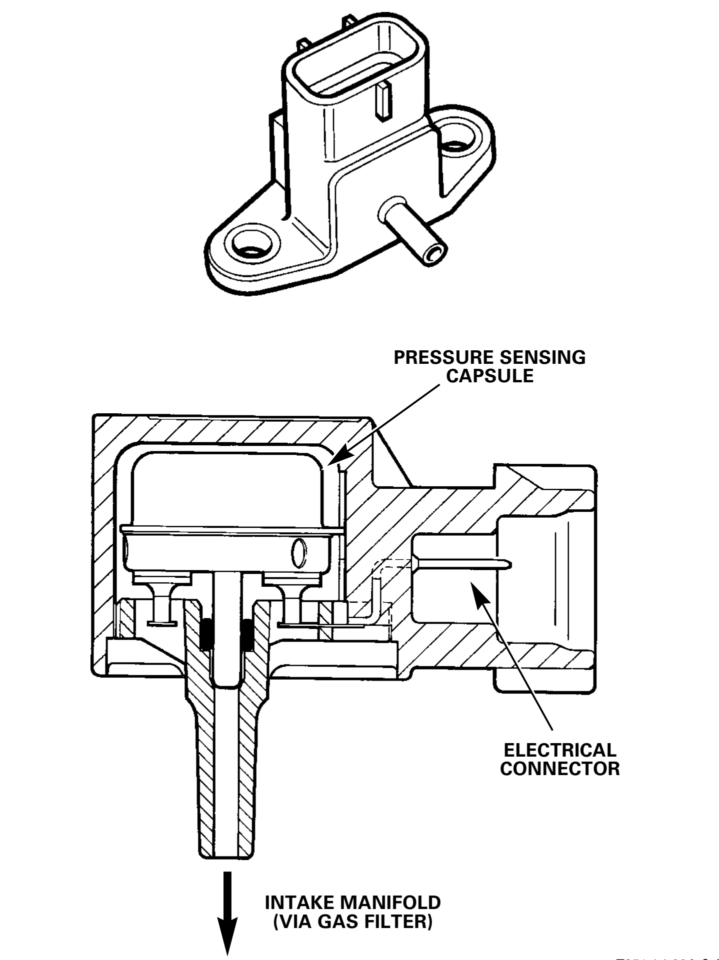
Long term fuel trim monitoring for OBD II
Fuel metering is monitored for adapted values at the rich / lean limit. If the value is beyond the limit(s), a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 6, page 57.

NOTES

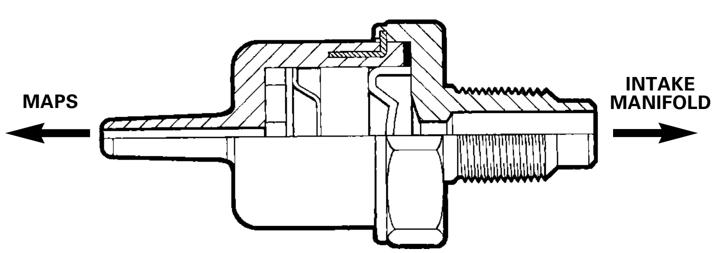
EMS Main Sensing Components: Engine Load

Manifold Absolute Pressure Sensors (MAPS)

MANIFOLD ABSOLUTE PRESSURE SENSOR WITH CROSS-SECTION



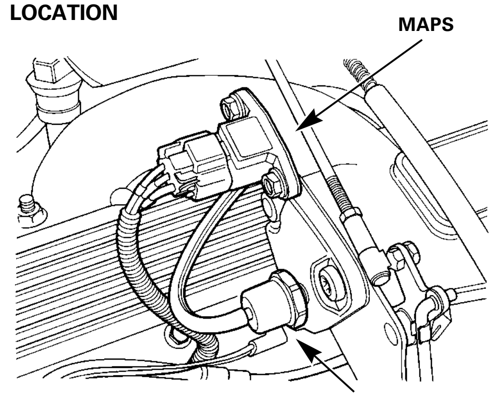
GAS FILTER CROSS-SECTION



A manifold absolute pressure sensor (MAPS) is connected to each intake manifold (A bank and B bank). The MAPS incorporates a pressure sensor capsule connected to a resistive element. Manifold absolute pressure changes (throttle valve opening / closing) act on the pressure capsule, which in turn acts on the resistive element to alter resistance. The MAPS is supplied with 5 volts from the ECM and outputs a voltage to the ECM that is directly proportional to manifold absolute pressure. The ECM uses the A and B bank MAPS inputs independently (not averaged) to control the respective bank in an aim for optimum combustion. Some averaged values (A bank and B bank) are used during OBD monitoring.

The MAPS are mounted on the rear of each intake manifold and connect to the manifold by a hose through a gas filter. The gas filter prevents MAPS contamination from crankcase vapors.

MANIFOLD ABSOLUTE PRESSURE SENSOR LOCATION



NOTES

Manifold Absolute Pressure (MAP) versus Gauge Vacuum (approximate)

MAP (in hg = inches of mercury)	Vacuum
30 in hg	0 in hg
29 in hg	1 in hg
28 in hg	2 in hg
27 in hg	3 in hg
26 in hg	4 in hg
25 in hg	5 in hg
24 in hg	6 in hg
23 in hg	7 in hg
22 in hg	8 in hg
21 in hg	9 in hg
20 in hg	10 in hg
19 in hg	11 in hg
18 in hg	12 in hg
17 in hg	13 in hg
16 in hg	14 in hg
15 in hg	15 in hg
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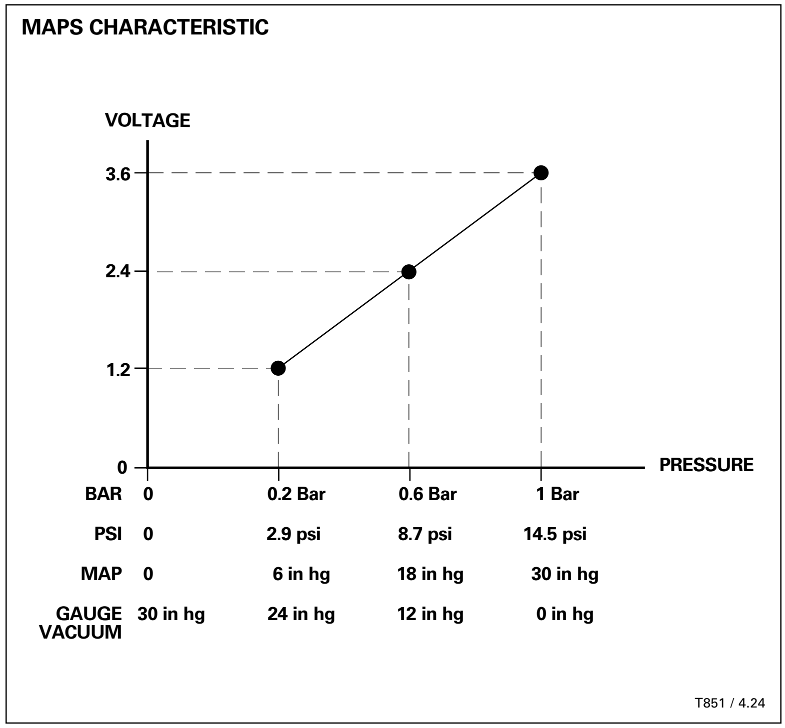
11 in hg	19 in hg
10 in hg	20 in hg



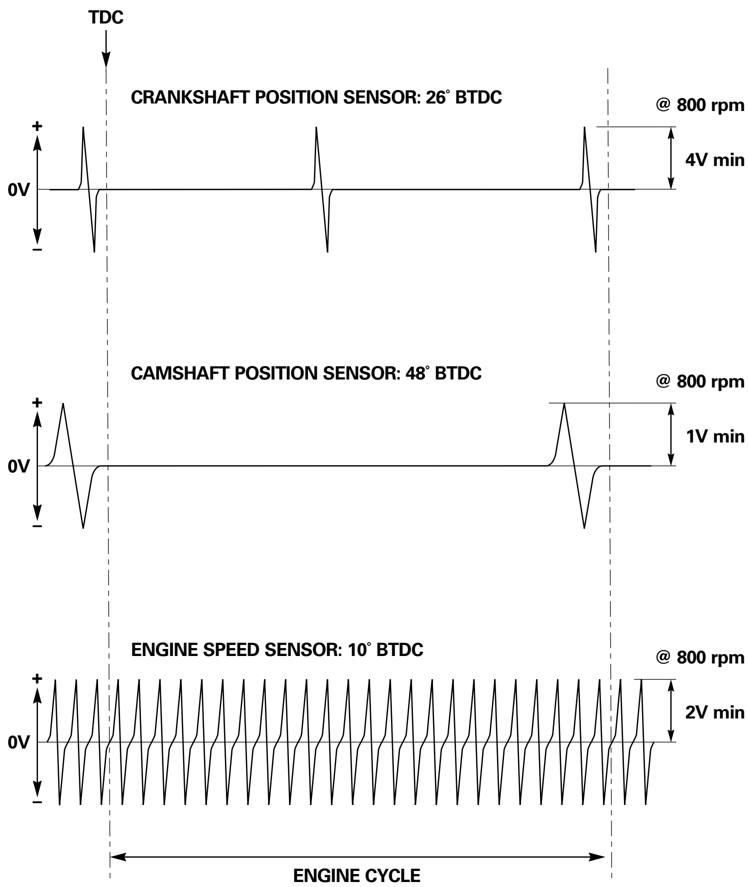
MAPS monitoring for OBD II

The range of the MAPS signal to the ECM is checked for values outside of the normal limits. If the signal stays high or low continuously (open / short circuit), a DTC is flagged and the CHECK ENGINE MIL is activated immediately. The MAPS signal is also monitored during acceleration after an idle period. If the signal does not change as expected, a DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 1, page 54.

NOTES

EMS Main Sensing Components: Engine Speed and Position

ELECTROMAGNETIC SENSOR PULSES: ONE ENGINE CYCLE



T851 / 4.25

Three electromagnetic sensors are installed on the engine: the engine speed sensor (RPM Sensor), the crankshaft position sensor (CKPS), and the camshaft position sensor (CMPS).

The ECM uses the engine speed sensor input to determine engine speed and for individual cylinder identification. The ECM uses the camshaft position sensor input for compression stroke identification (A bank). All three inputs are required semisequential fuel injection.

The illustration at left shows all of the pulses provided to the ECM during one engine cycle (two engine revolutions).

NOTES

Engine Speed Sensor (RPM Sensor)

The engine speed sensor (RPM Sensor) is located behind the flywheel at the rear of the engine vee. The sensor is a variable reluctance device that provides a pulse to the ECM at 30° intervals. A disc, mounted to the crankshaft, has twelve "spokes" that pass the RPM Sensor. The spokes are spaced 30˚ (crankshaft angle) apart on the disc. The ECM uses the RPM Sensor pulses for engine speed information. In addition, the ECM uses the pulse, in conjunction with the CKPS and CMPS pulses for cylinder synchronization.

The RPM Sensor provides twelve pulses per engine revolution starting at cylinder A1 at 10° BTDC and thereafter at every 30° of crankshaft rotation.

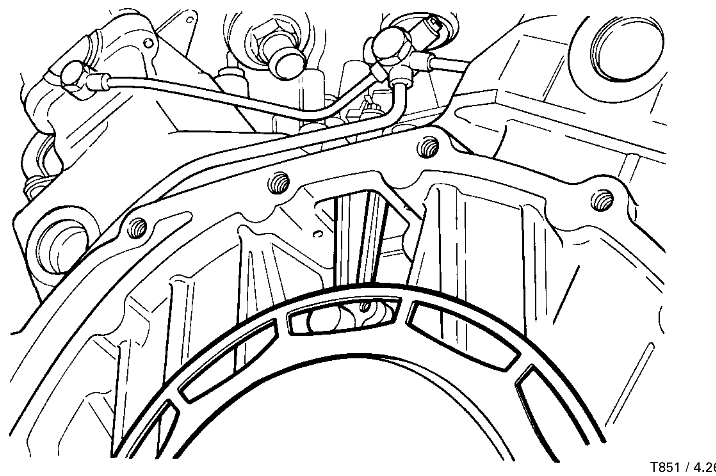
RPM Sensor monitoring for OBD II

The RPM Sensor signal is monitored during engine cranking (determined by the "cranking" signal input to the ECM). If there is no RPM Sensor signal while a "cranking" signal is present, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 14, page 60.

The RPM Sensor signal is also compared to the crankshaft position sensor input when the engine is running. If the expected number of RPM Sensor pulses are not received, a DTC is flagged and the CHECK ENGINE MIL is activated immediately.

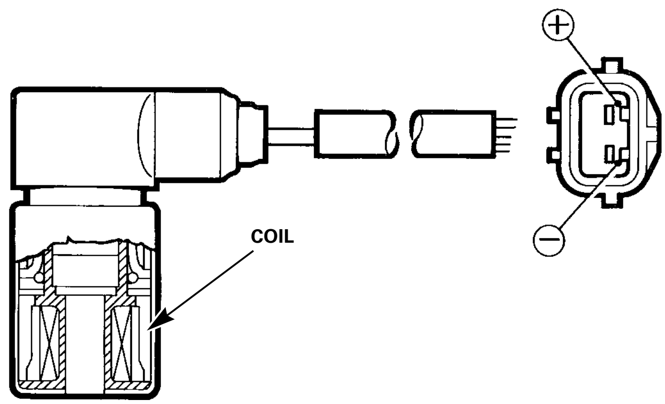
NOTES

ENGINE SPEED SENSOR LOCATION



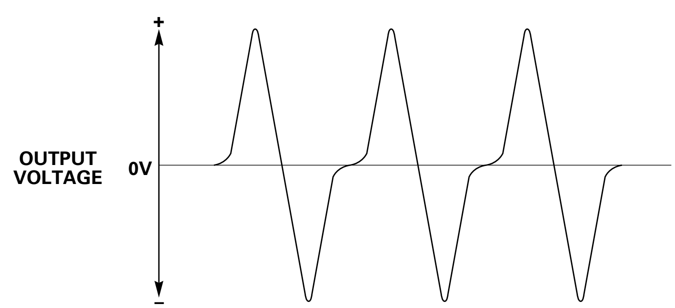
T851 / 4.26

ENGINE SPEED SENSOR CROSS-SECTION



T851 / 4.27

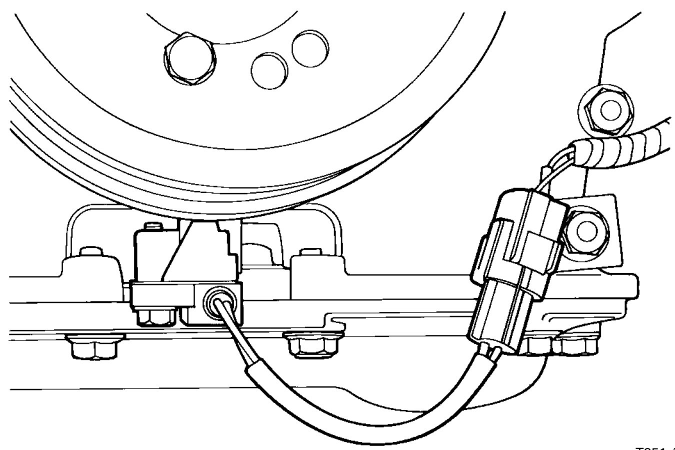
ENGINE SPEED SENSOR CHARACTERISTIC



T851 / 4.28

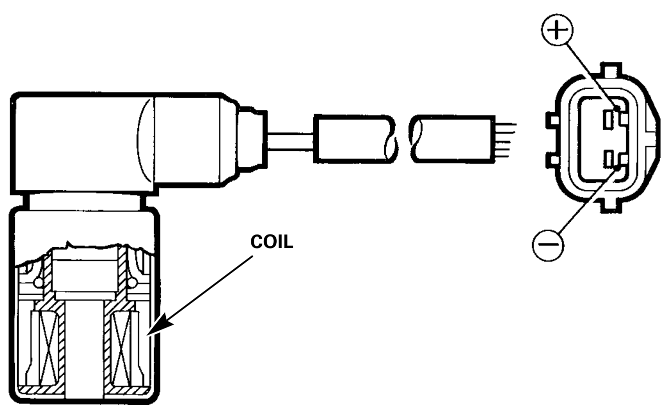
EMS Main Sensing Components: Engine Speed and Position (continued)

CRANKSHAFT SENSOR LOCATION



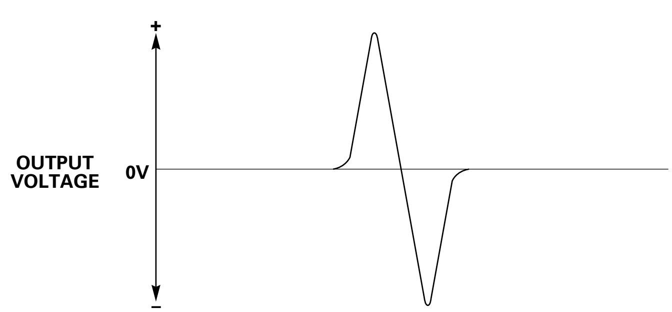
T851 / 4.29

CRANKSHAFT SENSOR CROSS-SECTION



T851 / 4.30

CRANKSHAFT SENSOR CHARACTERISTIC



T851 / 4.31

Crankshaft Position Sensor (CKPS)

The crankshaft position sensor (CKPS) is located at the bottom of the crankshaft front pulley. The sensor is a variable reluctance device that provides a pulse to the ECM once each engine revolution. A disc, mounted to crankshaft damper has one tooth that passes the CKPS. The ECM uses the CKPS pulse for semisequential fuel injection in conjunction with the RPM Sensor and CMPS pulses. In addition, the ECM uses the pulse, in conjunction with the RPM Sensor pulses for grouped (bank) fuel injection and ignition timing.

The CKPS provides a pulse once per engine revolution synchronized to cylinder A1 at 26° BTDC.

CKPS monitoring for OBD II

The CKPS signal is compared to the RPM Sensor signal. If there are 36 RPM Sensor pulses and no CKPS pulse, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 14, page 60.

The three sensors (RPM Sensor, CKPS, and CMPS) are also continuously compared to one another when the engine is running. If an unexpected signal is detected, a DTC is flagged and the CHECK ENGINE MIL is activated immediately.

NOTES

Camshaft Position Sensor (CMPS)

The camshaft position sensor (CMPS) is located on the A bank camshaft cover at the front of the engine. The sensor is a variable reluctance device that provides a pulse to the ECM once each engine cycle (two engine revolutions). A single peg on the A bank camshaft passes the CMPS once per camshaft revolution (two engine revolutions). The ECM uses the CMPS pulse in conjunction with the RPM Sensor and CKPS pulses for timing semisequential fuel injection in the engine firing order.

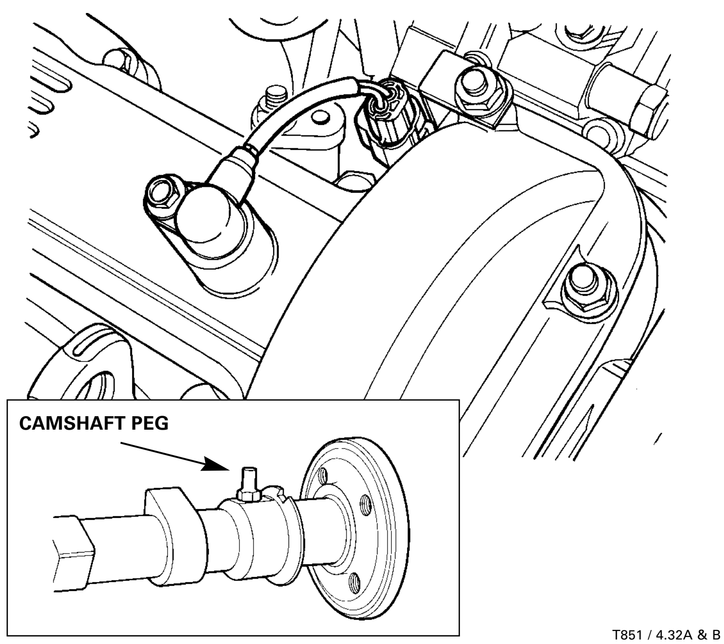
The CMPS provides one pulse per engine cycle (two engine revolutions) synchronized to cylinder A1 at 48° BTDC on the compression stroke.

CMPS monitoring for OBD II

The CMPS signal is compared to the CKPS signal. If there are 5 CKPS pulses and no CMPS pulse, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 14, page 60.

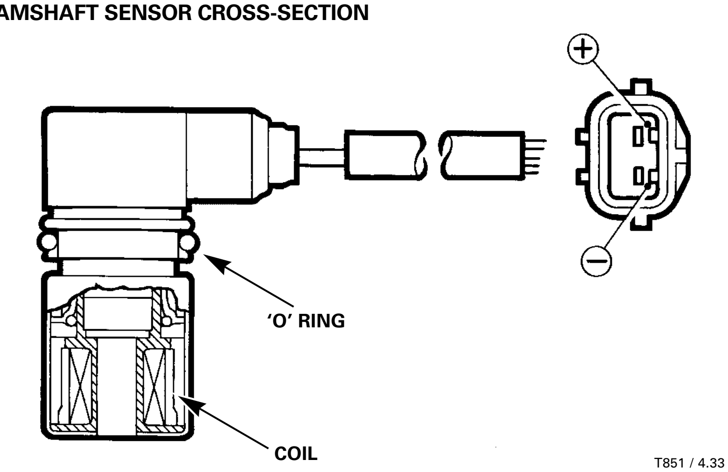
NOTES

CAMSHAFT SENSOR LOCATION



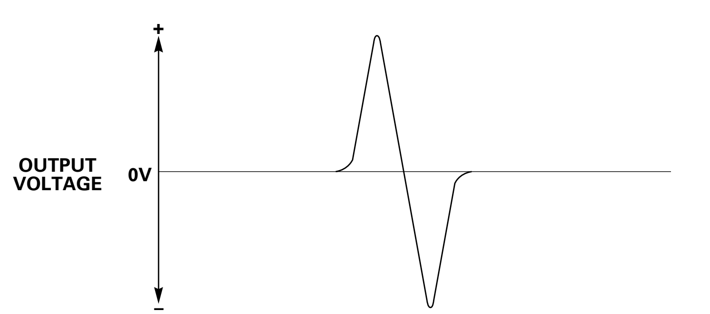
T851 / 4.32A & B

CAMSHAFT SENSOR CROSS-SECTION



T851 / 4.33

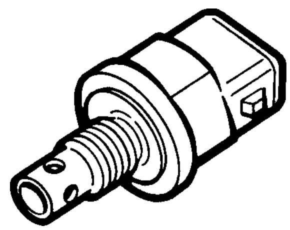
CAMSHAFT SENSOR CHARACTERISTIC



T851 / 4.34

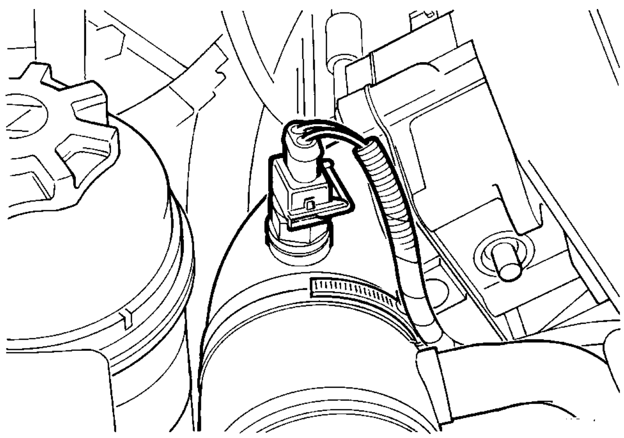
EMS Main Sensing Components: Temperature

INTAKE AIR TEMPERATURE SENSOR



T851 / 4.35

INTAKE AIR TEMPERATURE SENSOR LOCATION



T851 / 4.36

Intake Air Temperature Sensor (IATS)

The intake air temperature sensor (IATS) is a negative temperature coefficient (NTC) thermistor identical to the sensor used in V12 Lucas / Marelli EMS. Intake air temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

Intake air temperature sensor – temperature versus resistance:

Intake air temperature °F	°C	Resistance (kilo ohms)
68	20	2.50
176	80	0.325
212	100	0.19

IATS monitoring for OBD II

The IATS range is checked for values outside the normal limits while the engine is running. If the signal is out of the normal range for more than 25.6 seconds, a DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL.

If the IATS signal is high or low (open / short circuit) continuously, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 2, page 54.

NOTES

Engine Coolant Temperature Sensor (ECTS)

The engine coolant temperature sensor (ECTS), located on the B bank thermostat housing, is a negative temperature coefficient (NTC) thermistor. Engine coolant temperature is determined by the ECM by a change in resistance within the sensor. The ECM applies 5 volts to the sensor and monitors the voltage across the pins to detect the varying resistance.

Coolant temperature sensor – temperature versus resistance:

Coolant temperature °F	°C	Resistance (kilo ohms)
68	20	2.45
176	80	0.318
230	110	0.1417

Coolant temperature sensor – temperature versus voltage:

Coolant temperature °F	°C	Voltage
-13	-25	4.43
20	-7	3.8
40	4	3.18
60	16	2.55
86	29	1.93
112	45	1.31
158	70	0.68
247	119	0.2

ECTS monitoring for OBD II

Two test are performed to check the ECTS:

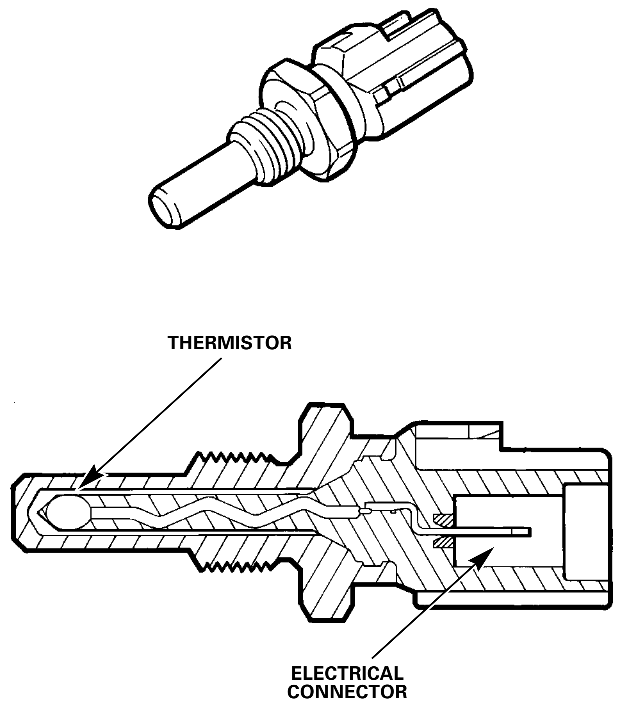
1 The ECTS signal is checked for values outside the normal range. If there is a fault, a DTC is flagged and the CHECK ENGINE MIL is activated immediately.

2 A "time to warm-up" test checks that the sensor responds to a rise in coolant temperature. If there is a fault, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL.

Refer to DTC Summary: Group 3, pages 54 and 55).

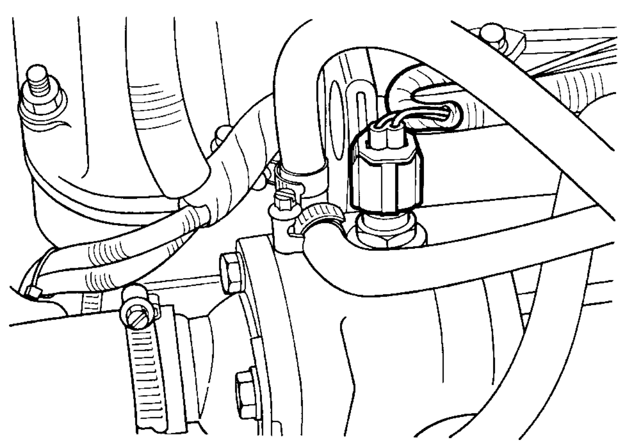
NOTES

ENGINE COOLANT TEMPERATURE SENSOR WITH CROSS-SECTION



T851 / 4.37A & B

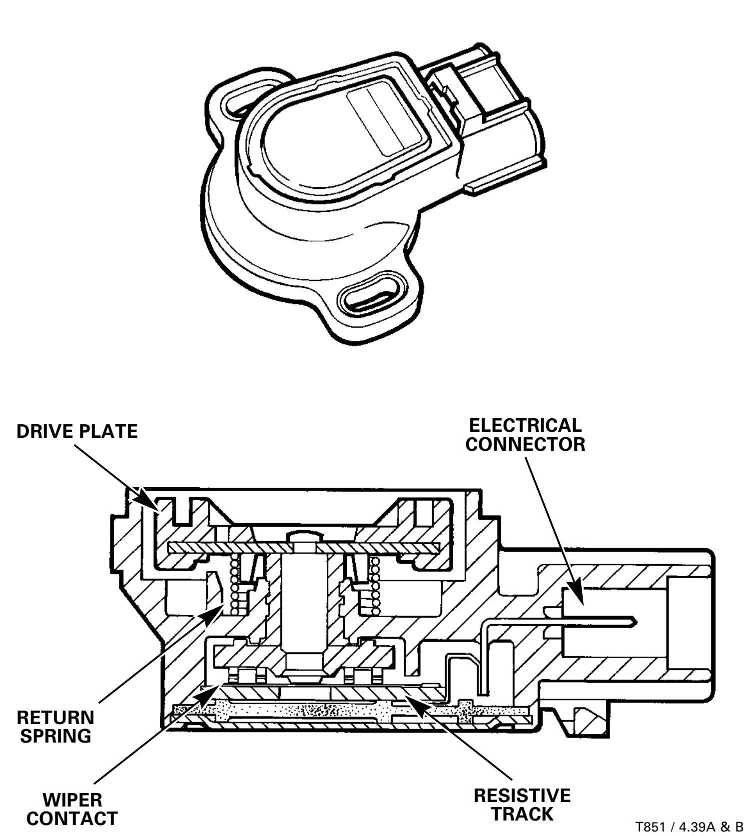
ENGINE COOLANT TEMPERATURE SENSOR



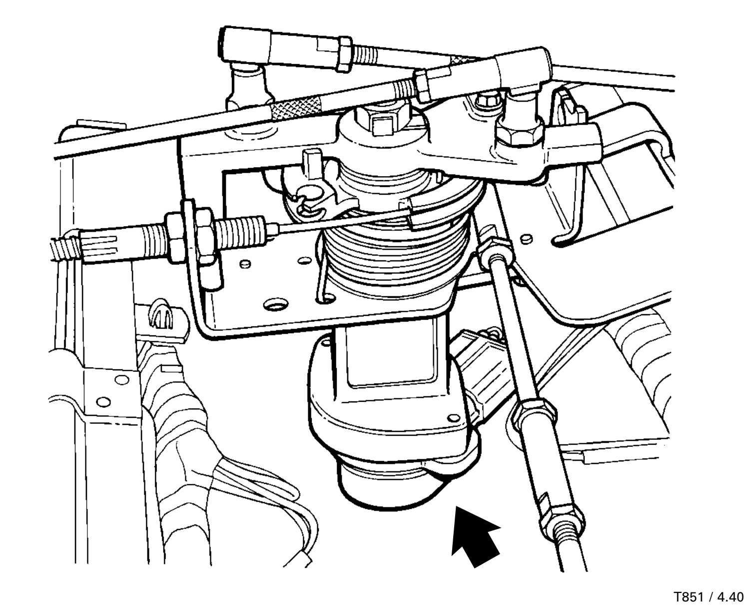
T851 / 4.38

EMS Main Sensing Components: Throttle Position

THROTTLE POSITION SENSOR WITH CROSS-SECTION



THROTTLE POSITION SENSOR LOCATION



Throttle Position Sensor (TPS)

The throttle position sensor (TPS) is an adjustable single-track potentiometer connected to the spindle of the throttle turntable. The TPS incorporates an idle switch that is closed when the throttle is closed.

The ECM applies 5 volts to the sensor and monitors the voltage across the pins to determine throttle position: low voltage / closed throttle, high voltage / opened throttle. At full throttle, the voltage signal to the ECM is approximately 3.4 volts. The idle switch provides a ground input to the ECM when the throttle is closed.

After installation of a TPS, initial adjustment must be performed using PDU.

NOTES

TPS monitoring for OBD II
Two test are performed to check the TPS:

1 The TPS signal is checked for values out side the normal range. If there is a fault, a DTC is flagged and the CHECK ENGINE MIL is activated immediately.

2 If, during steady driving, the sensor voltage does not change in comparison to changing MAP and RPM signals, a fault is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL.

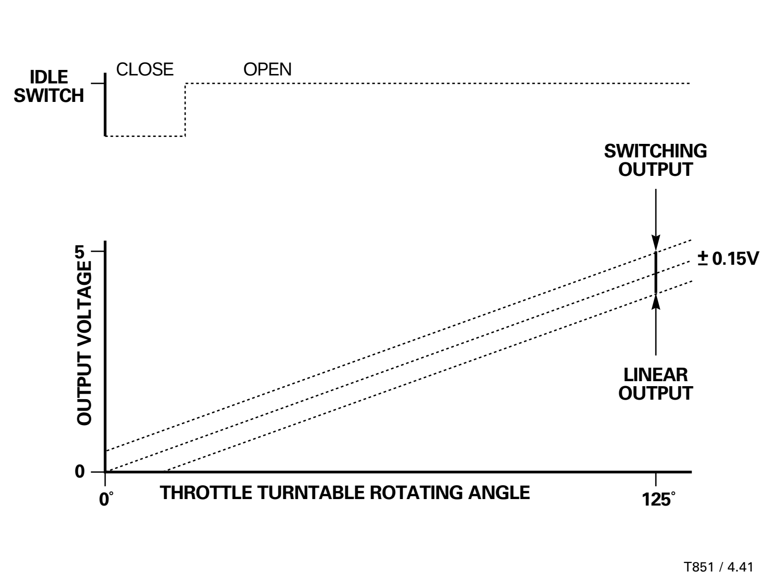
Refer to DTC Summary: Group 4, page 55.

Idle switch monitoring for OBD II
The idle switch is checked by the ECM during deceleration and acceleration. If the ECM does not receive an idle switch change of state during five consecutive deceleration/acceleration cycles, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 21, page 62.

Sensor power supply monitoring for OBD II
The supply voltage to the MAPS, IATS, ECTS and TPS is monitored for high or low voltage. If the voltage is high or low, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 12, page 58.

NOTE: If the A and B bank MAP sensors and the TPS have failed at the same time, a sensor power supply DTC will be flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL.

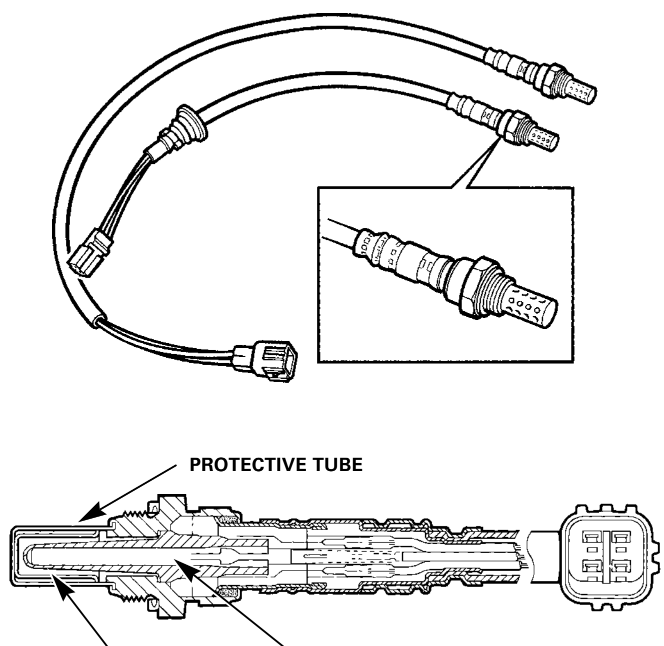
THROTTLE POSITION SENSOR CHARACTERISTIC



NOTES

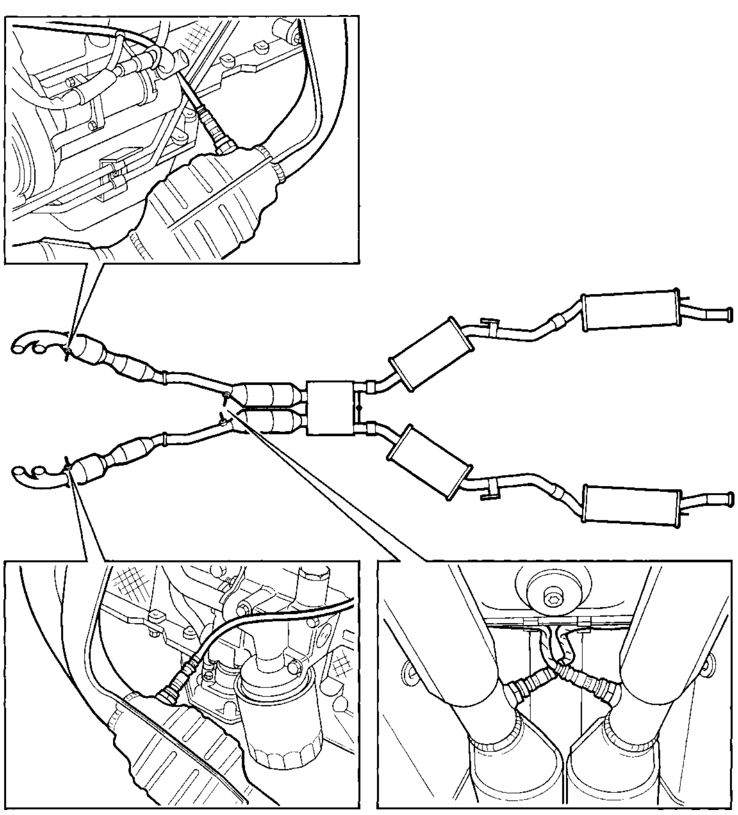
EMS Main Sensing Components: Exhaust Gas Oxygen Content

HEATED OXYGEN SENSOR WITH CROSS-SECTION



T851 / 4.43A & B

HEATED OXYGEN SENSORS LOCATION



T851 / 4.42

Heated Oxygen Sensors (HO2S)

The V12 / ND EMS uses four heated oxygen sensors (HO2S), one upstream and one downstream of the primary catalyst on each cylinder bank exhaust pipe.

The sensors used in the V12 / ND EMS are similar in characteristic to the HO2S used in the V12 Lucas / Marelli EMS. These produces voltage by conducting oxygen ions at approximate temperatures above 572°F (300°C). In order to reduce the amount of exhaust gas and resulting emission needed to bring the sensor up to working temperature, an internal electric heater is used. The heaters are controlled by the ECM. At engine speeds above approximately 3000 rpm, the ECM switches off the heaters. The tip portion of the sensor's ceramic element is in contact with the exhaust gas. The remaining portion of the ceramic element is in contact with ambient air via a filter through the sensor body.

Four oxygen sensors are installed on the exhaust system, one upstream and one downstream of the primary catalysts for each cylinder bank. The two upstream sensors are used by the ECM for closed loop fuel metering correction. The downstream sensors for used for OBD catalyst monitoring. Refer to Closed Loop Fuel Metering, pages 24 – 25.

The construction of the upstream and downstream sensor harnesses are different so that they cannot be interchanged. However, there are no orientation "rules". If the battery is disconnected, the ECM will relearn adaptive values during the next driving cycle when new sensors are installed, or if sensors are switched side-to-side.

NOTES

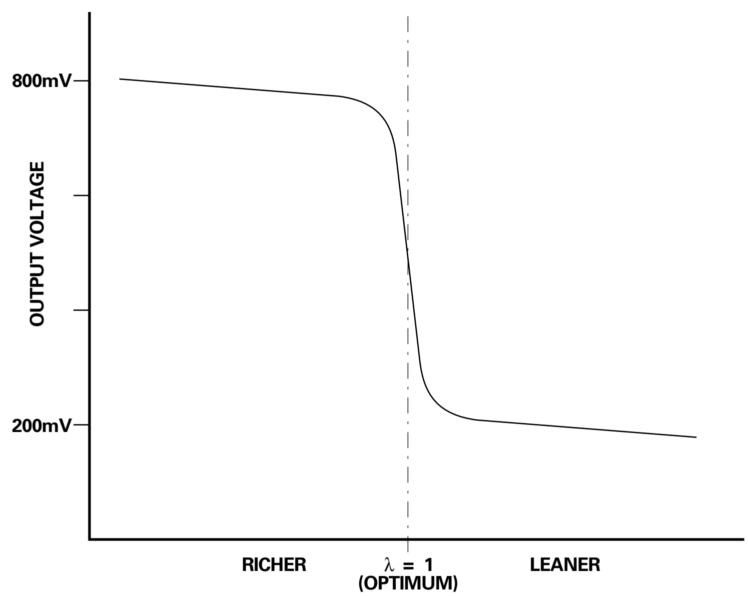
The sensor voltage output swings between approximately 800 millivolts and approximately 200 millivolts depending on the oxygen level differential between ambient air and exhaust gas on either side of the ceramic element. When the air / fuel ratio is richer than optimum, the voltage output is high; when the air / fuel ratio is leaner than optimum, the output voltage is low. Only a very small change in air / fuel ratio is required to switch the oxygen sensor.

HO2S monitoring for OBD II
The oxygen sensors and heater circuits are monitored during steady driving with a fully warmed-up engine.

The upstream and downstream sensor output voltages are compared to a normal range and to each other. The sensors are also tested when a fuel system fault has been detected. Periodically, the sensor response rates are compared to a standard. If there is a fault, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 5, pages 56 – 57.

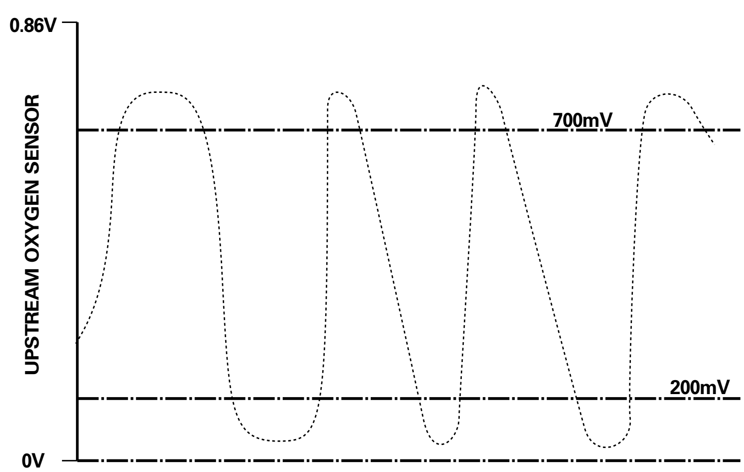
NOTES

HEATED OXYGEN SENSOR CHARACTERISTIC



T851 / 4.44

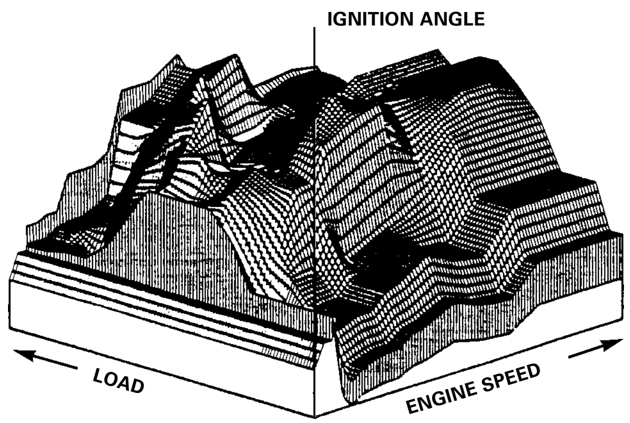
HEATED OXYGEN SENSOR VOLTAGE SWING TRACE – UPSTREAM



T851 / 4.45

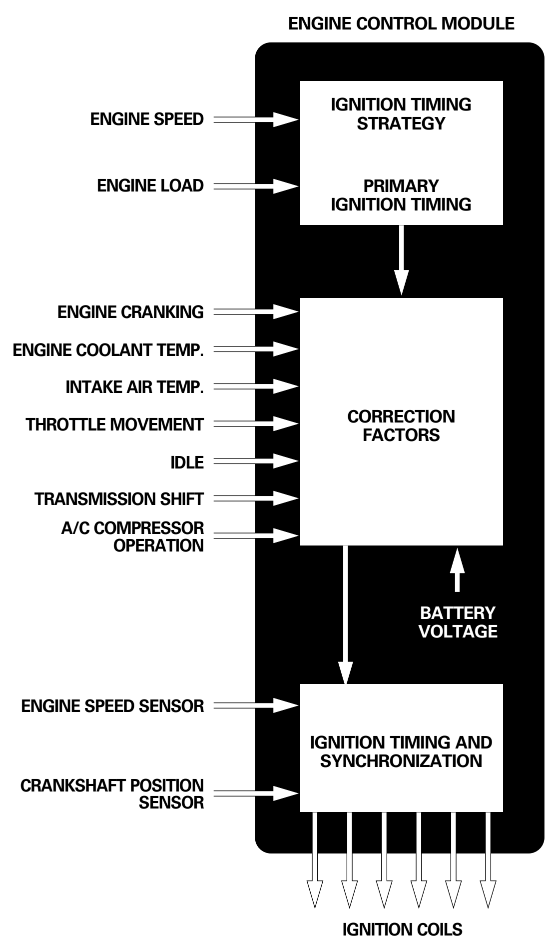
Ignition Control

IGNITION TIMING STRATEGY (TYPICAL)



T851 / 4.46

IGNITION PRIMARY AND SECONDARY CONTROL



T851 / 4.47

Ignition Timing and Spark Distribution

Ignition timing and spark distribution are controlled by the engine control module (ECM) according to sensor inputs. As with fuel injection, the sensed control inputs form two groups: primary and secondary. Primary control inputs are intake manifold absolute pressure (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature, throttle movement and position, and transmission shift status.

Ignition timing strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. Digital numbers representing ignition timing values fill each site. The resulting ignition timing values cover the entire engine load and speed range. Ignition timing is then calculated from the ignition timing strategy according to secondary input correction factors.

Spark distribution, in the engine firing order, is ECM controlled. The spark plugs are fired in pairs (each pair 360 degrees apart in the engine cycle) so that the cylinder on the exhaust stroke receives a “wasted” spark. The ECM determines spark synchronization based on the input pulses from the engine speed sensor (RPM Sensor) and the crankshaft position sensor (CKPS). Refer to the sensor descriptions, pages 27 – 28.

Engine Firing Order

A1 - B6 - A5 - B2 - A3 - B4 - A6 - B1 - A2 - B5 - A4 - B3

Ignition Primary Control

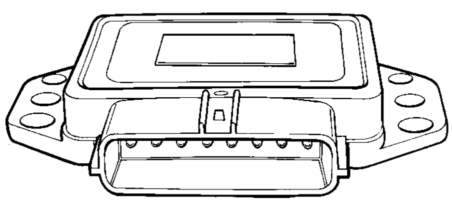
Ignition timing is controlled primarily as a function of engine load and speed. Engine load is sensed by the intake manifold absolute pressure sensors (MAPS) (one A bank, one B bank) connected to the rear of the engine air intake manifolds. Engine speed is sensed by the engine speed sensor (RPM Sensor) located at the rear of the engine vee. The ECM processes the inputs from the MAPS and the RPM sensor and accesses ignition timing from the ignition timing strategy.

NOTES

Ignition Modules

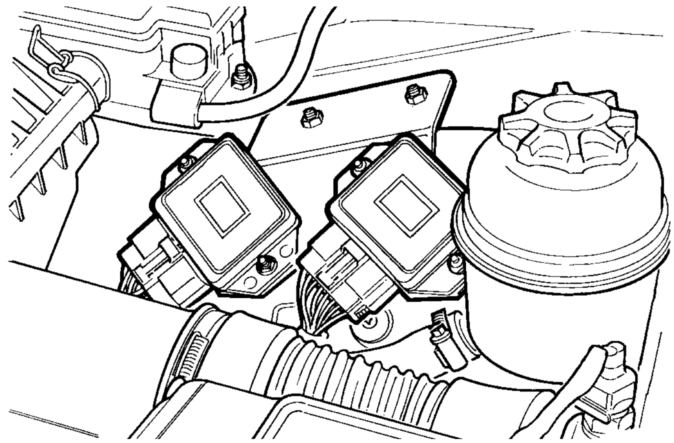
Two ignition modules (amplifiers) are installed, one for each ignition coil pack. The modules receive ignition drive signals from the ECM and, in turn control the primary current switching of the ignition coils (three coils per ignition coil pack). Dwell control for the ignition system is performed within the ECM.

IGNITION MODULE



T851 / 4.49

IGNITION MODULES LOCATION



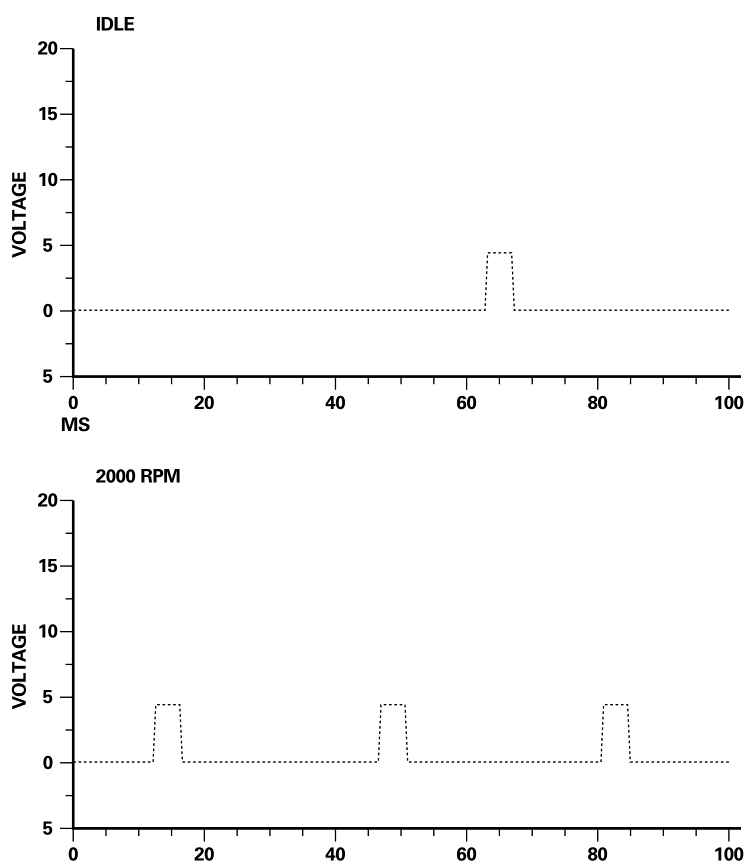
T851 / 4.48

Ignition module monitoring for OBD II

Each ignition module (A bank, B bank) outputs a feedback signal to the ECM when a correct ignition primary trigger signal has occurred. If the correct number of pulses is not received by the ECM, a DTC relating to the specific bank will be flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 15, page 60.

NOTES

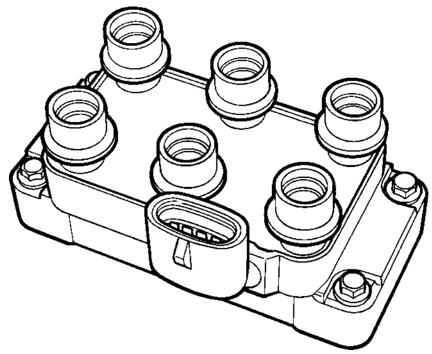
IGNITION MODULE DRIVE SIGNALS AT ECM



T851 / 4.50A & B

Ignition Control (continued)

IGNITION COIL PACK

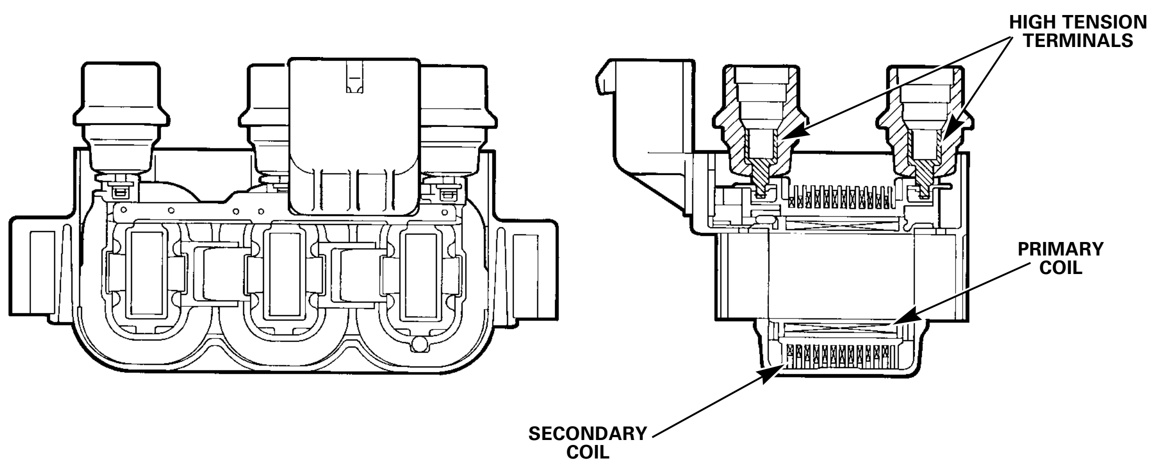


T851 / 4.52

Ignition Coil Packs

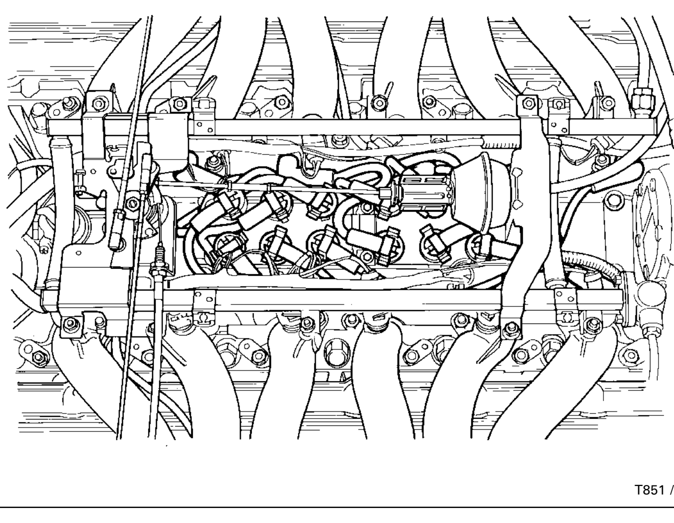
Each ignition coil pack contains three separate ignition coils. Each coil fires two spark plugs simultaneously (each pair 360 degrees apart in the engine cycle) so that one spark occurs on a compression stroke and one spark on an exhaust stroke. The spark fired on the exhaust stroke (wasted spark) uses only a small amount of the coil's stored energy, the majority going to the spark on the compression stroke. Since the spark plugs are connected in series, the ignition voltage of one spark plug is negative while the other spark plug is positive (referenced to ground).

IGNITION COIL PACK CROSS-SECTION



T851 / 4.53

IGNITION COIL PACKS LOCATION



T851 / 4.51

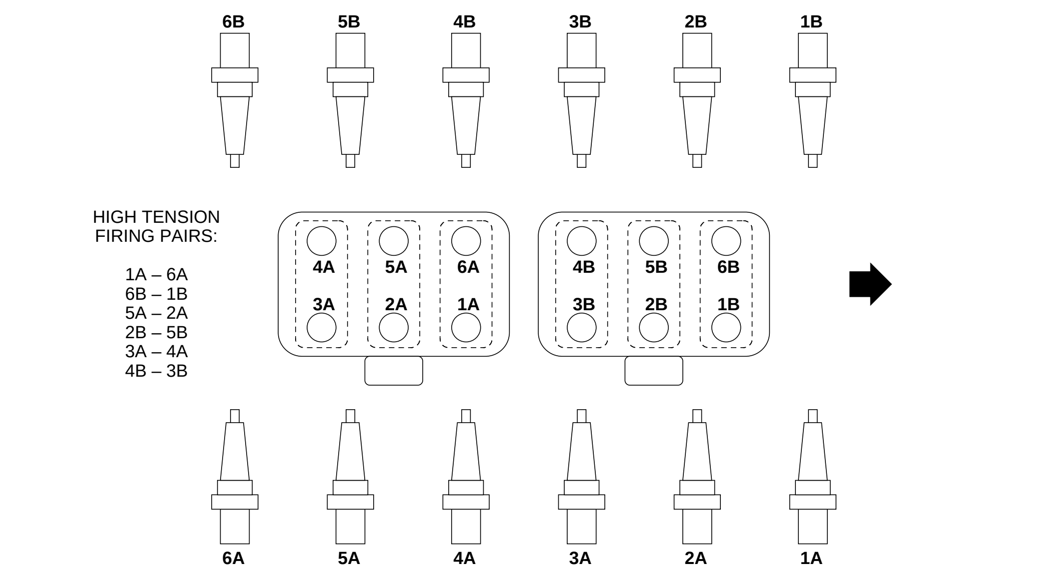
NOTES

The spark plugs are paired as shown in the high-tension wiring layout.

Spark plug specification

NGK BR6EF Electrode gap: 0.026 in (0.65 mm)

HIGH TENSION WIRING LAYOUT

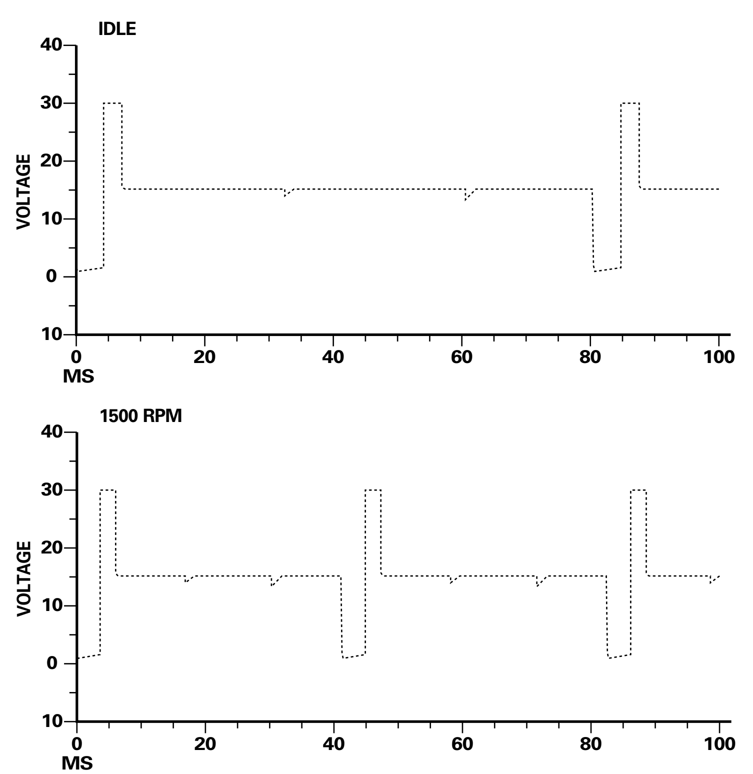


Ignition coil pack monitoring for OBD II

Ignition coil primary circuit current is monitored by the ignition modules while the engine is running. If incorrect ignition occurs, ignition module feedback to the ECM is disrupted and a DTC is flagged. Refer to Ignition Module Monitoring for OBD II, page 37, and DTC Summary: Group 15, page 60.

NOTES

IGNITION COIL PRIMARY CIRCUIT CHARACTERISTIC



Ignition Control (continued)

Ignition Secondary Control

Secondary ignition timing control inputs consist of battery voltage, engine coolant temperature, intake air temperature, throttle movement and position, and transmission shift.

Dwell control
The dwell angle and peak coil current are ECM controlled to maintain the required spark energy required throughout the operating range of the engine while keeping dwell to a minimum to avoid overheating of the ignition coils.

Engine coolant temperature correction
Ignition timing is corrected for engine coolant temperature by the ECM.

Intake air temperature correction
Ignition timing is corrected by the ECM for engine intake air temperature measured by the air temperature sensor mounted in the A bank air intake elbow. At higher intake air temperatures, the ignition is retarded to prevent detonation.

Closed throttle / idle correction
Separate idle ignition strategies are used for closed throttle based on idle switch input and engine speed. Refer to Idle Control, pages 41 – 43.

Full load correction
The ECM corrects ignition timing to compensate for full load conditions. Full load is determined by MAPS an TPS inputs to the ECM.

Engine starting and transient correction
Ignition timing is retarded during engine starting and after rapid throttle opening to prevent detonation.

Torque-based transmission shifting
Transmission shift quality is enhanced by "torque-based shifting". The ECM continuously provides the transmission control module (TCM) with a pulse width modulated (PWM) signal that represents the engine torque. This signal is generated by the ECM based on engine speed and load, plus the correction factors.

When a shift is to occur, the TCM calculates the necessary torque reduction and provides a PWM "ignition retard request" signal to the ECM. The PWM torque reduction signal will vary between 20% and 90% (20% equals 0° ignition retard; 90% equals 34° ignition retard). The actual amount of retard is applied to the ignition advance angle after other corrections are applied.

Ignition retard request monitoring for OBD II
The ECM monitors the ignition retard request signal from the TCM in two ways:

1 If the signal stays at 12% for a predetermined time, a DTC will be flagged and both the CHECK ENGINE and TRANSMISSION MILs will immediately be activated.

2 If the TCM requests ignition retard for too long, the ECM will flag a DTC and both the CHECK ENGINE and TRANSMISSION MILs will immediately be activated.

Refer to DTC Summary: Group 24, page 62.

NOTES

Idle Control

Idle speed is regulated by idle air control and ignition timing.

The idle air control valves (IACV) are driven by the ECM. The ECM uses inputs received from ignition ON, the engine speed sensor (RPM Sensor), the engine coolant temperature sensor (ECTS) and the throttle position sensor (TPS) as well as inputs for gear position, air conditioning compressor operation, power steering pump status, and road speed to control idle speed.

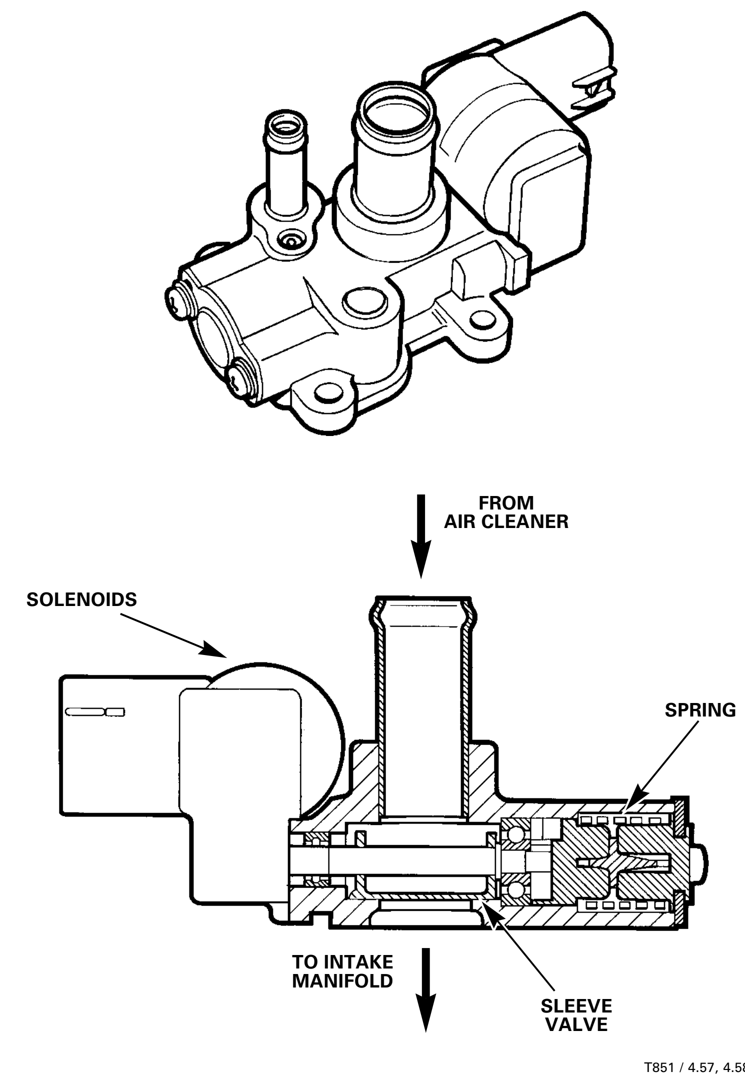
Idle Air Control Valves (IACV)

The throttle bodies of each bank incorporate connections to individual idle air control valves (IACV). The IACVs are mounted to manifolds that attach to the cylinder heads. The IACV and manifold assemblies connect to the air cleaners by hoses. Engine coolant is circulated through the IACVs to provide an engine temperature reference for the thermostatically-controlled mechanical guard. The guard prevents excessively high or low idle speed if the IACV fails electrically. The throttle bodies do not have an adjustable bleed to provide a base idle setting. The base idle setting is controlled by the IACV.

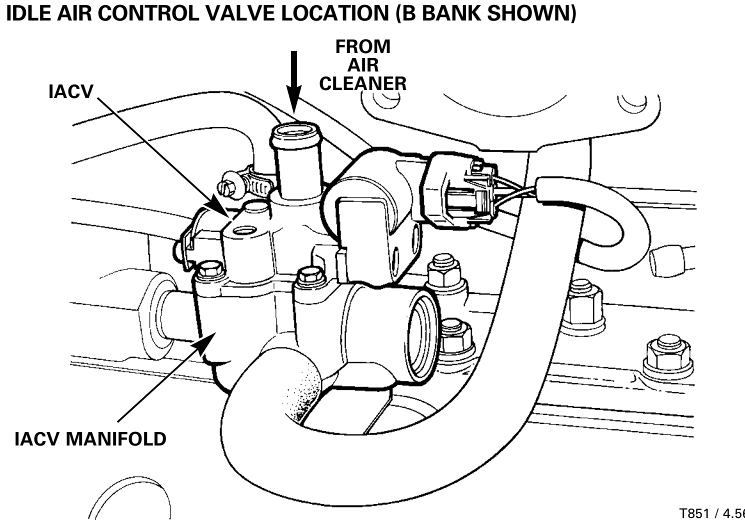
Bypass air flow is controlled by a sleeve valve operated by a rotary solenoid containing two coils. One coil is used to close the valve; the other coil is used to open the valve. One side of each coil receives battery voltage from an ignition switched supply. The ECM supplies each coil with a pulse width modulated (PWM) ground signal that is in “anti-phase” with the other so that the two coils work against each other to position the valve. When the ignition is switched OFF, a spring returns the valve to a fixed closed position. The ECM positions the valve for sufficient air during starting.

NOTES

IDLE AIR CONTROL VALVE WITH CROSS-SECTION

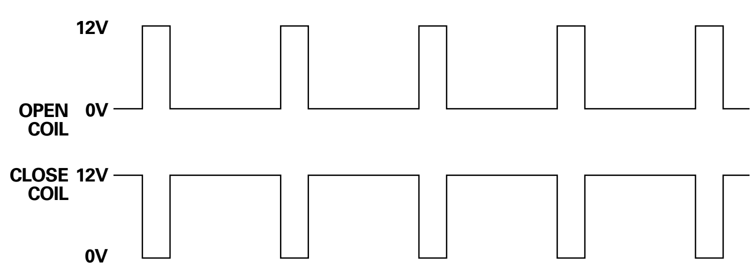


IDLE AIR CONTROL VALVE LOCATION (B BANK SHOWN)



Idle Control (continued)

IDLE AIR CONTROL VALVE OPEN / CLOSE PWM SIGNALS



Idle Air Control Valves (continued)

The PWM signals shown in the illustration are for a valve position that is relatively open. The signals would have an opposite "duty cycle" for a closed valve position.

During most operating modes, the ECM uses common control for both A and B bank IACVs; however, individual bank corrections are made to balance A and B bank manifold pressure and for OBD monitoring.

IACV monitoring for OBD II
The IACVs are tested during each drive cycle at the first long idle period at normal operating temperature. Each IACV is opened individually during which time the ECM monitors the MAP and RPM signals for the expected response. If the response is not as expected, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 20, page 62.

ECM Idle Speed Control

The ECM controls idle speed from an idle speed strategy. This strategy is accessed when the idle switch within the TPS closes (closed throttle). Refer to TPS, pages 32 – 33.

Closed loop idle speed control occurs at closed throttle (idle switch closed) when road speed is less than 1.25 mph (2 kph). The programmed idle speed accounts for engine temperature and the loads placed on the engine by the transmission (gear position N, D, etc.), air conditioning compressor clutch operation, power steering pump pressure, vehicle elevation and battery voltage.

Target stable idle speeds: (normal operating temperature)

Park / Neutral – 700 ± 25 rpm
Drive / R, D 2, D 3 – 600 ± 25 rpm

NOTE: At road speeds above 1.25 mph (2 kph), the idle air control valves (IACVs) are opened to limit overrun intake manifold pressure. The amount that the valves are opened is based on engine speed, engine temperature and throttle opening.

NOTES

Engine start-up
ECM idle speed control begins shortly after the engine is started, provided the throttle is closed (idle switch closed) and the road speed is less than 1.25 mph (2 kph). The rotary solenoid valves in the IACVs move toward close, until the target idle speed is reached.

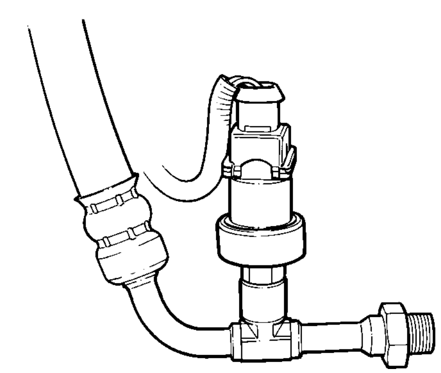
Gear position
When the gear selector is in Park or Neutral, the engine management ECM receives a ground signal from the linear gear position switch. The ECM then starts closing the idle air control valves in anticipation of the reduced engine load.

Electrical load
When the ECM receives an input from the climate control system that either the windshield heaters, heated backlight or the blowers (high speed) are switched ON, the ECM compensates for this increased engine load. The ECM drives the idle air control valves open by a programmed amount and advances the ignition timing to compensate for the change in engine load.

Air conditioning compressor clutch operation
When the air conditioning compressor clutch is energized, the ECM drives the idle air control valves further open and advances the ignition timing to compensate for the change in engine load.

Power steering pump pressure
The ECM compensates for increased engine load that occurs when the power steering hydraulic pressure is high. During low speed maneuvering and parking, a power steering pump pressure switch closes at 475 – 625 psi (32.75 – 43 bar) to provide the ECM with a ground signal when the pressure is high. The idle air control valves are driven open by a fixed amount.

POWER STEERING PRESSURE SWITCH



T851 / 4.60

Vehicle elevation
At high elevations, the ECM compensates for low atmospheric pressure at idle speed using the input from the high altitude correction sensor (HACS) within the ECM. Refer to High Altitude Correction, page 5.

Battery voltage
The ECM compensates for low battery voltage at idle by increasing the programmed idle speed by 100 rpm. The higher engine speed increases generator output.

Idle speed control adaptations
The ECM learns idle speed control adaptions at normal operating temperature in Drive and Neutral to improve the response rate to target idle speeds. In addition, other adaptions are learned to allow limited balancing of A and B bank manifold absolute pressures. The A and B bank MAPS signals are used by the ECM to help balance the banks through individual IACV control.

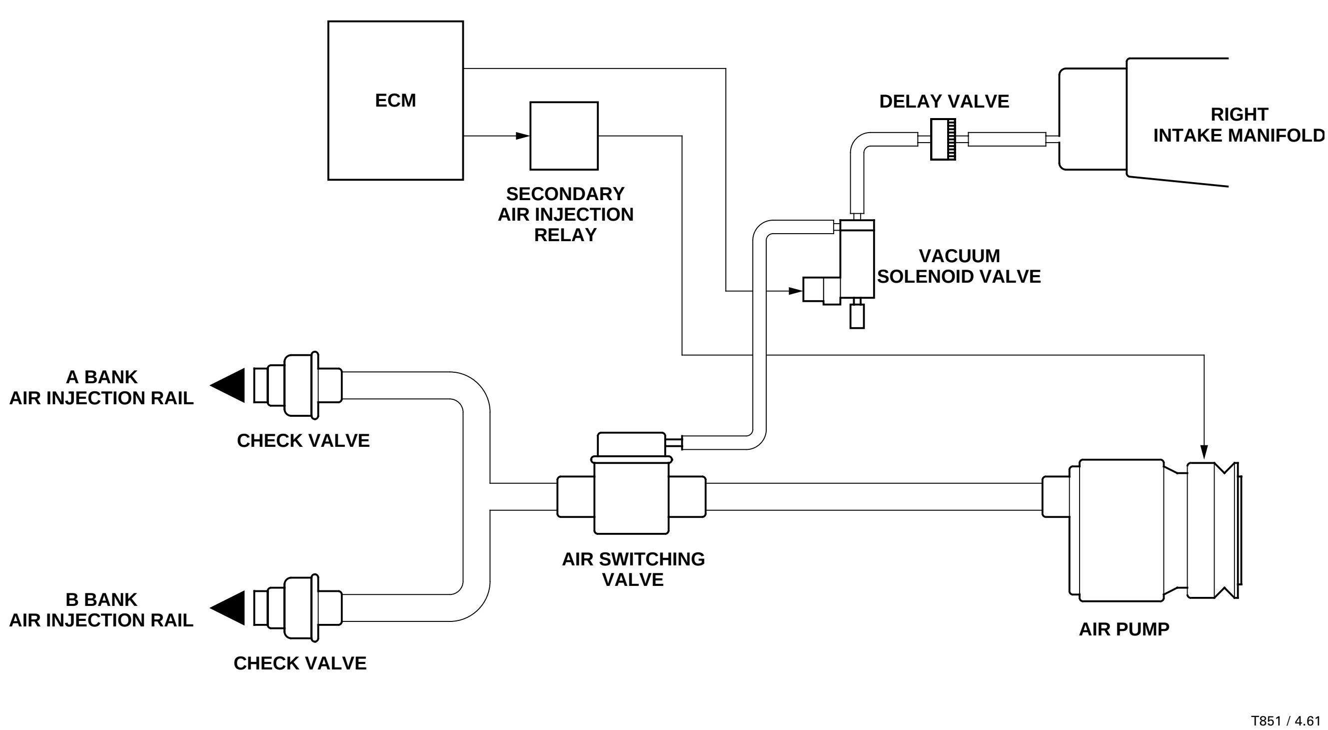
The adaptive values are held in memory and will be retained as long as the vehicle battery is connected. If the battery is disconnected, the adaptive values will be lost. The ECM will relearn the values during the next driving cycle.

NOTES

Secondary Air Injection (AIR)

Secondary air injection is employed to accelerate catalyst “light off”. “Light off” is the term used to describe the time taken to bring the catalyst to the ideal operation temperature. Initially, after engine start, the air / fuel mixture is rich. The exhaust from this rich mixture is still burning when it enters the catalyst. Air is delivered to the exhaust system to prolong the catalyst burning time and raise the catalyst operating temperature to the ideal level as soon as possible.

SECONDARY AIR INJECTION SYSTEM



The AIR system consists of a pump, AIR switching valve, solenoid vacuum valve, two check valves, and the necessary plumbing. The ECM enables secondary air injection as necessary depending on coolant temperature, engine speed, time after start, and OBD monitoring. Additionally, the ECM operates the secondary air injection pump after each engine start and for a short period during normal engine running (approximately every 30 minutes) to clear condensation from the air pipes.

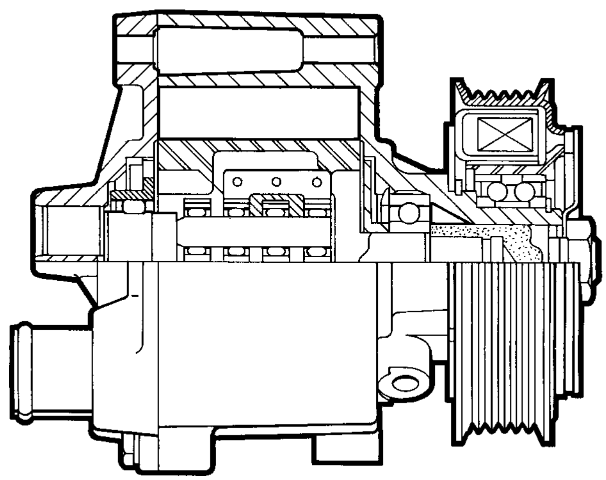
NOTES

Secondary Air Injection Pump (AIR Pump)

The secondary air injection pump (AIR Pump) is the same type and construction used on the V12 Lucas / Marelli EMS. The vane-type pump couples to an engine driven electromagnetic clutch. The clutch is activated via a relay that is switched by the ECM.

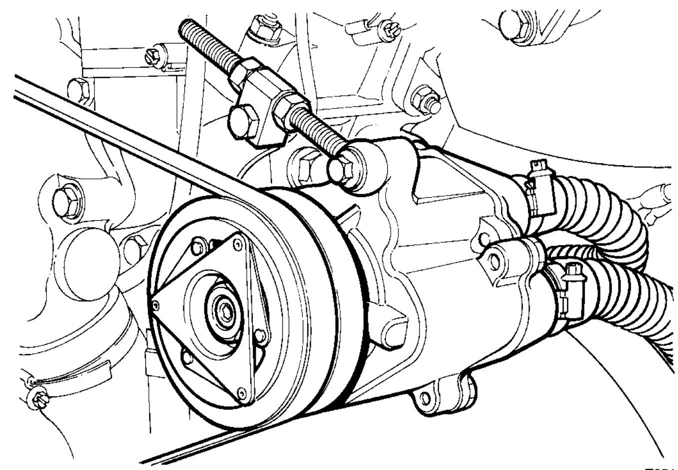
NOTES

SECONDARY AIR INJECTION PUMP CROSS-SECTION



T851 / 4.63

SECONDARY AIR INJECTION PUMP LOCATION



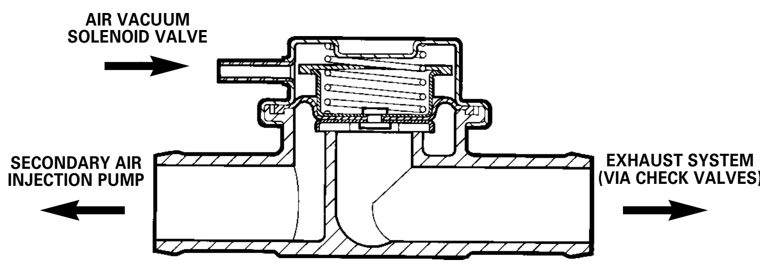
T851 / 4.62

Secondary Air Injection (continued)

AIR Switching Valve (ASV)

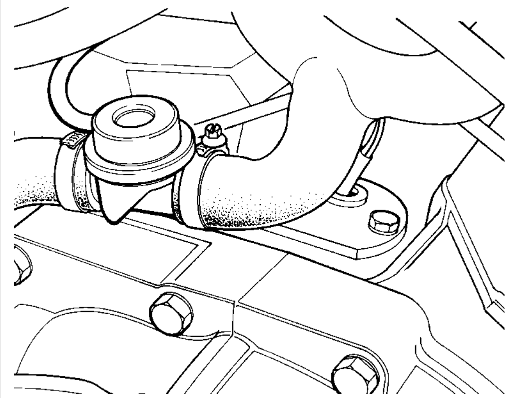
The vacuum operated AIR switching valve (ASV), located at the rear of the engine vee, controls the flow of air injection to the exhaust system.

AIR SWITCHING VALVE CROSS-SECTION



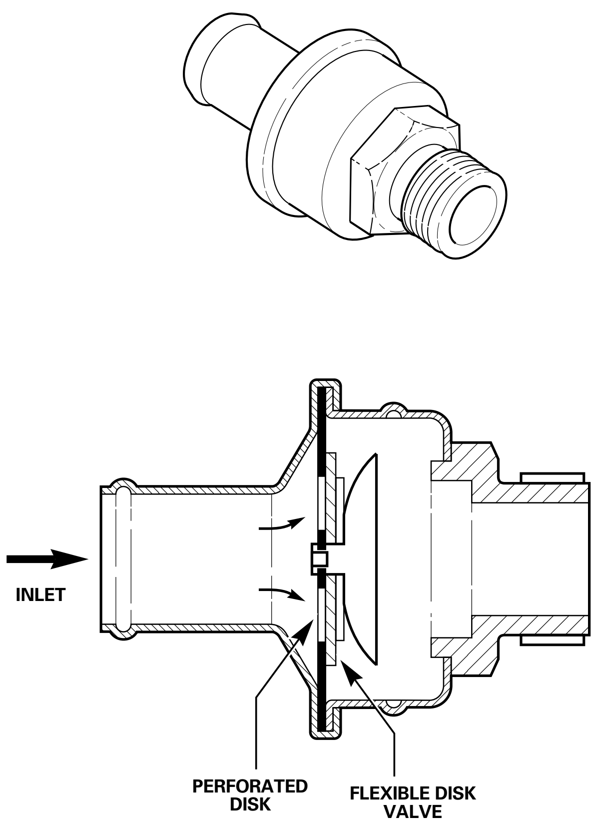
T851 / 4.65

AIR SWITCHING VALVE LOCATION



T851 / 4.64

SECONDARY AIR INJECTION CHECK VALVE WITH CROSS-SECTION



T851 / 4.66A & B

NOTES

AIR Vacuum Solenoid Valve (VSV)

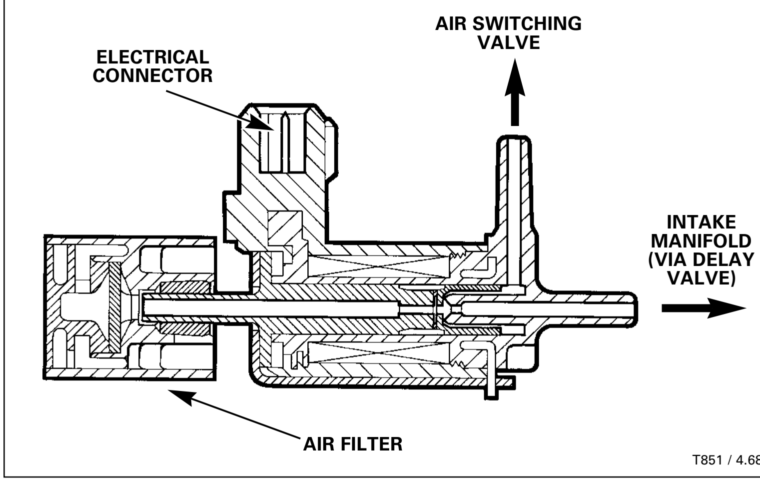
The vacuum solenoid valve (VSV), located at the rear of the A bank intake manifold, switches vacuum to the ASV. The ECM activates the VSV one second after the AIR Pump clutch relay, enabling the pump to reach operating pressure before the ASV is opened. When activated, ported vacuum is applied to the ASV, opening the ASV.

AIR monitoring for OBD II

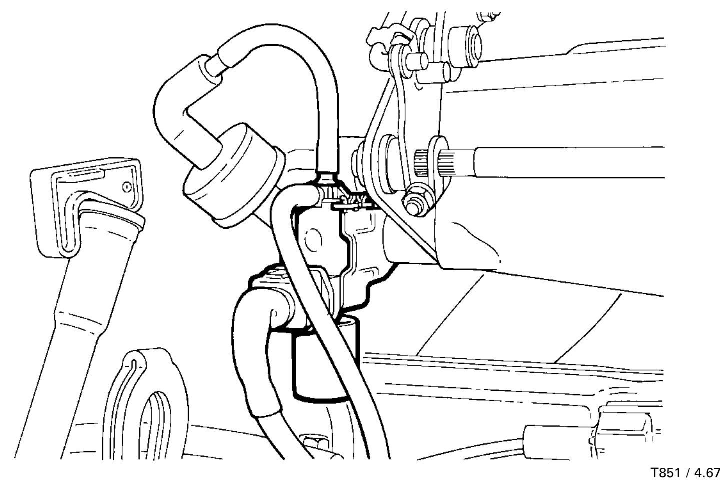
Secondary air injection is monitored for decreasing flow. The ECM can determine the air injection flow volume by monitoring the change in short term fuel trim. The test of the AIR system is performed once each ignition cycle during the first long hot idle period. If the AIR related values do not respond as expected, a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 16, page 61.

NOTES

AIR VACUUM SOLENOID VALVE CROSS-SECTION



AIR VACUUM SOLENOID VALVE LOCATION

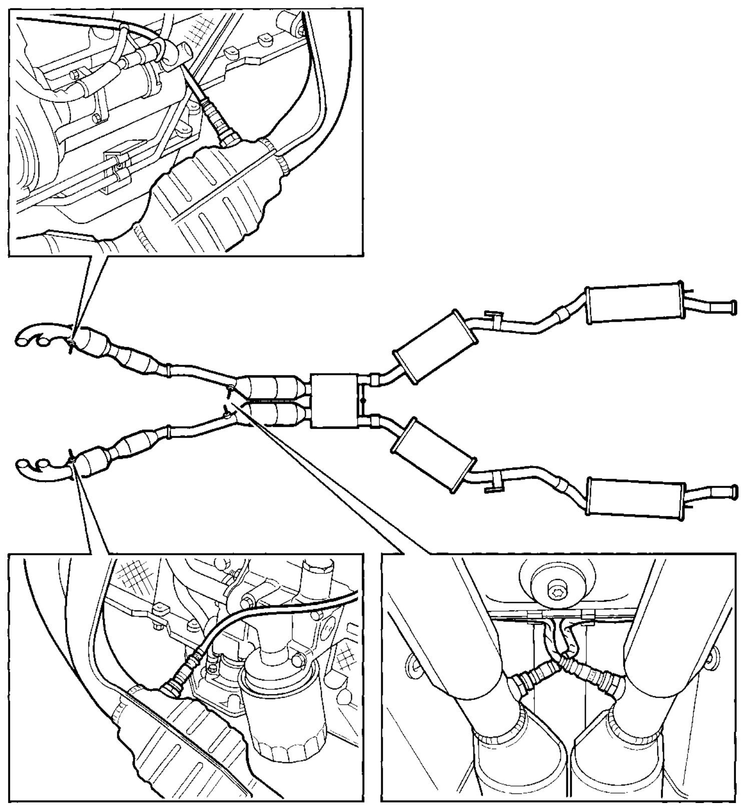


Catalytic Converters

Catalyst monitoring for OBD II

Deterioration of catalytic conversion efficiency will create higher than legally acceptable HC, CO and NOx exhaust emission.

HEATED OXYGEN SENSORS LOCATION



T851 / 4.69

The efficiency of the catalytic converter system is monitored and a deterioration in efficiency is flagged as a fault by the ECM. Monitoring for catalyst efficiency is achieved by sampling both the incoming and outgoing exhaust gas at the primary catalysts. Two oxygen sensors are positioned in each exhaust downpipe assembly — one upstream of the primary catalyst and one downstream of the primary catalyst. By comparing the voltage swings of each set of sensors, the ECM can detect when catalyst efficiency drops off.

The catalyst operation is monitored two ways during steady speed driving:

1 The average downstream HO2S voltage swings are monitored. If the swing amplitude is less than the maximum limit, the catalyst is considered to be operating normally.

2 If the average test is not passed, the upstream and downstream HO2S values are then compared. A DTC is flagged if the values do not correspond to the expected efficient catalyst values. The fault must be flagged three successive times to activate the CHECK ENGINE MIL.

Refer to DTC Summary: Group 17, page 61.

NOTE: The CHECK ENGINE MIL will not be activated for catalyst monitoring faults on 1995 model year vehicles; however, a DTC will be flagged by the ECM that can be retrieved using PDU.

NOTES

Engine Misfire

Misfire monitoring for OBD II
Engine misfire may cause catalytic converter damage and/or cause a vehicle to fail an emission inspection.

The ECM monitors the engine for individual cylinder misfire by monitoring the engine speed sensor (RPM Sensor). At each cylinder firing, the crankshaft momentarily accelerates. The ECM records and compares the time intervals between cylinder firings and the engine sensor pulses.

If a misfire is detected, the ECM flags a DTC that identifies the misfiring cylinder and activates the CHECK ENGINE MIL. During certain types of misfire, the CHECK ENGINE MIL will flash once per second, then remain lit if misfiring stops.

There are two levels of misfire that can be detected:

Level 1 If the misfire is not severe but will increase emission levels, the fault must occur on two consecutive trips before a DTC is flagged.

Level 2 If the misfire is severe enough so that catalyst damage can occur, the DTC is flagged immediately.

Refer to DTC Summary: Group 13, page 59.

NOTE: The CHECK ENGINE MIL will not be activated (flash or steady ON) for misfire monitoring faults on 1995 model year vehicles; however, a DTC will be flagged by the ECM.

NOTES

Vehicle Systems Interfaces

The engine management system interfaces with the instrument pack, the climate control system, and the transmission control module to provide data and sensor input, and operational control.

Instrument Pack

Low fuel level
The fuel level sensor outputs a fuel level voltage signal to the ECM. When the voltage drops below a specified value, fuel metering DTCs are disabled. Canceling the fuel metering diagnostics prevents the ECM from flagging DTCs caused by the vehicle running out of fuel.

Fuel level signal monitoring for OBD II
The fuel level signal is monitored for out of range high or low voltage. If there is a fault, a DTC is flagged and the CHECK ENGINE MIL is activated immediately. Refer to DTC Summary: Group 9, page 57.

Engine speed
The ECM outputs a shared engine speed signal to the instrument pack, the air conditioning control module (A/CCM) and the transmission control module (TCM). The engine speed output is generated by the ECM to give three rectangular wave pulses per engine revolution. The signal duration is 50° active per 120° of crankshaft rotation.

The instrument pack uses the engine speed signal for tachometer operation.

CHECK ENGINE MIL
If the OBD system detects a fault, the ECM outputs a warning signal (ground) to the instrument pack for operation of the CHECK ENGINE MIL. Refer to On-Board Diagnostic Facility on pages 2 – 4.

Climate Control

Air conditioning compressor
The ECM controls air conditioning compressor clutch operation from a request made by the climate control module. When an air conditioning compressor ON request (12 volt signal) is received from the climate control module, the ECM switches ON the compressor (via the air conditioning compressor relay). The ECM cancels (or does not switch ON) air conditioning during the following engine conditions: starting, acceleration, high coolant temperature, excessively low idle speed, or the loss of the request signal.

Engine speed
The ECM-supplied engine speed signal (refer to Instrument Pack: Engine Speed above) is used by the A/CCM to enable or cancel coolant pump operation and window and mirror heater operation. The signal is also used for A/CCM diagnostic functions.

NOTES

Automatic Transmission

Throttle position

The ECM processes the throttle position input signal from the single track throttle position sensor (TPS) and supplies the TCM with a pulse width modulated signal to indicate throttle position.

Vehicle road speed

The transmission TCM outputs a road speed signal (pulsed signal) to the ECM. The ECM uses the signal to determine idle speed control and OBD functions. The TCM receives the signal input from the transmission output speed sensor.

Vehicle speed input monitoring for OBD II

If a vehicle speed signal is not sensed by the ECM, but other signals indicate vehicle speed (rpm, neutral switch, MAP), a DTC is flagged. The fault must occur on two consecutive trips to activate the CHECK ENGINE MIL. Refer to DTC Summary: Group 19, page 61.

Gear selector position

Gear selector position signals are output to the ECM by the linear gear position switches. When the gear selector is in R, D, 2 or 3, the signal is 5 volts; when the gear selector is in P or N, the signal is ground or 0 volts. The ECM uses the gear position inputs to help control idle speed. Refer to Ignition Control, pages 36 – 40, and Idle Control, pages 41 – 43, for a detailed explanation.

Gear selector position monitoring for OBD II

Gear selector position faults are detected by using two tests. One test monitors for high engine load or gear change request signals while the gear position is P or N. The other test monitors for engine starting when the gear position is not P or N. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 4, and DTC Summary: Group 22, page 62.

Engine speed and torque

In addition to the engine speed signal, the ECM supplies the TCM with an engine torque signal. Refer to Instrument Pack: Engine Speed, page 50. The engine torque signal (derived from injector pulse duration) is supplied as a pulse width modulated (PWM) signal. The TCM uses the engine speed signal for diagnostic function. Refer to Torque-Based Transmission Shifting, page 40, for torque signal uses.

Serial Communication

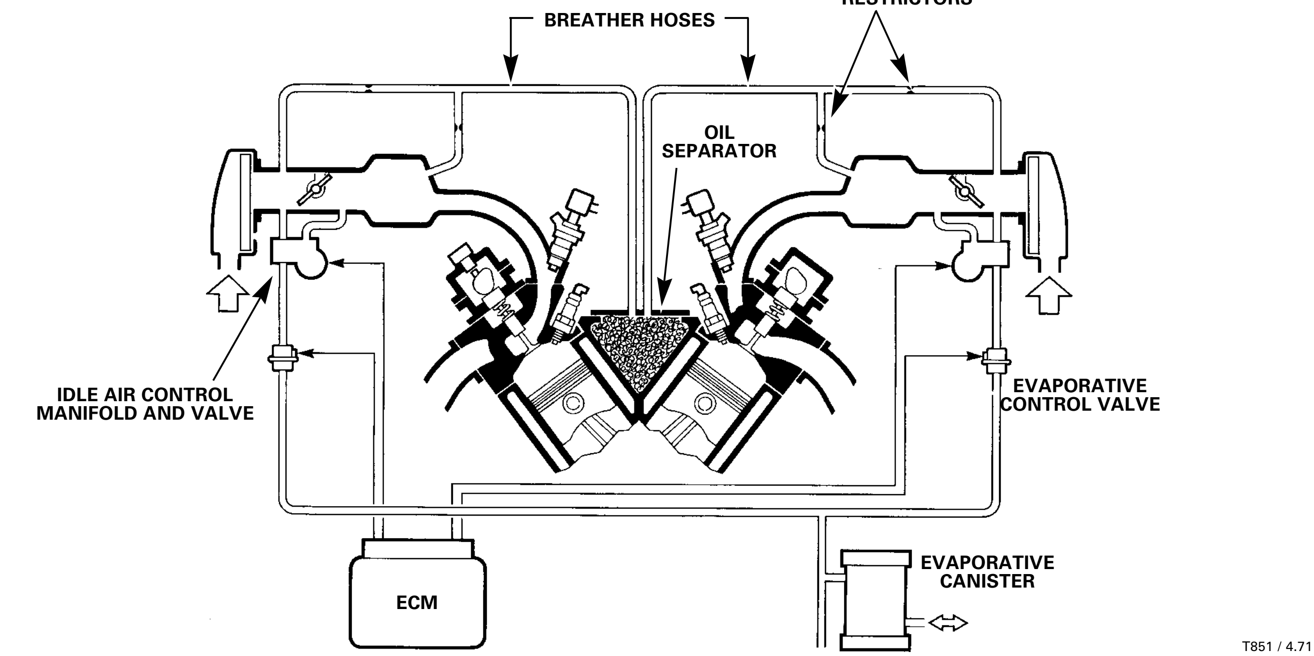
Serial communication between the engine management system and PDU takes place via the serial communication data link. Only one bidirectional serial line connects to the ECM. Serial communication is used for engine setup, accessing stored DTCs, fault diagnosis and erasing DTCs.

NOTES

Crankcase Emission Control

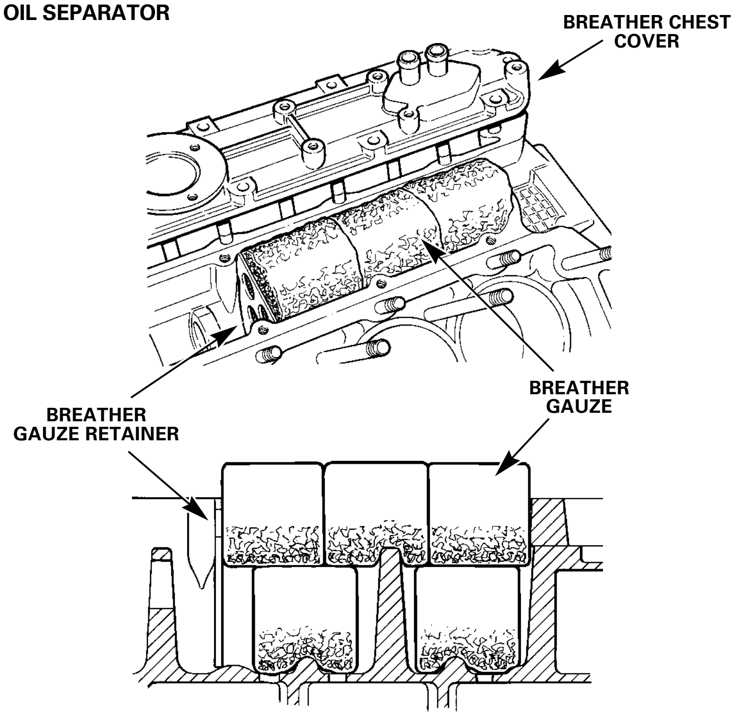
The crankcase ventilation system ports crankcase gases to the air intakes. The oil separator consists of five cylinders of breather gauze held in place by a sliding-fit retainer. The oil separator is located in the rear half of the breather chest (engine vee). Hoses run from the breather chest cover to the A and B bank air intakes. Each hose Y's at the intake manifold with one connection made downstream of the throttle valve and one connection made to the air cleaner housing. Both hoses between the Y's and the air intakes incorporate restrictors.

CRANKCASE VENTILATION / IDLE AIR CONTROL / EVAPORATIVE PURGE



T851 / 4.71

OIL SEPARATOR



T851 / 4.72A & B

When the engine is running at part load, intake manifold vacuum draws the crankcase gases into the intake manifold. When the engine is running at full load (throttle valves fully open), the vacuum in the air cleaners draws the crankcase gases. The restrictors ensure that correct gas flow occurs during all engine operating conditions. As the crankcase gases pass through the gauze assembly, oil vapor condenses and drains back to the sump.

NOTES

The following DTC section is extracted from the DTC Summaries manual and is included here as an aid to understanding the system. Do not use this information to diagnose vehicle faults.

Always refer to the Model Year specific section contained in the DTC Summaries manual for accurate information.

DTC Summary
6.0 Litre V12 / ND Engine Management System

OBD II MONITORING CONDITIONS:

When testing for DTC reoccurrence, it can be determined if the Service Drive Cycle was of sufficient length by performing a PDU "Systems Readiness Test".
The Systems Readiness Test occurs automatically when the PDU reads the DTCs from the ECM memory and reports if a full OBD check has or has not been completed since the memory was last cleared.

If DTC P1000 is stored in memory, the on-board diagnostic tests have not been completed; if DTC P1111 is stored in memory, all on-board diagnostic tests have been completed.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
	P1000	System Readiness Check	OBD tests not complete since last memory clear	1	System Readiness Check report only
	P1111	System Readiness Check	OBD tests completed since last memory clear	1	System Readiness Check report only
7	P0105	HACS circuit malfunction	Ignition ON > 5 seconds	1	HACS failure (internal ECM fault)
1	P0106	A Bank MAPS range / performance	Engine at normal operating temperature; idle, then accelerate	2	Throttle rod disconnected or incorrectly adjusted Leaking or blocked hose between MAPS and intake manifold Blocked gas filter Failed sensor element
	P1106	B Bank MAPS range / performance	Engine at normal operating temperature; idle, then accelerate	2	Throttle rod disconnected or incorrectly adjusted Leaking or blocked hose between MAPS and intake manifold Blocked gas filter Failed sensor element
	P0107	A Bank MAPS sense circuit low voltage	Ignition ON > 5 seconds	1	MAPS disconnected MAPS to ECM sense wire open circuit or short circuit to ground MAPS to ECM power supply wire open circuit or short circuit to ground MAPS internal failure
	P1107	B Bank MAPS sense circuit low voltage	Ignition ON > 5 seconds	1	MAPS disconnected MAPS to ECM sense wire open circuit or short circuit to ground MAPS to ECM power supply wire open circuit or short circuit to ground MAPS internal failure
	P0108	A Bank MAPS sense circuit high voltage	Ignition ON > 5 seconds	1	MAPS to ECM signal ground wire open circuit MAPS to ECM wiring (supply, sense, signal ground) short circuit to each other MAPS sensing circuit short circuit to B+ voltage MAPS internal failure
	P1108	B Bank MAPS sense circuit high voltage	Ignition ON > 5 seconds	1	MAPS to ECM signal ground wire open circuit MAPS to ECM wiring (supply, sense, signal ground) short circuit to each other MAPS sensing circuit short circuit to B+ voltage MAPS internal failure
2	P0111	IATS range / performance	Engine idle > 30 seconds	2	IATS power supply failure; short or open circuit IATS internal failure
	P0112	IATS sense circuit high voltage (low air temperature)	Ignition ON > 5 seconds	1	IATS disconnected IATS to ECM wiring open circuit or high resistance IATS sensing circuit short circuit to B+ voltage IATS internal failure
	P0113	IATS sense circuit low voltage (high air temperature)	Ignition ON > 5 seconds	1	IATS to ECM wiring short circuit to ground IATS internal failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
3	P0116	ECTS range / performance	Engine at normal operating temperature; idle > 20 minutes	2	Low coolant level Engine thermostat stuck open ECTS connector high resistance when hot ECTS element failure
	P0117	ECTS sense circuit high voltage (low coolant temperature)	Ignition ON > 5 seconds	1	ECTS disconnected ECTS to ECM wiring open circuit or high resistance ECTS sensing circuit short circuit to B+ voltage ECTS internal failure
	P0118	ECTS sense circuit low voltage (high coolant temperature)	Ignition ON > 5 minutes	1	ECTS to ECM wiring short circuit to ground ECTS internal failure
4	P0121	TPS range / performance	Engine at normal operating temperature; drive steadily at 45 mph (engine between 1500 – 2000 rpm) > 5 seconds	2	Blocked air filter Incorrect TPS setting or loose mounting screws Incorrect throttle linkage setting TPS power supply failure MAPS signal incorrect or not sensed IATS signal incorrect or not sensed TPS internal failure
	P0122	TPS sense circuit low voltage	Ignition ON > 5 seconds	1	TPS disconnected TPS to ECM position sense wire open circuit or short circuit to ground TPS to ECM power supply wire open circuit or short circuit to ground TPS internal failure
	P0123	TPS sense circuit high voltage	Ignition ON > 5 seconds	1	TPS to ECM signal ground wire open circuit TPS to ECM wiring (supply, sense, signal ground) short circuit to each other TPS sensing circuit short circuit to B+ voltage TPS internal failure
3	P0125	Insufficient coolant temperature for closed loop fuel control	Engine at normal operating temperature; idle > 20 minutes	2	Low coolant level Engine thermostat stuck open ECTS connector high resistance when hot ECTS internal failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
5	P0131	HO2S sense circuit low voltage – A bank, upstream (1)	Engine at normal operating temperature; drive steadily at 56 mph > 1 minute (DTC P0131 may flag with warm engine @ 2000 rpm for 3 minutes)	2	HO2S disconnected HO2S to ECM wiring open circuit HO2S short circuit to ground HO2S internal failure
	P0132	HO2S sense circuit high voltage – A bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	HO2S sensing circuit short circuit to B+ voltage HO2S ground (BRD – braided shield) open circuit HO2S internal failure
	P0133	HO2S sense circuit slow response – A bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Engine misfire HO2S disconnected HO2S mechanical damage HO2S to ECM wiring open circuit HO2S sensing circuit short circuit to B+ voltage HO2S short circuit to ground HO2S ground (BRD – braided shield) open circuit Exhaust leak Low exhaust gas temperature Injector flow partially blocked Catalyst efficiency decrease HO2S internal failure HO2S heater circuit failure
	P0134	HO2S sense circuit no activity – A bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Engine misfire HO2S disconnected HO2S mechanical damage HO2S to ECM wiring open circuit HO2S sensing circuit short circuit to B+ voltage HO2S short circuit to ground HO2S ground (BRD – braided shield) open circuit Exhaust leak Low exhaust gas temperature Injector flow partially blocked Catalyst efficiency decrease HO2S internal failure
	P0135	HO2S heater circuit malfunction – A bank, upstream (1)	Engine run > 45 seconds, idle	2	HO2S disconnected No HO2S heater power supply HO2S heater to power supply wiring open circuit HO2S heater to ECM wiring short circuit HO2S heater to ECM wiring open circuit HO2S internal failure
	P0137	HO2S sense circuit low voltage – A bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0131 possible causes
	P0138	HO2S sense circuit high voltage – A bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0132 possible causes
	P0139	HO2S sense circuit slow response – A bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0133 possible causes
	P0140	HO2S sense circuit no activity – A bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0134 possible causes
	P0141	HO2S heater circuit malfunction – A bank, downstream (2)	Engine run > 45 seconds, idle	2	Refer to P0135 possible causes
	P0151	HO2S sense circuit low voltage – B bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute (DTC P0131 may flag with warm engine @ 2000 rpm for 3 minutes)	2	Refer to P0131 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
5	P0152	HO2S sense circuit high voltage – B bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0132 possible causes
	P0153	HO2S sense circuit slow response – B bank), upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0133 possible causes
	P0154	HO2S sense circuit no activity – B bank, upstream (1)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0134 possible causes
	P0155	HO2S heater circuit malfunction – B bank, upstream (1)	Engine run > 45 seconds, idle	2	Refer to P0135 possible causes
	P0157	HO2S sense circuit low voltage – B bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0131 possible causes
	P0158	HO2S sense circuit high voltage – B bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0132 possible causes
	P0159	HO2S sense circuit slow response – B bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0133 possible causes
	P0160	HO2S sense circuit no activity – B bank, downstream (2)	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0134 possible causes
	P0161	HO2S heater circuit malfunction – B bank, downstream (2)	Engine run > 45 seconds, idle	2	Refer to P0135 possible causes
6	P0171	A Bank combustion too lean	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Engine misfire Fuel filter, system blockage Fuel injector blockage Fuel injector wiring open circuit Fuel pressure regulator failure (low fuel pressure) Low fuel pump output HO2S harness wiring condition fault Exhaust leak (before catalyst) ECM receiving incorrect signal from one or more of the following components: ECTS, MAPS, TPS, IATS
	P0172	A Bank combustion too rich	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Blocked air filter Fuel system return pipe blockage Leaking fuel injector Fuel injector harness short circuit to ground Fuel pressure regulator failure (high fuel pressure) ECM receiving incorrect signal from one or more of the following components: ECTS, MAPS, TPS, IATS
	P0174	B Bank combustion too lean	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0171 possible causes
	P0175	B Bank combustion too rich	Engine at normal operating temperature; drive at 56 mph > 1 minute	2	Refer to P0172 possible causes
9	P1198	Fuel level sense circuit high voltage	Ignition ON > 1 minute	1	Fuel level sense wire short circuit to B+ voltage Fuel level sense wire open circuit Fuel level sensor failure
	P1199	Fuel level sense circuit low voltage / malfunction	Ignition ON > 1 minute	1	Fuel level sense wire short circuit to ground Fuel level sensor failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
11	P0201	Fuel injector circuit malfunction – A bank, cylinder 1	Engine at normal operating temperature; engine run > 10 seconds (DTC P0201 may flag at fast idle)	2	Injector disconnected Injector harness wiring open or short circuit Injector failure
	P0202	Fuel injector circuit malfunction – A bank, cylinder 2	Engine at normal operating temperature; engine run > 10 seconds (DTC P0202 may flag at fast idle)	2	Refer to P0201 possible causes
	P0203	Fuel injector circuit malfunction – A bank, cylinder 3	Engine at normal operating temperature; engine run > 10 seconds (DTC P0203 may flag at fast idle)	2	Refer to P0201 possible causes
	P0204	Fuel injector circuit malfunction – A bank, cylinder 4	Engine at normal operating temperature; engine run > 10 seconds (DTC P0204 may flag at fast idle)	2	Refer to P0201 possible causes
	P0205	Fuel injector circuit malfunction – A bank, cylinder 5	Engine at normal operating temperature; engine run > 10 seconds (DTC P0205 may flag at fast idle)	2	Refer to P0201 possible causes
	P0206	Fuel injector circuit malfunction – A bank, cylinder 6	Engine at normal operating temperature; engine run > 10 seconds (DTC P0206 may flag at fast idle)	2	Refer to P0201 possible causes
	P0207	Fuel injector circuit malfunction – B bank, cylinder 1	Engine at normal operating temperature; engine run > 10 seconds (DTC P0207 may flag at fast idle)	2	Refer to P0201 possible causes
	P0208	Fuel injector circuit malfunction – B bank, cylinder 2	Engine at normal operating temperature; engine run > 10 seconds (DTC P0208 may flag at fast idle)	2	Refer to P0201 possible causes
	P0209	Fuel injector circuit malfunction – B bank, cylinder 3	Engine at normal operating temperature; engine run > 10 seconds (DTC P0209 may flag at fast idle)	2	Refer to P0201 possible causes
	P0210	Fuel injector circuit malfunction – B bank, cylinder 4	Engine at normal operating temperature; engine run > 10 seconds (DTC P0210 may flag at fast idle)	2	Refer to P0201 possible causes
	P0211	Fuel injector circuit malfunction – B bank, cylinder 5	Engine at normal operating temperature; engine run > 10 seconds (DTC P0211 may flag at fast idle)	2	Refer to P0201 possible causes
	P0212	Fuel injector circuit malfunction – B bank, cylinder 6	Engine at normal operating temperature; engine run > 10 seconds (DTC P0212 may flag at fast idle)	2	Refer to P0201 possible causes
12	P1240	Sensor power supply malfunction	Engine at normal operating temperature; MAPS and TPS tests complete	2	A Bank MAPS, B Bank MAPS and TPS failure DTCs flagged at once Refer to P1241 and P1242 possible causes
	P1241	Sensor power supply circuit low voltage	Ignition ON > 5 seconds	2	MAPS and TPS sensor power supply wire(s) short circuit to ground
	P1242	Sensor power supply circuit high voltage	Ignition ON > 5 seconds	2	MAPS and TPS sensor power supply wire(s) high resistance or short circuit MAPS and TPS sensor power supply wire(s) short circuit to B+ voltage
7	P1244	HACS range / performance	Ignition ON > 5 seconds; not cranking	2	HACS failure (internal ECM fault)

* Number of consecutive trips required to activate CHECK ENGINE MIL.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
8	P1245	Engine crank signal low voltage	Start engine, idle	2	Starter relay coil to ECM wire (parallel circuit to BPM) open circuit
	P1246	Engine crank signal high voltage	Engine at normal operating temperature; accelerate from stop to 31 mph; decelerate to stop; repeat 5 times	2	Starter relay coil to ECM wire (parallel circuit to BPM) short circuit to B+ voltage Body Processor Module (BPM) fault
13	P0300**	Random misfire detected	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Fuel contaminated Fuel injector(s) blocked or leaking Ignition secondary circuit breakdown (spark plugs, leads) Ignition coil pack internal failure Fuel pressure low Cylinder compression low Broken valve spring(s)
	P0301**	Misfire detected – A bank, cylinder 1	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0302**	Misfire detected – A bank, cylinder 2	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0303**	Misfire detected – A bank, cylinder 3	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0304**	Misfire detected – A bank, cylinder 4	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0305**	Misfire detected – A bank, cylinder 5	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0306**	Misfire detected – A bank, cylinder 6	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0307**	Misfire detected – B bank, cylinder 1	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0308**	Misfire detected – B bank, cylinder 2	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0309**	Misfire detected – B bank, cylinder 3	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0310**	Misfire detected – B bank, cylinder 4	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0311**	Misfire detected – B bank, cylinder 5	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P0312**	Misfire detected – B bank, cylinder 6	Engine at idle > 2 minutes; drive below 2000 rpm > 2 minutes	1 or 2	Refer to P0300 possible causes
	P1313**	Catalyst damage misfire detected – A bank	Drive with rpm below 2100 at steady speed > 2 minutes	1	Refer to P0300 possible causes
	P1314**	Catalyst damage misfire detected – B bank	Drive with rpm below 2100 at steady speed > 2 minutes	1	Refer to P0300 possible causes
	P1316**	Misfire excess emission	Drive with rpm below 2100 at steady speed > 2 minutes	2	Refer to P0300 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

** Flagged DTCs P1313, P1314 and P1316 will activate the CHECK ENGINE MIL (1996 model year ON). In addition one or more of the cylinder identification DTCs will be flagged (random misfire P0300 or individual cylinder P0301 – P0312.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
14	P0335	RPM Sensor circuit malfunction	Start engine, idle	1	RPM Sensor disconnected RPM Sensor sensing circuit open circuit RPM Sensor sensing circuit short circuit to ground RPM Sensor sensing circuit short circuit to B+ voltage RPM Sensor internal failure
	P1335	CKPS circuit malfunction***	Engine run > 5 seconds, idle	1	CKPS disconnected CKPS sensing circuit open circuit CKPS sensing circuit short circuit to ground CKPS sensing circuit short circuit to B+ voltage CKPS / crankshaft disc alignment Damaged or missing pulser ring tooth CKPS internal failure
	P0336	RPM Sensor range / performance***	Start engine, idle	1	Foreign material on RPM Sensor face RPM Sensor / flywheel disc alignment Damaged flywheel disc Excessive crankshaft end float RPM Sensor internal failure
	P1336	CKPS range / performance	Engine run > 5 seconds, idle	1	Foreign material on CKPS face CKPS / crankshaft disc alignment Damaged or missing pulser ring tooth CKPS internal failure
	P0340	CMPS circuit malfunction***	Engine run > 5 seconds, idle	1	CMPS disconnected CMPS sensing circuit open circuit CMPS sensing circuit short circuit to ground CMPS sensing circuit short circuit to B+ voltage Damaged or missing CMPS camshaft peg CMPS internal failure
15	P1367	Ignition monitor – A bank***	Engine run > 10 seconds, idle	1	Ignition module disconnected Ignition module to ECM harness open circuit Ignition module to ECM harness short circuit to ground Ignition module to ECM harness short circuit to B+ voltage Ignition coil failure Ignition coil relay failure Ignition module internal failure
	P1368	Ignition monitor – B bank***	Engine run > 10 seconds, idle	1	Refer to P1367 possible causes

* Number of consecutive trips required to activate CHECK ENGINE MIL.

*** Engine must be running to retrieve DTC

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
16	P0410	AIR System malfunction	Engine at normal operating temperature; start, idle > 30 seconds	2	AIR pump drive belt failure AIR hose(s) failure AIR relay power supply failure AIR relay failure AIR pump clutch failure AIR pump internal failure AIR wiring harness open or short circuit ASV disconnected (vacuum) ASV internal failure AIR VSV wiring harness open or short circuit AIR check valve internal failure
	P0414	AIR system VSV circuit short circuit	Fuel system tests complete (Refer to DTCs P0171 and P0172)	2	AIR pump drive belt failure AIR hose(s) failure AIR relay power supply failure AIR relay failure AIR pump clutch failure AIR pump internal failure AIR wiring harness open or short circuit ASV disconnected (vacuum) ASV internal failure AIR VSV wiring harness open or short circuit AIR check valve internal failure
17	P0420	Catalyst efficiency below threshold – A bank	Engine at normal operating temperature; drive steadily at 35 mph > 3 minutes	****	Fuel contamination Exhaust system air leak (before catalyst) Engine misfire Catalyst mechanical damage Downstream HO2S fault present but undetected Excessive oil consumption
	P0430	Catalyst efficiency below threshold – B bank	Engine at normal operating temperature; drive steadily at 35 mph > 3 minutes	****	Refer to P0420 possible causes
18	P0441	EVAP system incorrect purge flow – A bank	Engine at normal operating temperature; vehicle stopped, idle > 2 minutes; fuel tank < 1/2 full; A/C OFF	2	A and B Bank EVAP valve harness connectors reversed EVAP purge hose blocked or disconnected EVAP canister atmosphere vent blocked EVAP valve failure
	P1441	EVAP system incorrect purge flow – B bank	Engine at normal operating temperature; vehicle stopped, idle > 2 minutes; fuel tank < 1/2 full; A/C OFF	2	Refer to P0441 possible causes
	P0433	EVAP valve circuit malfunction – A bank	Ignition ON, not cranking > 10 seconds	2	EVAP valve disconnected ECM to EVAP valve "drive" circuit short circuit to EVAP valve "supply" circuit ECM to EVAP valve "drive" circuit short circuit to B+ voltage EVAP valve internal failure
	P1443	EVAP valve circuit malfunction – B bank	Ignition ON, not cranking > 10 seconds	2	Refer to P0433 possible causes
19	P0500	Vehicle speed sensor malfunction (signal from TCM)	Engine at normal operating temperature; drive at engine speed > 1600 rpm; release throttle and decelerate 1600 to 1400 rpm in DRIVE, without using brakes	2	VSS Wiring harness between TCM and ECM open or short circuit VSS Internal failure

* Number of consecutive trips required to activate CHECK ENGINE MIL.

**** Three successive fail judgments. Diagnostic tests are performed continuously. Use PDU Systems Readiness Test to determine if tests are complete.

GROUP	DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS (see page 53)	TRIPS*	POSSIBLE CAUSES
20	P0506	Idle air control system: rpm lower than expected – A bank	Engine at normal operating temperature; vehicle stopped, idle > 30 seconds	2	IACV hoses blocked or leaking IACV disconnected IACV internal failure IACV stuck closed (foreign material) IACV "drive" circuits open or short circuit Undetected MAPS fault (hose blocked or disconnected) Incorrect fuel pressure Misfire Seized power steering pump Seized air conditioning compressor
	P1506	Idle air control system: rpm lower than expected – B bank	Engine at normal operating temperature; vehicle stopped, idle > 3 minutes	2	Refer to P0506 possible causes
	P0507	Idle air control system: rpm higher than expected – A bank	Engine at normal operating temperature; vehicle stopped, idle > 3 minutes	2	IACV disconnected Brake servo diaphragm failure Intake manifold leak IACV gasket air leak IACV stuck open (foreign material) IACV "drive" circuits open or short circuit Undetected MAPS fault (hose blocked or disconnected) Incorrect fuel pressure TPS setting incorrect Throttle linkage / valve setting incorrect
	P1507	Idle air control system: rpm higher than expected – B bank	Engine at normal operating temperature; vehicle stopped, idle > 3 minutes	2	Refer to P0507 possible causes
21	P1512	TPS Idle switch sense circuit low voltage	Accelerate from stop to 35 mph; decelerate to stop; repeat 5 times	2	TPS incorrect setting TPS harness short circuit to ground TPS harness short circuit across wires
	P1513	TPS Idle switch sense circuit high voltage	Accelerate from stop to 35 mph; decelerate to stop; repeat 5 times	2	TPS incorrect setting TPS disconnected TPS harness open circuit
22	P1516	Gear change NEUTRAL / DRIVE malfunction	Drive steadily at 55 mph > 30 seconds	2	Linear gear position switch setting incorrect Gear selector cable setting incorrect Linear gear position switch to ECM wiring harness open circuit
	P1517	Engine cranking NEUTRAL / DRIVE malfunction	Start engine	2	Linear gear position switch setting incorrect Gear selector cable setting incorrect Linear gear position switch wiring harness short circuit to ground
23	P0603	ECM PECUS programmed data corrupted	Ignition ON > 5 seconds	1	ECM failure
25	P0605	ECM ROM data corrupted	Ignition ON > 5 seconds	1	ECM failure
10	P1641	Fuel pump relay 1 malfunction	Ignition ON > 5 seconds	2	Relay failure Relay to ECM wiring (coil circuit) open or short circuit Relay to fuel pump wiring (switched circuit) open or short circuit
	P1646	Fuel pump relay 2 malfunction	Ignition ON > 5 seconds	2	Refer to P1641 possible faults
24	P1775	TCM / CHECK ENGINE MIL request	Ignition ON > 5 seconds	1	Possible transmission fault – check for flagged TCM DTCs
	P1776	Torque reduction request signal duration fault	Ignition ON > 5 seconds	1	Torque reduction signal wire open circuit Torque reduction signal wire short circuit to ground Torque reduction signal wire short circuit to B+ voltage

* Number of consecutive trips required to activate CHECK ENGINE MIL.

The following Figures and Data pages are extracted from select Electrical Guides and are included here as an aid to understanding the Engine Management system. Do not use this information to diagnose vehicle faults.

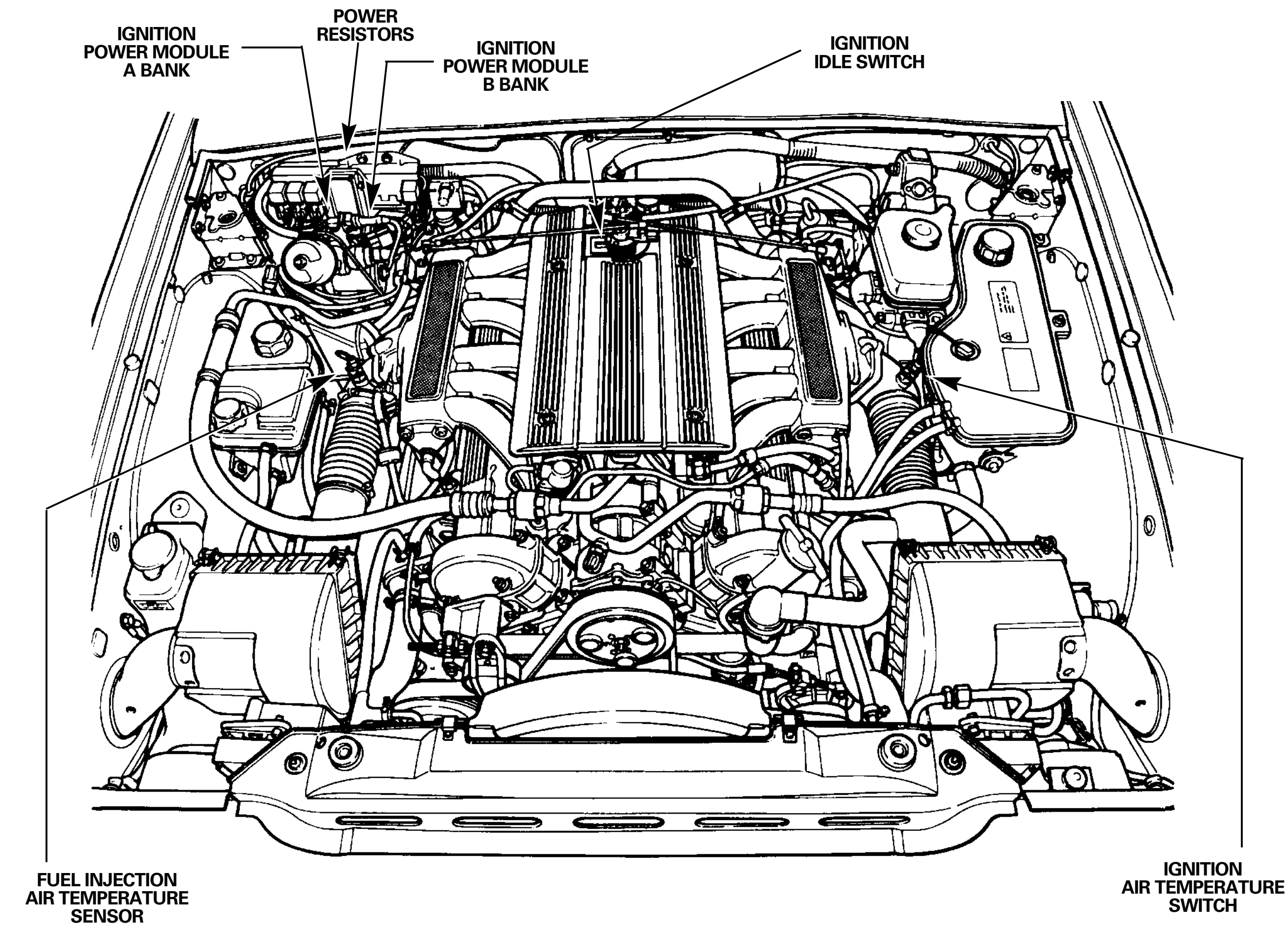
Always refer to the Model and Model Year specific Electrical Guide for accurate information.

Contents

6.0 Litre V12 / LM Engine Management System Overview

The 6.0 litre V12 Lucas / Marelli (V12 / LM) Engine Management System is the same for both the XJS and the XJ12 Sedan. This system employs a combination Lucas / Marelli fuel injection / ignition system that incorporates revisions to include new and expanded functions over the previous 1992 model year 5.3 litre V12 system. In addition to revised ECM functions, subsystems that are not ECM controlled have been revised.

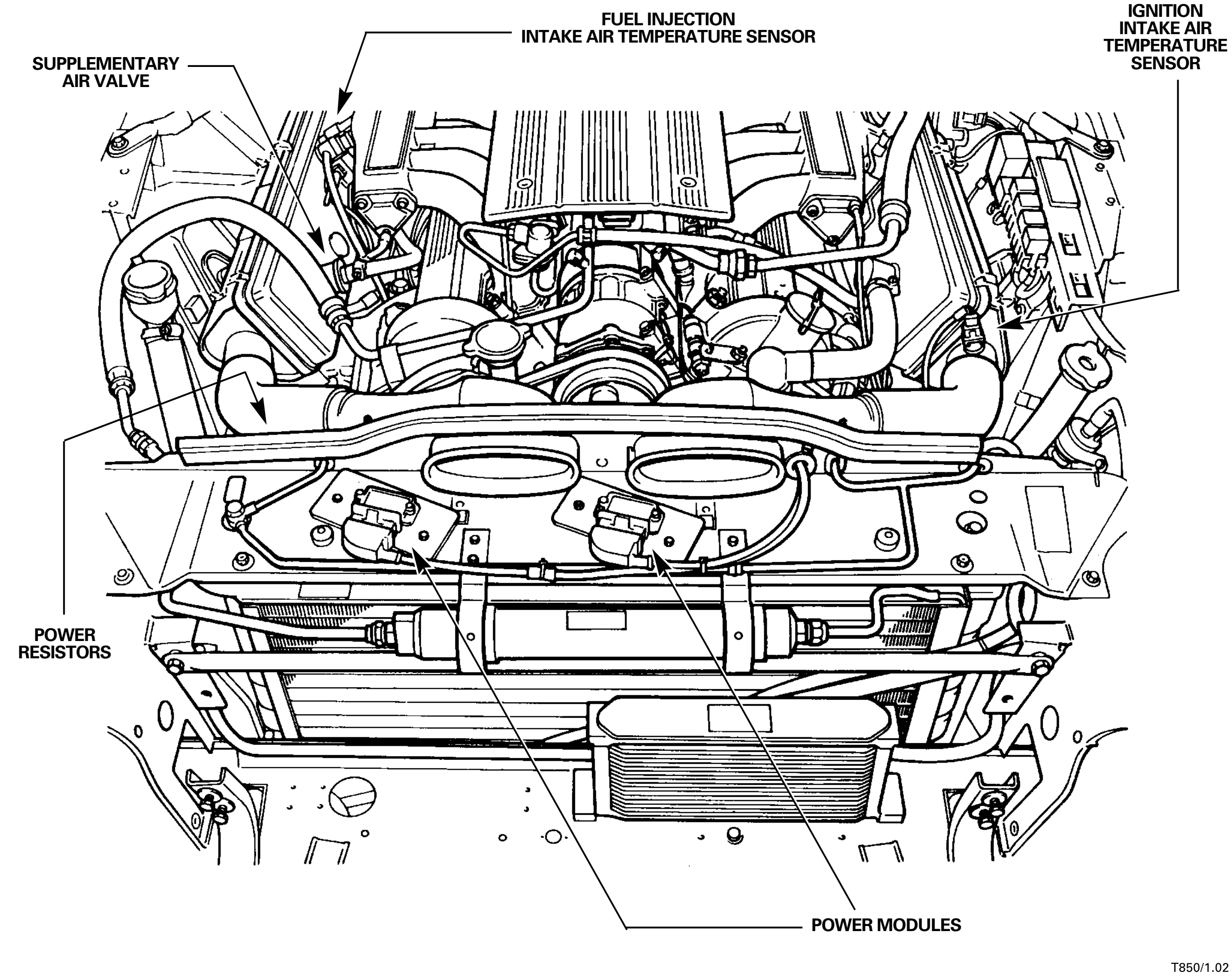
6.0 LITRE V12 ENGINE INSTALLATION: XJ12 SEDAN



T850/1.01

6.0 Litre V12 / LM Engine Management System Overview (continued)

6.0 LITRE V12 ENGINE INSTALLATION: XJS

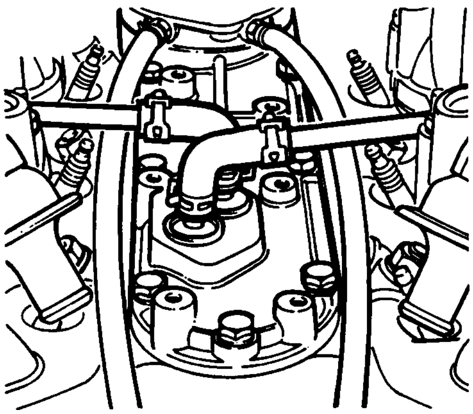


Crankcase Breather System

Part-load engine breather system

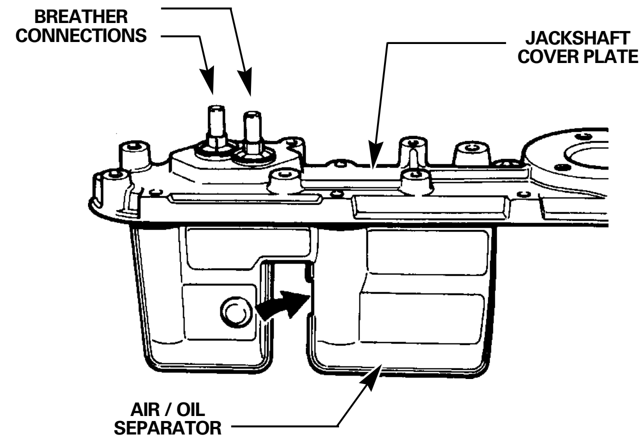
The part-load engine breather system consists of an air / oil separator chamber, integral with the jack shaft cover plate. The system connects to the intake manifolds down stream of the throttle housings.

OIL SEPARATOR WITH HOSES CONNECTED



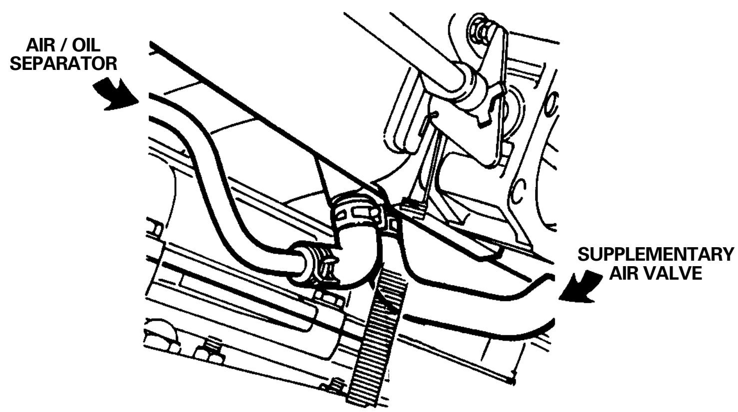
(VIEWED FROM REAR OF ENGINE) T850/1.04

OIL SEPARATOR



T850/1.03

A BANK UNDERSIDE

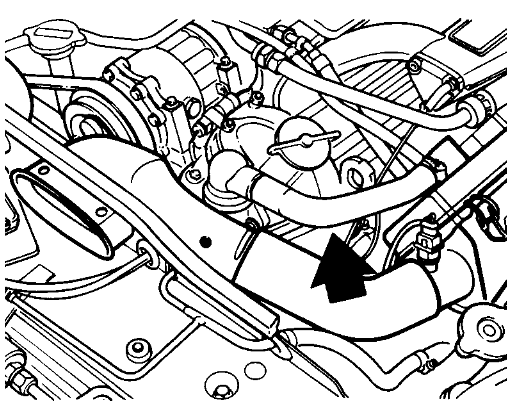


T850/1.05

Full-load engine breather

The full load breather is connected from the B bank timing cover to the B bank air cleaner housing.

FULL LOAD BREATHER



T850/1.06

Fuel Injection: Overview

The fuel injection system maintains optimum fuel flow control over the entire engine operating range by precisely metering the fuel into each cylinder. The main parameters for determining fuel flow requirements are engine load and speed. The ECM senses engine load from intake manifold absolute pressure and engine speed from the ignition pulses.

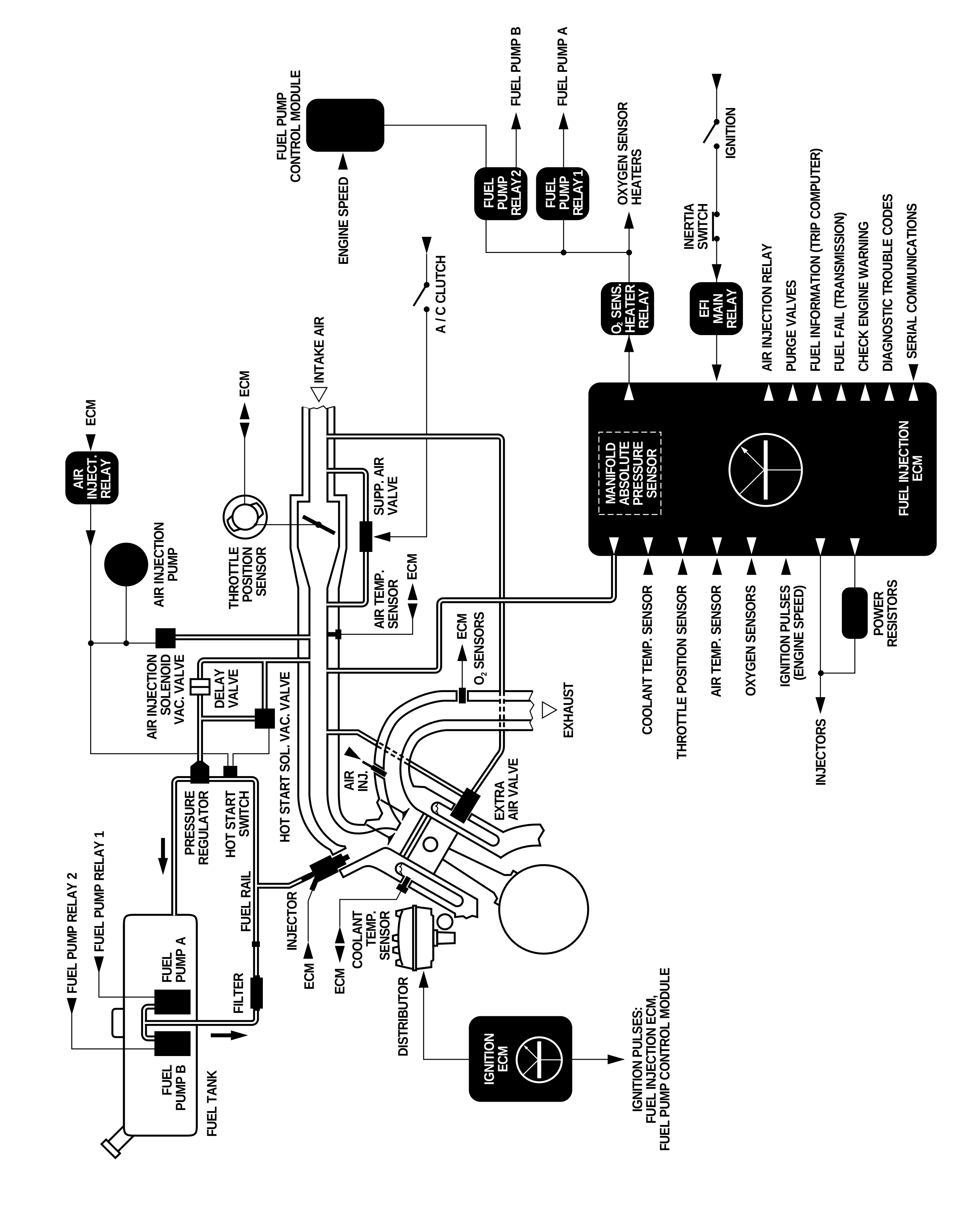
The ECM incorporates a manifold pressure sensor (transducer) and has a memory with stored fuel-flow strategy for various combinations of engine load and speed. The ECM receives inputs from sensors, switches and the ignition system that are applied to its memory to determine the required fuel flow.

The 36CU ECM incorporates new and expanded function over the previous 26CU ECM. The complete range of fuel injection ECM functions is as follows:

- ECM self-test
- Fuel delivery (fuel pumps A and B)
- Fuel injection
- Cold start
- Warm-up
- Exhaust oxygen content feedback
- Fuel cutoff during engine overrun
- Evaporative canister purge control
- Adaptive idle fueling trim
- Air injection control
- Hot start system timing
- Fuel level sensing
- Fuel fail output to transmission control module
- Fuel monitoring (trip computer)
- On Board Diagnostics (OBD) with “Limp home” capability
- Serial Communications (ISO)

NOTE: The sensors and switches are unique to the fuel injection system and are not used or shared by the digital ignition system.

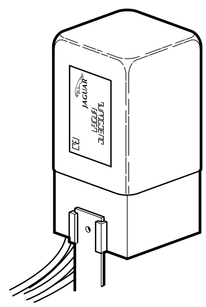
6.0 LITRE ENGINE MANAGEMENT SYSTEM: XJ12 SEDAN



Fuel Delivery

In order to meet the fuel requirements of the 6.0 litre engine, two fuel pump modules are used. The modules are identical but operate independently with staged control. One pump runs continuously when the engine is running, the other is activated when the engine speed exceeds 2840 rpm. Each pump is activated by a separate relay.

FUEL PUMP CONTROL MODULE



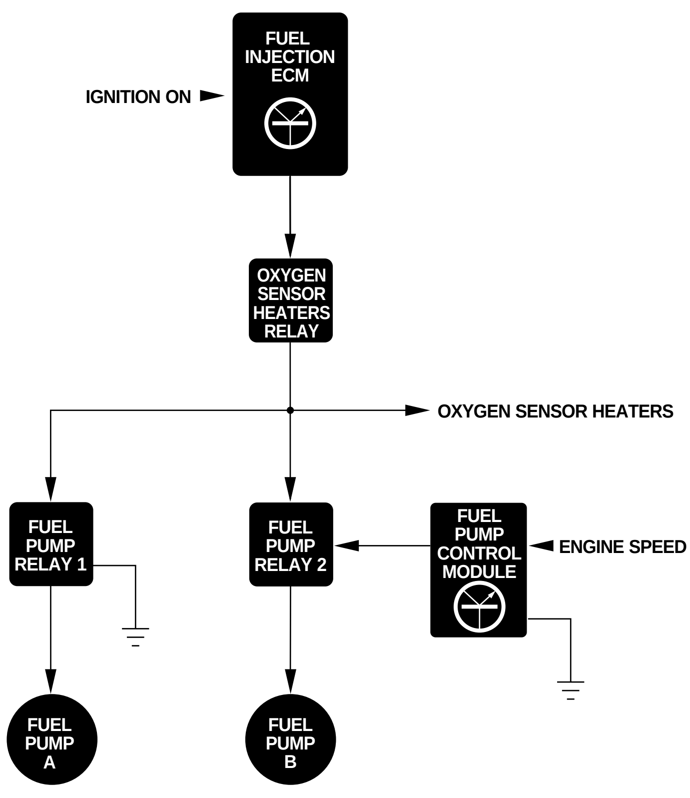
T850/1.10

The fuel pump control module, located on the trunk right side, receives an engine speed input from the Ignition ECM and switches the relay 2 coil ground as follows. When the engine speed reaches 2840 rpm, the ground is completed; as the engine speed decreases, the ground is interrupted at 2000 rpm. Switching of fuel pump B requires just 1/4 of a second, ensuring instant response for additional fuel delivery.

XJ12 Sedan

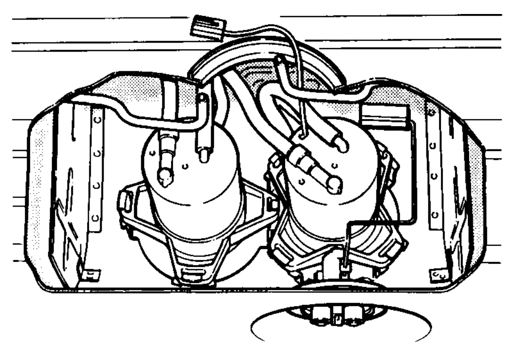
The two fuel pump relays are switched by the Fuel Injection ECM via the oxygen sensor heaters relay; however, the coil circuit of relay 2 is completed to ground via the fuel pump control module.

FUEL PUMP CONTROL: XJ12 SEDAN



T850/1.11

FUEL PUMPS: XJ12 SEDAN

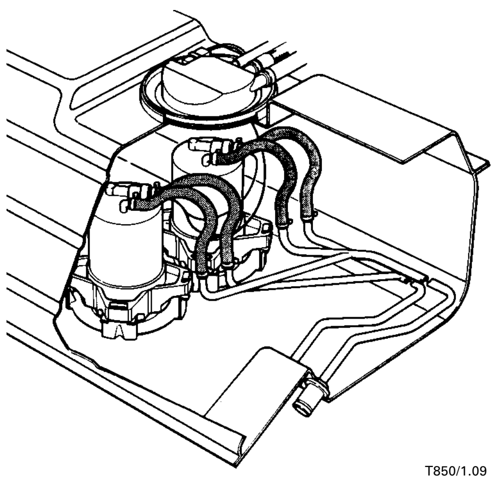


T850/1.08

XJS

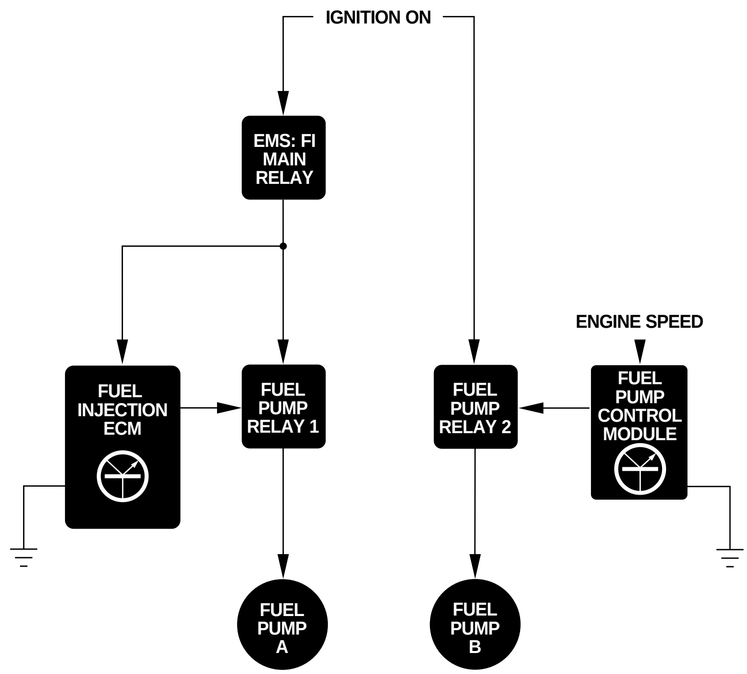
Fuel pump relay 1 is switched by the Fuel Injection ECM. Fuel pump relay 2 is switched by the fuel pump control module.

FUEL PUMPS: XJS



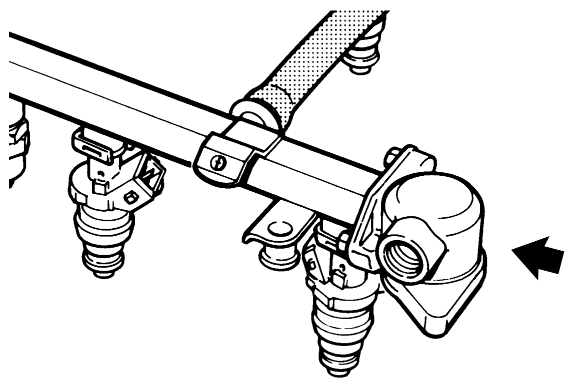
T850/1.09

FUEL PUMP CONTROL: XJS



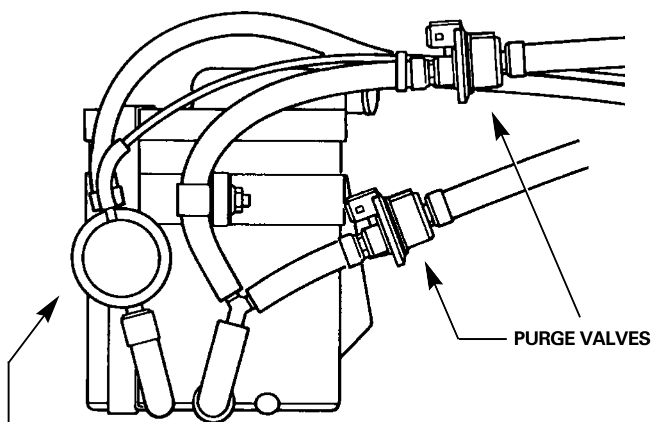
T850/1.12

FUEL PRESSURE REGULATOR



T850/1.13

CHARCOAL CANISTER: XJS



T850/1.14

Fuel Delivery (continued)

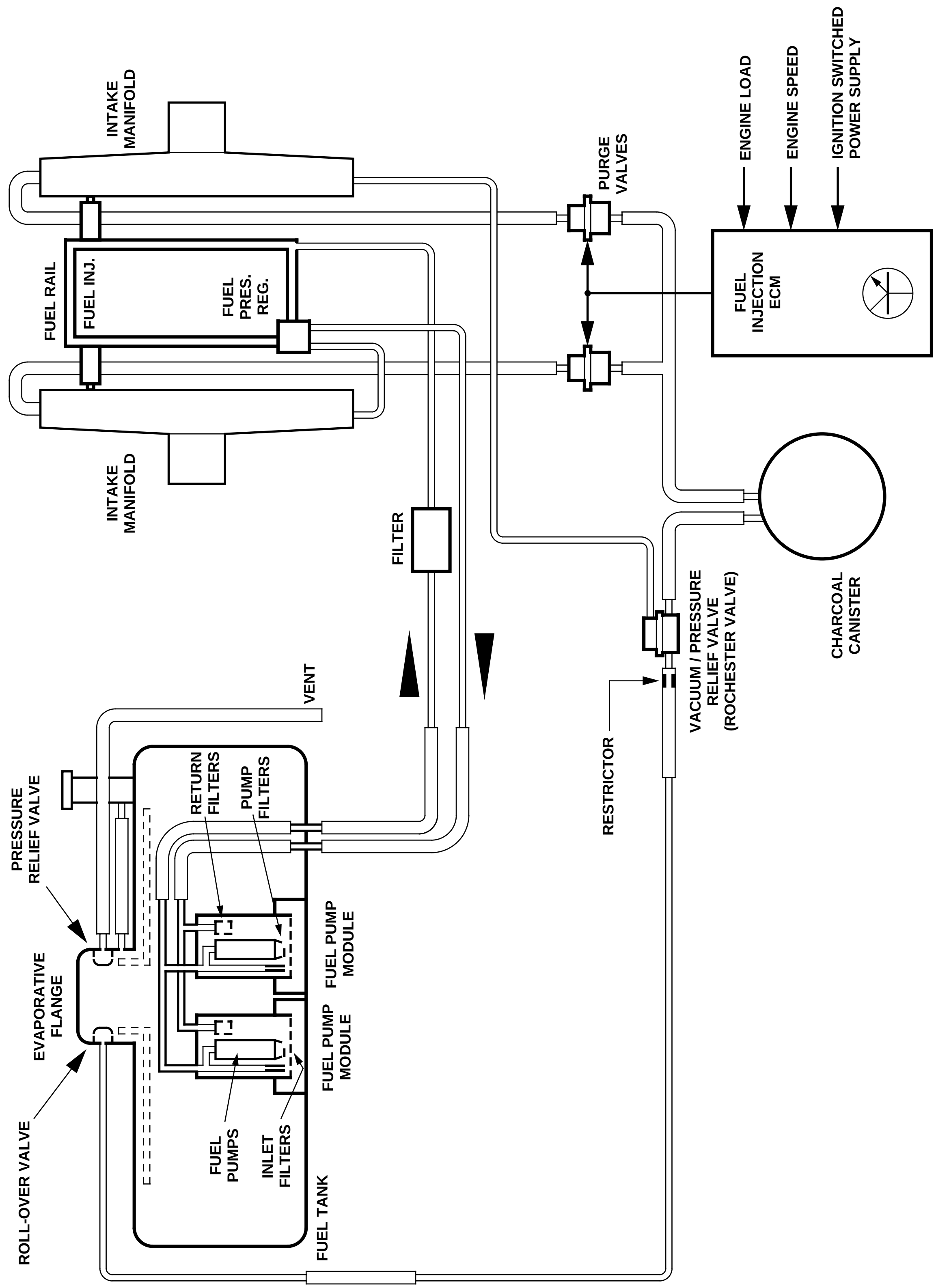
Fuel pressure regulator

The fuel pressure regulator maintains the fuel rail pressure at 44 psi (3 bar).

Evaporative emission control

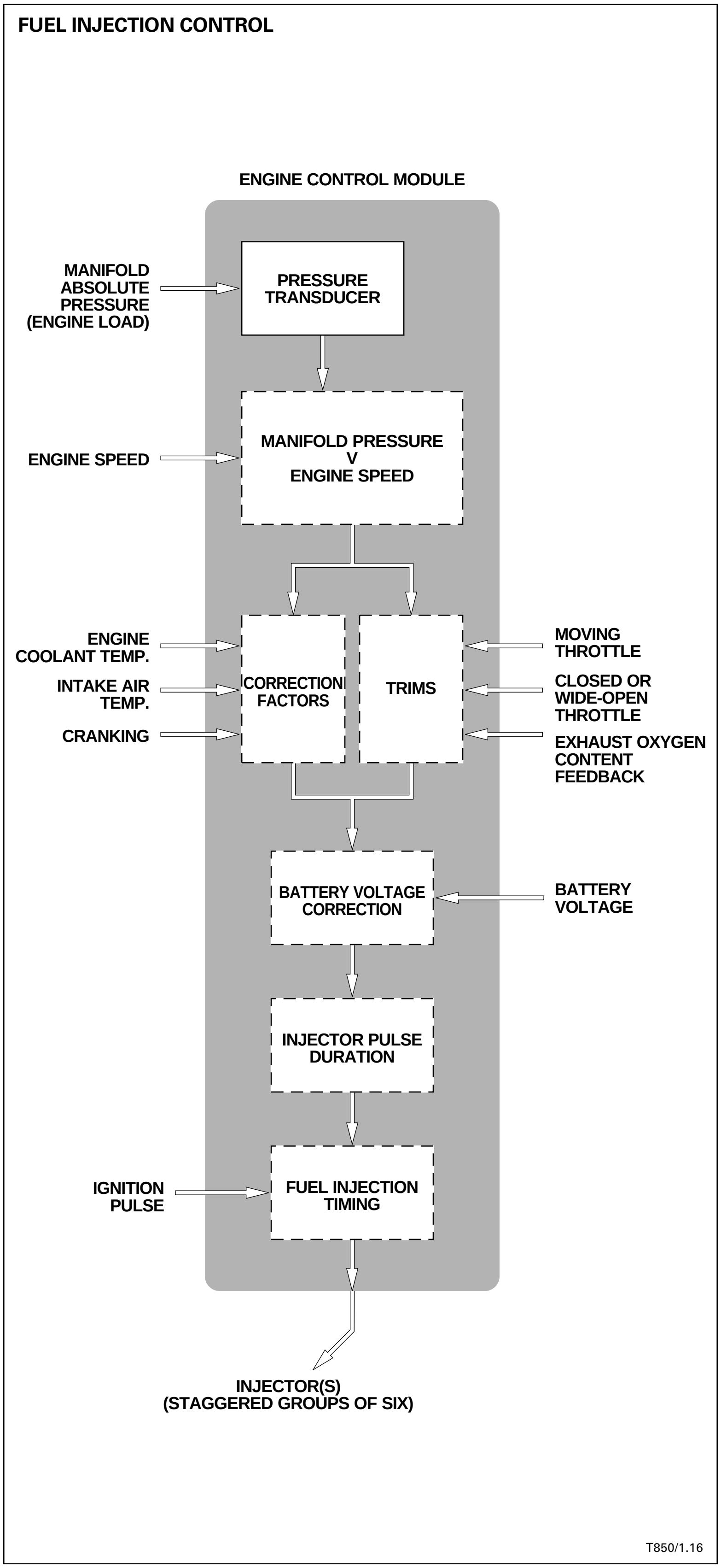
The evaporative emission control system uses the same canister and vacuum / pressure relief valve as the 4.0 liter XJS and the Sedan Range. Two purge control valves, one for each cylinder bank, are located at the charcoal canister. The purge valves are controlled by the fuel injection ECM. The ECM opens the valves simultaneously, according to an engine load and speed strategy, allowing purge flow to both intake manifolds. Purge flow is enabled at idle after adaptive idle fueling is completed. The charcoal canister is located at the front of the left front wheel arch.

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL SYSTEM



T850/1.15

Fuel Injection



Fuel metering control

Fuel metering is obtained by controlling the injector pulse duration (on-time) during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups — primary and secondary. Primary control inputs are intake manifold absolute pressure (MAP) and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature, throttle movement and position, exhaust oxygen content, cranking signal and battery voltage. The injectors are triggered via the power resistors, in staggered groups of six. Except during starting and sudden throttle opening, injector pulses occur every third ignition pulse (once per engine revolution).

Primary control

Fuel metering is controlled primarily as a function of intake manifold absolute pressure (MAP) and engine speed. Manifold pressure is sensed by a pressure transducer located in the engine control module and connected to the A bank manifold by a vacuum line. Engine speed is sensed from an ignition ECM output.

Fueling strategies are held in memory (EPROM) in the ECM and form a manifold pressure v engine speed matrix. Injector pulse duration is then calculated according to secondary correction factors and trims. The resulting injector pulse duration is further modified to account for battery voltage.

Injection timing depends on the crankshaft position and the ECM internal state at start-up. The ECM internal state is determined from the crankshaft position when the engine was last stopped and the ECM state when the ignition was turned off.

Secondary control
Secondary fueling enrichment is provided for engine starting, warm-up and throttle response at all temperatures within the engine's operating range.

Coolant temperature The coolant temperature sensor provides an electrical input to the ECM. During engine starting and warm-up, enrichment is provided by increasing the injector pulse duration when coolant temperature is below normal operating temperature. Enrichment is reduced with increasing engine speed and load.

Engine starting At engine cranking speeds, the ECM increases the number of injector pulses to three per engine revolution. It also increases the injector pulse duration in relation to coolant temperature sensor input. As engine speed increases, cranking enrichment is reduced to transition to the warm-up phase.

After start enrichment After engine start-up, the ECM increases the injector pulse duration above the normal running requirement and then decreases the pulse duration as a function of elapsed time after engine start.

Throttle movement and position The throttle position sensor provides electrical signals to the ECM for opened and closed throttle operation as well as throttle movement during acceleration and deceleration. In order to ensure good response when rapid throttle opening occurs, the ECM triggers an extra injector pulse to all injectors simultaneously. The duration of the extra pulse is dependent on coolant temperature.

Intake air temperature Fuel metering is adjusted to vary approximately with the density of the engine intake air. Intake air density is sensed by measuring the air temperature at the right air intakes.

Full load Full load fuel metering varies with throttle position and engine speed. Under full load conditions, exhaust oxygen sensor closed loop control is disabled.

Air / fuel ratio (closed loop control) In order to achieve optimum performance from the exhaust three-way catalyst system, the exhaust oxygen content is monitored and controlled by trimming the fuel metering. Two oxygen sensors are used: one in each exhaust down-pipe, after the primary catalyst. Closed loop control is disabled under these conditions:

- during engine warm-up when the air injection is operating
- during full load operation
- during deceleration fuel cutoff (engine overrun).

Battery voltage The time necessary for full injector open and close to occur varies with battery voltage. For example, with low battery voltage, the time necessary for full injector open to occur is long; therefore, less fuel is delivered for a given pulse duration. The opposite is true for high battery voltage. The ECM corrects the injector pulse duration to achieve the fuel delivery that would be obtained at a nominal reference voltage.

Fuel Injection (continued)

Adaptive idle fueling trim
In order to ensure optimum performance throughout the life of the vehicle, the fuel injection ECM software contains an adaptive idle fueling function that automatically trims the fuel injector idle pulse duration strategy, The total available trim to the nominal injector pulse duration is ± 20%. This function eliminates the manual adjustment of idle trim. Adaptive fueling is performed by the ECM software only when there are no diagnostic trouble codes (DTCs) present, and the listed preconditions are met.

Adaptive idle fueling preconditions:

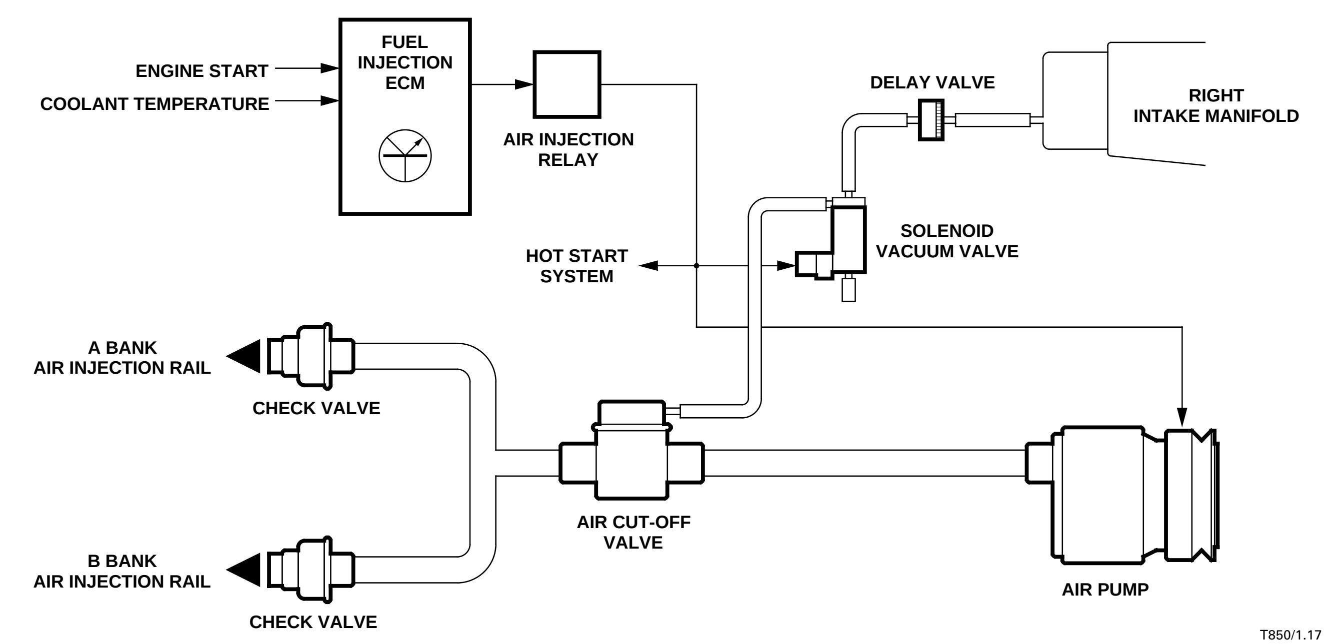
- Throttle closed
- Engine speed below 900 rpm
- Air injection disabled after engine start
- Closed loop fueling control enabled

If there are no DTCs present and the preconditions are met, the ECM cancels purge flow and adapts the idle fueling. Between fueling adaptations, there is a delay of approximately eight minutes during which the preconditions must be met. If the preconditions are interrupted, the delay will be lengthened.

Air injection
The 6.0 litre air injection system is similar to the AJ6 4.0 litre air injection system. An air injection pump with an electric clutch, and a vacuum operated air cutoff valve are controlled by the fuel injection ECM. Air injection is enabled after all engine starts. The ECM uses a strategy comprised of a number of injector pulses versus engine coolant temperature for air injection switch-off. Air injection is enabled following all hot starts and always operates below 115°F (47°C) engine coolant temperature. The air shut-off valve is operated by vacuum applied by the solenoid vacuum valve when signaled from the ECM.

NOTE: The XJS air injection pump is operationally the same as the XJ12 pump, however, it is manufactured by a different supplier.

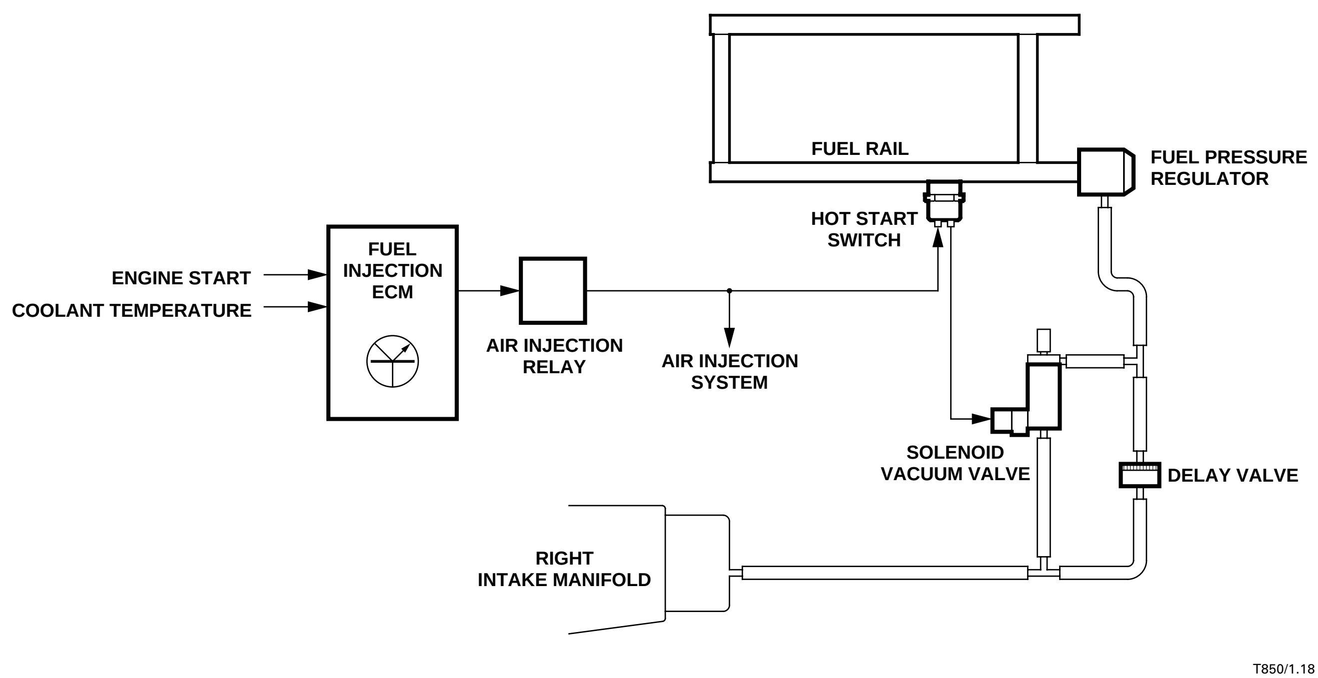
AIR INJECTION



Hot start system

The hot start system remains the same as the previous 5.3 liter system with the exception of the timing control. The function of the previous 45-second timer is replaced by fuel injection ECM control. When air injection is enabled, current is applied to the hot start switch. If the fuel rail temperature is 158°F (70°C) or above, the switch closes and activates the solenoid vacuum valve. The solenoid vacuum valve is mounted on the front of the right throttle body. The activated valve closes and directs vacuum to the fuel pressure regulator through the delay valve. The momentary vacuum delay increases fuel pressure to purge the fuel rail.

HOT START SYSTEM

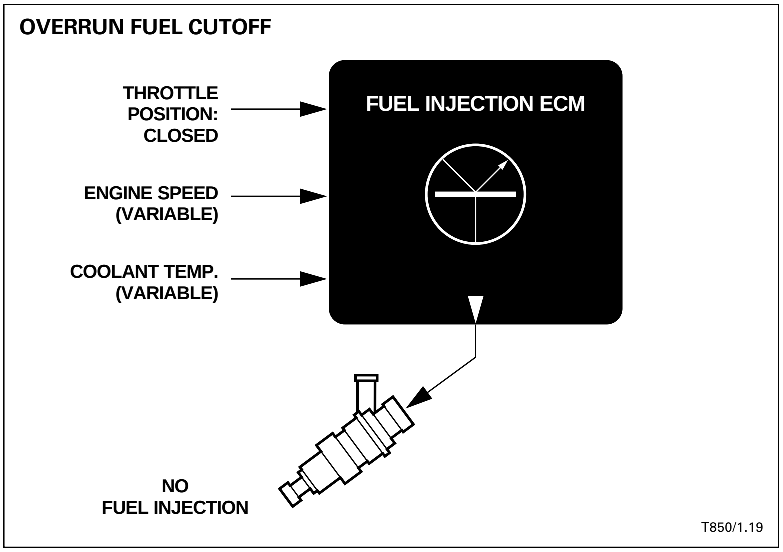


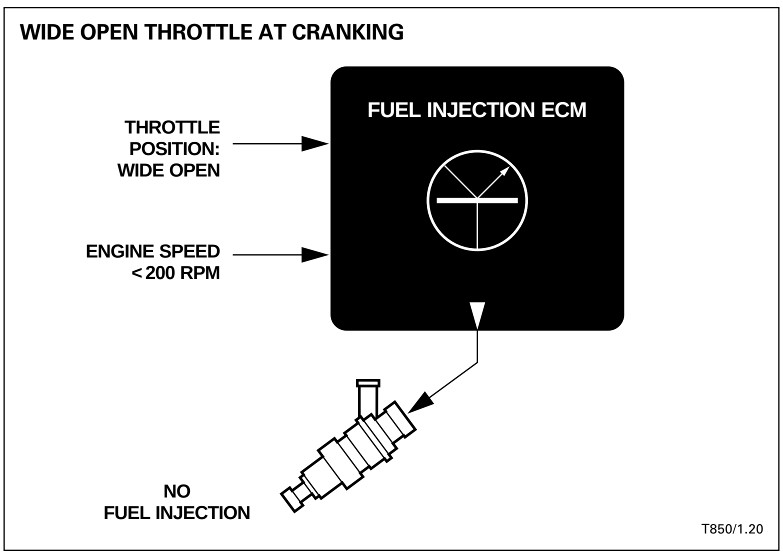
Idle speed control

Base idle speed control is maintained solely by the adjustable idle air bleed at the extra air valve.

Idle speed stabilization Idle speed stabilization is enabled when the air conditioning compressor is operating. The supplementary air valve is activated with the compressor clutch to allow throttle-valve-bypass air flow to the right intake manifold. The valve operates in all gear selector positions.

Fuel Injection (continued)





Fuel Cutoff

Overrun fuel cutoff To improve fuel economy and aid in controlling exhaust emissions, the ECM cuts off fuel injection during engine overrun conditions. The ECM determines overrun conditions from throttle position (throttle position sensor), engine speed (ignition pulses) and coolant temperature.

Coolant Temperature	Cutoff RPM	Reinstatement RPM
Up to -5°F (-15°C)	5000	4000
32°F(0°C)	3000	2000
50°F(10°C)	2000	1500
68°F(20°C)	1900	1400
86°F(30°C)	1900	1400
104°F(40°C)	1800	1300
149°F(65°C) and above	1500	1100

Wide Open Throttle during cranking When the ECM senses that the throttle is wide open (throttle position sensor) during cranking (<200 rpm, ignition pulse input), fuel injection is canceled to prevent the engine from flooding.

On-Board Diagnostics System (OBD)

The ECM includes a fault diagnosis facility that continuously monitors the operation of the engine management sensors and components. If a fault is detected, the OBD system will activate the CHECK ENGINE warning in the instrument pack and on the trip computer display. In addition, it will flag a diagnostic trouble code (DTC) in the ECM memory. The ECM can, at any time, be interrogated through the trip computer display by switching off the ignition then switching on the ignition. The CHECK ENGINE warning will display and the DTC will appear 5 seconds later. If two or more DTCs are flagged in memory, only the highest priority code will be displayed. The remaining codes will be displayed, in turn, as the faults are corrected and erased from memory.

NOTE: In order to prevent the erroneous flagging of codes, a fuel level input (voltage) to the fuel injection ECM is supplied. The ECM will not flag DTCs 13, 18, 19, 23, 34, 36, 44 and 45 when the fuel tank level falls below approximately 1 gallon.

Serial communications
Serial communications between the engine management system and JDS or PDU are available via the serial communications data link connector located in the trunk. Serial communication is used for engine setup, fault diagnosis and erasing diagnostic trouble codes.

Limp home mode
In order to allow vehicle operation if a malfunction occurs, "limp home" default strategies are incorporated as an ECM facility. The ECM will substitute a nominal value for missing inputs from various sensors and components.

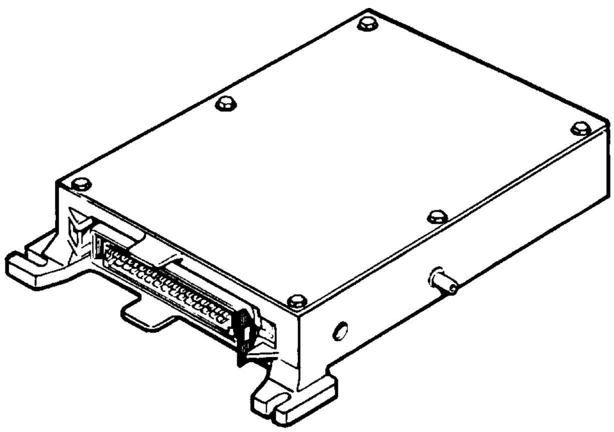
Diagnostic trouble code summary
The available DTCs are listed in order of priority on the following table. Limp home mode is available as indicated. When multiple faults occur, only the highest priority code will be displayed.

DTC	Limp Home Mode	Input or Component checked
29		ECM Self-test
44	X	Oxygen sensor circuit — A bank
45	X	Oxygen sensor circuit — B bank
13	X	Manifold pressure transducer and sensing hose
34		Injector electrical circuits — A bank
36		Injector electrical circuits — B bank
14	X	Coolant temperature sensor circuit
17	X	Throttle position sensor circuit
18	X	Manifold pressure transducer / throttle position sensor circuit (high throttle voltage / low MAP)
19	X	Manifold pressure transducer / throttle position sensor circuit (low throttle voltage / high MAP)
23		Fuel metering at idle — banks A and B combined
49	X	Power resistors electrical circuits
11	X	Pressure transducer / throttle position sensor circuit
16	X	Intake air temperature sensor circuit
67		Air injection operation (oxygen sensor response)
77		Engine speed (loss of input from ignition ECM)

Clearing diagnostic trouble codes
All DTCs are held in the ECM memory until cleared using serial communication. If the vehicle battery is disconnected, the DTC(s) will be cleared.

Fuel Injection Components

36CU ENGINE CONTROL MODULE: FUEL INJECTION



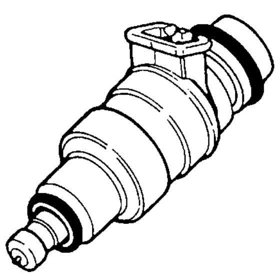
T850/1.21

Engine control module (ECM): Fuel Injection

Location Trunk, right front.

Description The 36CU ECM contains an integrated circuit for a dedicated fuel injection control chip and an analog / digital converter for the manifold pressure input. A manifold absolute pressure sensor (transducer) is built into the ECM. Fuel injection information is stored in ROM (read only memory), so that for a given combination of manifold pressure and engine speed, the memory assigns a number proportional to the required injector pulse duration. The ECM also contains facilities for OBD and serial communications.

FUEL INJECTOR



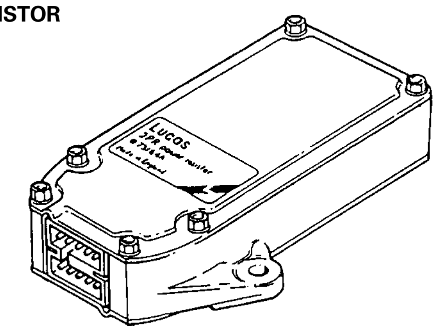
T850/1.22

Fuel injectors

Location Intake manifolds.

Description Each fuel injector contains a solenoid-operated needle valve, which is held against a seat by spring pressure. When energized, the coil moves the needle away from the seat, allowing pressurized fuel to flow through the tip.

POWER RESISTOR



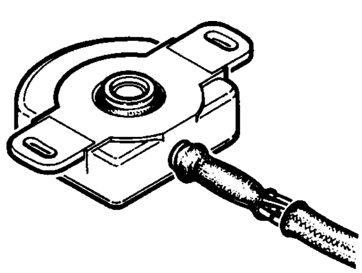
T850/1.23

Power resistors

Location Engine compartment: right bulkhead (XJ12); right front (XJS).

Description The power resistor pack contains four 6-ohm resistors. Each resistor is connected to a group of 3 injectors to limit the current during the "hold" portion of the injector pulse duration. Limiting the current protects the ECM.

THROTTLE POSITION SENSOR



T850/1.24

Throttle position sensor

Location Under the throttle turntable.

Description The twin track throttle position sensor is mechanically connected to the throttle valve shaft and provides a reference voltage input to the ECM dependent on throttle position and rate of acceleration. The second track is used by the transmission control system.

Coolant temperature sensor

Location Left thermostat housing.

Description The coolant temperature sensor is a temperature-sensitive resistor. As the coolant temperature rises, the electrical resistance decreases providing a coolant temperature input to the ECM.

Coolant Temp. (°F)	(°C)	Resistance (kilohms)	Voltage (±)
14	-10	9.2	3.27
32	0	5.9	3.11
50	10	3.7	2.91
78	20	2.5	2.66
86	30	1.7	2.38
104	40	1.18	2.07
122	50	0.84	1.76
140	60	0.60	1.48
158	70	0.435	1.22
176	80	0.325	0.99
193	90	0.250	0.80
212	100	0.190	0.65

Intake air temperature sensor

Location Right air cleaner intake (XJ12); right air cleaner (XJS).

Description The air temperature sensor is a temperature-sensitive resistor. As the ambient (intake) air temperature rises, the electrical resistance decreases providing an input to the ECM. The ECM uses this input as a measure of intake air density (as air temperature rises, its density decreases).

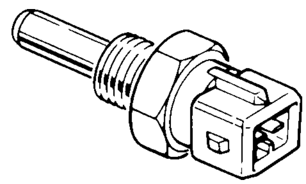
Air Temp. (°F)	(°C)	Resistance (kilohms)	Voltage (±)
14	-10	9.2	3.27
32	0	5.9	3.11
50	10	3.7	2.91
78	20	2.5	2.66
86	30	1.7	2.38
104	40	1.18	2.07
122	50	0.84	1.76
140	60	0.60	1.48

Oxygen sensor

Location Exhaust down-pipes.

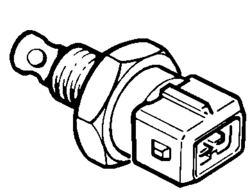
Description The oxygen sensors (2) measure the oxygen concentration in the exhaust gases and provide an input to the ECM.

COOLANT TEMPERATURE SENSOR



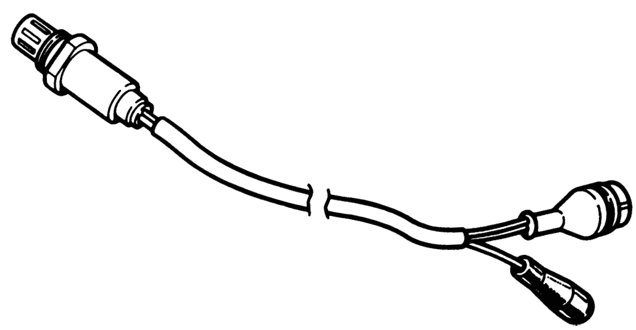
T850/1.25

AIR TEMPERATURE SENSOR



T850/1.26

OXYGEN SENSOR



T850/1.27

Fuel Injection Components (continued)

Extra air valve

Location Left cylinder head, rear.

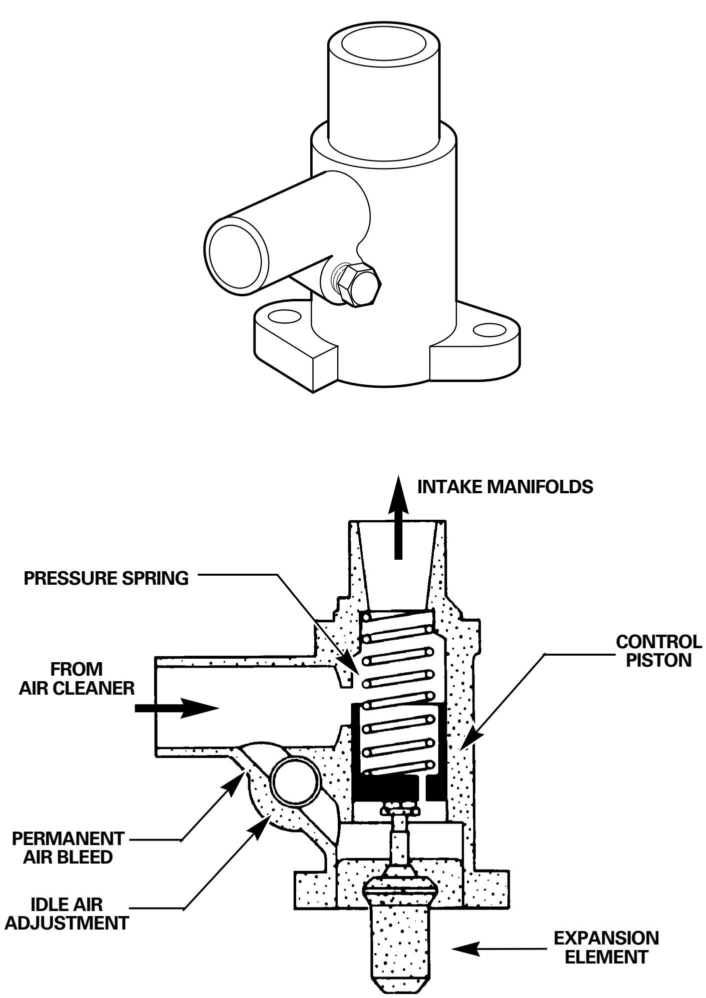
Description The extra air valve has two functions: it provides the engine base idle speed through the adjustable idle air bleed, and it provides warm-up idle speed stabilization through the variable air duct. The duct area is varied by a temperature sensitive expansion element, in contact with engine coolant, that moves a control piston. As the coolant temperature increases, the area of the duct is gradually reduced until, at a coolant temperature of 140 to 158°F, it closes completely.

Supplementary air valve

Location Right air cleaner back plate.

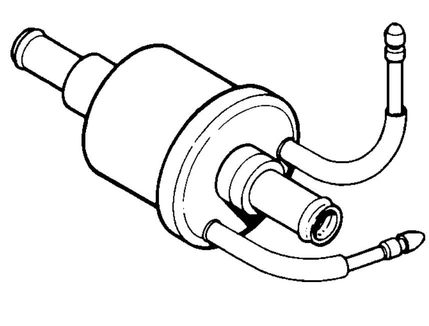
Description The supplementary air valve allows additional throttle bypass air into the intake manifolds to stabilize the idle speed during air conditioning compressor operation. The valve operates in all gear selector positions.

EXTRA AIR VALVE



T850/1.28, 1.29

SUPPLEMENTARY AIR VALVE



T850/1.30

Hot start switch

Location Fuel rail, right.

Description The hot start switch switches current between the air injection relay (switched by the ECM) and the hot start solenoid vacuum valve. The switch contacts close at 158°F and above.

Hot start solenoid vacuum valve

Location Above right thermostat housing.

Description The normally open solenoid vacuum valve closes when current is applied.

Air injection solenoid vacuum valve

Location Right cylinder head, rear.

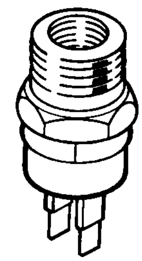
Description The normally closed solenoid vacuum valve opens when current is applied.

Purge valves

Location Right front inner fender (XJ12); charcoal canister (XJS).

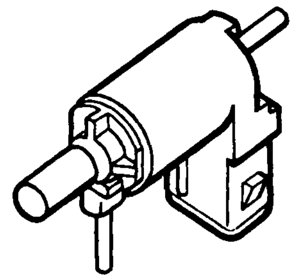
Description The purge valve is a solenoid operated valve that is normally open. The valve closing and subsequent rate of vapor flow (opening) is varied by the "length" of the pulsed electrical signal provided from the ECM.

HOT START SWITCH



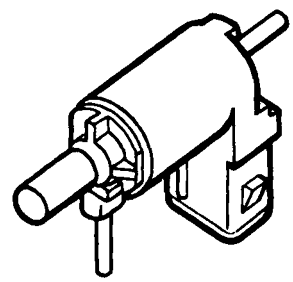
T850/1.31

HOT START SOLENOID VACUUM VALVE



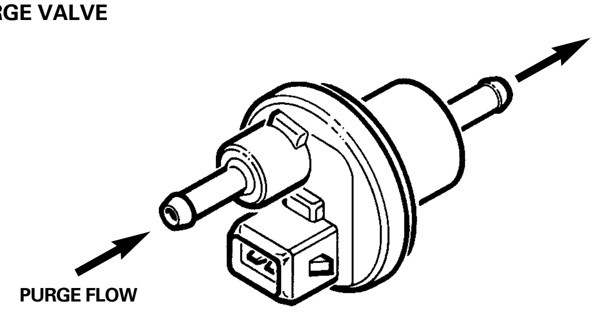
T850/1.32

AIR INJECTION SOLENOID VACUUM VALVE



T850/1.33

PURGE VALVE



T850/1.34

Ignition: Overview

The ignition system is a digital microprocessor controlled system that eliminates vacuum and mechanical advance controls. The microprocessor memory contains ignition timing strategy with precise timing for engine speeds, loads, and modes of operation. The microprocessor, in the ignition ECM, receives inputs from engine sensors to program the necessary ignition timing. The double-deck two-rotor distributor distributes the high tension voltage to A bank (right) via the lower deck and to B bank (left) via the upper deck. The low-voltage circuit is switched by the ignition ECM via the two power modules to the two ignition coils. High voltage is generated by the ignition coils and supplied to the distributor.

The inputs supplied to the ECM from the engine sensors form two groups of control parameters: primary inputs and secondary inputs. The crankshaft position and engine-speed inputs are necessary for the engine to start. The remaining inputs effect engine operation but are not necessary for engine start.

Primary Inputs

- Crankshaft position — TDC sensor
- Engine speed — engine speed (flywheel) sensor
- Engine load — manifold absolute pressure sensor

Secondary Inputs

- Throttle position — idle switch
- Intake air temperature — air temperature switch

Other Functions

- Engine speed output
- Ignition retard (torque reduction) during transmission shift

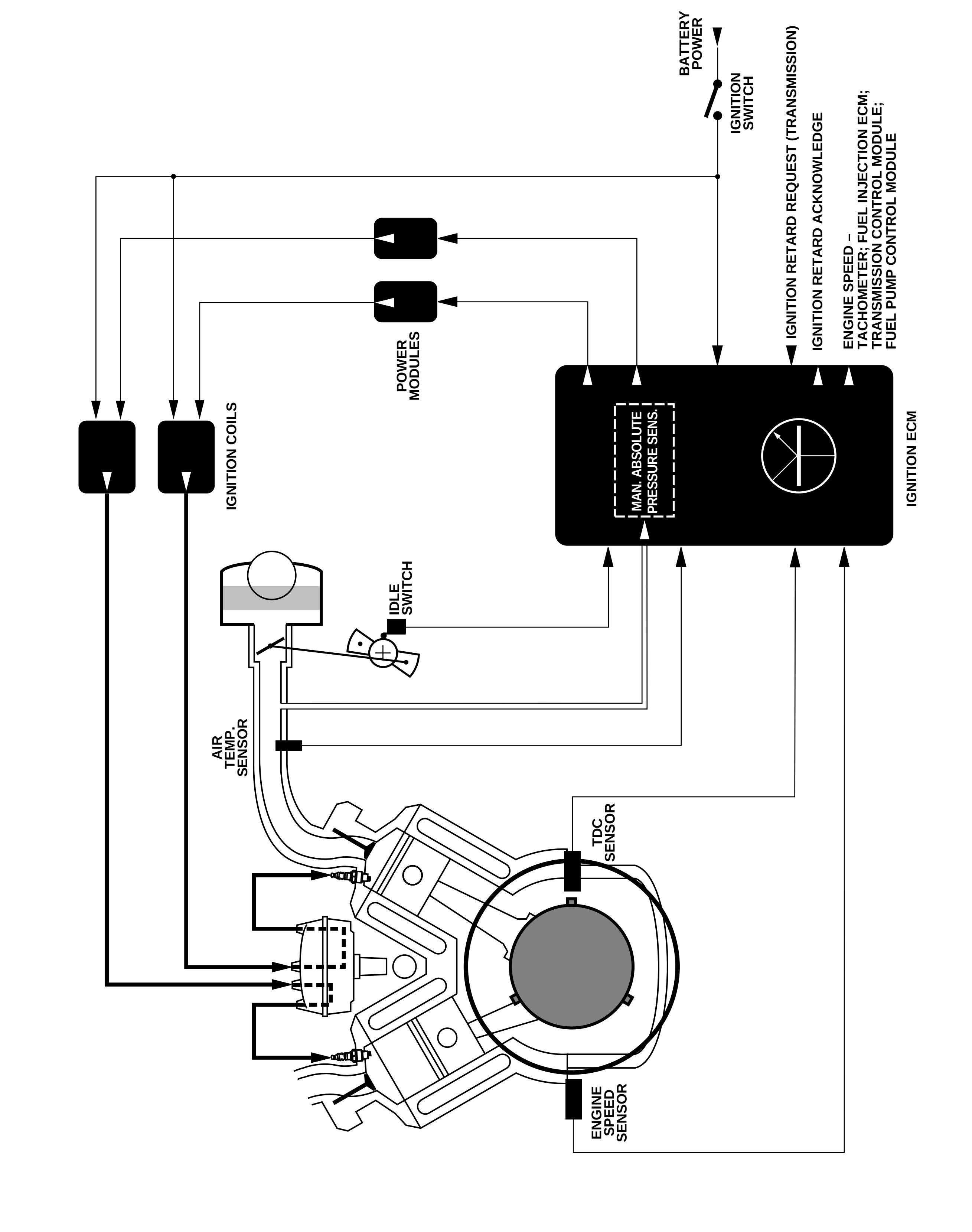
NOTE: The sensors and switches are unique to the digital ignition system and are not used or shared by the fuel injection system.

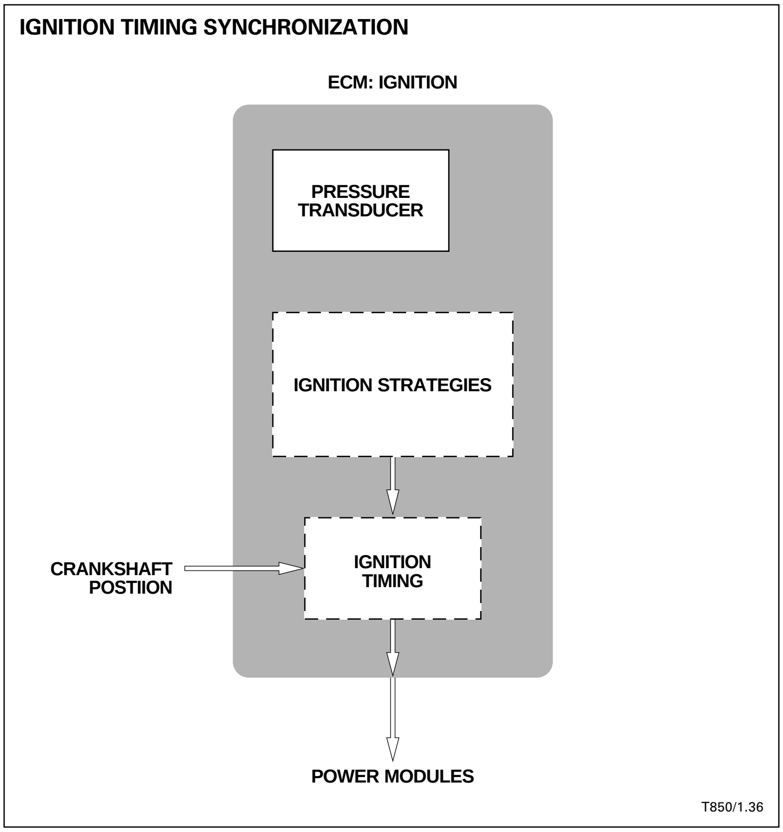
Engine speed outputs

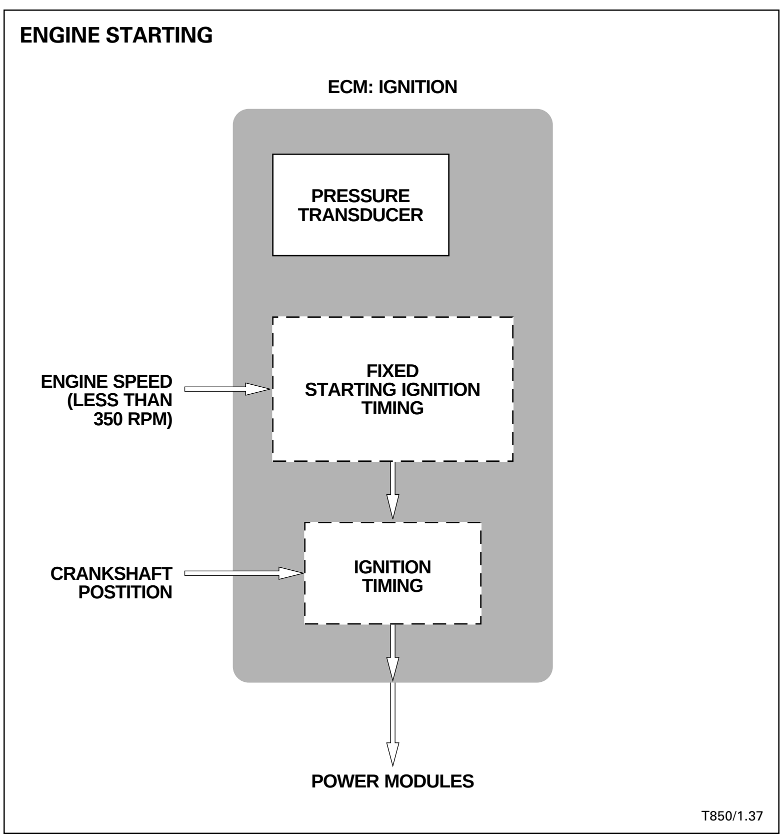
The ignition ECM provides engine speed outputs for the following:

- Tachometer
- Fuel injection control
- Fuel pump B control
- Transmission control

6.0 LITRE V12 IGNITION CONTROL







Ignition Timing Control

Ignition timing synchronization
During all engine operating modes, the crankshaft position sensor (TDC sensor) input is used by the ECM to time spark delivery. Crankshaft position is referenced from A bank. The ECM times spark delivery for both banks from the A bank reference.

Engine starting
Ignition timing during cranking and start-up is determined from engine speed, intake air temperature and throttle position. Ignition timing moves from engine starting to normal running at 350 rpm.

Engine speed is obtained from the engine speed (flywheel) sensor; intake air temperature is obtained from the intake air temperature sensor; throttle position is obtained from the throttle switch.

Closed throttle running

Ignition timing during closed throttle operation is programmed separately for idle and deceleration. Closed throttle running is enabled by the ECM from the idle switch input.

When the idle switch is closed, the ECM does not recognize the engine load (manifold absolute pressure sensor) input and uses the idle portion of the ignition strategy for ignition timing. The idle strategy uses engine speed and intake air temperature.

Engine speed is obtained from the engine speed (flywheel) sensor; engine intake air temperature is obtained from the intake air temperature sensor.

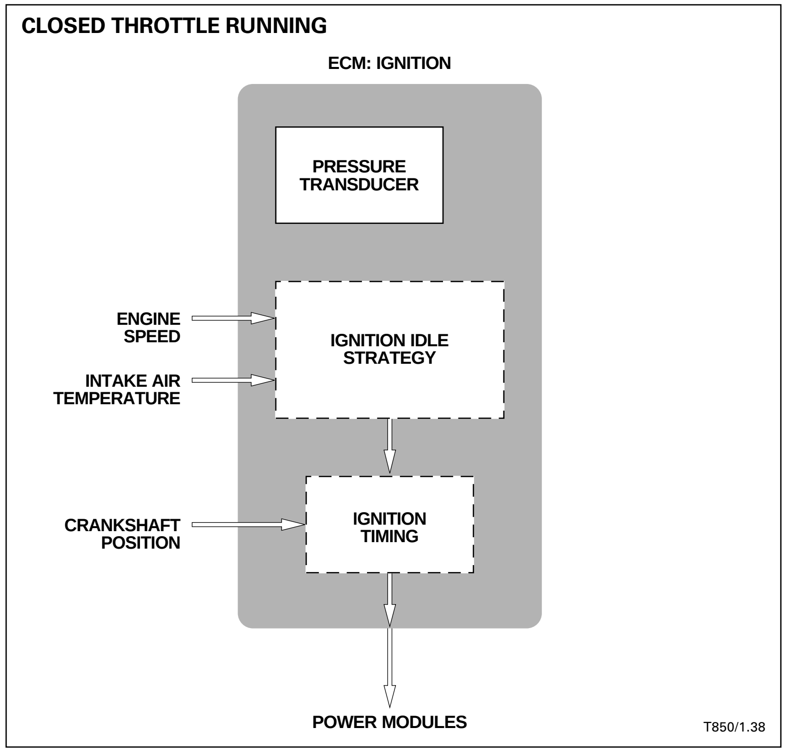
Open throttle running

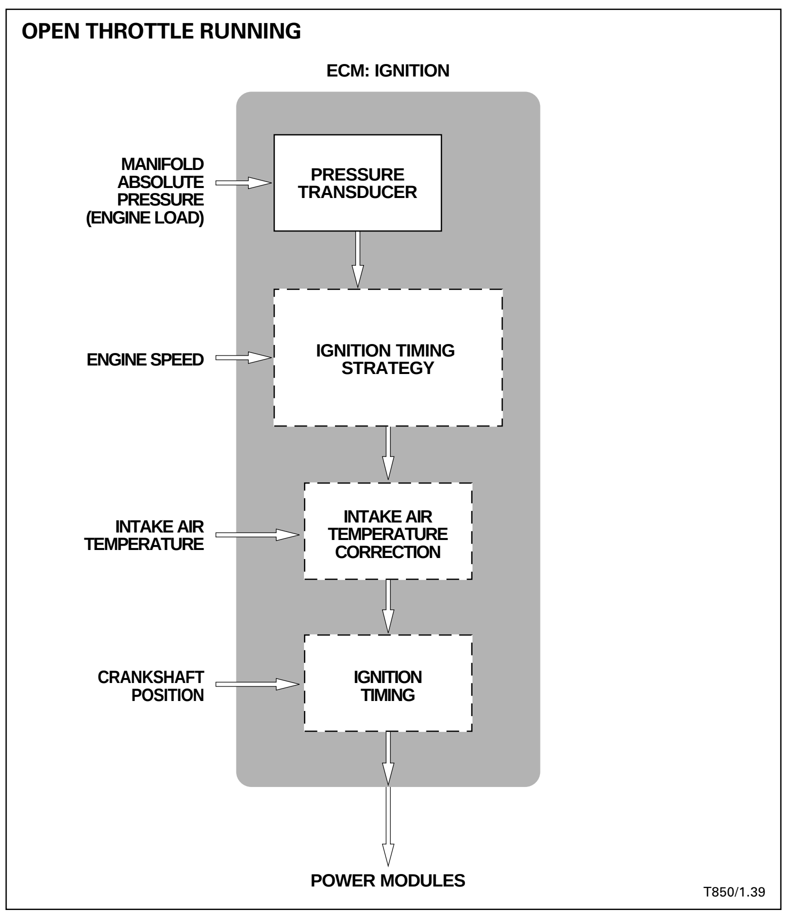
Ignition timing during open throttle running is determined by primary inputs from engine speed and engine load and from secondary inputs from intake air temperature. Engine speed is obtained from the engine speed (flywheel) sensor; engine load is obtained from the manifold absolute pressure sensor; intake air temperature is obtained from the intake air temperature sensor.

The ECM memory incorporates an ignition timing strategy with ignition timing information stored for 16 engine load and 16 engine speed sites. A value number relating to the required ignition timing is generated from the strategy based on the engine load and speed inputs. If the engine load and speed is between sites, a value number is calculated from the surrounding sites. The ignition timing requirement is then modified depending on intake air temperature.

Ignition retard / transmission control

The ignition ECM receives an ignition retard request from the transmission control module during certain transmission apply and release functions. Before the transmission completes the function, an acknowledgment of the request is made by the ignition ECM. The momentary ignition retard reduces engine torque to ensure a "quality" shift. Ignition timing is retarded up to 20° with a limit of 8° ATDC. The retard is applied for a maximum of 1.2 seconds after which the ECM gradually returns to the engine speed / load strategy over a 0.5 second period.





Ignition Components

Engine control module (ECM): Ignition

Location Front passenger footwell, A post trim panel.

Description The ECM contains the microprocessor for receiving analog inputs from the engine sensors and producing the ignition timing, which is accessed and delivered from the ignition strategy stored in the memory. Integral in the ECM is the manifold absolute pressure sensor.

Top dead-center sensor

Location Front crankshaft pulley.

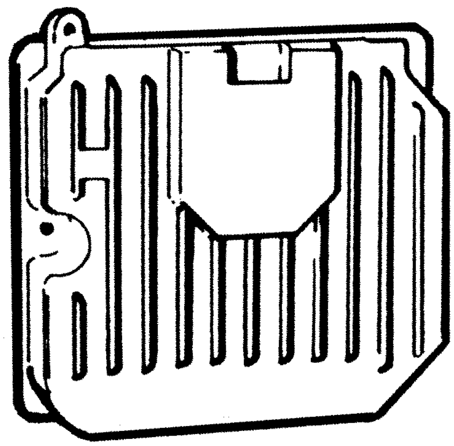
Description The sensor is triggered by a three toothed reluctor to produce a TDC reference for A bank.

Engine speed sensor

Location Flywheel ring gear.

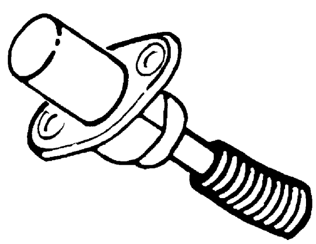
Description The sensor is triggered by the flywheel ring gear teeth, which act as a reluctor to produce an engine speed input to the ECM.

ENGINE CONTROL MODULE: IGNITION



T850/1.40

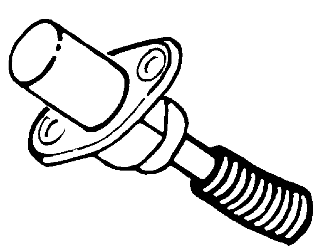
TOP DEAD-CENTER SENSOR



RESISTANCE: 700 – 800 OHMS

T850/1.41

ENGINE SPEED SENSOR



RESISTANCE: 700 – 800 OHMS

T850/1.42

Idle switch

Location Throttle turntable.

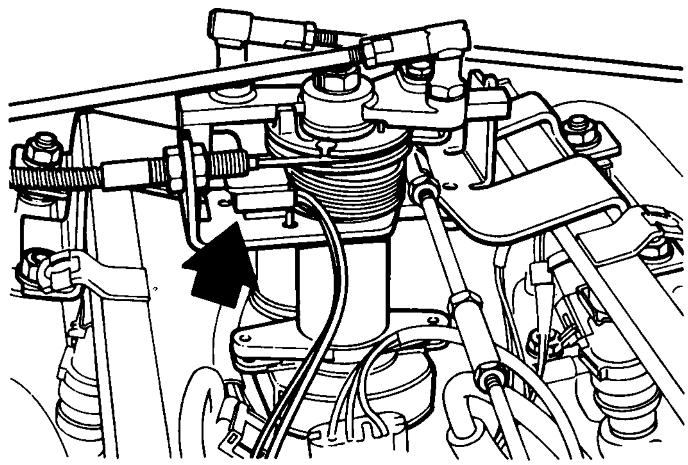
Description The micro switch closes when the throttle is closed, signaling the ECM that the engine is at idle or decelerating.

Intake air temperature sensor

Location Right air cleaner back plate.

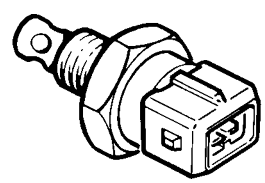
Description The intake air temperature sensor is a temperature-sensitive resistor. As the air temperature rises, the electrical resistance decreases providing an air temperature input to the ECM.

IDLE SWITCH



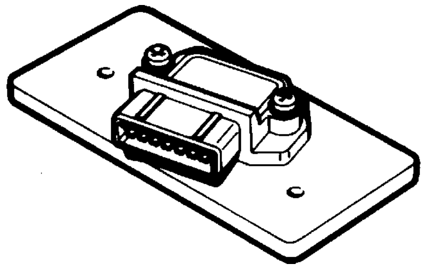
T850/1.43

INTAKE AIR TEMPERATURE SENSOR



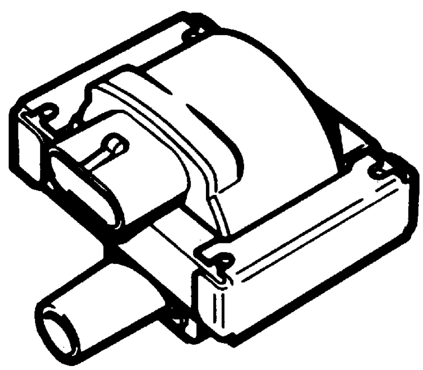
T850/1.44

POWER MODULE



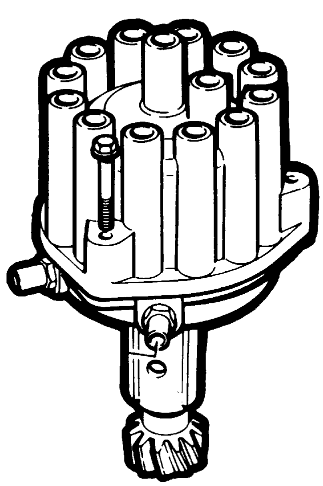
T850/1.45

IGNITION COIL



T850/1.46

DISTRIBUTOR



T850/1.47

Ignition Components (continued)

Power modules

Location Front bulkhead component panel (XJ12); upper radiator support (XJS).

Description The power modules switch the low voltage circuit to ground when signaled by the ECM.

Ignition coils

Location Engine vee: A bank – red ident on harness plug; B bank – yellow ident on harness plug.

Description The ignition coils generate high voltage current for distribution to the spark plugs.

Distributor

Location Engine vee.

Description The distributor is a double-deck design with the upper rotor distributing high voltage current to B bank spark plugs and the lower rotor distributing high voltage current to A bank spark plugs.

The following Figures and Data pages are extracted from select Electrical Guides and are included here as an aid to understanding the Engine Management system. Do not use this information to diagnose vehicle faults.

Always refer to the Model and Model Year specific Electrical Guide for accurate information.

Contents

System Introduction

The 5.3 litre V12 engine uses electronic systems, vacuum systems and air injection to govern engine and engine-related functions. These are independent systems; however, they are dependent on each other to achieve an overall efficiency of operation, while providing precise control over each individual function. The independent systems should be thought of as one engine management system when evaluating engine performance.

1992 Model Year Although the engine management system remained fundamentally similar to previous 5.3 litre V12 systems, many of the components were new and the operation was revised. In the interest of clarity, a complete 1992 model year system description is detailed first followed by the differences for the earlier 1989 / 90 model year system.

5.3 Litre V12 tuning specifications:

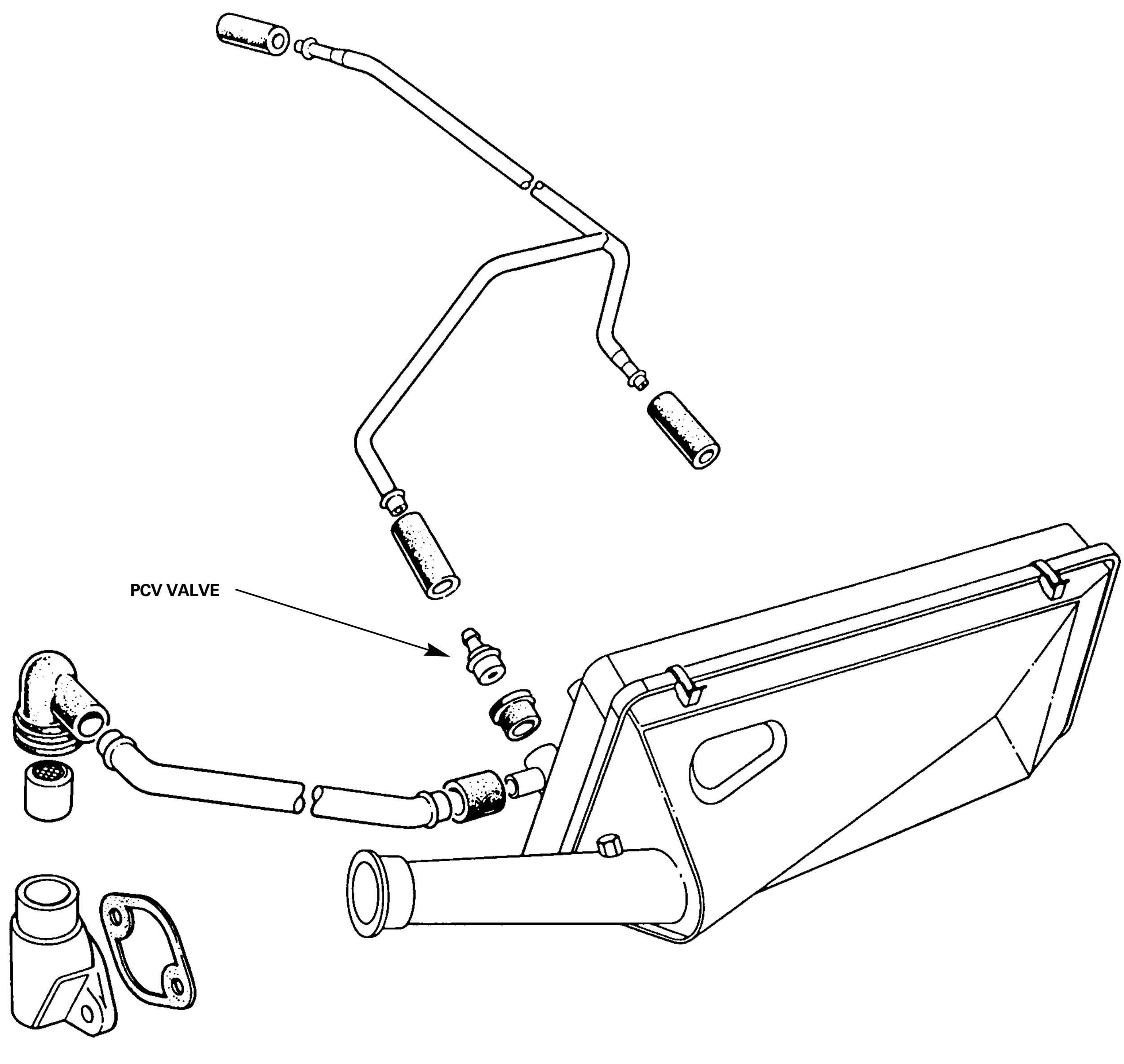
Firing order	1A 6B 5A 2B 3A 4B 6A 1B 2A 5B 4A 3B (A bank – right; B bank – left)
Idle speed	800 rpm (+50 - 0 rpm)
Fuel pressure	28.5 – 30 psi in fuel rail (vacuum connected at idle)
Spark plug gap (1992 MY)	0.024 – 0.028 in.
Engine speed sensor gap	0.018 – 0.042 in.
TDC sensor gap	0.018 – 0.042 in.

Crankcase Emission Control

Crankcase ventilation

Piston blowby gases are scavenged from the crankcase and the camshaft housings via the left timing housing and the camshaft covers. The gases are collected and fed into the engine through the left air cleaner.

5.3 LITRE V12 CRANKCASE EMISSION CONTROL



T850/2.01

Engine Management System: Fuel Injection — Overview

Starting in model year 1992, the fuel injection system employed a new fuel injection engine control module (26 CU) and revised components and subsystems.

The fuel injection system maintains optimum fuel flow control over the entire engine operating range by precisely metering the fuel into each cylinder. The main parameters for determining fuel flow requirements are engine load and speed. The ECM senses engine load from intake manifold absolute pressure and engine speed from the ignition pulses.

The ECM incorporates a manifold pressure sensor (transducer) and has a memory with stored fuel-flow strategy for various combinations of engine load and speed. The ECM receives inputs from sensors, switches and the ignition system that are applied to its memory to determine the required fuel flow.

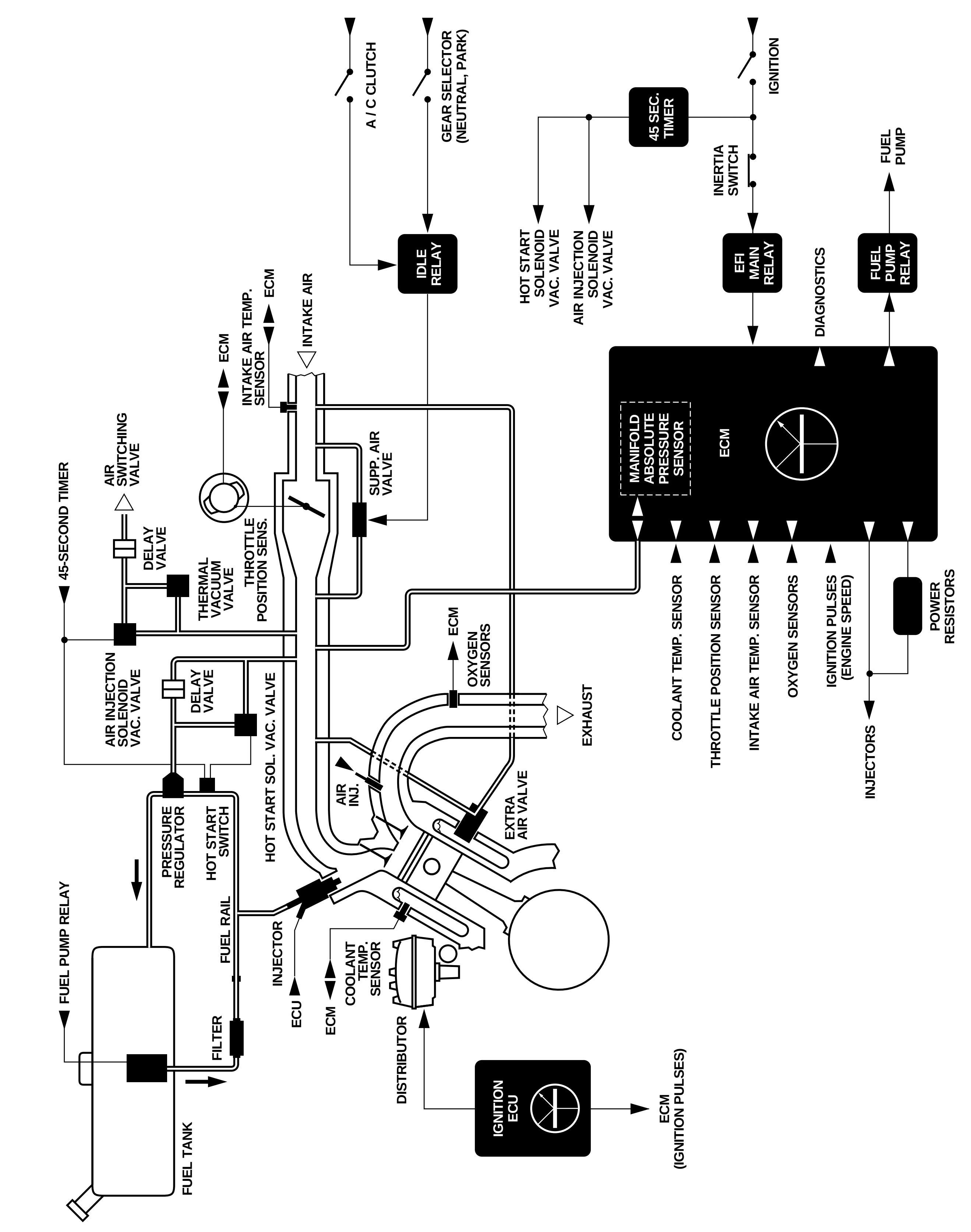
The 26CU ECM incorporates an expanded strategy that provided more precise control over the full range of fuel injection control. In particular, starting and warm-up control were expanded and refined. A facility for On Board Diagnostics (OBD) that stores fault data during engine operation was added. Diagnostic trouble codes (DTCs) are displayed on the center console message display. Additionally, a serial communications serial link is used to access the stored fault data and test the system.

The complete range of fuel injection ECM functions is as follows:

- ECM self-test
- Fuel delivery (fuel pump)
- Fuel injection
- Cold start
- Warm-up
- Exhaust Oxygen Content feedback
- Fuel cutoff during engine overrun
- “Limp home” capability
- Collision safety
- Fuel monitoring (trip computer)
- On Board Diagnostics (OBD)
- Serial Communications (ISO)

NOTE: The sensors and switches are unique to the fuel injection system and are not used or shared by the digital ignition system.

5.3 LITRE V12 ENGINE MANAGEMENT SYSTEM: FUEL INJECTION (1992 MY)

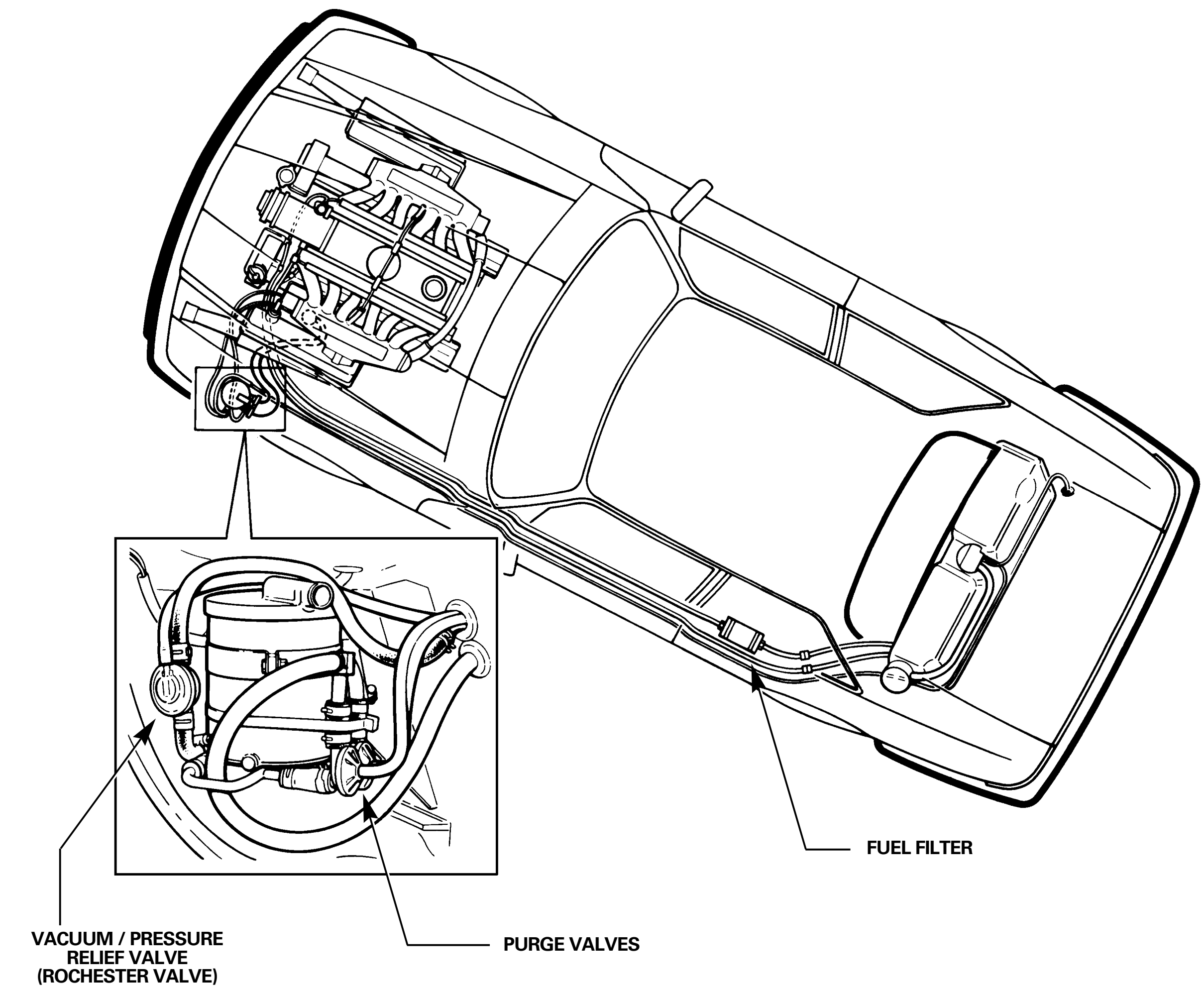


T850/2.02

Fuel Delivery

The fuel delivery system follows the same principals and layout as the system in Sedan Range vehicles from 1991 model year on. The fuel pump is part of an in-tank fuel pump module that gives superior fuel handling qualities under varying conditions and reduces operating noise. An external filter is located under the vehicle. Approximate fuel tank capacity: 23.5 gallons (Coupe), 21.6 gallons (Convertible).

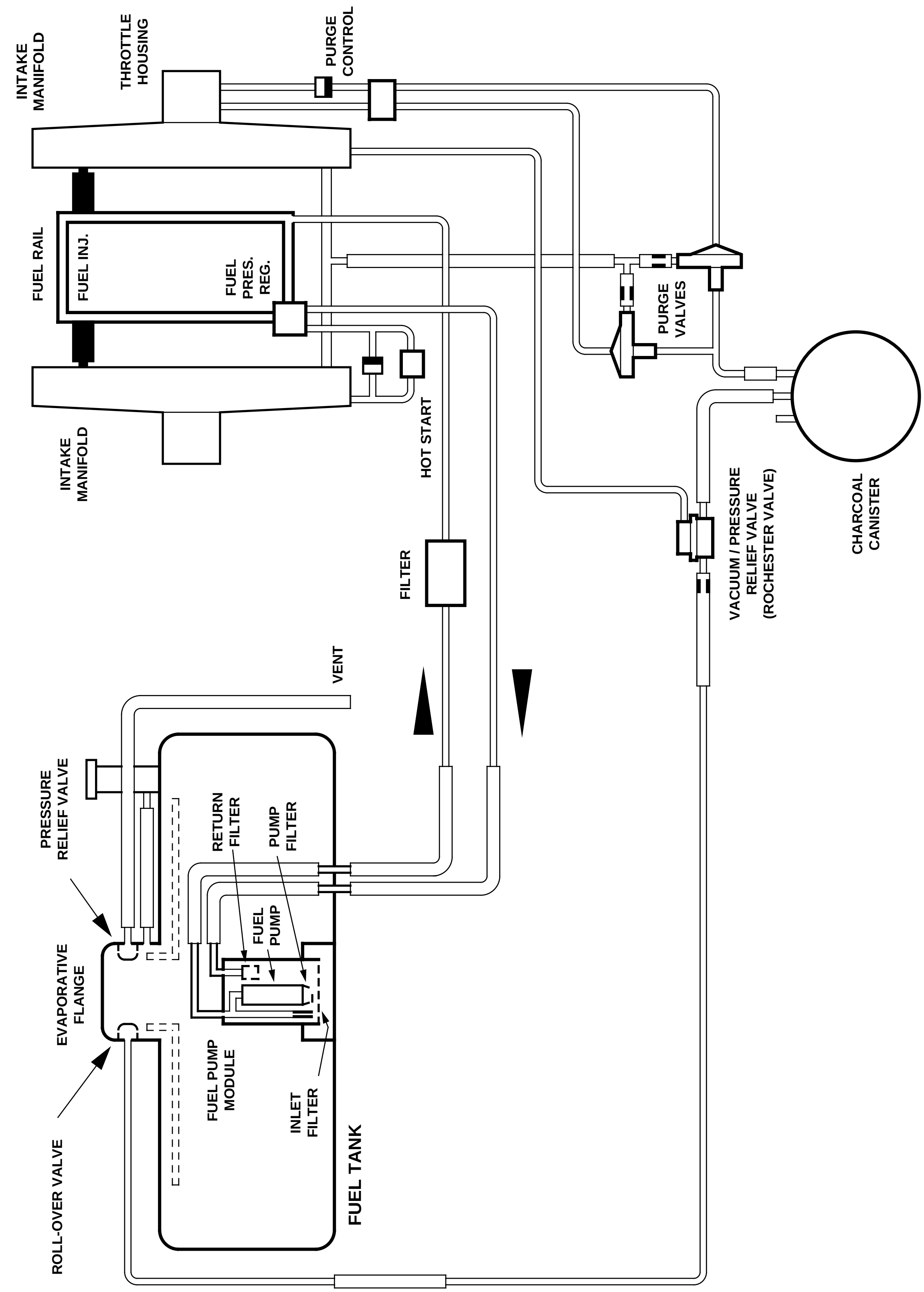
FUEL DELIVERY SYSTEM (1992 MY)



Fuel lines and connectors

Steel braided PTFE hoses run between the fuel tank flange and the steel underbody lines. Flexible plastic hoses that can be clamped during service operations are used in the engine compartment. Quick fit connectors are used throughout the system (except for internal fuel tank, fuel filter, and fuel rail connections). Feed lines have 3/8 in. connectors; return lines have 8 mm connectors.

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL SYSTEM : XJS (1992 MY)



T850/2.04

Fuel Delivery (continued)

Fuel tank
The fuel tank assemblies are similar for Coupe and Convertible models with the exception of the filler necks. The previous sump tank was eliminated.

Fuel pump module
The fuel pump is contained in a module that mounts in a rubber holder attached to the bottom of the fuel tank on brackets. The fuel pump module and the rubber holder are indexed to ensure correct alignment in the tank. The design diverts some of the fuel flow from the pump through a venturi to maintain full fuel in the module at all times. Fuel enters the module through a 70-micron filter then into the pump inlet through a 400 micron filter. Returning fuel from the engine fuel rail enters the module through a 70-micron filter. Both the outlet and return feed ports into the pump module have check valves. The outlet check valve reduces backflow from the fuel rail when the pump is off. The return check valve prevents siphoning of the fuel tank when the fuel line is disconnected. Two rubber hoses connect the assembly to the tank inlet and outlet bosses. The hoses are retained by clamps that are installed and removed with special tool JD 175. Electrical connection to the pump is made through the evaporative loss flange.

Fuel pump specifications:

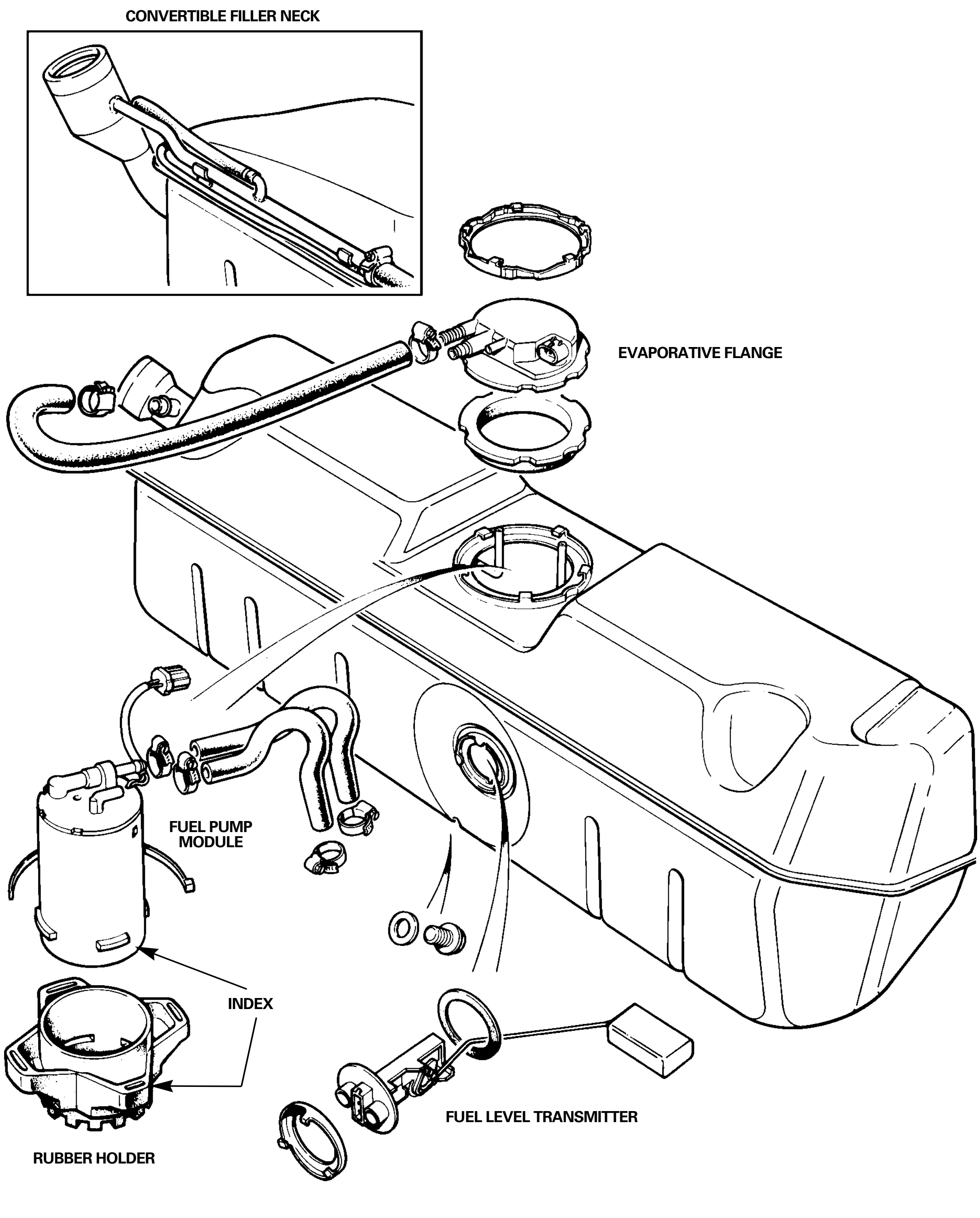
Speed	7000 rpm
Flow rate	170 litres per hour
Current	8 – 9 amps @ 13.2 volts

Tool JD 175 is a nonferrous wrench for use when loosening / tightening in-tank fuel hose clamps. Using JD 175 will eliminate the possibility of a spark being created.

Evaporative loss flange
The removable evaporative loss flange allows installation and removal of the fuel pump assembly, provides three outlet ports for evaporative loss and provides electrical connection to the fuel pump. Additionally, the flange incorporates a pressure relief valve in the vent port and a roll-over valve in the evaporative emissions port. The flange is retained by a locking ring that requires special tool JD 174 for installation and removal.

Fuel level sensing
The instrument pack low fuel warning illuminates with approximately 3.2 gallons of fuel remaining in the tank. An anti-slosh module in the circuit dampens the low level warning by delaying the signal 20 seconds.

FUEL TANK ASSEMBLY



Fuel Delivery (continued)

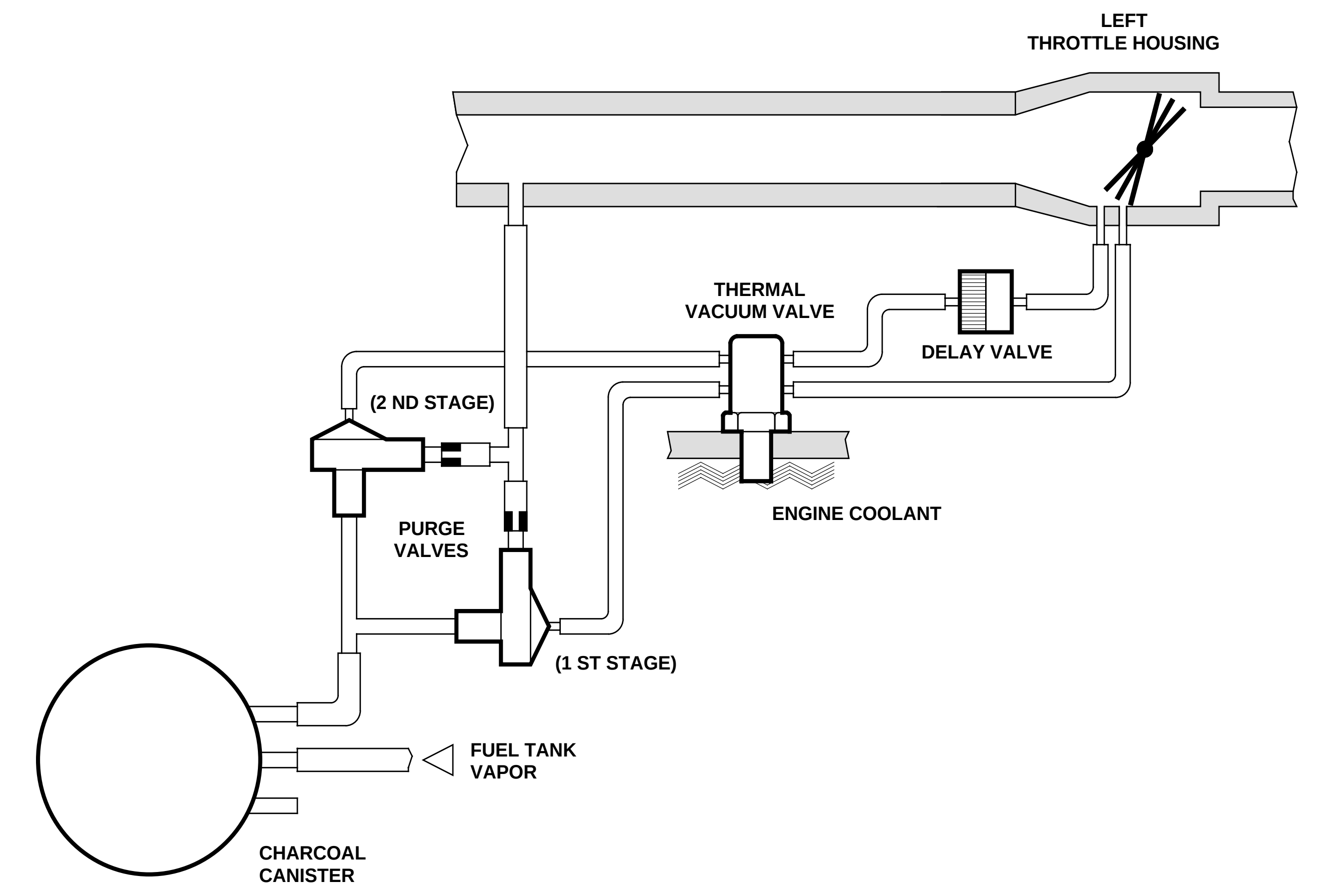
Evaporative emission control
The fuel tank design includes a lengthened fill tube that limits the fill level and allows for 10% fuel expansion. Tank venting is via the fuel tank evaporative flange. From there, a tube leads to the charcoal canister located in the left front wheel well. Vapor flow to the canister is controlled by a pressure / vacuum relief (Rochester) valve that holds 1 – 1.25 psi when the engine is not running. Fuel tank pressure is released to the canister upon engine start-up.

The system incorporates two safety pressure relief valves that vent to the atmosphere: a 2-psi relief valve in the evaporative flange and a 4 psi relief valve in the fill cap.

Canister purging is accomplished by a two-stage system. Two purge control valves are vacuum-controlled from two left throttle body ports via a thermal vacuum valve. The vacuum ports are situated so that there is no purge when the throttle plate is in the idle position. Progressive purge is obtained as the throttle is opened. The thermal vacuum valve controls both vacuum circuits. The vapor flows to the intake manifolds via the crankcase breather pipe.

At engine coolant temperatures of 95°F and above, the thermal vacuum valve opens allowing canister purge. As the throttle plate moves off idle, the first vacuum port is exposed applying vacuum to the first stage purge valve. Further throttle plate movement exposes the second vacuum port and vacuum is applied to the second stage purge valve. A delay valve in the second stage further delays full canister purge as the engine speed increases preventing an over-rich fuel mixture.

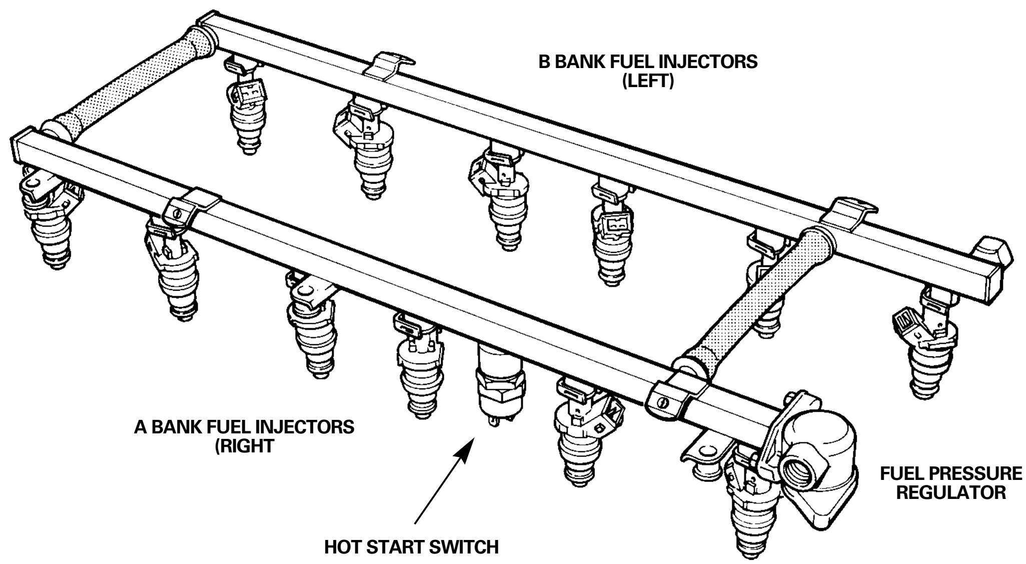
PURGE CONTROL



Fuel Distribution

The fuel rail assembly, fuel injectors, and fuel pressure regulator were all new in the 1992 model year system.

FUEL RAIL ASSEMBLY



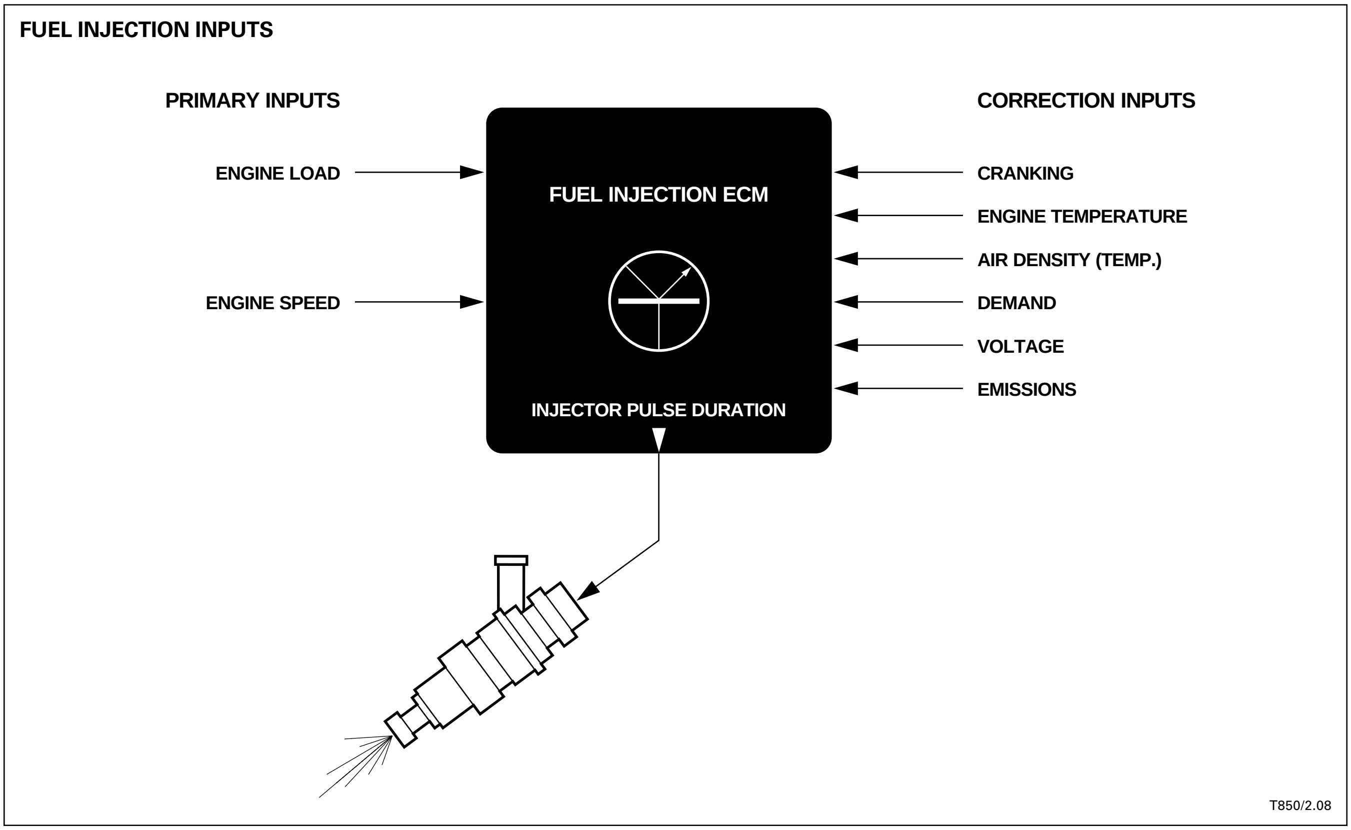
Injectors The injectors are smaller and lighter and allow a lower mounted fuel rail. The injectors are refined to give improved control of fuel flow at small pulse widths. Connection to the fuel rail is by 'O' rings and clips.

Fuel rail The fuel rail has improved flow characteristics to allow equal injector fuel flow. The rail assembly is comprised of two separate rails joined by two hoses. The assembly is secured to the manifolds by integral lugs. The need for a fuel cooler is eliminated by the improved hot fuel handling capacity of the revised system.

Fuel pressure regulator A single 36-psi regulator mounts in a cast housing connected to the fuel rail. The vacuum signal from the right intake manifold to the regulator passes through a solenoid vacuum valve that is a component of the hot start system.

Engine Management System: Fuel Injection

Primary inputs
The fuel injectors are triggered and held open by electrical pulses that operate the injector solenoid valves. Injector pulse duration determines the quantity of fuel injected and is primarily determined by engine load and speed. The fuel injection ECM uses the input from the manifold absolute pressure sensor and ignition pulses to output the required injector pulse duration from its memory. The injectors are triggered via the power resistors, in staggered groups of six. Except during starting and sudden throttle opening, injector pulses occur every third ignition pulse (once per engine revolution).



Correction inputs
Additional correction inputs are used by the ECM to vary injector pulse duration as necessary.

Cranking enrichment At engine cranking speeds, the ECM increases the number of injector pulses to three per engine revolution. It also increases the injector pulse duration in relation to coolant temperature sensor input. As engine speed increases, cranking enrichment is reduced to transition to the warm-up phase.

Engine warm-up correction During warm-up, the ECM lengthens the injector pulse duration in response to the input received from the coolant temperature sensor. Enrichment is reduced as engine speed increases.

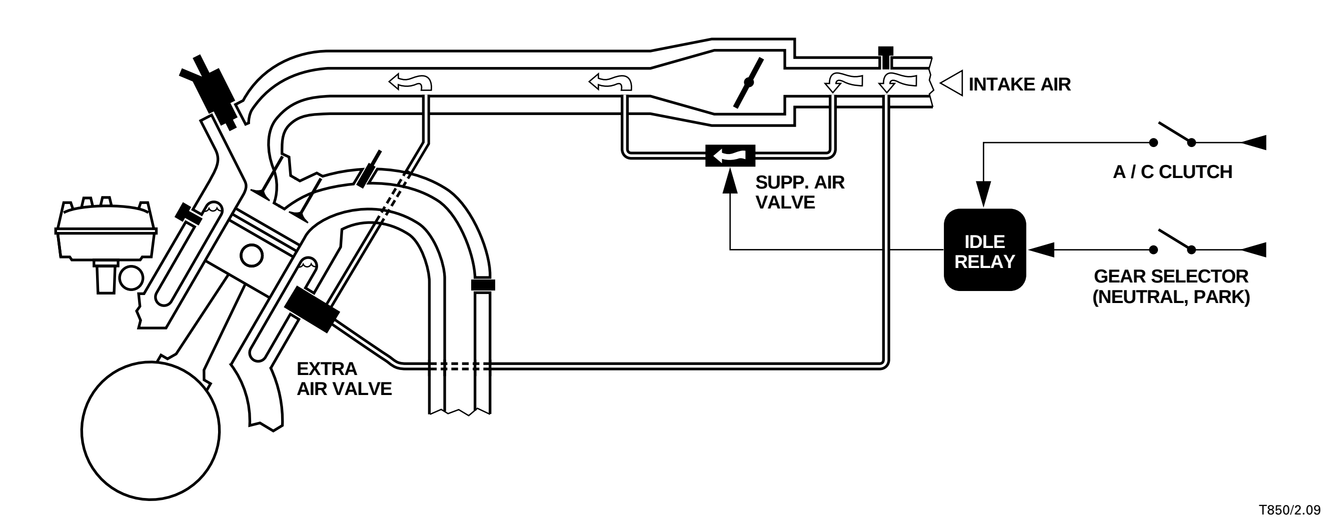
Air density correction Intake air density is sensed by temperature measurement and supplied to the ECM as an input. The ECM alters the injector pulse duration to lean or enrich the fuel flow as necessary.

Demand corrections During acceleration and full power demands, the injector pulse duration is lengthened by the ECM in response to input received from the throttle position sensor.

Voltage correction The system uses stabilized voltage for sensing and injector operation.

Emission corrections "Closed loop" exhaust emission control is provided by inputs from the two heated oxygen sensors. At coolant temperatures below 95°F and for 45 seconds after start-up, air injection is applied to the exhaust manifolds. During this period, inputs form the oxygen sensors are not used by the ECM.

IDLE SPEED CONTROL



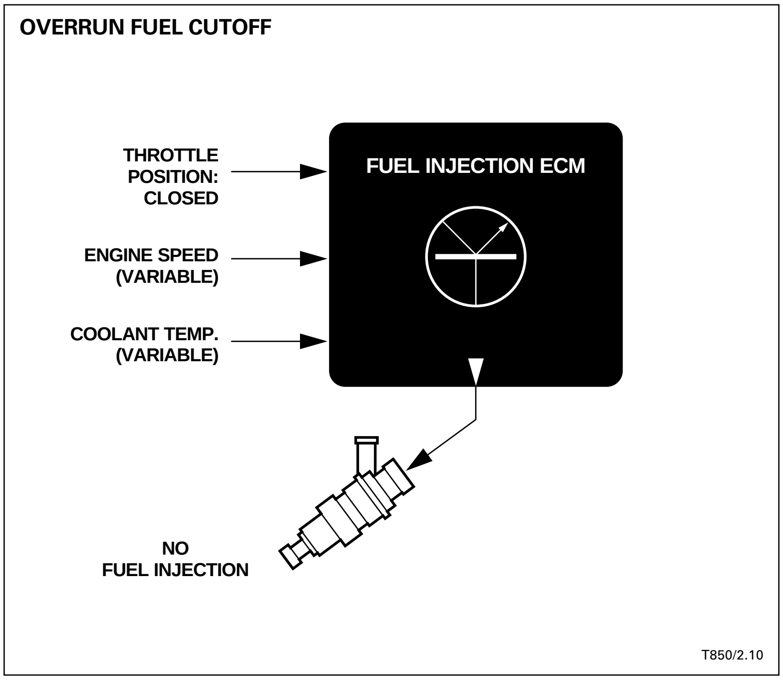
Idle speed

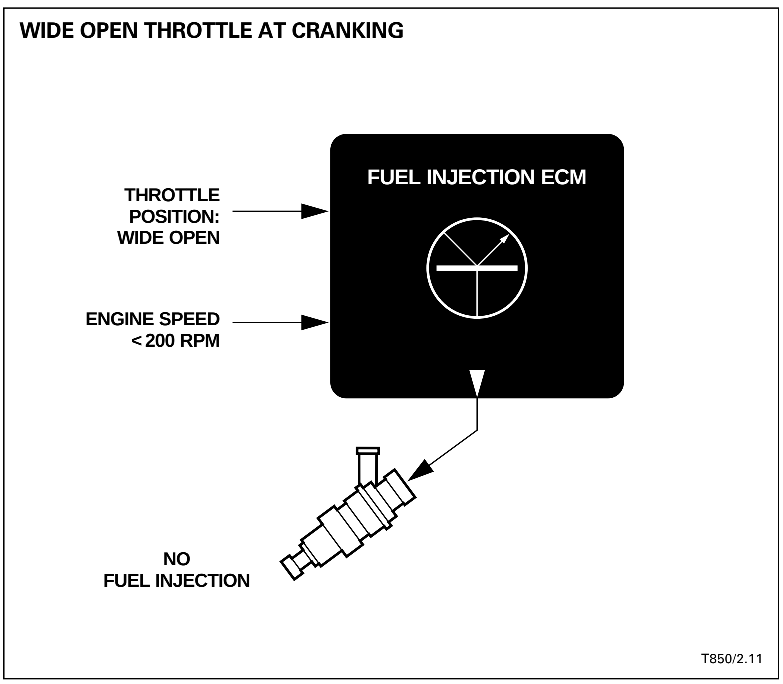
Base idle The base idle speed is set with the adjustment screw on the extra air valve. The adjustment regulates the throttle valve bypass idle air flow.

Warm-up Dependent on engine coolant temperature, the extra air valve allows additional air to bypass the throttle valve to maintain idle speed during warm-up.

Idle stabilization During air conditioning compressor operation, the supplementary air valve is opened via the de-energized idle relay, allowing additional throttle-valve bypass and stabilizing the idle speed. To prevent excessive idle speed with no engine load (neutral, park), the idle relay is energized to switch off the supplementary air valve.

Engine Management System: Fuel Injection (continued)





Overrun fuel cutoff

To improve fuel economy and aid in controlling exhaust emissions, the ECM cuts off fuel injection during engine overrun conditions. The ECM determines overrun conditions from throttle position (throttle position sensor), engine speed (ignition pulses) and coolant temperature.

Coolant Temperature	Cutoff RPM	Reinstatement RPM
Up to -5°F (-15°C)	5000	4000
32°F(0°C)	3000	2000
50°F(10°C)	2000	1500
68°F(20°C)	1900	1400
86°F(30°C)	1900	1400
104°F(40°C)	1800	1300
149°F(65°C) and above	1500	1100

Wide Open Throttle during cranking

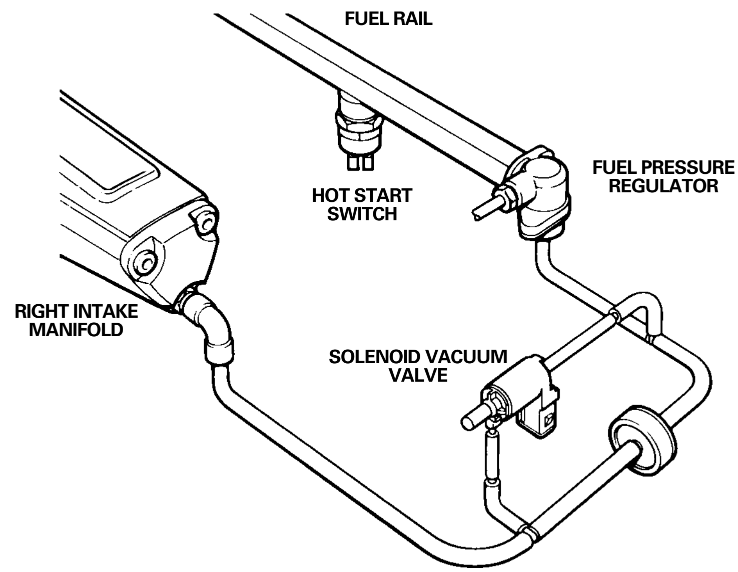
When the ECM senses that the throttle is wide open (throttle position sensor) during cranking (<200 rpm, ignition pulse input), fuel injection is canceled to prevent the engine from flooding.

Hot start

During conditions of high underhood temperatures, a hot start system aids in engine starting by increasing fuel pressure and purging the fuel rail. The system consists of: a fuel rail temperature sensitive switch, a 45-second timer and a normally open solenoid vacuum valve located in the fuel pressure regulator vacuum line. During normal operation, vacuum is applied to the regulator through the solenoid vacuum valve.

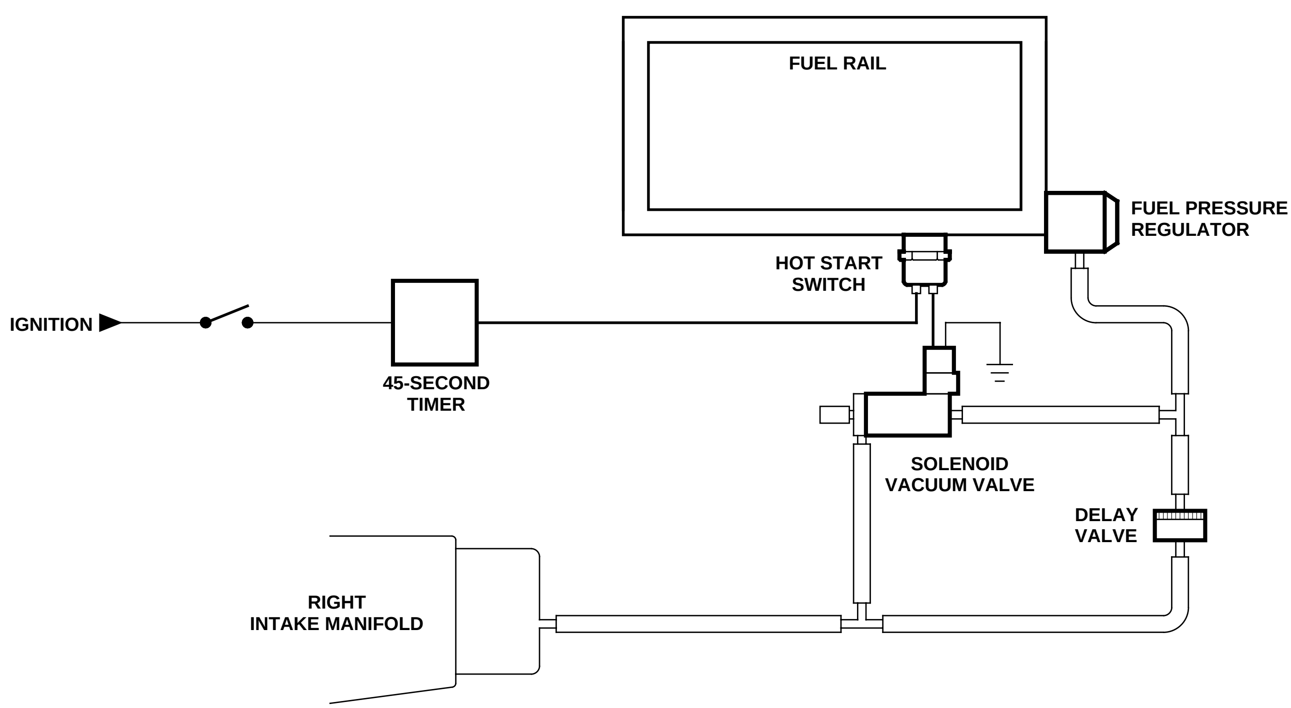
Each time the ignition is switched ON, the 45-second timer is activated and applies current to the hot start switch. If the fuel rail temperature is 158°F or above, the switch closes and allows current flow to close the solenoid vacuum valve. Vacuum to the regulator is delayed causing the regulator to momentarily increase fuel pressure to purge the fuel rail.

HOT START COMPONENTS



T850/2.12

HOT START SYSTEM



T850/2.13

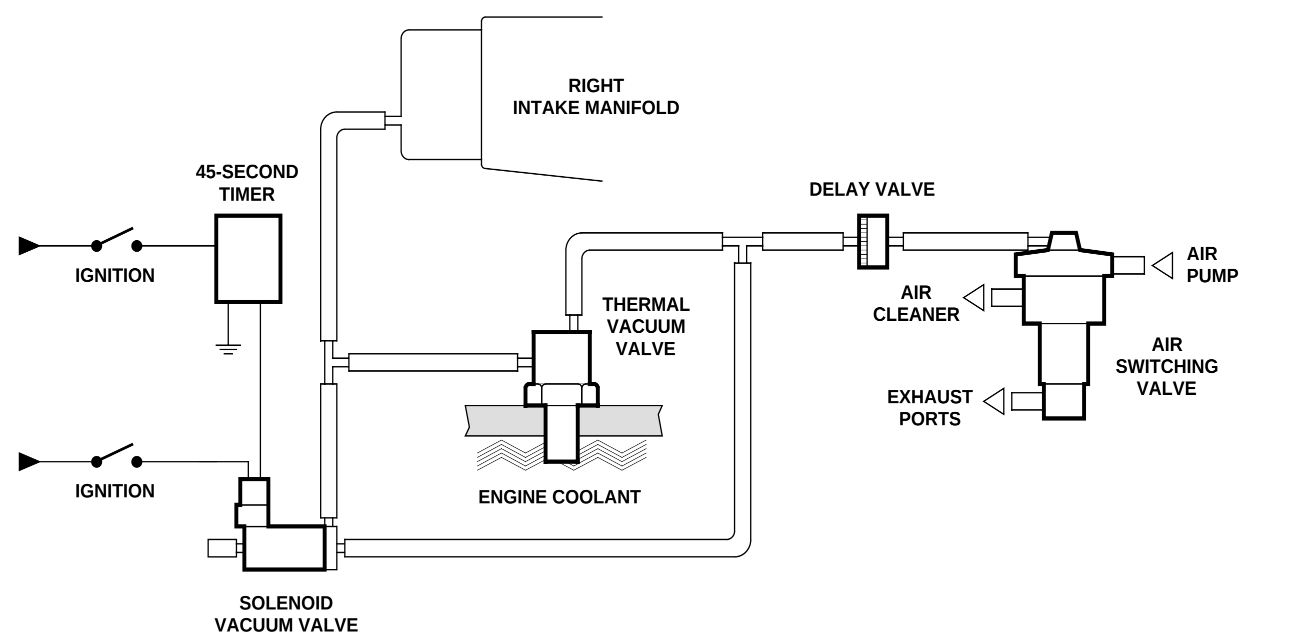
Engine Management System: Fuel Injection (continued)

Air injection

Secondary air is delivered to the exhaust manifolds during the initial engine warm-up period to aid oxidation. The rotary vane air pump is belt driven from the crankshaft pulley. Air is delivered to the exhaust manifolds via the air switching valve, which is controlled by either a thermal vacuum valve or the 45-second timer via a solenoid vacuum valve. The vacuum circuit also contains a delay valve.

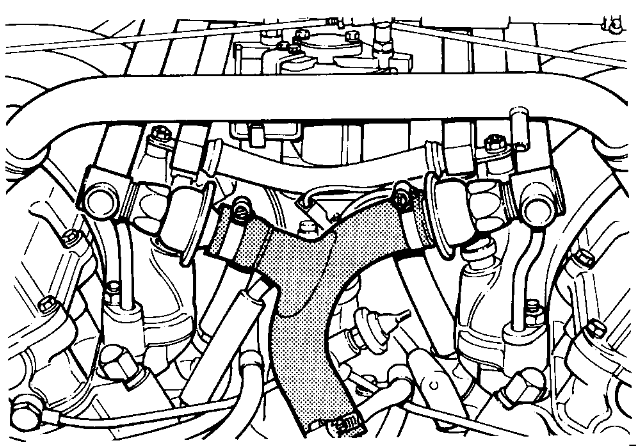
Each time the ignition is switched ON, the 45-second timer is activated and the normally closed solenoid vacuum valve is opened. If the coolant temperature is below 95° F, the thermal vacuum valve opens. Manifold vacuum is applied to the air switching valve for 45 seconds after start-up or until the coolant temperature reaches 95°F, which ever is longer. The delay valve prevents vacuum loss to the air switching valve when the throttle is suddenly opened.

AIR INJECTION SYSTEM



T850/2.14

AIR INJECTION CHECK VALVES



T850/2.15

Air injection rails

The air injection rails are designed to clear the revised fuel rail. This arrangement uses two check valves located at the rear of the engine.

Additional Fuel Injection ECM functions

Collision Safety
In the event of a vehicle impact, the inertia switch will switch off all power supply to the system. The fuel pump will cease to operate, preventing fuel flow to the engine compartment.

Serial Communications (ISO)
A serial communications serial link is used to access stored fault data in the OBD facility. In addition, the serial link allows ECM input and output values to be transmitted to check the current status of the system. The serial link connector is the brown PM 4 located under the passenger's center console kick panel.

On-Board Diagnostics
A facility for on-board diagnostics (OBD) that stores fault data during engine operation is contained in the ECM.

Limp home A "limp home" facility is provided in the memory of the ECM. This facility will allow engine operation in the event of system failure(s). The ECM will substitute a nominal value for missing inputs from the coolant temperature sensor, air temperature sensor, throttle position sensor, oxygen sensor(s), and the manifold pressure sensor.

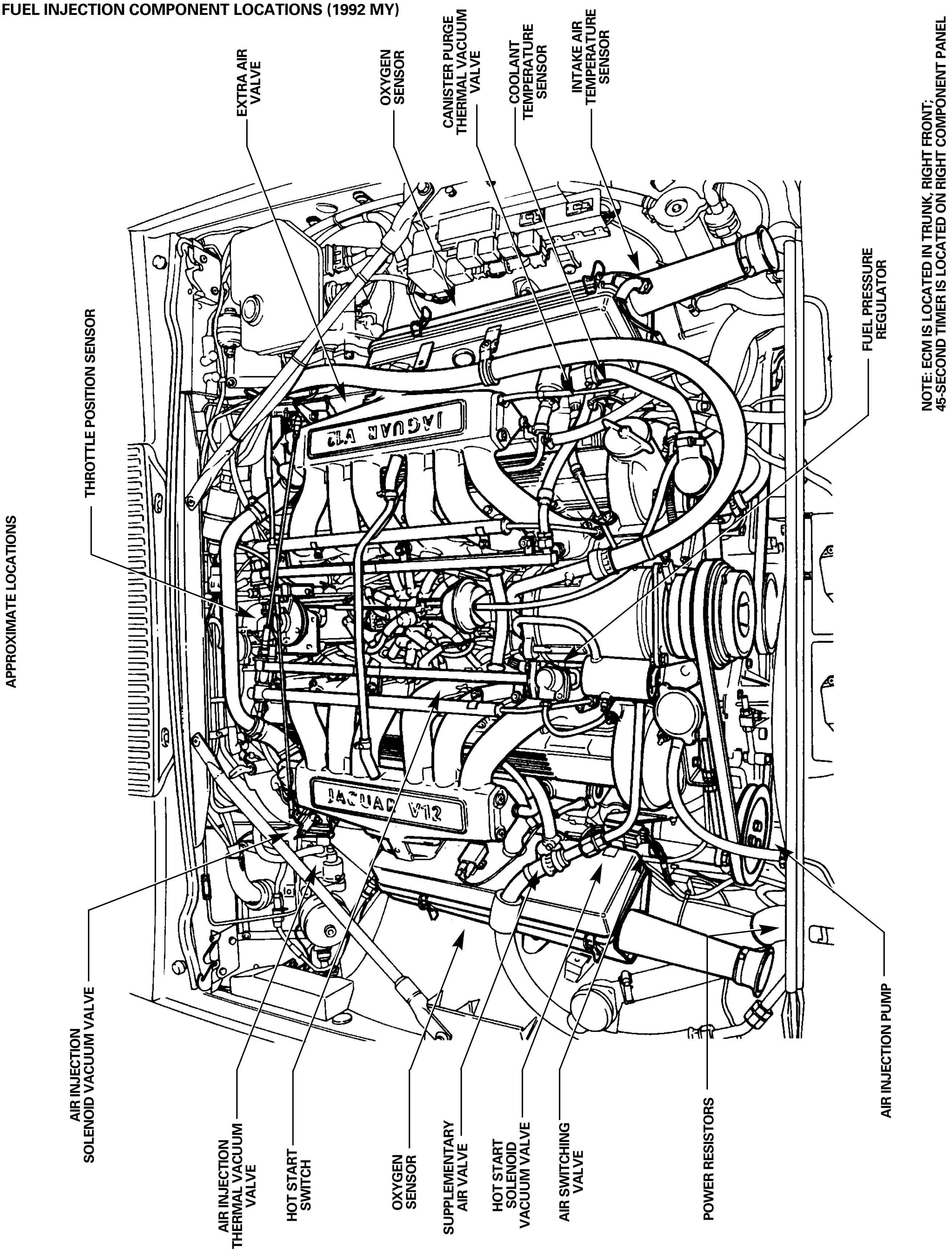
Check Engine; Diagnostic Trouble Codes If a fault occurs in the system, a diagnostic trouble code (DTC) is generated. The CHECK ENGINE warning is immediately displayed on the center console message display. If the ignition is switched off, and then on, the CHECK ENGINE warning is displayed with the DTC appearing five seconds later. When the engine is cranked, the message is cleared and the clock displays. The CHECK ENGINE warning and DTCs will be displayed at every ignition cycle.

Diagnostic trouble codes (listed in order of priority):

Code	Fault area	Limp home	Failure
29	ECM self-test	NO	Checks microprocessor function
44	Oxygen sensor — A bank (right)	YES	No oxygen sensor response to fueling change (A bank)
45	Oxygen sensor — B bank (left)	YES	No oxygen sensor response to fueling change (B bank)
13	Manifold absolute pressure sensor	YES	Manifold pressure does not change on engine starts or manifold pressure is out of range
34	Fuel injectors or air leak — A bank (right)	NO	Poor feedback control — rich or lean (A bank)
36	Fuel injectors or air leak — B bank (left)	NO	Poor feedback control — rich or lean (B bank)
14	Coolant temperature sensor	YES	Sensor voltage does not change after engine start or sensor voltage is out of normal range
17	Throttle position sensor	YES	Throttle position sensor voltage is out of normal range
18	Calibration 1 (engine speed, manifold throttle position)	YES	High throttle position sensor voltage / low load pressure, (manifold pressure)
19	Calibration 2 (engine speed, manifold throttle position)	YES	Low throttle position sensor voltage / high load pressure, (manifold pressure)
23	Fuel supply	NO	Poor feedback control — both banks rich or lean
49	Power resistors	YES	No current through power resistors
11	ECM idle potentiometer	YES	Idle trim potentiometer is out of normal range
16	Air temperature sensor	YES	Sensor voltage is out of normal range

NOTE: When multiple faults occur, only the highest priority code will be displayed.

FUEL INJECTION COMPONENT LOCATIONS (1992 MY)



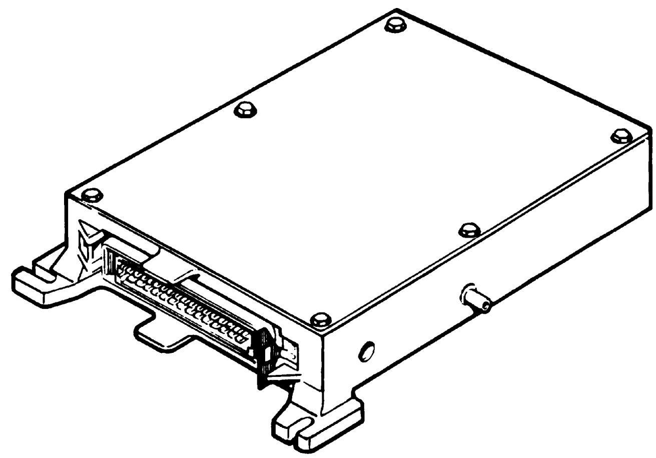
Fuel Injection Components

Engine control module (ECM): Fuel injection

Location Trunk, right front.

Description The 26CU ECM contains an integrated circuit for a dedicated fuel injection control chip and an analog / digital converter for the manifold pressure input. A manifold absolute pressure sensor (transducer) is built into the ECM. Fuel injection information is stored in ROM (read only memory), so that for a given combination of manifold pressure and engine speed, the memory assigns a number proportional to the required injector pulse duration. The ECM also contains facilities for OBD and serial communications.

26CU ENGINE CONTROL MODULE: FUEL INJECTION



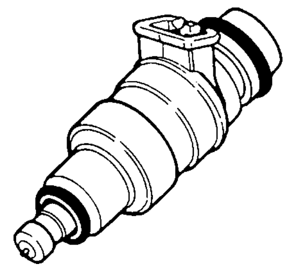
T850/2.17

Fuel injectors

Location Intake manifolds.

Description Each fuel injector contains a solenoid-operated needle valve, which is held against a seat by spring pressure. When energized, the coil moves the needle away from the seat, allowing pressurized fuel to flow through the tip.

FUEL INJECTOR



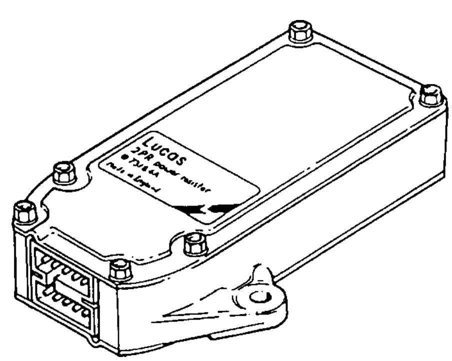
T850/2.18

Power resistors

Location Engine compartment, right front.

Description The power resistor pack contains four 6-ohm resistors. Each resistor is connected to a group of 3 injectors to limit the current during the "hold" portion of the injector pulse duration. Limiting the current protects the ECM.

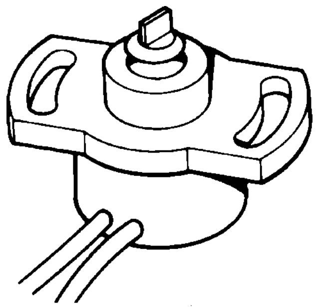
POWER RESISTOR



T850/2.19

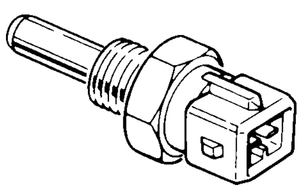
Fuel Injection Components (continued)

THROTTLE POSITION SENSOR



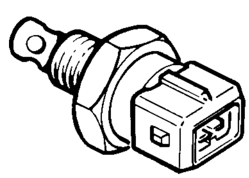
T850/2.20

COOLANT TEMPERATURE SENSOR



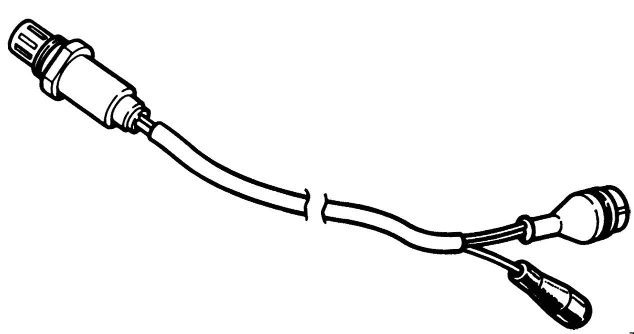
T850/2.21

AIR TEMPERATURE SENSOR



T850/2.22

OXYGEN SENSOR



T850/2.23

Throttle position sensor

Location Under the throttle turntable.

Description The throttle position sensor is mechanically connected to the throttle valve shaft and provides a reference voltage input to the ECM dependent on throttle position.

Coolant temperature sensor

Location Left thermostat housing.

Description The coolant temperature sensor is a temperature-sensitive resistor. As the coolant temperature rises, the electrical resistance decreases providing a coolant temperature input to the ECM.

Intake air temperature sensor

Location Left air cleaner intake.

Description The air temperature sensor is a temperature-sensitive resistor. As the ambient (intake) air temperature rises, the electrical resistance decreases providing an input to the ECM. The ECM uses this input as a measure of intake air density (as air temperature rises, its density decreases).

Oxygen sensor

Location Exhaust down pipes.

Description The oxygen sensors (2) measure the oxygen concentration in the exhaust gases and provide an input to the ECM.

Extra air valve

Location Left cylinder head, rear.

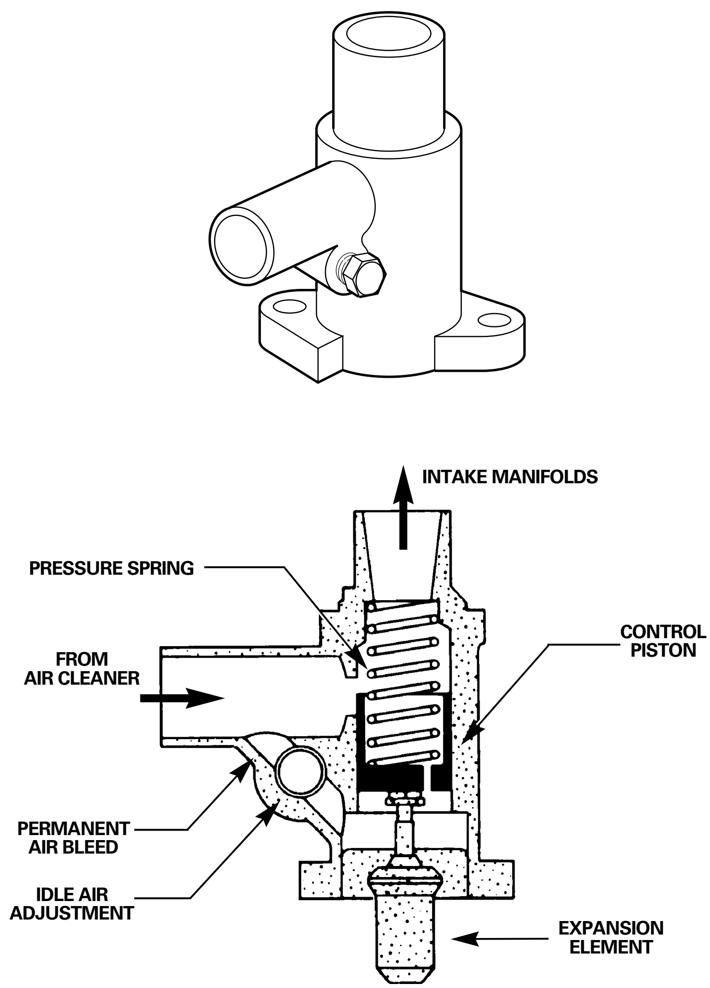
Description The extra air valve has two functions: it provides the engine base idle speed through the adjustable idle air bleed, and it provides warm-up idle speed stabilization through the variable air duct. The duct area is varied by a temperature sensitive expansion element, in contact with engine coolant, that moves a control piston. As the coolant temperature increases, the area of the duct is gradually reduced until, at a coolant temperature of 140 to 158°F, it closes completely.

Supplementary air valve

Location Right air cleaner back plate.

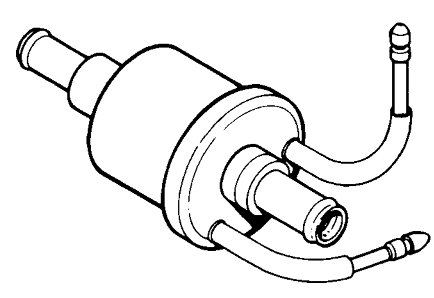
Description The supplementary air valve allows additional throttle bypass air into the intake manifolds to stabilize the idle speed during air conditioning compressor operation (except when in neutral or park).

EXTRA AIR VALVE



T850/2.24, 2.25

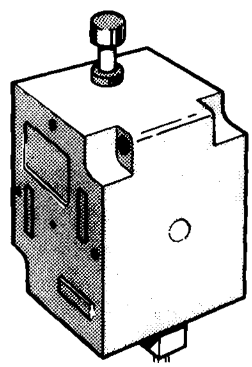
SUPPLEMENTARY AIR VALVE



T850/2.26

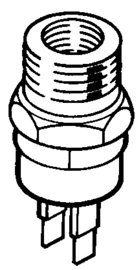
Fuel Injection Components (continued)

INERTIA SWITCH



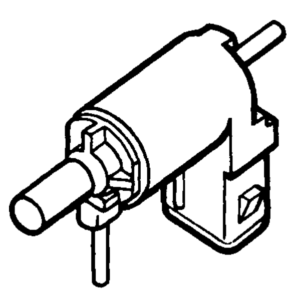
T850/2.27

HOT START SWITCH



T850/2.28

HOT START SOLENOID VACUUM VALVE



T850/2.29

Inertia switch

Location Passenger's side 'A' post.

Description In the event of a vehicle impact, the inertia switch switches off all power supply the engine management system.

Hot start switch

Location Fuel rail, right.

Description The hot start switch switches current between the 45-second timer and the hot start solenoid vacuum valve. The switch contacts close at 158°F and above.

Hot start solenoid vacuum valve

Location Above right thermostat housing.

Description The normally open solenoid vacuum valve closes when the circuit is completed via the 45-second timer and the hot start switch.

Air injection solenoid vacuum valve

Location Right cylinder head, rear.

Description The normally closed solenoid vacuum valve opens when the circuit is completed via the 45-second timer.

Air switching valve

Location Engine, right front.

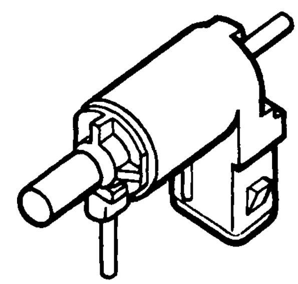
Description The air switching valve directs air injection to the exhaust manifolds or the air cleaner dependent on vacuum signal.

45-second timer

Location Right component panel.

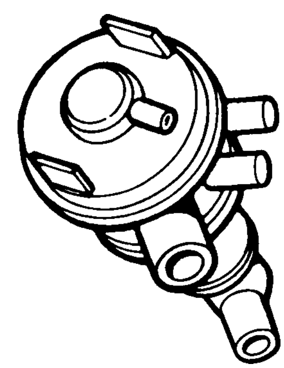
Description The 45-second timer provides a timed ground for 45 seconds each time the ignition is switched on.

AIR INJECTION SOLENOID VACUUM VALVE



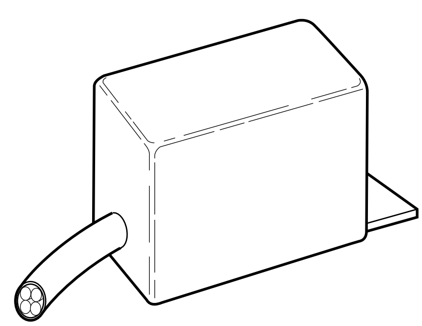
T850/2.30

AIR SWITCHING VALVE



T850/2.31

45-SECOND TIMER



T850/2.32

System Variations

The 5.3 litre engine management system used in 1989 and 1990 model year vehicles is similar in construction and operation to the 1992 system. The following variations in the fuel injection system should be noted:

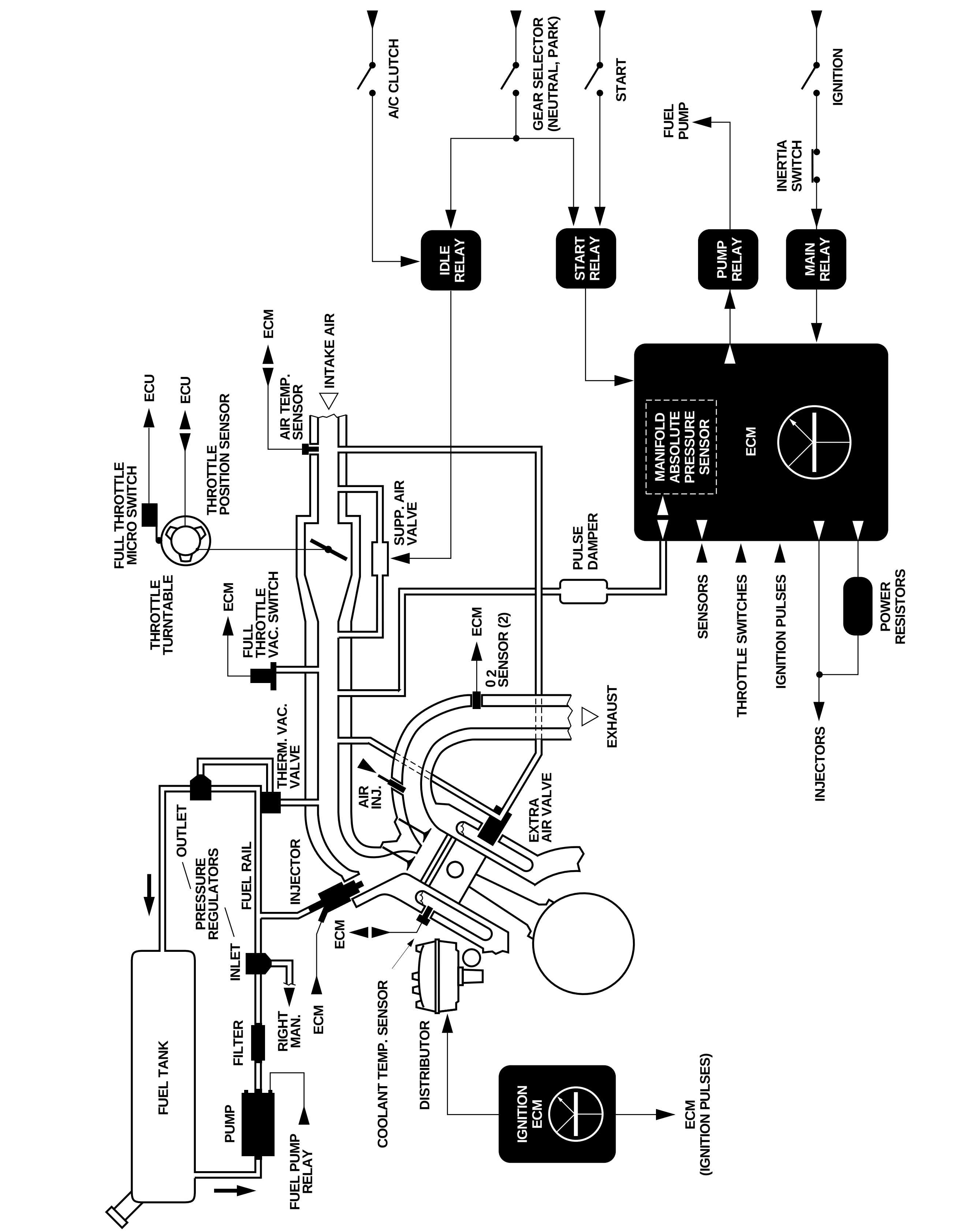
- Fuel delivery system with external sump tank, fuel pump and fuel cooler
- Evaporative emission system with vapor separator
- Fuel rail with hose connection to injectors and two pressure regulators
- Fuel injection ECM without self-test; specification differences (cranking enrichment, etc.)
- Full throttle enrichment via mechanical and vacuum switches
- Hot start system without timer control
- Air injection system without timer control
- No On-Board Diagnostics (OBD)
- No "limp home" facility
- No serial communications (ISO)

The complete range of fuel injection 16CU ECM functions is as follows:

- Fuel delivery (fuel pump)
- Fuel injection
- Cold start
- Warm-up
- Exhaust emissions feedback
- Fuel cutoff during engine overrun
- Collision safety

NOTE: The sensors and switches are unique to the fuel system and are not used or shared by the digital ignition system.

5.3 LITRE V12 ENGINE MANAGEMENT SYSTEM: FUEL INJECTION (1989 – 90 MY)



T850/2.33

Fuel Delivery

A recirculating fuel delivery system is used to provide a continuous supply of pressurized fuel to the fuel rail.

Fuel is drawn from the small sump through a pre-filter by an external electric pump and delivered to the fuel rail through a renewable filter. The pump incorporates a check valve.

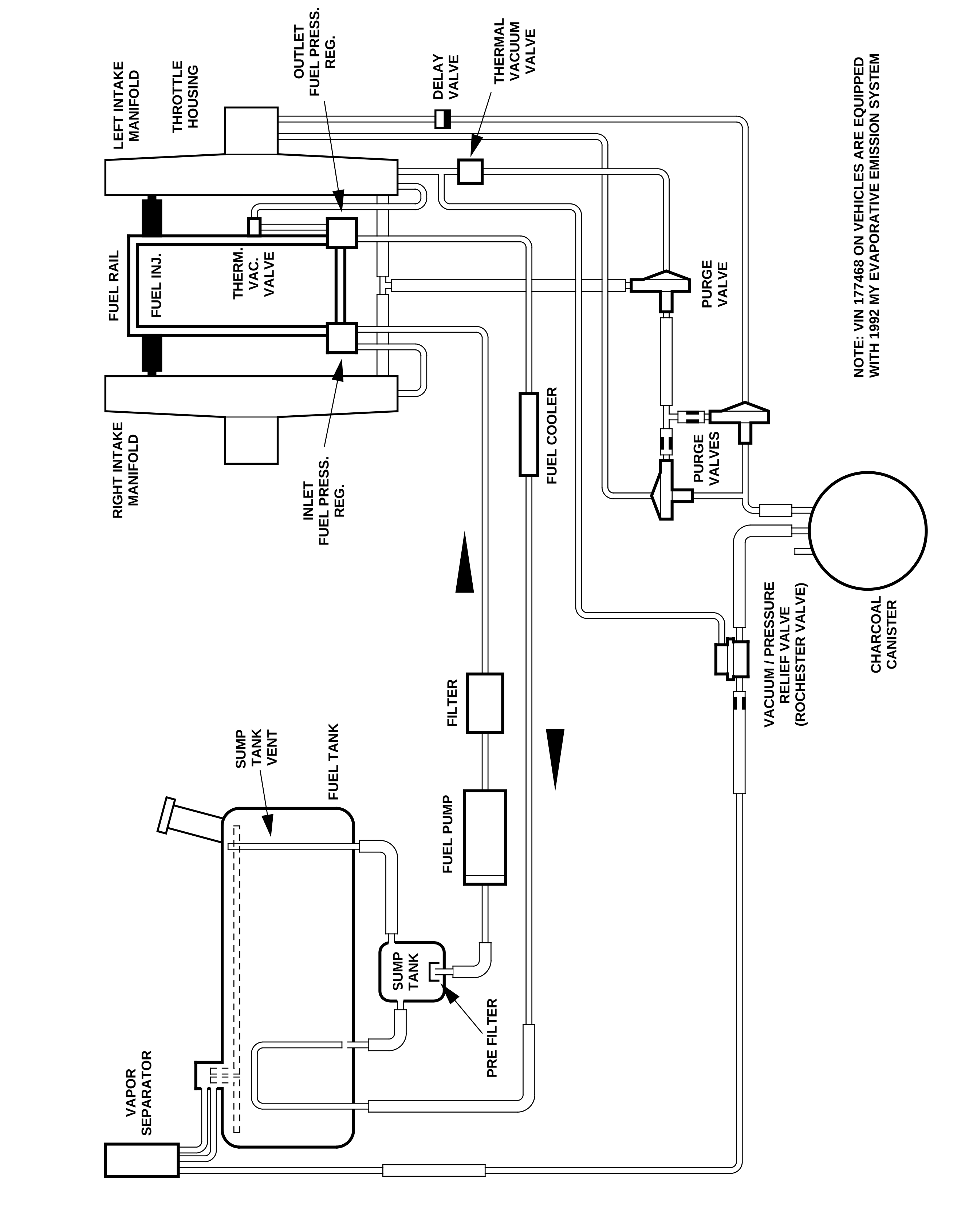
Two pressure regulators are used on the fuel rail. The inlet regulator maintains fuel pressure in the delivery line; the outlet regulator controls fuel pressure in the fuel rail. Both regulators sense intake manifold absolute pressure. The outlet regulator sensing line passes through a thermal vacuum valve controlled by fuel rail temperature. Fuel pressure in the rail is controlled so that the pressure drop across the injector nozzles is maintained at approximately 36 psi. The inlet regulator is set at 45± psi; the outlet regulator is set at 36± psi.

If the temperature of the fuel rail exceeds a specified temperature, the thermal vacuum valve closes the intake manifold sensing port and vents the regulator sensing line to the atmosphere. When this occurs, the regulator interprets the atmospheric pressure as full throttle (maximum manifold pressure) and increases fuel pressure in the rail to maximum. The increased fuel pressure prevents vapor formation in the fuel rail at high underhood temperatures and purges the fuel rail for hot starts.

The fuel pump is activated by the ECM when the ignition is switched on. If no immediate cranking occurs, the ECM activates the pump for two seconds only to raise the pressure in the fuel rail and then switches it off to prevent flooding. After cranking has started, the ECM switches on the pump.

Returning fuel is cooled by the fuel cooler when the air conditioning compressor is operating. Convertible models have a fuel temperature sensing circuit that independently operates the air conditioning compressor.

FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL: XJS (1990 MY)



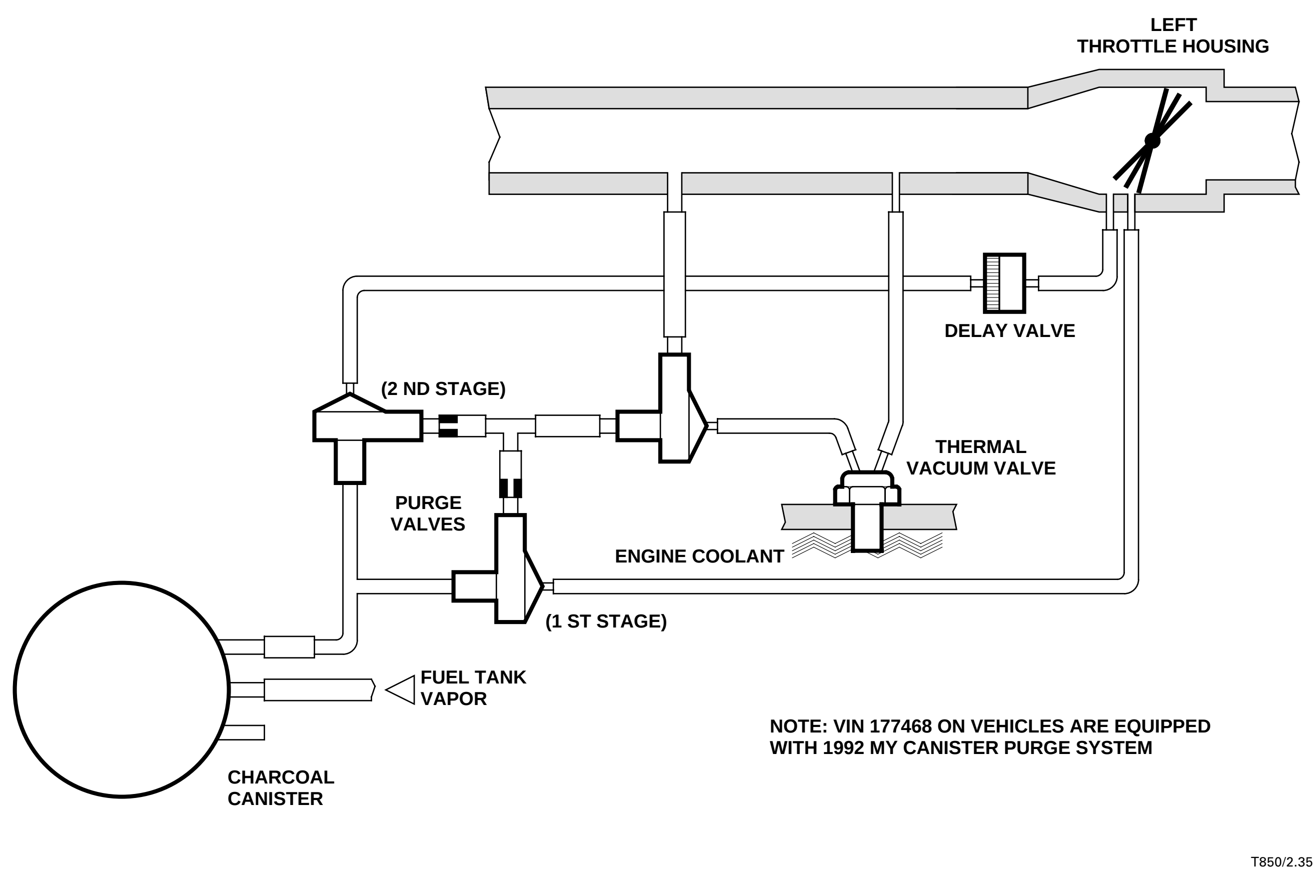
Fuel Delivery (continued)

Evaporative emission control
The fuel tank design includes a lengthened fill tube that limits the fill level and allows for 10% fuel expansion. Tank venting is via the fuel tank vapor separator. From there, a tube leads to the charcoal canister located in the left front wheel well. Vapor flow to the canister is controlled by a pressure / vacuum relief (Rochester) valve that holds 1 – 1.25 psi when the engine is not running. Fuel tank pressure is released to the canister upon engine start-up.

Canister purging is accomplished by a two stage system. Two purge control valves are vacuum controlled from two left throttle body ports, one via a delay valve. The vacuum ports are situated so that there is no purge when the throttle plate is in the idle position. Progressive purge is obtained as the throttle is opened. Purge flow to the intake manifolds flows through a third purge valve controlled by a thermal vacuum valve. The vapor flows to the intake manifolds via the crankcase breather pipe.

At engine coolant temperatures of 95°F and above, the thermal vacuum valve opens allowing canister purge. As the throttle plate moves off idle, the first vacuum port is exposed applying vacuum to the first stage purge valve. Further throttle plate movement exposes the second vacuum port and vacuum is applied to the second stage purge valve. A delay valve in the second stage further delays full canister purge as the engine speed increases preventing an over-rich fuel mixture.

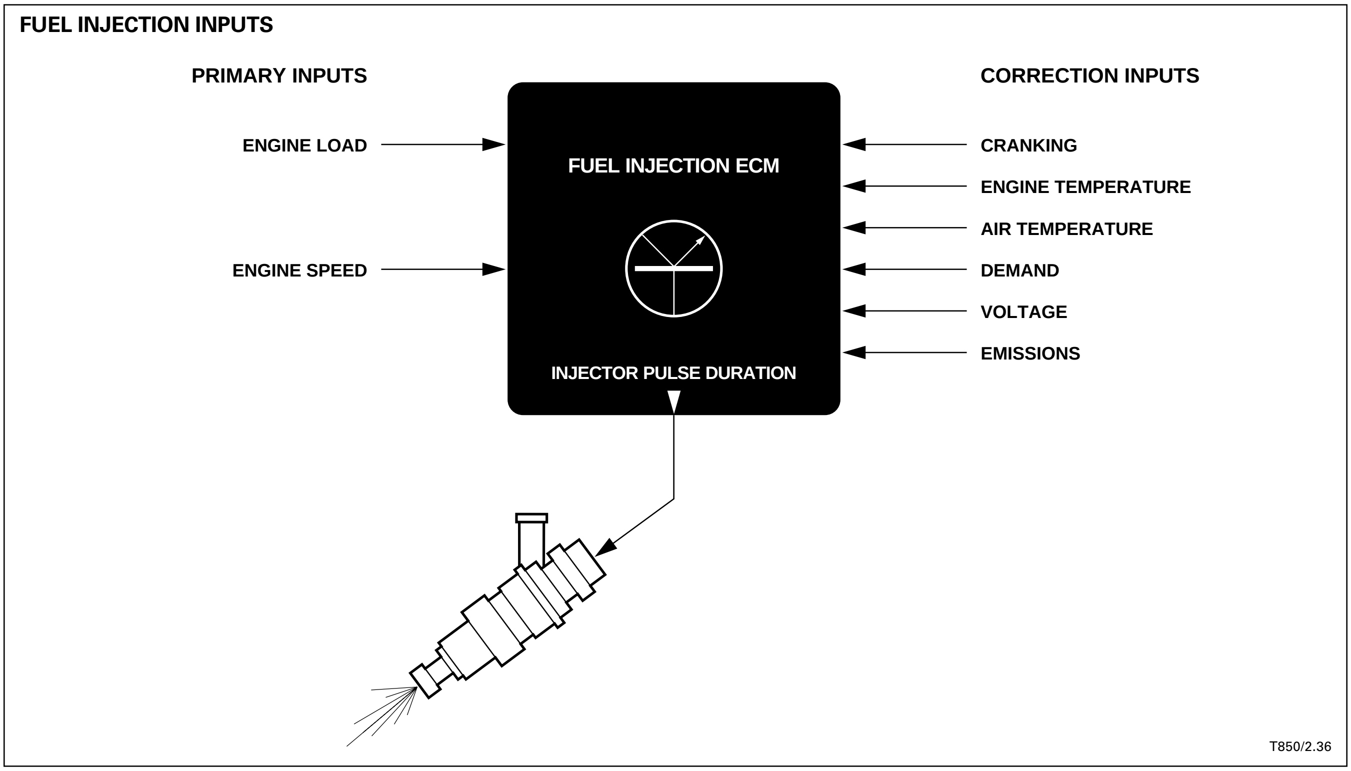
CANISTER PURGE (1990 MY)



Engine Management System: Fuel Injection

Primary inputs

The fuel injectors are triggered and held open by electrical pulses that operate the injector solenoid valves. Injector pulse duration determines the quantity of fuel injected and is primarily determined by engine load and speed. The ECM uses the input from the manifold absolute pressure sensor and ignition pulses to output the required injector pulse duration from its memory. The injectors are triggered via the power resistors, in staggered groups of six. Except during sudden throttle opening, injector pulses occur every third ignition pulse (once per engine revolution).



Correction inputs

Additional correction inputs are used by the ECM to vary injector pulse duration as necessary.

Cranking enrichment The ECM receives an input via the starter relay each time the engine is started and increases the injector pulse duration during cranking to enrich the fuel mixture.

Engine warm-up correction During warm-up, the ECM lengthens the injector pulse duration in response to the input received from the coolant temperature sensor.

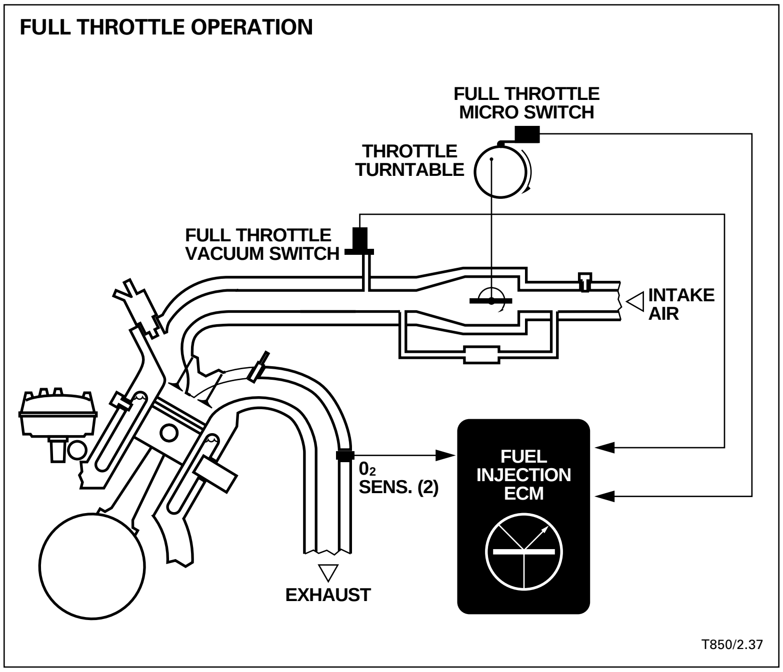
Air density correction Intake air density is sensed by temperature measurement and supplied to the ECM as an input. The ECM alters the injector pulse duration to lean or enrich the fuel flow as necessary.

Demand corrections During acceleration and full power demands, the injector pulse duration is lengthened by the ECM in response to input received from the throttle position sensor and two full throttle switches. When sudden throttle opening is sensed, the ECM pulses all injectors once to balance the rapid increase in air intake.

Voltage correction The system uses stabilized voltage for sensing and injector operation.

Emissions corrections “Closed loop” exhaust emissions control is provided by inputs from the two heated oxygen sensors. At coolant temperatures below 95°F (35°C), air injection is applied to the exhaust manifolds. During this period, inputs form the oxygen sensors are not used by the ECM.

Engine Management System: Fuel Injection (continued)



Full throttle operation

During full load operation, the engine must produce maximum power. When activated by high manifold absolute pressure or full throttle position (approximately 80% open), the full load switches provide a ground input to the ECM.

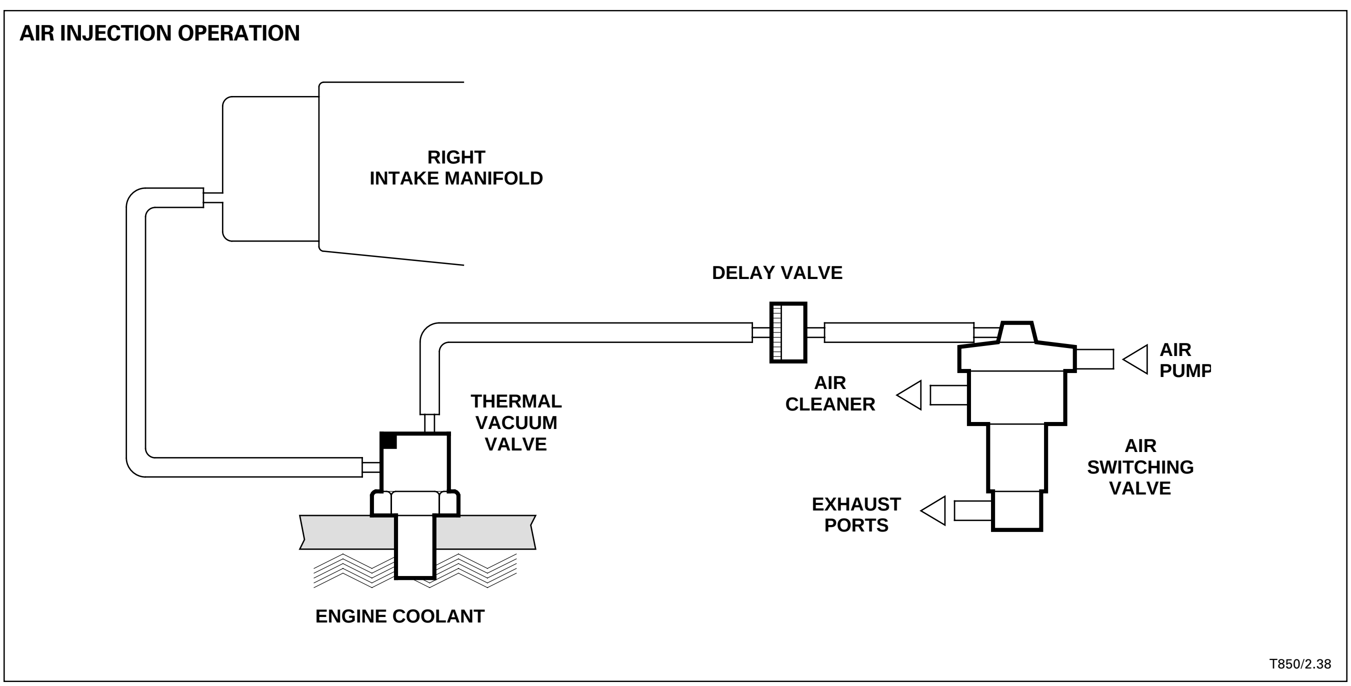
The full load switches are wires in parallel. At idle, both switches are open (the vacuum switch is held open by manifold vacuum). As the throttle is opened to full throttle, the vacuum switch closes (low manifold vacuum) and provides a ground input to the ECM. At approximately 80% throttle opening, the micro switch closes and provides a ground input to the ECM.

The ECM enriches the fuel / air mixture by lengthening the injector pulse duration and ignores the oxygen sensors feedback input.

Air injection

Secondary air is delivered to the exhaust manifolds during the initial engine warm-up period to aid oxidation. The rotary vane air pump is belt driven from the crankshaft pulley. Air is delivered to the exhaust manifolds via the air switching valve, which is controlled by a thermal vacuum valve. The vacuum circuit also contains a delay valve.

At engine coolant temperatures below 95°F (35°C), the thermal vacuum valve opens. Manifold vacuum is applied to the air switching valve, which in turn directs air injection to the exhaust ports. The delay valve prevents vacuum loss to the air switching valve when the throttle is suddenly opened.



Fuel Injection Components

Engine control module (ECM): Fuel injection

Location Trunk, right front.

Description The 16CU ECM contains an integrated circuit for a dedicated fuel injection control chip and an analog / digital converter for the manifold pressure input. A manifold absolute pressure sensor (transducer) is built into the ECM. Fuel injection information is stored in ROM (read only memory), so that for a given combination of manifold pressure and engine speed, the memory assigns a number proportional to the required injector pulse duration.

Fuel injectors

Location Intake manifolds.

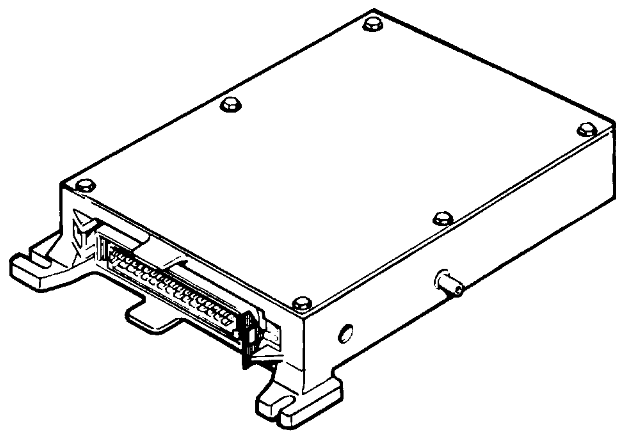
Description Each fuel injector contains a solenoid-operated needle valve, which is held against a seat by spring pressure. When energized, the coil moves the needle away from the seat, allowing pressurized fuel to flow through the tip.

Full-load throttle switches

Location Vacuum: right of throttle turntable; Micro: on throttle turntable pedestal.

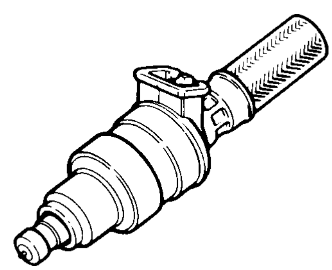
Description The full-load switches provide a ground input to the ECM during full-load conditions.

16CU ENGINE CONTROL MODULE: FUEL INJECTION



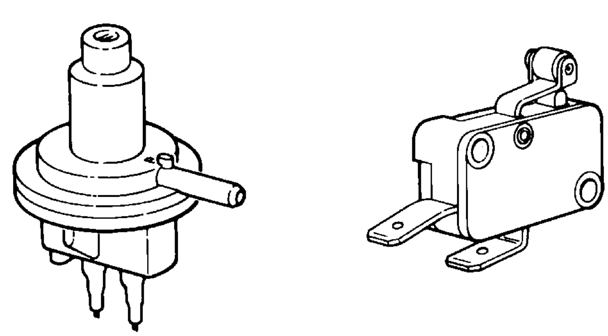
T850/2.39

FUEL INJECTOR



T850/2.40

FULL LOAD SWITCHES



T850/2.41

Engine Management System: Ignition — Overview

The ignition system is a digital microprocessor-controlled system that eliminates vacuum and mechanical advance controls. The microprocessor memory contains ignition timing strategy with precise timing for engine speeds, loads, and modes of operation. The microprocessor, in the ignition ECM, receives inputs from engine sensors to program the necessary ignition timing. The double-deck two-rotor distributor distributes the high tension voltage to A bank (right) via the lower deck and to B bank (left) via the upper deck. The low-voltage circuit is switched by the ignition ECM via the two power modules to the two ignition coils. High voltage is generated by the ignition coils and supplied to the distributor.

The inputs supplied to the ECM from the engine sensors form two groups of control parameters: primary inputs and correction inputs. The crankshaft position and engine-speed inputs are necessary for the engine to start. The remaining inputs affect engine operation but are not necessary for engine start.

Primary Inputs

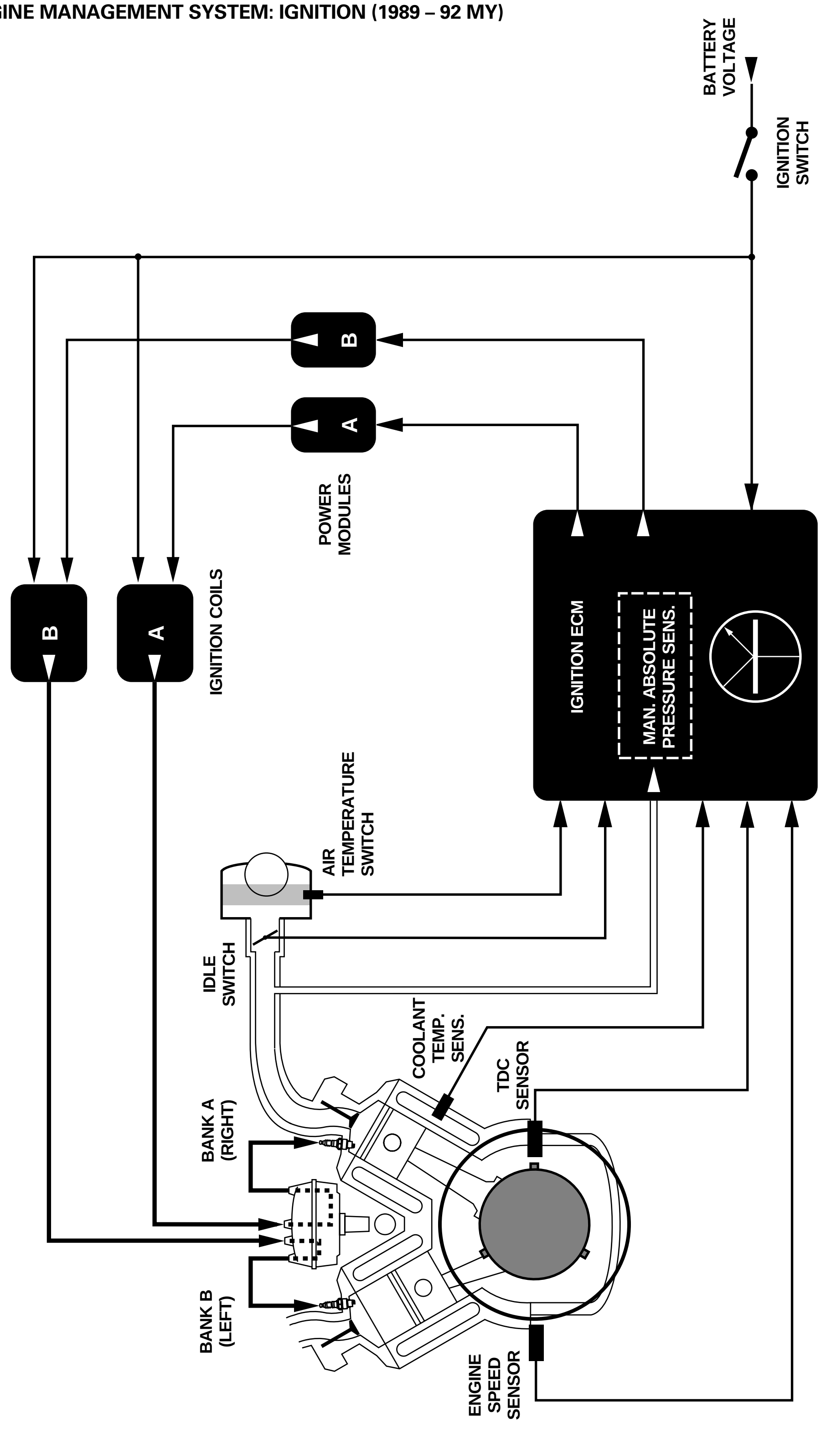
- Crankshaft position — TDC sensor
- Engine speed — Engine speed (flywheel) sensor
- Engine load — Manifold absolute pressure sensor

Correction Inputs

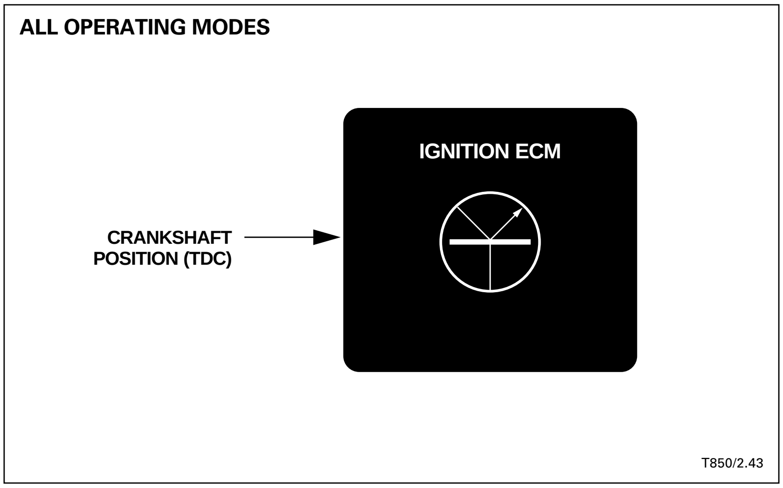
- Throttle position — Idle switch
- Engine coolant temperature — Coolant temperature sensor
- Intake air temperature — Air temperature switch

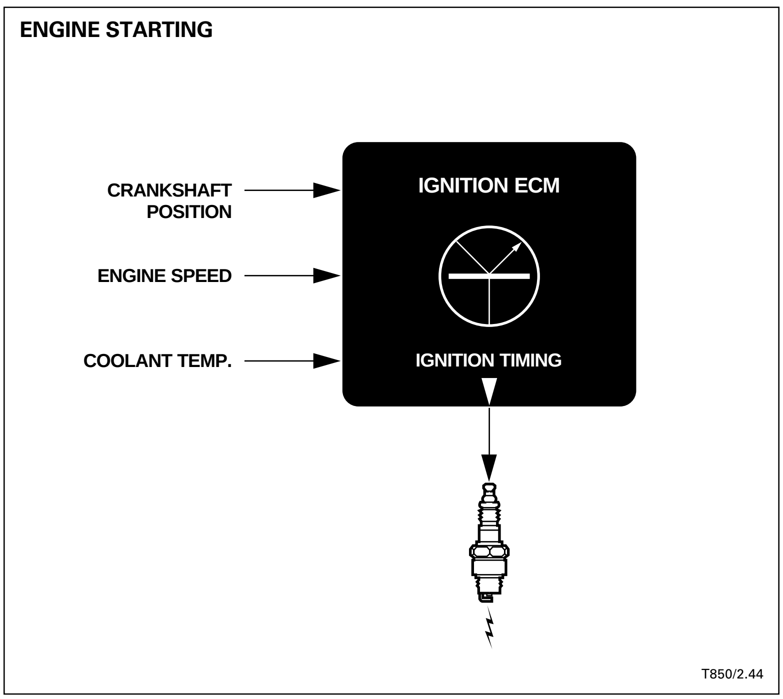
NOTE: The sensors and switches are unique to the digital ignition system and are not used or shared by the fuel injection system.

5.3 LITRE V12 ENGINE MANAGEMENT SYSTEM: IGNITION (1989 – 92 MY)



T850/2.42





Ignition: Engine Operating Modes

All operating modes
During all engine operating modes, the crankshaft position sensor (TDC sensor) input is used by the ECM to program spark delivery. Crankshaft position is referenced from A bank. The ECM programs spark delivery for both banks from the A bank reference.

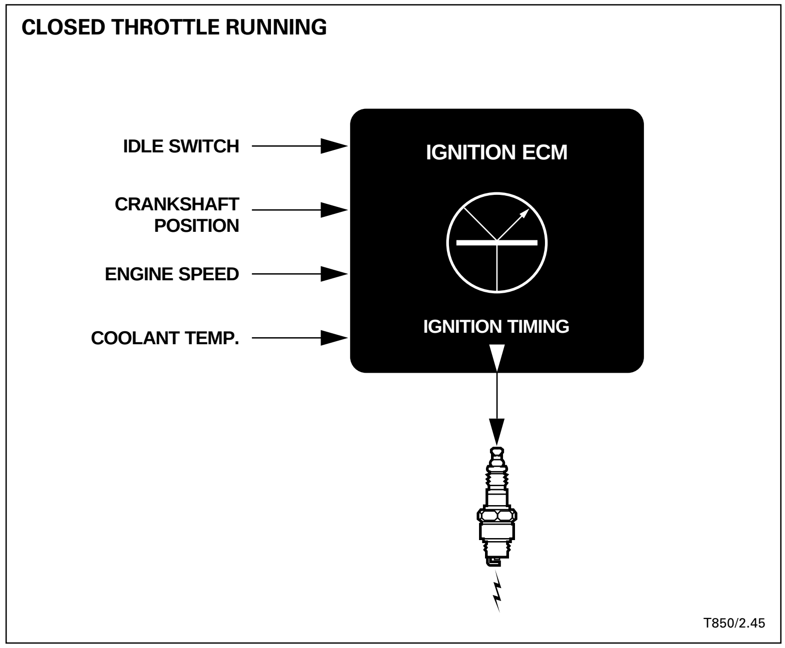
Engine starting
Ignition timing during cranking and start-up is programmed by engine speed and coolant temperature. Engine speed is obtained from the engine speed (flywheel) sensor; engine coolant temperature is obtained from the coolant temperature sensor.

Closed throttle running

Ignition timing during closed throttle operation is programmed separately for idle and deceleration. Closed throttle running is controlled by the idle switch and is programmed by engine speed and coolant temperature.

When the idle switch is closed, the ECM does not recognize the engine load (manifold absolute pressure sensor) input and uses the idle portion of the ignition strategy for ignition timing.

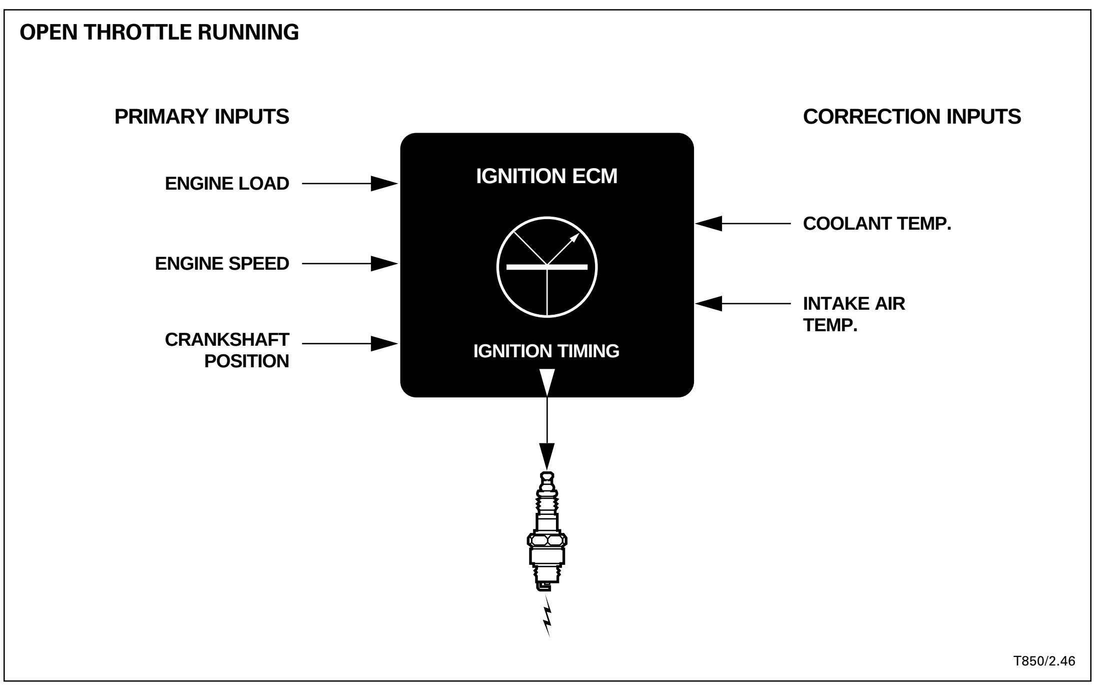
Engine speed is obtained from the engine speed (flywheel) sensor; engine coolant temperature is obtained from the coolant temperature sensor.



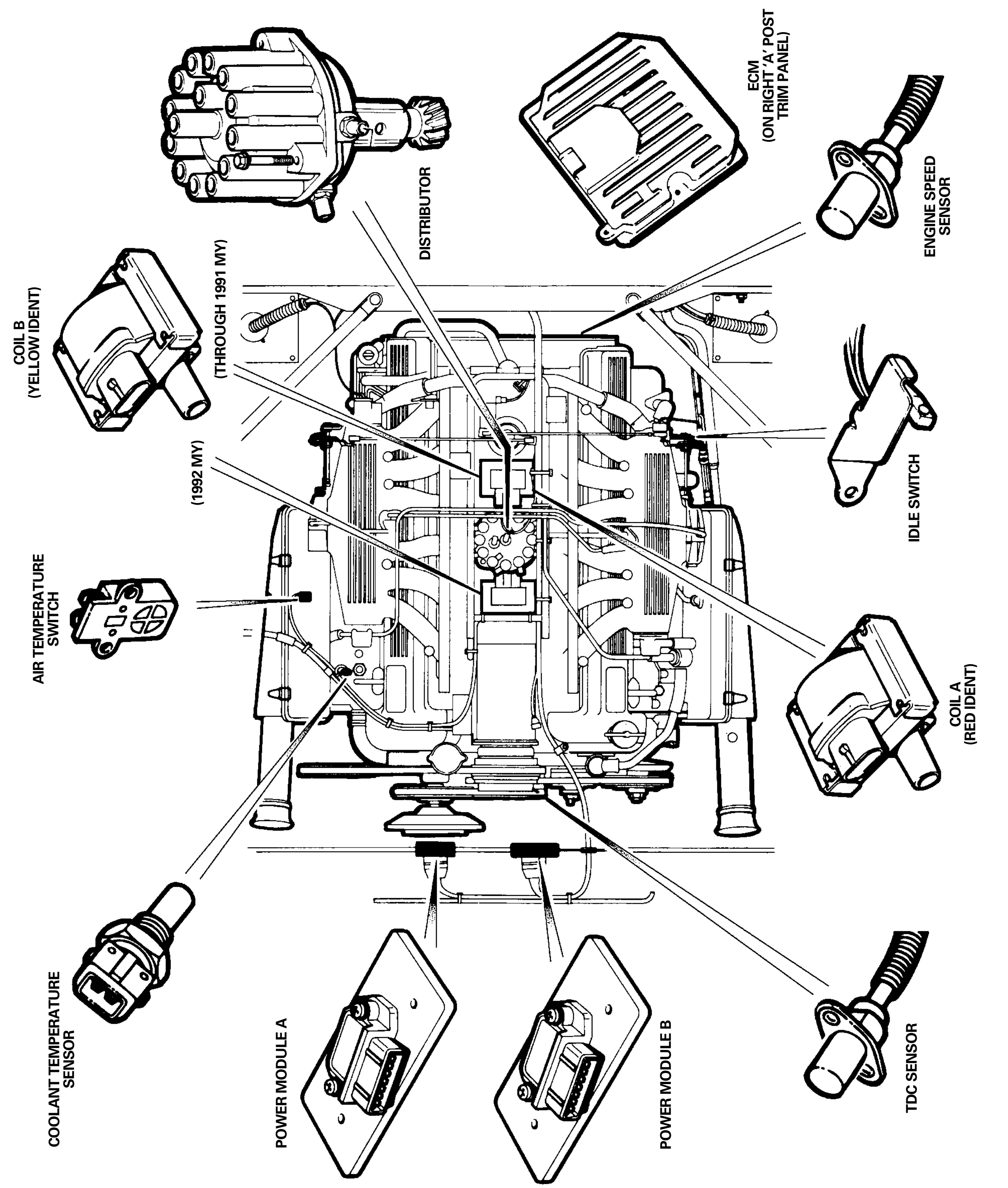
Open throttle running

Ignition timing during open throttle running is programmed by primary inputs from engine speed and engine load and from correction inputs from coolant temperature and intake air temperature.

Engine speed is obtained from the engine speed (flywheel) sensor; engine load is obtained from the manifold absolute pressure sensor; engine coolant temperature is obtained from the coolant temperature sensor; intake air temperature information is obtained from the intake air temperature switch.



DIGITAL IGNITION SYSTEM COMPONENT LOCATIONS



T850/2.47

Ignition Components

Engine control module (ECM): Ignition

Location Front passenger footwell, 'A' post trim panel.

Description The ECM contains the microprocessor for receiving analog inputs from the engine sensors and programming the ignition timing, which is accessed and delivered from the ignition strategy stored in the memory. Integral in the ECM is the manifold absolute pressure sensor.

Top dead-center sensor

Location Front crankshaft pulley.

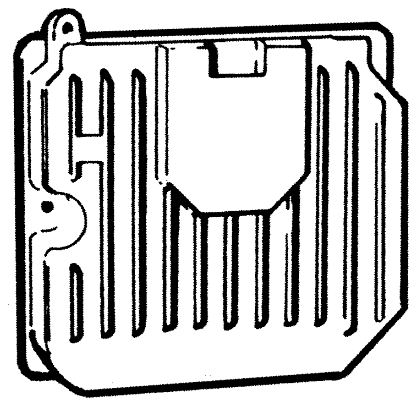
Description The sensor is triggered by a three-toothed reluctor to produce a TDC reference for A bank.

Engine speed sensor

Location Flywheel ring gear.

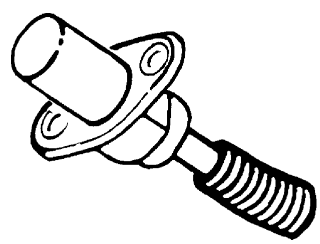
Description The sensor is triggered by the flywheel ring gear teeth, which act as a reluctor to produce an engine speed input to the ECM.

ENGINE CONTROL MODULE: IGNITION



T850/2.48

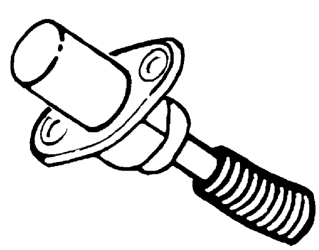
TOP DEAD-CENTER SENSOR



RESISTANCE: 700 – 800 OHMS

T850/2.49

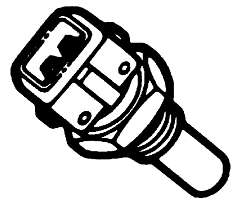
ENGINE SPEED SENSOR



RESISTANCE: 700 – 800 OHMS

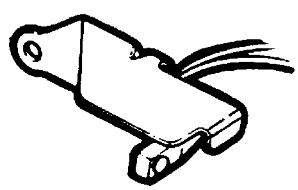
T850/2.50

COOLANT TEMPERATURE SENSOR



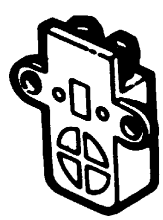
T850/2.51

IDLE SWITCH



T850/2.52

AIR TEMPERATURE SENSOR



T850/2.53

Ignition Components (continued)

Coolant temperature sensor

Location Right cylinder head coolant rail, front.

Description The coolant temperature sensor is a temperature-sensitive resistor. As the coolant temperature rises, the electrical resistance decreases providing a coolant temperature input to the ECM.

Idle switch

Location Left throttle linkage bellcrank.

Description The micro switch closes when the throttle is closed, signaling the ECM that the engine is at idle or decelerating.

Air temperature sensor

Location Right air cleaner back plate.

Description The bimetal switch closes at 167°F (75°C) to signal the ECM to retard the ignition timing at high intake air temperature.

Power modules

Location Upper radiator support.

Description The power modules switch the low voltage circuit to ground when signaled by the ECM.

Ignition coils

Location Engine vee: A bank – red ident on harness plug; B bank – yellow ident on harness plug.

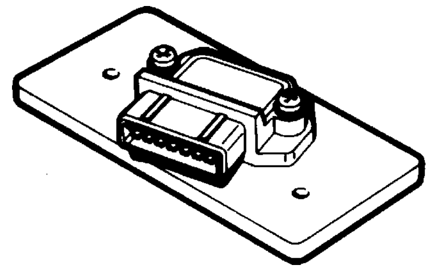
Description The ignition coils generate high voltage current for distribution to the spark plugs.

Distributor

Location Engine vee.

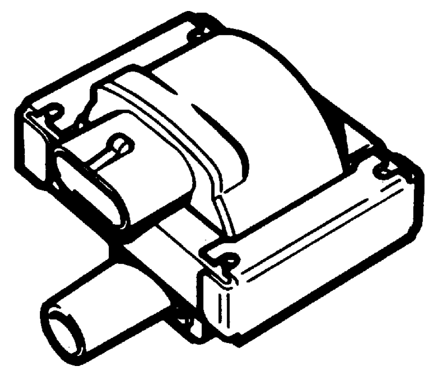
Description The distributor is a double-deck design with the upper rotor distributing high voltage current to B bank spark plugs and the lower rotor distributing high voltage current to A bank spark plugs.

POWER MODULE



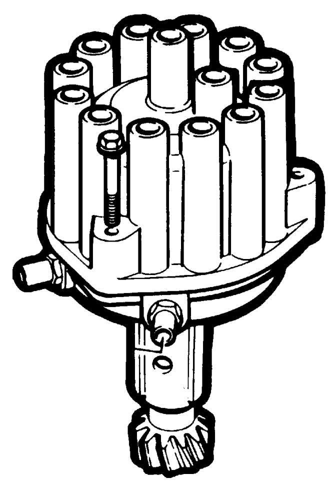
T850/2.54

IGNITION COIL



T850/2.55

DISTRIBUTOR



T850/2.56

The following Figures and Data pages are extracted from select Electrical Guides and are included here as an aid to understanding the Engine Management system. Do not use this information to diagnose vehicle faults.

Always refer to the Model and Model Year specific Electrical Guide for accurate information.

FIG 25 ENGINE MANAGEMENT — ELECTRONIC FUEL INJECTION

COMPONENTS

DESCRIPTION	LOCATION	ACCESS
EFI ECU	TRUNK, RIGHT WHEEL ARCH	RIGHT TRIM
FUEL INJECTORS	INTAKE MANIFOLD	BETWEEN CYLINDER BANKS
FUEL PUMP	IN-TANK FUEL PUMP	BEHIND FUEL TANK TRIM
POWER RESISTORS	RIGHT FRONT INNER FENDER	ENGINE COMPARTMENT, RIGHT
RELAY — EFI MAIN (LI47)	TRUNK, RIGHT WHEEL ARCH	RIGHT TRIM
RELAY — FUEL PUMP (LI46)	TRUNK, RIGHT WHEEL ARCH	RIGHT TRIM
RFI FILTER	TOP OF FUEL TANK	REAR BULKHEAD
SENSOR — OXYGEN, BANK A	RIGHT EXHAUST DOWN-PIPE	BENEATH ENGINE
SENSOR — OXYGEN, BANK B	LEFT EXHAUST DOWN-PIPE	BENEATH ENGINE
SENSOR — COOLANT TEMPERATURE	B BANK WATER MANIFOLD	ENGINE, LEFT FRONT
SENSOR — AIR TEMPERATURE	B BANK AIR FILTER HOUSING	ENGINE, LEFT FRONT
THROTTLE POTENTIOMETER	ENGINE, REAR CENTER	BELOW THROTTLE TURNTABLE

CONNECTORS

CODE	DESCRIPTION	LOCATION / INTERFACE
EM19	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM20	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM21	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM22	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM23	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM24	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK A INJECTORS
EM25	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
EM26	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
EM27	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
EM28	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
EM29	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
EM30	2-WAY SPADE (GRAY)	CENTER OF INTAKE MANIFOLD / BANK B INJECTORS
FP1	2-WAY ECONOSEAL III (BLACK)	CENTER/TOP OF FUEL TANK / IN-TANK FUEL PUMP
LI41	2-WAY ECONOSEAL (BLACK)	RIGHT REAR WHEEL ARCH / IN-TANK FUEL PUMP
LI45	35-WAY AMP (BLACK)	RIGHT REAR WHEEL ARCH / EFI ECU
LI46	RELAY BASE (BLACK)	RIGHT REAR WHEEL ARCH / FUEL PUMP RELAY
LI47	RELAY BASE (RED)	RIGHT REAR WHEEL ARCH / EFI MAIN RELAY
LI62	2-WAY SPADE (BLACK)	BELOW REAR EDGE OF BANK B AIR FILTER / BANK B LAMBDA HEATER
LI63	SPADE	LEFT EXHAUST DOWN-PIPE / BANK B LAMBDA
LI64	2-WAY SPADE (BLACK)	LEFT FRONT BANK B AIR FILTER / AMBIENT TEMP. SENSOR
LI65	2-WAY SPADE (WHITE)	LEFT FRONT BANK B CYLINDER HEAD / COOLANT TEMP. SENSOR
LI66	4-WAY SUMITOMO SEALED (GREEN)	CENTER OF BULKHEAD / THROTTLE POTENTIOMETER
LI73	10-WAY AMP (NATURAL)	RIGHT FRONT INNER FENDER / POWER RESISTOR PACK
LI75	SPADE	RIGHT EXHAUST DOWN-PIPE / BANK A LAMBDA
LI76	2-WAY SPADE (BLACK)	BELOW REAR EDGE OF BANK A AIR FILTER / BANK A LAMBDA HEATER
LI90	6-WAY PM 4 (BROWN)	BELOW RIGHT A/C OUTLET / JDS DIAGNOSTIC PLUG
LI129	6-WAY SUMITOMO BLOCK (BLUE)	BELOW RIGHT A/C OUTLET / TRIP COMPUTER FUEL FAIL CODE
LI138	6-WAY SUMITOMO SEALED (GREEN)	FRONT OF BANK A AIR CLEANER / EFI HARNESS

GROUNDS

CODE	DESCRIPTION	LOCATION / INTERFACE
LIG68	EYELET	REAR OF BANK A INTAKE MANIFOLD / POWER GROUND
LIG81	EYELET	BETWEEN BATTERY AND INNER WHEEL ARCH / POWER GROUND
LIG83	EYELET	BETWEEN BATTERY AND INNER WHEEL ARCH / POWER GROUND
LIG139	EYELET	BETWEEN BATTERY AND INNER WHEEL ARCH / POWER GROUND
LIG140	EYELET	BETWEEN BATTERY AND INNER WHEEL ARCH / POWER GROUND

INPUTS / OUTPUTS

EFI ECU

CODE	IN / OUT	CIRCUIT	ACTIVE	INACTIVE
LI45-1	IN	POWER GROUND	GROUND	GROUND
LI45-2	OUT	TRIP COMPUTER FUEL INFORMATION	AC VOLTS INCREASE W/ENGINE RPM	0V
LI45-3	IN	BATTERY POWER	12V	12V
LI45-4	OUT	DIAGNOSTIC SOCKET	—	—
LI45-5	IN	COOLANT TEMP. SENSOR	APPROX. 2.9V @30°C	0V
LI45-6	IN	BANK A OXYGEN SENSOR	0-1V SWING	ENGINE OFF: 0V
LI45-7	OUT	THROTTLE POTENTIOMETER SWEEP	MIN: APPROX. 0.28V – 0.32V, MAX: APPROX. 4.5V	0V
LI45-8	OUT	BANK B INJECTOR ON — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-9	OUT	BANK B INJECTOR ON — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-10	OUT	DIAGNOSTIC SOCKET	—	—
LI45-11	OUT	BANK B INJECTOR HOLD — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-12	OUT	BANK A INJECTOR HOLD — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-13	OUT	BANK A INJECTOR ON — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-14	OUT	BANK A INJECTOR ON — INJECTORS 1,2,3	PULSED SIGNAL	0V
LI45-15	IN	FUEL PUMP RELAY	GROUND	12V
LI45-16	IN	POWER GROUND	GROUND	GROUND
LI45-17	IN	POWER GROUND	GROUND	GROUND
LI45-18	IN	ENGINE SPEED FLYWHEEL	AC VOLTS INCREASE W/ENGINE RPM	0V
LI45-19	IN	COOLANT/THROTTLE POTENTIOMETER GROUND	GROUND	GROUND
LI45-20	OUT	THROTTLE POT./AIR TEMP. SENSOR REFERENCE VOLTAGE	KEY ON: APPROX.5V	KEY OFF: 0V
LI45-21	IN	AIR TEMP. SENSOR	APPROX. 2.2V @30°C	0V
LI45-22	IN	EFI MAIN RELAY	KEY ON: 12V	KEY OFF: 0V
LI45-23	IN	POWER GROUND	GROUND	GROUND
LI45-24	IN	BANK B OXYGEN SENSOR	0 - 1V SWING	ENGINE OFF: 0V
LI45-25	NOT USED			
LI45-26	NOT USED			
LI45-27	OUT	BANK B INJECTOR ON — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-28	OUT	BANK B INJECTOR ON — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-29	OUT	BANK B INJECTOR HOLD — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-30	OUT	BANK A INJECTOR HOLD — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-31	OUT	BANK A INJECTOR ON — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-32	OUT	BANK A INJECTOR ON — INJECTORS 4,5,6	PULSED SIGNAL	0V
LI45-33	OUT	FUEL FAIL/TRIP COMPUTER	LIGHT ON: APPROX. 1V	LIGHT OFF: 12V
LI45-34	IN	POWER GROUND	GROUND	GROUND
LI45-35	IN	POWER GROUND	GROUND	GROUND

Contents

System Introduction

The XJR-S is a specialized Jaguar model that uses a 6.0 litre version of the basic 5.3 litre V12 engine. A Zytek engine management system that integrates sequential fuel injection, ignition and emission control is used to provide ultra high performance.

Engine Specifications

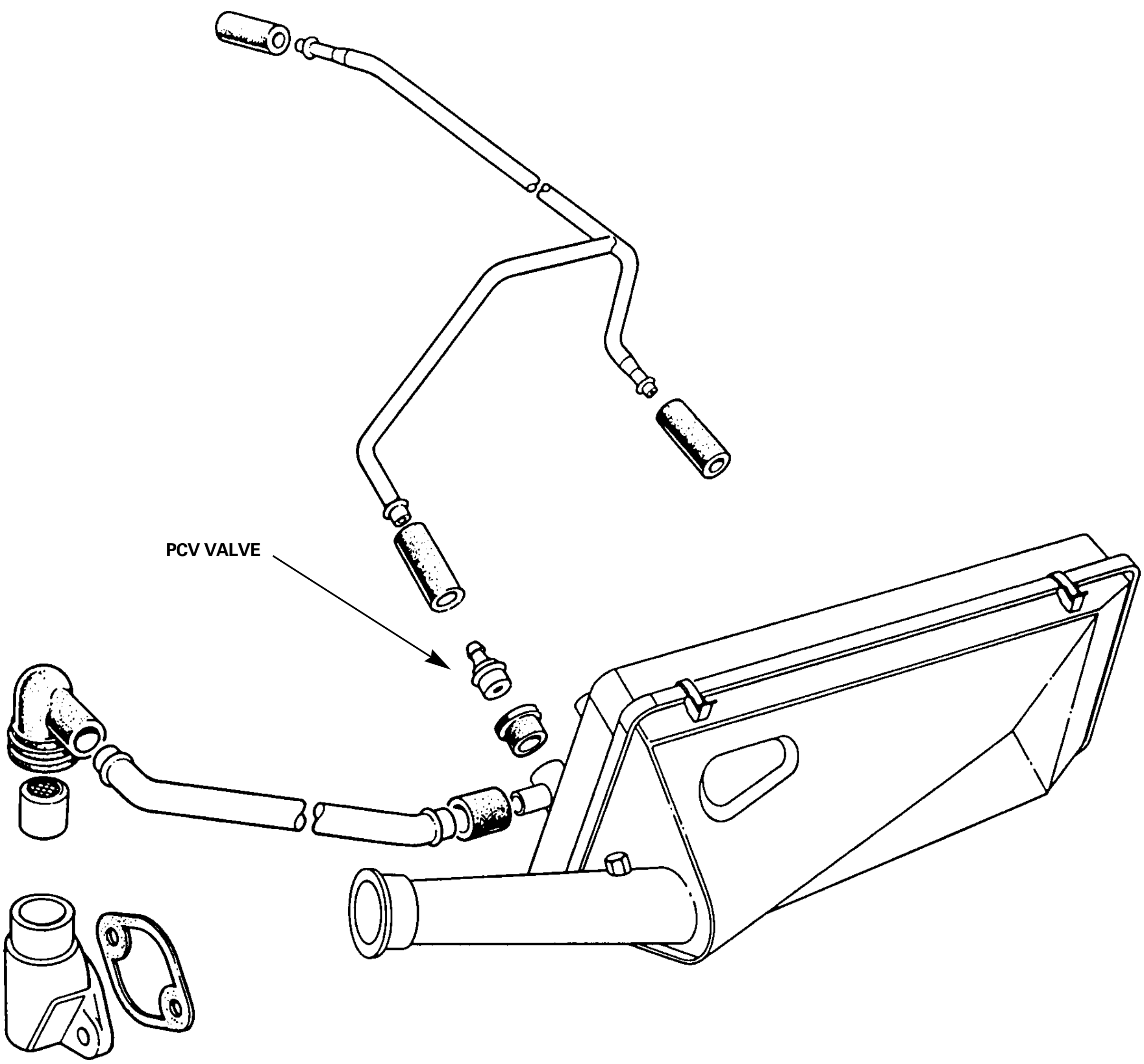
Displacement	5993 cc	
Bore / stroke	90 mm x 78.5 mm	
Compression ratio	11.0:1	
Power (DIN)	318 hp @ 5200 rpm	
Torque (DIN)	339 ft lbs @ 3750 rpm	
Spark plugs	Champion RS6 YCC	0.025 in gap
Fuel requirement	Unleaded gasoline — 95 RON octane rating	
Idle speed	750 rpm — N or P	

Crankcase Emission Control

Crankcase ventilation

The 5.3 litre crankcase ventilation system is retained. Piston blowby gases are scavenged from the crankcase and the camshaft housings via the left timing housing and the camshaft covers. The gases are collected and fed into the engine through the left air cleaner.

XJR-S 6.0 LITRE V12 CRANKCASE EMISSION CONTROL



T850/3.01

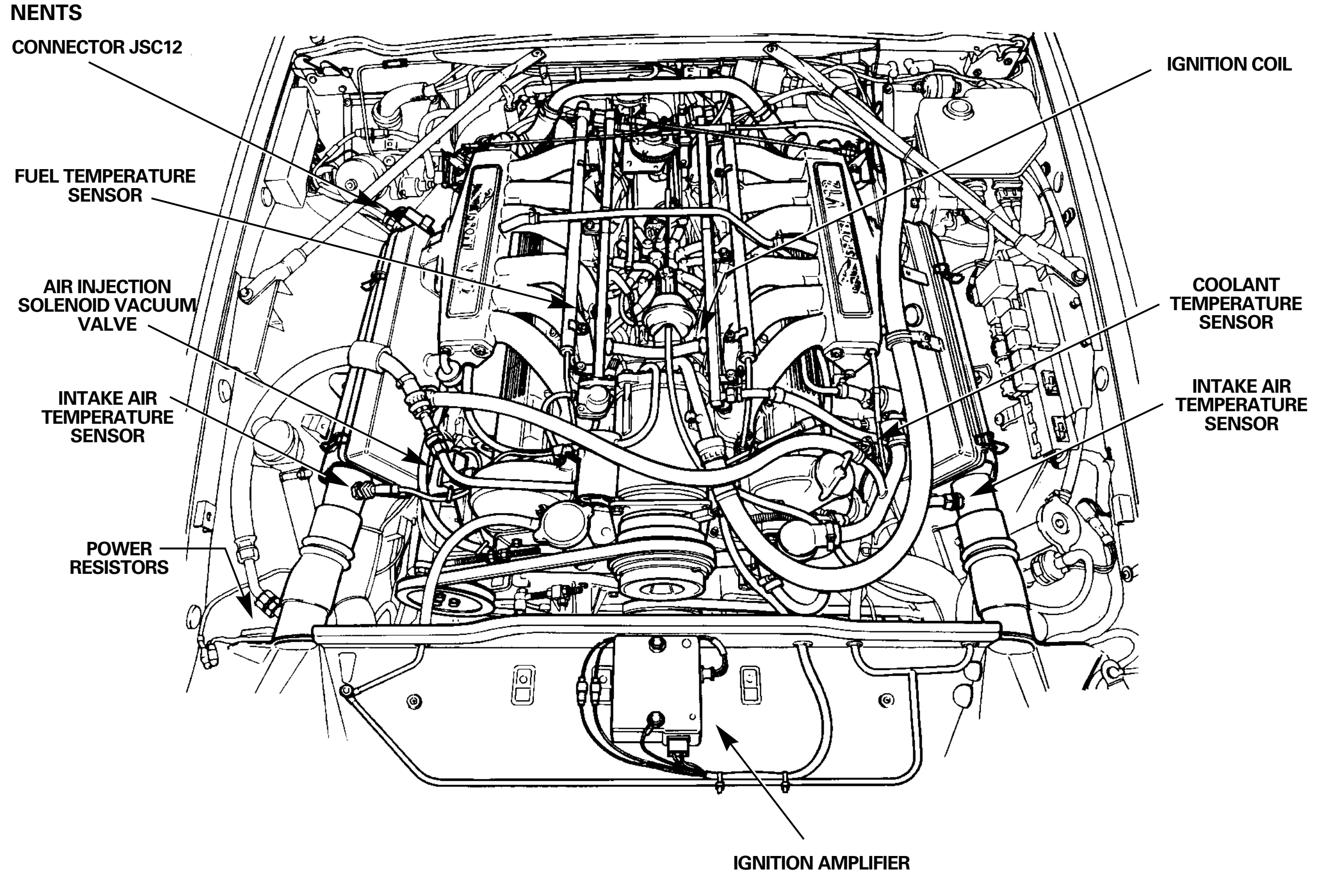
Engine Management System Overview

The Zytek engine management system is a microprocessor based system with control over fuel delivery, evaporative emission purging, sequential fuel injection, exhaust emission, ignition timing and air injection. A single engine control module incorporating a manifold absolute pressure sensor drives the various functions by applying inputs received from engine sensors with the strategies stored in memory. The ECM contains an on-board diagnostic capability that can be accessed via serial communication through a lap top computer using special software.

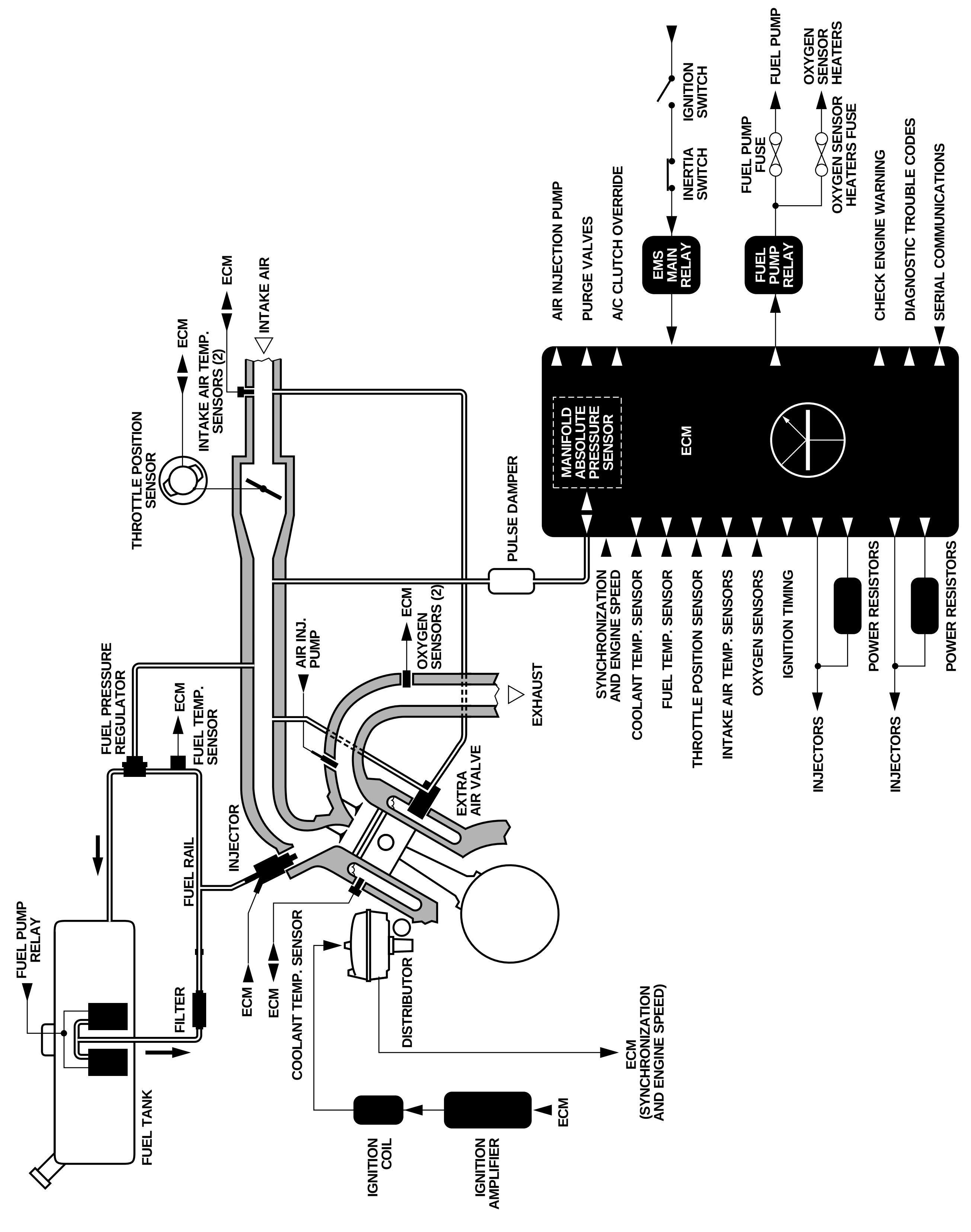
The complete list of engine management ECM functions is as follows:

- Fuel delivery
- Evaporative emission canister purging
- Sequential fuel injection – idle, acceleration, cruise, deceleration
- Cold start
- Warm-up
- Closed loop exhaust emission control
- Air injection control
- Wide open throttle injector disable on cranking
- Overrun fuel cutoff
- Engine speed limitation
- Ignition timing
- Air conditioning compressor override (high engine temperature)
- Engine speed output signal (tachometer)
- Fuel monitoring (trip computer)
- On-board diagnostics (OBD)
- CHECK ENGINE warning and diagnostic trouble codes
- Limp home capability
- Serial communication

XJR-S ENGINE MANAGEMENT COMPONENTS



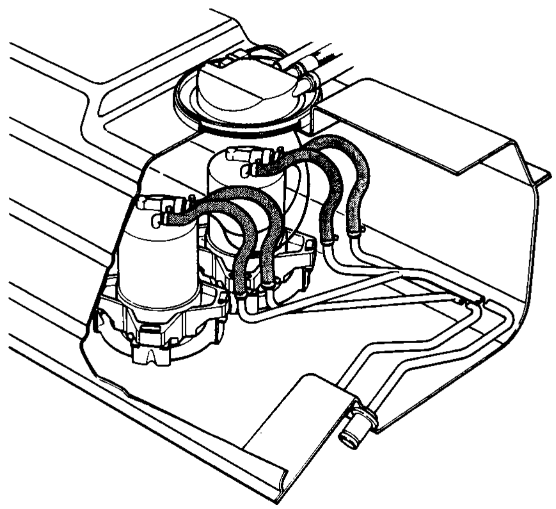
XJR-S ENGINE MANAGEMENT SYSTEM



T850/3.03

Fuel Delivery and Evaporative Emission Control

XJR-S FUEL PUMPS



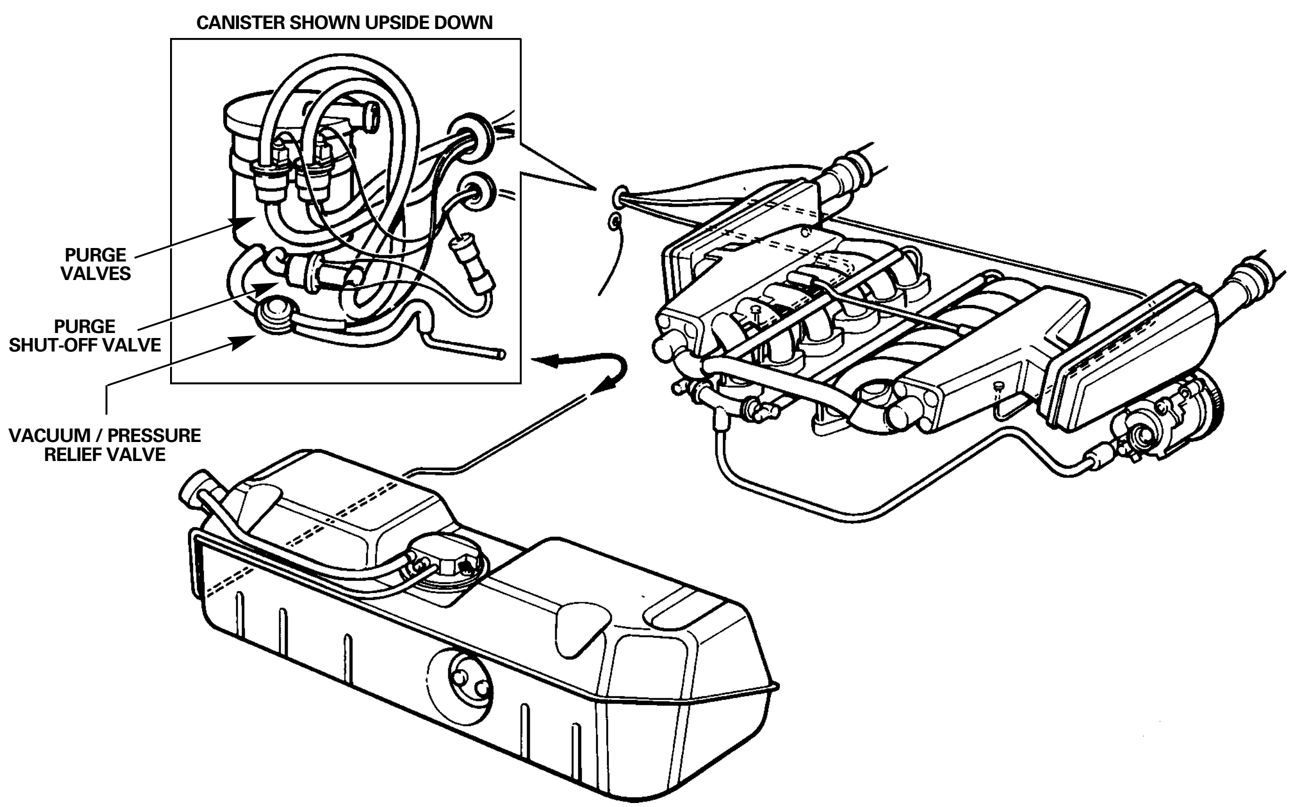
Fuel delivery

The basic fuel delivery system is unchanged from the 1992 model year XJS V12 vehicles. In order to meet the demands of the 6 litre engine, two downrated versions of the standard fuel pump modules are used. These must be replaced as a matched pair. The fuel pumps are activated by the ECM (electronic control module) only when engine cranking or engine speed signals are received. Two vertical black stripes identify the twin fuel pump tank.

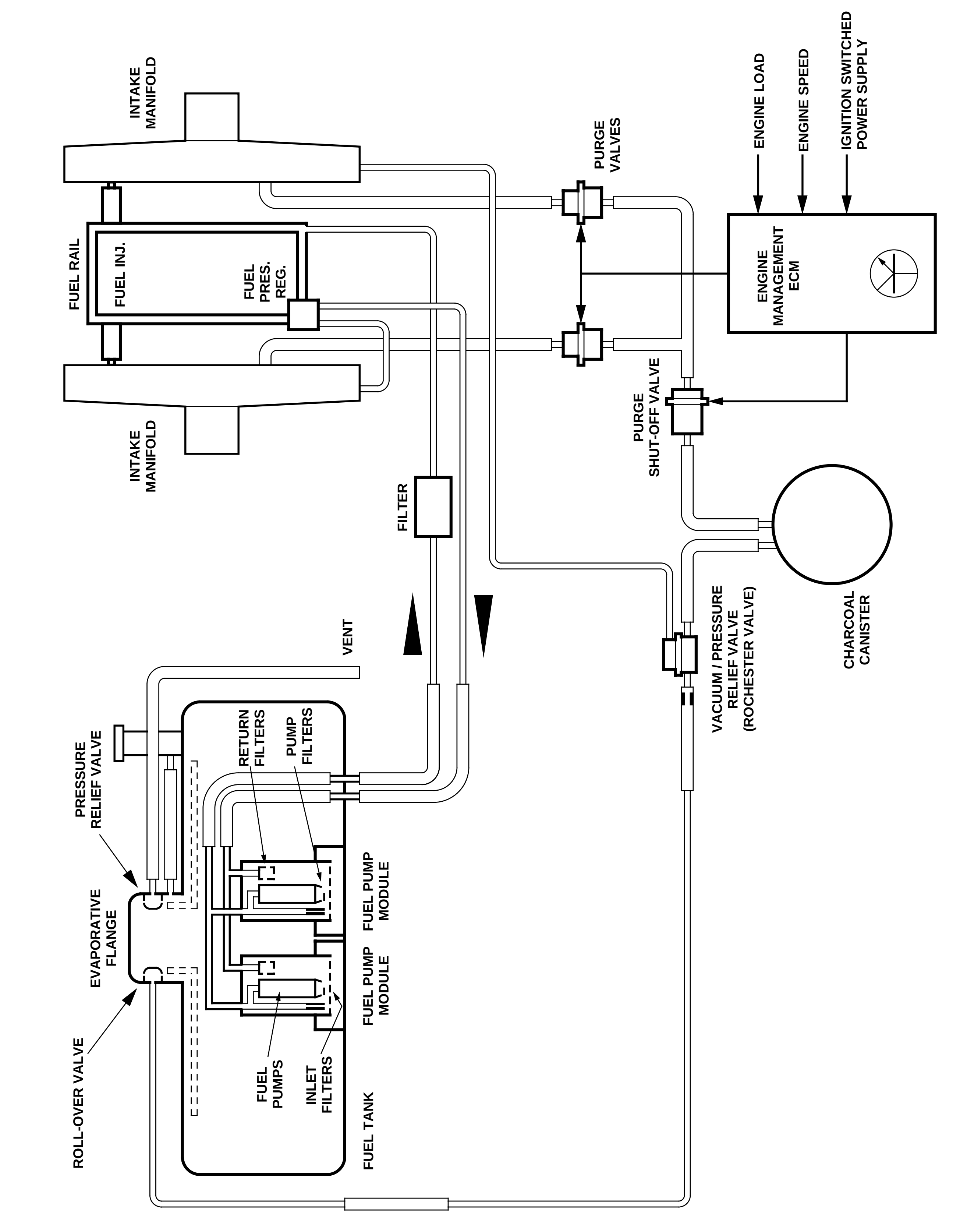
Evaporative emission control

The evaporative emission control system uses the same canister and vacuum / pressure relief valve as the 1992 model year XJS V12 vehicle, however, the canister is inverted. Engine run-on is prevented by a normally closed purge shut-off valve. The valve opens when the ignition is switch ON. Canister purging is controlled by the ECM via two purge control valves in the purge lines to the left and right intake manifolds. The ECM opens the valves simultaneously according to an engine load and speed strategy. Correct functioning of the purge shut-off valve and the purge control valves is monitored by the on-board diagnostic system in the ECM.

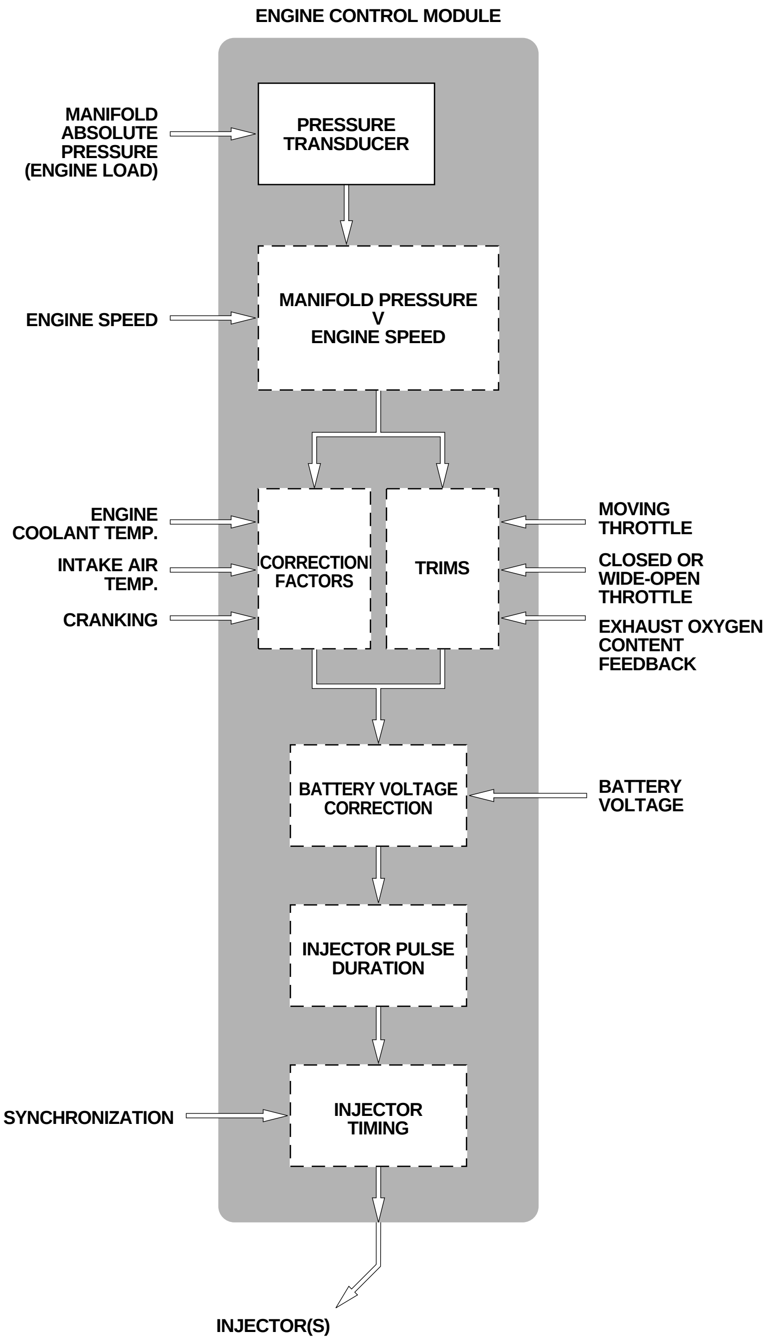
XJR-S EVAPORATIVE EMISSION CONTROL SYSTEM



XJR-S FUEL DELIVERY AND EVAPORATIVE EMISSION CONTROL SYSTEM



XJR-S FUEL INJECTION CONTROL



T850/3.07

Fuel Injection

Fuel metering control

Fuel metering is obtained by controlling the injector pulse duration during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups — primary and secondary. Primary control inputs are intake manifold absolute pressure (MAP) and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature, throttle movement and position, exhaust oxygen content, crankshaft position, cranking signal, fuel temperature and battery voltage. The injectors are pulsed sequentially, once per engine cycle in the engine firing order.

Primary control

Fuel metering is controlled primarily as a function of intake manifold absolute pressure (MAP) and engine speed. Manifold pressure is sensed by a pressure transducer located in the engine control module and connected to the A bank manifold by a vacuum line. Engine speed is sensed by a reluctor mounted in the ignition distributor. In addition to engine speed, the Hall effect reluctor supplies a synchronization input to the ECM for fuel injection timing.

Fueling strategies are held in memory (EPROM) in the ECM and form a manifold pressure v engine speed matrix. Injector pulse duration is then calculated according to secondary correction factors and trims. The resulting injector pulse duration is further modified to account for battery voltage.

Secondary control
Secondary fueling enrichment is provided for engine starting, warm-up and throttle response at all temperatures within the engine's operating range.

Coolant temperature The coolant temperature sensor provides an electrical input to the ECM. During engine starting and warm-up, enrichment is provided by increasing the injector pulse duration when coolant temperature is below normal operating temperature. Enrichment is reduced with increasing engine speed and load.

Engine starting When the engine starts at low temperatures, the ECM pulses all injectors together, six injections per engine cycle (2 crankshaft revolutions). Normal sequential timing of the injectors is resumed after a preset number of injections.

After start enrichment After engine start-up, the ECM increases the injector pulse duration above the normal running requirement and then decreases the pulse duration at a fixed rate over a preset number of engine revolutions.

Throttle movement and position The throttle position sensor provides electrical signals to the ECM for opened and closed throttle operation as well as throttle movement during acceleration and deceleration.

Intake air temperature Fuel metering is adjusted to vary approximately with the density of the engine intake air. Intake air density is sensed by measuring the air temperature at both the left and right air intakes. Independent correction is provided for each cylinder bank.

Full load Full load fuel metering varies with throttle position and engine speed. Under full load conditions, exhaust oxygen sensor closed loop control is disabled.

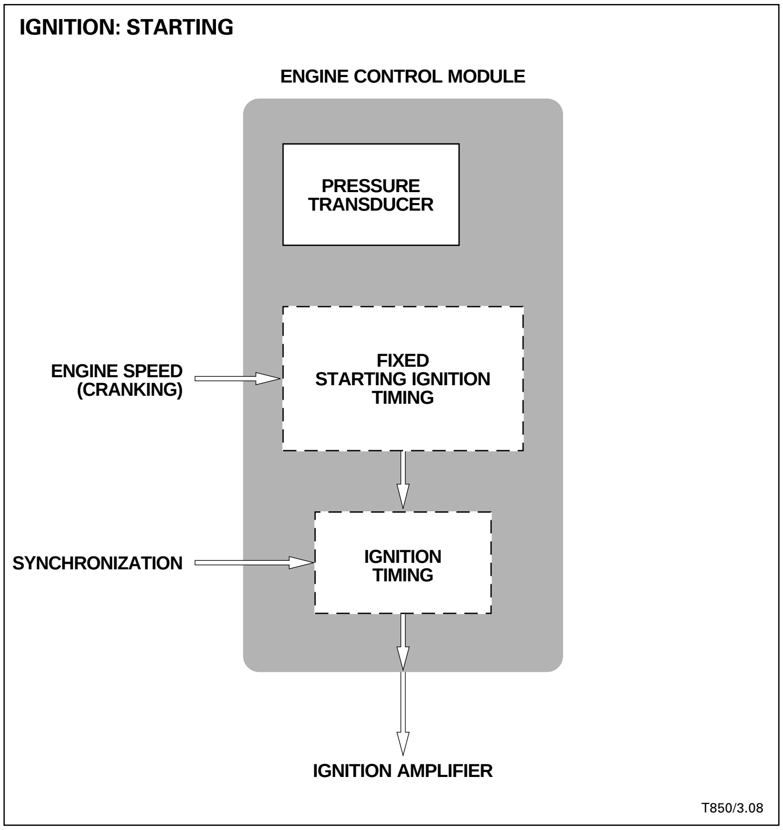
Idle fuel To compensate for variable injector flow at short pulse durations, the ECM has an adjustable idle trim function to optimize the idle fuel metering for each cylinder bank. Adjustments are made using a lap-top computer with special software.

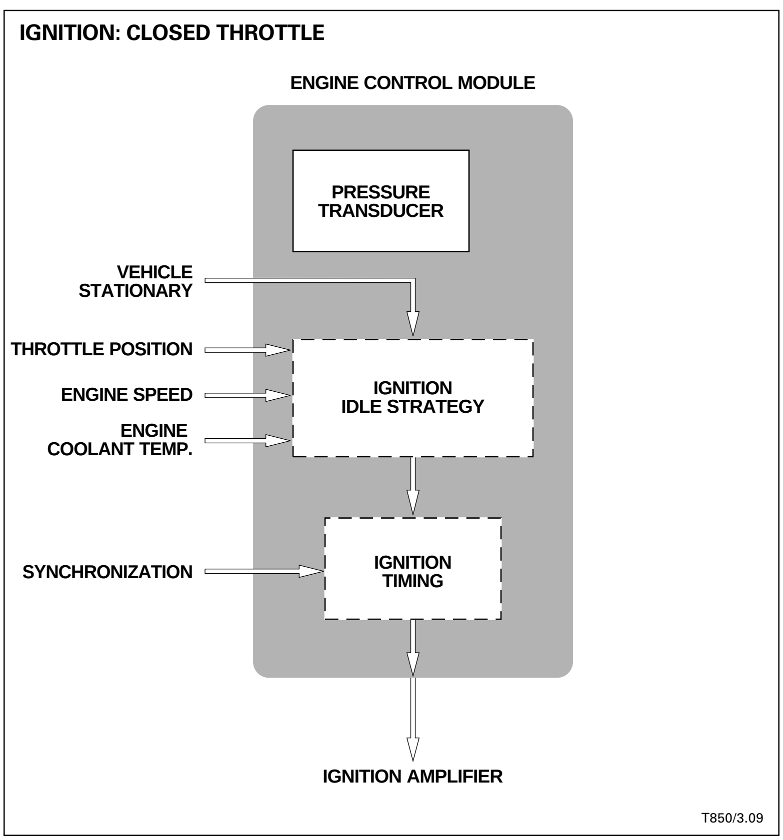
Fuel temperature To improve hot starting and running at high ambient temperature, additional fuel is supplied as a function of fuel temperature. A fuel temperature sensor on the fuel rail provides an input to the ECM.

Air / fuel ratio (closed loop control) In order to achieve optimum performance from the exhaust three-way catalyst system, the exhaust oxygen content is monitored and controlled by trimming the fuel metering. Two oxygen sensors are used–one in each exhaust down pipe, after the primary catalyst. Closed loop control is disabled under these conditions:

- during engine warm-up when the air injection is operating
- following hot starts until the oxygen sensors reach operating temperature
- during full load operation
- during deceleration fuel cutoff (engine overrun).

Battery voltage The time necessary for full injector open and close to occur varies with battery voltage. For example, with low battery voltage, the time necessary for full injector open to occur is long; therefore, less fuel is delivered for a given pulse duration. The opposite is true for high battery voltage. The ECM corrects the injector pulse duration to achieve the fuel delivery that would be obtained at a nominal reference voltage.





Ignition

Ignition timing control

The ignition timing is varied by the ECM according to several sensor inputs. The sensed control inputs form two groups – primary and secondary. Primary control inputs are intake manifold absolute pressure and engine speed; secondary control inputs consist of engine coolant temperature, intake air temperature and throttle position. Crankshaft position is determined by the Hall effect reluctor (synchronization sensor) in the distributor.

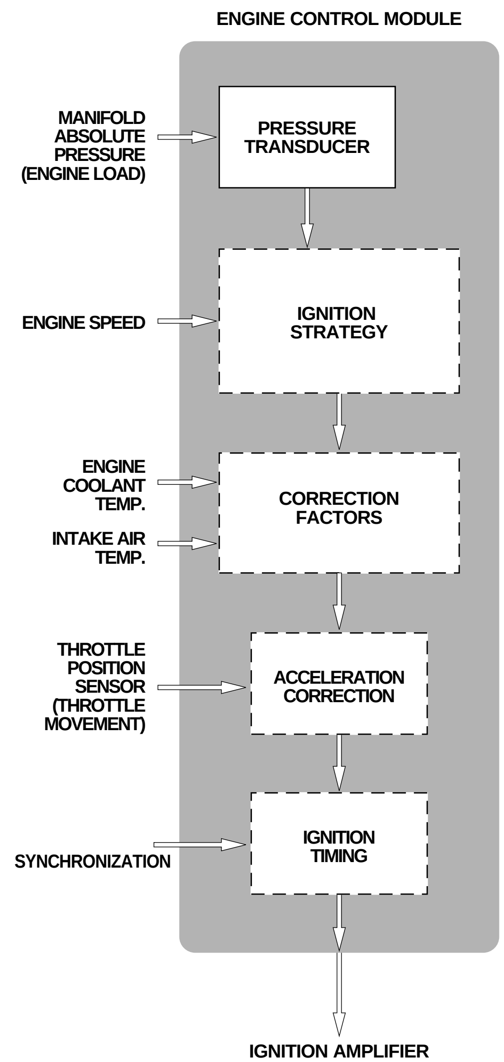
Ignition timing strategies are held in memory (EPROM) in the ECM. The ECM uses secondary sensor inputs to determine the engine operating condition — starting, closed throttle operation or open throttle operation — and then applies the correct ignition timing.

Engine starting During engine cranking, the ignition timing is fixed by the ECM. After starting, the ignition timing is varied as determined by an idle strategy.

Idle A separate “short” idle strategy that ensures steady idle is employed when the vehicle is stationary and the throttle closed. The input from the road speed sensor is used to determine whether the vehicle is in motion or stationary. Closed throttle operation is sensed from the throttle position sensor. The engine speed change-over points between starting and idle are written in the ECM memory.

Open throttle operation For any given manifold absolute pressure (MAP) and engine speed, the ECM will determine the required ignition timing from the "lookup" table. The timing is then corrected for engine temperature, intake air temperature and for acceleration.

IGNITION: OPEN THROTTLE



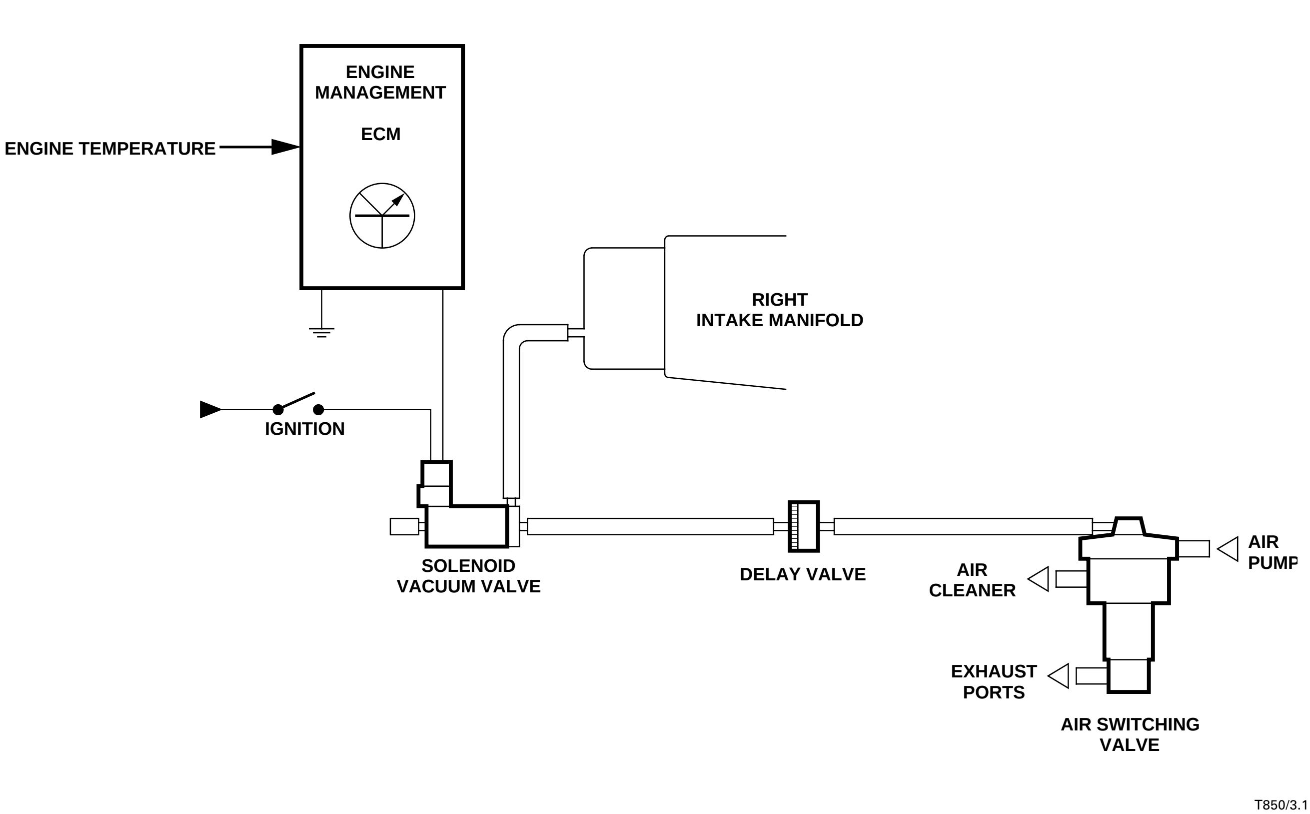
T850/3.10

Additional ECM functions

Additional ECM functions include air injection control, fuel cutoff and air conditioning compressor clutch override.

Air injection Air injection is enabled by the ECM during engine warm-up. The ECM activates the solenoid vacuum valve to apply intake manifold vacuum to the air switching valve to switch air delivery to the exhaust ports. When the coolant temperature reaches 125°F, the ECM switches off the vacuum valve causing the air delivery to be switched from the exhaust ports back to the right air cleaner. The air switching valve, solenoid vacuum valve and delay valve are carry-over components from the 1992 model year XJS V12.

AIR INJECTION OPERATION



Fuel cutoff Fuel cutoff is used during engine overrun conditions, for engine overspeed protection, and for flooding protection during wide-open-throttle start. The following table lists the fuel cutoff conditions and control specifications:

Controlled parameter	Fuel cutoff (engine speed)	Reinstate
Engine overrun (deceleration)	1395 plus rpm (engine temp. above 60°C, throttle position below threshold level, vehicle in motion)	930 rpm
Engine overspeed	6498 rpm	6494 rpm
Wide-open-throttle start	Engine cranking	Throttle closed

NOTE: The ECM uses the road speed input to determine "vehicle in motion" when applying deceleration fuel cutoff.

Air conditioner compressor clutch override The ECM switches the compressor clutch relay coil ground circuit to override the compressor operation if the engine coolant temperature reaches 257°F (125°C) or higher. Compressor operation is reinstated when the temperature drops to 253°F (123°C).

Idle speed control
Idle speed control is maintained solely by the adjustable idle air bleed at the extra air valve. No supplementary air valve or electronic idle speed control is provided.

On-Board Diagnostics System (OBD)

The ECM includes a fault diagnosis facility that continuously monitors the operation of the engine management sensors and components. If a fault is detected, the OBD system will activate the CHECK ENGINE warning in the instrument pack and on the trip computer display. In addition, it will flag a diagnostic trouble code (DTC) in the ECM memory. The ECM can, at any time, be interrogated through the trip computer display by switching off the ignition then switching on the ignition. The CHECK ENGINE warning will display and the DTC will appear 5 seconds later. If two or more DTCs are flagged in memory, only the highest priority code will be displayed. The remaining codes will be displayed, in turn, as the faults are corrected and erased from memory.

NOTE: Fueling diagnostics are disabled when the fuel tank level falls below approximately 6.5 gallons (25 litres).

Serial communications

Serial communications between the engine management system and a lap top diagnostic computer are available via the EMS data link connector (PM 4) located in the passenger's footwell. Serial communication is used for engine setup, fault diagnosis and erasing diagnostic trouble codes.

Limp home mode

In order to allow vehicle operation if a malfunction occurs, "limp home" default strategies are incorporated as an ECM facility. The ECM will substitute a nominal value for missing inputs from various sensors and components.

Open loop default

Certain malfunctions have "open loop" default when in limp home mode. If a malfunction has open loop default, oxygen sensor inputs are ignored. If a malfunction does not have open loop default, oxygen sensor inputs are used.

Diagnostic trouble codes
The available DTCs are listed in order of priority on the following table. Limp home and/or open loop default are available as indicated.

DTC	Limp Home Default	Open Loop Default	Input or Component Checked
29			ECM Self-test
55	X	X	Engine ground sensing circuit
44	X	X	Oxygen sensor circuit — A bank
45	X	X	Oxygen sensor circuit — B bank
18			Fuel metering above idle — A bank
19			Fuel metering above idle — B bank
12			Engine speed and synchronization sensors circuit
24			Ignition drive circuit
36	X	X	Injector electrical circuit — Injector 1A
56	X	X	Injector electrical circuit — Injector 2A
46	X	X	Injector electrical circuit — Injector 3A
58	X	X	Injector electrical circuit — Injector 4A
38	X	X	Injector electrical circuit — Injector 5A
48	X	X	Injector electrical circuit — Injector 6A
49	X	X	Injector electrical circuit — Injector 1B
39	X	X	Injector electrical circuit — Injector 2B
59	X	X	Injector electrical circuit — Injector 3B
47	X	X	Injector electrical circuit — Injector 4B
57	X	X	Injector electrical circuit — Injector 5B
37	X	X	Injector electrical circuit — Injector 6B
34	X	X	Injector drive circuit
33	X	X	Fuel metering at idle — A bank
35	X	X	Fuel metering at idle — B bank
23			Fuel metering at idle — A and B banks combined
13	X		Pressure transducer and sensing hose
17	X		Throttle position sensor circuit
11	X		Pressure transducer / throttle position sensor circuit
27	X		Sensor ground circuit (coolant, intake air, fuel temp.)
14	X		Coolant temperature sensor circuit
15	X		Intake air temperature sensor circuit — A bank
16	X		Intake air temperature sensor circuit — B bank
26	X		Intake air temperature sensor circuits — excessive difference, A bank to B bank
25	X		Fuel temperature sensor circuit
22			Fuel pump relay control circuit
88			Purge valves circuit
79			Purge shut-off valve circuit
66	X	X	Air injection solenoid vacuum valve circuit
68	X		Road speed sensor circuit

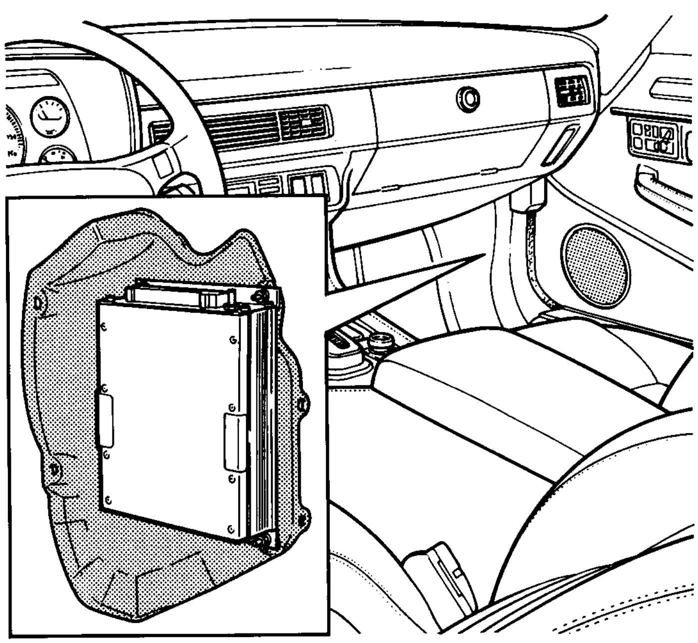
Engine Management Components

Engine control module

Location Passenger's side 'A' post

Description The ECM is a microprocessor based unit with control over fuel injection, emission control and ignition The ECM contains an integral pressure transducer for sensing engine manifold absolute pressure. A vacuum line runs from the right intake manifold to the ECM through a damper. The vacuum line is routed behind the passenger's 'A' post trim. The damper is located above the passenger footwell.

ENGINE CONTROL MODULE



T850/3.12

Fuel injectors

Location Fuel rail / intake manifolds

Description The fuel injectors are carry-over components from the 1992 model year XJS V12.

Power resistors

Location Engine compartment, right front

Description Twin power resistor packs contain a resistor for each injector.

Throttle position sensor

Location Under the throttle turntable

Description The throttle position sensor is a carry-over component from the 1992 model year XJS V12.

Coolant temperature sensor

Location Left thermostat housing

Description The coolant temperature sensor is a carry-over component from the 1992 model year XJS V12.

Intake air temperature sensors

Location Right and left air cleaner intakes

Description Two intake air temperature sensors are used. The sensors are carry-over components from the 1992 model year XJS V12.

Fuel temperature sensor

Location Fuel rail, right

Description The fuel temperature sensor is a temperature sensitive resistor (thermistor). As the fuel temperature rises, the electrical resistance decreases providing a fuel temperature input to the ECM.

Oxygen sensors

Location Exhaust down pipes

Description The oxygen sensors are carry-over components from the 1992 model year XJS V12.

Extra air valve

Location Left cylinder head, rear

Description The extra air valve is carry-over component from the 1992 model year XJS V12.

Inertia switch

Location Passenger's side A post

Description The inertia switch is carry-over component from the 1992 model year XJS V12.

Air injection solenoid vacuum valve

Location Right cylinder head, front

Description The solenoid vacuum valve is carry-over component from the 1992 model year XJS V12.

Air switching valve

Location Engine, right front

Description The air switching valve is carry-over component from the 1992 model year XJS V12.

Purge valves

Location Charcoal canister

Description The purge valves are solenoid-operated vacuum switching valves identical to the purge valve used in the AJ6 4.0L engine installation.

Purge shut-off valve

Location Charcoal canister

Description The purge shut-off valve is a solenoid-operated vacuum switching valve identical to the supplementary air valve used in the 1992 model year XJS V12.

Ignition amplifier

Location Radiator support, top

Description The electronic ignition amplifier performs primary circuit switching as signaled by the ECM.

Ignition coil

Location Engine vee

Description The ignition coil generates high voltage current for distribution to the spark plugs.

Ignition distributor

Location Engine vee

Description The distributor is a single deck design incorporating sensors for engine speed and crankshaft position. Engine speed output is derived from a Hall effect twelve segment reluctor. The reluctor has an integral inner one segment rotor that generates a crankshaft position output for synchronization of the sequential fuel injection.

Engine Management System Service Aid

Zytek Systems, the supplier of the XJR-S engine management system have developed a computerized engine management service aid consisting of special software run on a standard portable lap-top computer with custom connection to the engine management system. The Zytek service aid allows monitoring of the system under both static and dynamic conditions.

Main menu options

The main menu options are outlined here. Complete information is contained in the XJR-S Product Support Manual.

DYNAMIC DISPLAY OF SYSTEM PARAMETERS

```
COOLANT TEMPERATURE : 193 Deg. F        AIR TEMPERATURE-BANK A : 123 Deg. F
FUEL TEMPERATURE    : 119 Deg. F        AIR TEMPERATURE-BANK B : 143 Deg. F

ENGINE SPEED   : 780 RPM        THROTTLE POSITION     : 323 mV
ROAD SPEED     :   0 MPH        MANIFOLD DEPRESSION : 13.1 InHg

BATTERY VOLTAGE   : 13.9 V   PURGE VALVE VOLTAGE: 11.1 V   AIR PUMP: DISABLED
FUEL TANK VOLTAGE:  11.0 V   AIR COND : ENABLED            PURGE FLOW  :  2 %

LAMBDA A VOLTS: 0.75 V  LAMBDA B VOLTS: 0.39 V   INJECTOR OPEN TIME : 4.47 mS
      LAMBDA GROUND VOLTS: 0.45 V                IGNITION ADVANCE   : 3.4 Deg

▲
DYNAMIC DISPLAY OF SYSTEM PARAMETERS          Press <Q> to return to main menu
```

T850/3.14

Dynamic display of system parameters This option presents a visual display of the engine inputs monitored by the ECM, and the outputs for engine operation from the ECM. The values will be generated with the engine off or running; however, the ignition must be ON for the computer to assemble the information. An expanded explanation of the values and their interpretation is given on pages 20 – 23. Press <Q> to return to the main menu.

DIAGNOSTICS

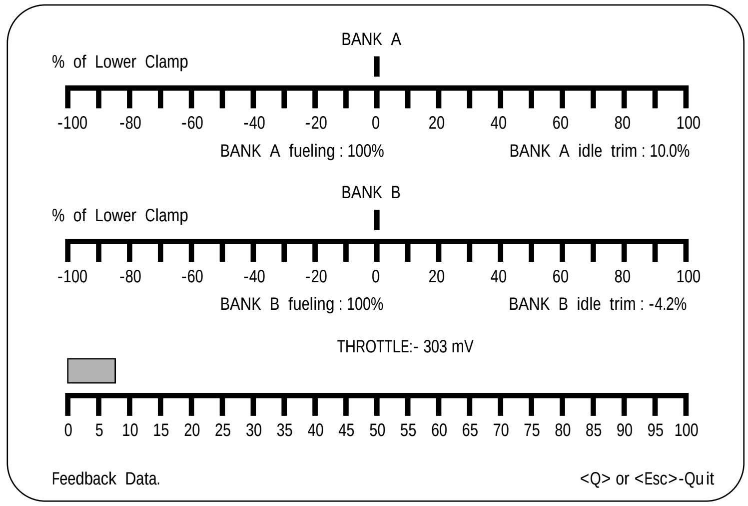
```
                        FAULT CODE ANALYSIS

Total number of Faults found is 1

        Code         Fault
         15     AIR THERMISTOR / WIRING -A BANK

                        DELETE FAULT CODE

          WARNING! Only delete if the fault has been rectified!

Delete #15,AIR THERMISTOR / WIRING -A BANK.  Are You Sure (Y/N)

<D>-Delete Fault          <t  I  PgDn  PgUp> -Select Fault          <Q>-Quit
```

T850/3.15

Diagnostics This option is used only to access and erase Diagnostic Trouble Codes flagged in the ECM memory. No computerized diagnostic routines are provided. Press <Q> to return to the main menu.

Closed loop control data This option displays the ECM closed loop fuel metering control in the form of bar graphs for A and B banks. In addition, the throttle opening is represented as a percent (0 = closed; 100 = wide open). An expanded explanation of the values and their interpretation is given on page 23. Press <Q> to return to the main menu.

CLOSED LOOP CONTROL DATA



T850/3.16

Display program and data identification details This option provides the identification of the software program within the ECM. Switch the ignition ON (do not start the engine) and press <ENTER>. The computer will display the program data. Press <Q> to return to the main menu.

DISPLAY PROGRAM AND DATA IDENTIFICATION DETAILS

Program /data currently in engine control unit:-

Program Identification : EMO00004 CS 6- 7-92

Data Identification : JSFEDL93 CA 17- 6-92

Additional information : -

1993 MODEL YEAR, FEDERAL SPECIFICATION, PRODUCTION DATA-LISTING

DISPLAY IDENTIFICATION DETAILS — Press <Q> to quit

T850/3.17

Set up engine This option provides a step-by-step procedure for engine set up using the computer screen displays. It is not necessary to complete the procedures in sequence as each procedure can be accessed independently. Press <SPACE> to cycle to the next procedure. An expanded explanation of the procedures is given on pages 24 – 25. Press <Q> or <ESCAPE> to return to the main menu.

IMPORTANT: Under normal circumstances, the engine set up procedures should only be carried out after component replacement or engine disassembly and reassembly.

SET UP ENGINE

Before proceeding with the engine set-up function, ensure that the following conditions have been met.

1). Turn the engine OFF.

2). Set the gear selector to PARK or NEUTRAL.

3). Turn the air conditioning unit OFF.

4). Ensure Ignition is off, connect to timing light, then turn ignition on.

5). Be sure that there are no diagnostic faults outstanding.

1). Set up engine. — <Q> or <Esc> quits, <SPACE> cycles to next page

T850/3.18

IGNITION ON; ENGINE STOPPED / COLD (AMBIENT)

COOLANT TEMPERATURE : 68 Deg. F   AIR TEMPERATURE-BANK A : 73 Deg. F
FUEL TEMPERATURE : 71 Deg. F   AIR TEMPERATURE-BANK B : 72 Deg. F

ENGINE SPEED : STOPPED   THROTTLE POSITION : 303 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 30.3 InHg

BATTERY VOLTAGE : 12.1 V   PURGE VALVE VOLTAGE: 9.3 V   AIR PUMP: DISABLED
FUEL TANK VOLTAGE: 9.5 V   AIR COND : ENABLED   PURGE FLOW : 0 %

LAMBDA A VOLTS: 4.71 V   LAMBDA B VOLTS: 4.80 V   INJECTOR OPEN TIME : 65.54mS
LAMBDA GROUND VOLTS: 0.47 V   IGNITION ADVANCE : 0.0 Deg

▼
DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.19

ENGINE AFTER-START WARM UP

COOLANT TEMPERATURE : 75 Deg. F   AIR TEMPERATURE-BANK A : 72 Deg. F
FUEL TEMPERATURE : 71 Deg. F   AIR TEMPERATURE-BANK B : 70 Deg. F

ENGINE SPEED : 880 RPM   THROTTLE POSITION : 303 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 17.8 InHg

BATTERY VOLTAGE : 14.4 V   PURGE VALVE VOLTAGE: 11.2 V   AIR PUMP: ENABLED
FUEL TANK VOLTAGE: 11.3 V   AIR COND : ENABLED   PURGE FLOW : 0 %

LAMBDA A VOLTS: 0.33 V   LAMBDA B VOLTS: 1.02 V   INJECTOR OPEN TIME : 7.90mS
LAMBDA GROUND VOLTS: 0.43 V   IGNITION ADVANCE : 0.0 Deg

▲
DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.20

ENGINE AT IDLE / NORMAL TEMPERATURE

COOLANT TEMPERATURE : 193 Deg. F   AIR TEMPERATURE-BANK A : 123 Deg. F
FUEL TEMPERATURE : 119 Deg. F   AIR TEMPERATURE-BANK B : 143 Deg. F

ENGINE SPEED : 780 RPM   THROTTLE POSITION : 323 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 13.1 InHg

BATTERY VOLTAGE : 13.9 V   PURGE VALVE VOLTAGE: 11.1 V   AIR PUMP: DISABLED
FUEL TANK VOLTAGE: 11.0 V   AIR COND : ENABLED   PURGE FLOW : 2 %

LAMBDA A VOLTS: 0.75 V   LAMBDA B VOLTS: 0.39 V   INJECTOR OPEN TIME : 4.47 mS
LAMBDA GROUND VOLTS: 0.45 V   IGNITION ADVANCE : 3.4 Deg

▲
DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.21

Dynamic Display of System Parameters

By selecting this option from the main menu, the engine inputs monitored by the ECM, and the outputs for engine operation from the ECM will be displayed. The values will be generated with the engine off or running; however, the ignition must be ON for the computer to assemble the information. The information provided in this sub section explains each value and adds additional detail as necessary to the understanding of the value displayed.

Coolant, air and fuel temperatures

The upper box displays coolant temperature, A bank air temperature, B bank air temperature and fuel temperature as input to the ECM from the respective sensors. Sensor temperature is expressed in degrees Fahrenheit. The sensor temperatures will be displayed in one of three possible ways:

- Actual temperature in degrees Fahrenheit
- "Short circuit" indicating a short circuit within the sensor or the sensor circuit.
- "Open circuit" indicating an open circuit within the sensor or the sensor circuit

Engine speed

Engine speed is expressed in rpm (revolutions per minute). The screen displayed value represents the actual engine speed sensed by the ECM from the engine speed sensor.

If "stopped" is displayed during cranking, the ECM is not receiving an engine speed input from the speed sensor.

Throttle position

Throttle opening is expressed as a voltage on a scale of 0 to 5000 mVolts. The throttle position sensor input to the ECM can be observed with the engine stopped and the ignition on. Closed throttle (idle) should indicate very low voltage. As the throttle is opened, the voltage should rise smoothly. When held full open, the voltage should be high and steady.

Road speed
Road speed is expressed in mph. The screen displayed value represents the actual road speed sensed by the ECM from the road speed sensor via the speed interface unit.

Manifold absolute pressure (manifold depression)
Manifold absolute pressure (MAP) is identified as manifold depression on the display. Do not confuse this value with manifold vacuum. Manifold absolute pressure is expressed in inches of mercury (in. hg). When the ignition is switched on (engine stopped) the display should indicate ambient atmospheric pressure (29.92 in. hg at sea level). After starting the engine, the MAP should vary from approximately 13 in. hg at idle to slightly less than ambient atmospheric pressure at full throttle.

Any faults indicated by this display can be detected by static values as the engine modes vary (level surface v climbing grade; idle v acceleration) or by fluctuating values as the engine mode remain steady (idle; cruise on level surface).

Manifold Absolute Pressure (MAP) v Gauge Vacuum (approximate):

MAP	Vacuum	MAP	Vacuum	MAP	Vacuum
30 in hg	0	23 in hg	7 in hg	16 in hg	14 in hg
29 in hg	1 in hg	22 in hg	8 in hg	15 in hg	15 in hg
28 in hg	2 in hg	21 in hg	9 in hg	14 in hg	16 in hg
27 in hg	3 in hg	20 in hg	10 in hg	13 in hg	17 in hg
26 in hg	4 in hg	19 in hg	11 in hg	12 in hg	18 in hg
25 in hg	5 in hg	18 in hg	12 in hg	11 in hg	19 in hg
44 in hg	6 in hg	17 in hg	13 in hg	10 in hg	20 in hg

Battery voltage
Battery voltage as measured by the ECM is displayed.

Purge valve voltage
In order to open the purge shut off valve, the ECM applies voltage to the valve when the ignition is switched on. This voltage is less than battery voltage (approximately 9 - 11.5 V). The displayed value will indicate if the valve is open.

Air injection pump
ENABLED indicates that the air pump flow is being directed to the exhaust ports. DISABLED indicates that the air pump flow is being diverted to the right air cleaner.

Fuel tank level (voltage)
The fuel tank level is expressed as a voltage measured directly from the fuel tank level sender and ranges from 2 to 10 volts (full to empty). Diagnostic trouble codes related to engine fueling are disabled when the fuel level is below 6.5 gallons.

Air conditioning compressor
ENABLED indicates that the compressor clutch override circuit is not activated thus allowing compressor operation. DISABLED indicates that the override circuit is activated thus preventing compressor operation.

Purge flow
The % value indicates if the purge valves are open allowing canister purging. 0% indicates that the valves are closed. The value at idle (engine at normal operating temperature) will be approximately 2%. Above idle, the % value will vary above 2% depending on engine operating conditions.

Dynamic Display of System Parameters (continued)

IGNITION ON; ENGINE STOPPED / COLD (AMBIENT)

COOLANT TEMPERATURE : 68 Deg. F   AIR TEMPERATURE-BANK A : 73 Deg. F
FUEL TEMPERATURE : 71 Deg. F   AIR TEMPERATURE-BANK B : 72 Deg. F

ENGINE SPEED : STOPPED   THROTTLE POSITION : 303 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 30.3 InHg

BATTERY VOLTAGE : 12.1 V   PURGE VALVE VOLTAGE: 9.3 V   AIR PUMP: DISABLED
FUEL TANK VOLTAGE: 9.5 V   AIR COND : ENABLED   PURGE FLOW : 0 %

LAMBDA A VOLTS: 4.71 V   LAMBDA B VOLTS: 4.80 V
LAMBDA GROUND VOLTS: 0.47 V

INJECTOR OPEN TIME : 65.54mS
IGNITION ADVANCE : 0.0 Deg

▼

DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.19

ENGINE AFTER-START WARM UP

COOLANT TEMPERATURE : 75 Deg. F   AIR TEMPERATURE-BANK A : 72 Deg. F
FUEL TEMPERATURE : 71 Deg. F   AIR TEMPERATURE-BANK B : 70 Deg. F

ENGINE SPEED : 880 RPM   THROTTLE POSITION : 303 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 17.8 InHg

BATTERY VOLTAGE : 14.4 V   PURGE VALVE VOLTAGE: 11.2 V   AIR PUMP: ENABLED
FUEL TANK VOLTAGE: 11.3 V   AIR COND : ENABLED   PURGE FLOW : 0 %

LAMBDA A VOLTS: 0.33 V   LAMBDA B VOLTS: 1.02 V
LAMBDA GROUND VOLTS: 0.43 V

INJECTOR OPEN TIME : 7.90mS
IGNITION ADVANCE : 0.0 Deg

▲

DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.20

ENGINE AT IDLE / NORMAL TEMPERATURE

COOLANT TEMPERATURE : 193 Deg. F   AIR TEMPERATURE-BANK A : 123 Deg. F
FUEL TEMPERATURE : 119 Deg. F   AIR TEMPERATURE-BANK B : 143 Deg. F

ENGINE SPEED : 780 RPM   THROTTLE POSITION : 323 mV
ROAD SPEED : 0 MPH   MANIFOLD DEPRESSION : 13.1 InHg

BATTERY VOLTAGE : 13.9 V   PURGE VALVE VOLTAGE: 11.1 V   AIR PUMP: DISABLED
FUEL TANK VOLTAGE: 11.0 V   AIR COND : ENABLED   PURGE FLOW : 2 %

LAMBDA A VOLTS: 0.75 V   LAMBDA B VOLTS: 0.39 V
LAMBDA GROUND VOLTS: 0.45 V

INJECTOR OPEN TIME : 4.47 mS
IGNITION ADVANCE : 3.4 Deg

▲

DYNAMIC DISPLAY OF SYSTEM PARAMETERS   Press <Q> to return to main menu

T850/3.21

Oxygen sensor (Lambda) ground voltage

The voltage of the ground sensing circuit between the ECM, the A bank intake manifold stud and the engine ground is displayed. With the ignition switched on (engine stopped) the ground signal voltage should read 0.4 - 0.55 V.

Injector open time (pulse duration)

Injector pulse duration is expressed in milliseconds. The screen displayed value represents the actual pulse duration output from the ECM for the prevailing engine operating condition. The pulse duration should increase and decrease as engine speed and load (MAP) varies.

Ignition advance

The actual ignition timing as referenced from the synchronization sensor is displayed.

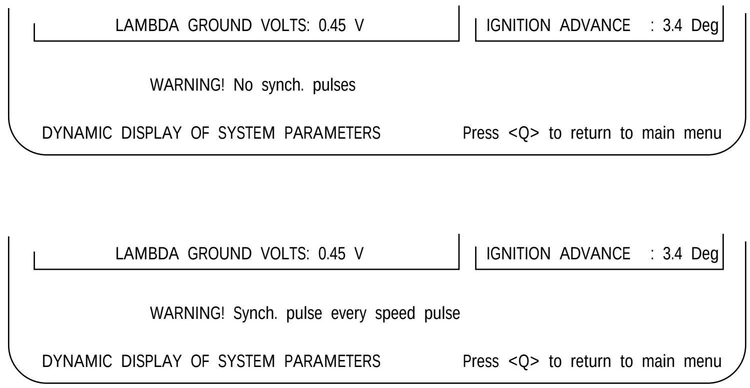
NOTE: It is possible for this timing to be incorrect if the distributor is not referenced to the crankshaft.

Synchronization sensor

There is no value display for the synchronization sensor output. Two possible warnings may be displayed at the bottom of the screen:

The No synch. pulses warning indicates that the ECM is not receiving the synchronization pulse to identify cylinder A 1 at T.D.C. The Synch. pulse every speed pulse warning indicates that the ECM is receiving 12 synchronization pulses each engine cycle instead of just one. Either warning identifies a fault in the synchronization sensor or engine speed sensor and/or circuits.

SYNCHRONIZATION WARNINGS



T850/3.22

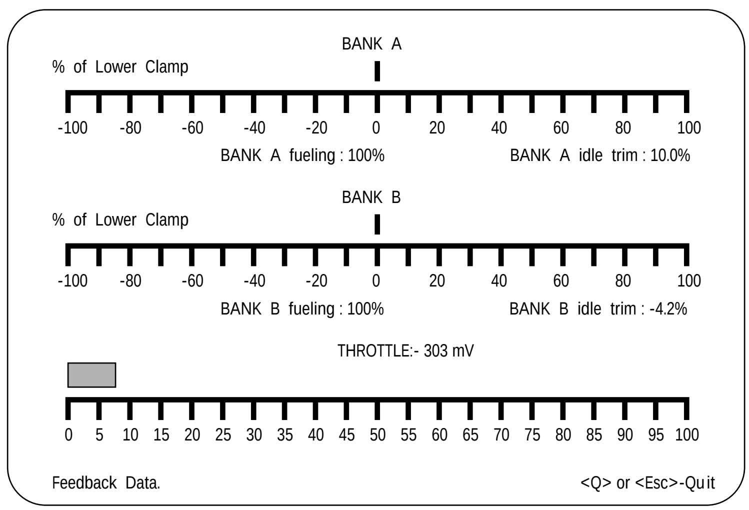
Oxygen Sensor Feedback Data / Throttle Position (Closed Loop Control Data)

By selecting this option from the main menu, the operation of the closed loop fuel metering control will be displayed. Values will be displayed only when the engine is running in closed loop control mode (the oxygen sensors are controlling fuel metering).

The display includes two bar graphs indicating the idle fuel metering trim for each bank and a bar graph indicating throttle opening as a percent (0 = closed; 100 = wide open). After starting the engine and bringing it to normal operating temperature, the ECM outputs will control the idle fuel metering trim. As the ECM attempts to maintain the optimum air/fuel ratio, the bars on the graphs should "hunt" to either side of the zero position. The graph scales represent how close to the optimum idle fuel metering strategy the system is operating. The center of the scales (100%) is optimum. Idle trim is adjustable.

NOTE: A slight deviation between A and B bank fueling is acceptable.

CLOSED LOOP CONTROL DATA



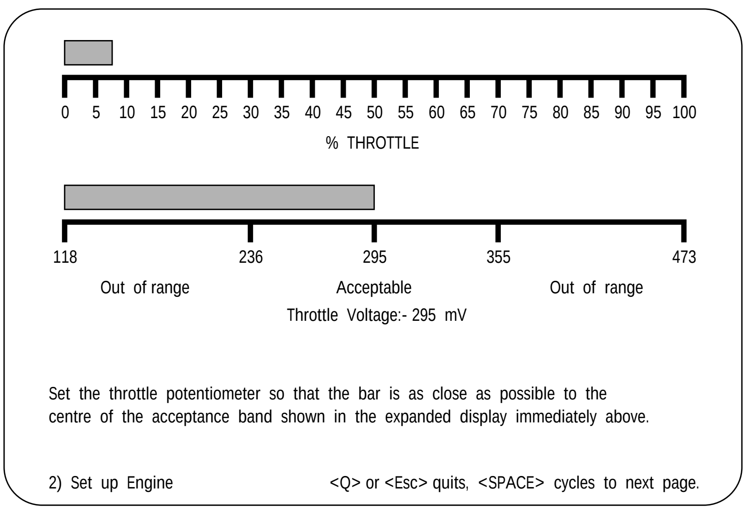
T850/3.23

Engine Set Up

The Zytek Engine Management Service Aid provides an Engine Set Up option in a step-by-step procedure. Many of the displays for the procedures can be used for system operating analysis as an aid to fault diagnosis. It is not necessary to run the procedures in sequence as each item can be accessed independently as long as the engine is running.

IMPORTANT: Under normal circumstances, the engine set up procedures should only be carried out after component replacement or engine disassembly and reassembly.

THROTTLE POSITION SENSOR



T850/3.24

Throttle position sensor

Two bar graphs are displayed for the throttle position sensor check. The upper graph indicates throttle opening as a percent (0 = closed; 100 = wide open). The lower graph displays the output voltage from the throttle position sensor as measured by the ECM. With the throttle closed (idle), the voltage should be within the acceptable range: 236-355 mV. If adjustment is necessary, attempt to center the bar at 295 mV. Adjust only if the voltage is outside the acceptable range.

Throttle linkage adjustment

Three screens cover a verbal description of a complete throttle linkage adjustment. This procedure should not be necessary during normal service or fault diagnosis.

Ignition advance

After starting the engine and ensuring that the displayed conditions are met, the actual ignition timing advance as referenced from the synchronization sensor will be fixed at 10 Deg. It is possible for this timing to be incorrect if the distributor is not correctly referenced to the crankshaft. The reference to the crankshaft can be checked by using a timing strobe light to check the engine timing marks on the front pulley. If necessary, adjust the distributor to 10 Deg. B.T.D.C. when observed at the crankshaft pulley. Exiting this screen will cause the ignition timing to revert to control by the ECM strategy.

IGNITION ADVANCE

If the following conditions have been met, the ignition will be fixed to a constant advance angle of 10 Deg. Exiting this page will cause the ignition to revert to the normal settings. Parameters shown in highlights are those which are out of limits. The advance will not be fixed until these parameters are brought within the limits stated.

ENSURE THAT;

Water temperature is greater than 165 F	Current value is:	188 F
Engine speed is between 100 and 1000 RPM	Current value is:	831 RPM
Throttle is set between 276 and 335mV	Current value is:	308mV
Road speed is zero	Current value is:	0 MPH
No faults are present	System is currently:	OK

Ignition fixed at 10 Deg.

Adjust distributor if required to give 10 Deg when measured at the crank pulley.

7) Set up engine. <Q> or <Esc> quits, <SPACE> cycles to next page

T850/3.25

Idle speed

Idle speed is adjusted at the extra air valve idle bleed screw. If necessary, adjust the speed to 750 rpm.

ECM idle fuel trim

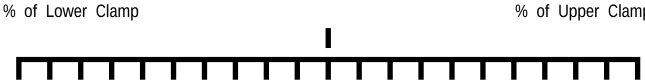
The closed loop control system automatically adjusts the idle fuel metering, however; to correctly position the idle fueling on the ECM strategy, the ECM idle fuel trim can be adjusted. Before adjustment, stop the engine and disconnect the purge line at the B bank intake manifold. Block off the intake manifold port.

The displayed bar graph is for B bank; therefore, keep in mind that the adjustment will affect both banks as observed in the Oxygen Sensor Feedback Data / Throttle Position option. Start the engine and allow to idle for at least one minute. Use the left and right arrow keys on the computer to adjust the trim so that the bar "hunts" to either side of the zero position. Before exiting this screen, press <S> to save the trim adjustment.

IDLE FUEL TRIM

<T> - show trim relevant parameters, <S> - save trim in ECU
← decrease trim ( ) → increase trim

% of Lower Clamp % of Upper Clamp



-100 -80 -60 -40 -20 0 20 40 60 80 100

fueling : 100% idle trim : 3.1%

Set the idle fuel trim potentiometer to cause the feedback bar shown above to oscillate equally about the zero position

10) Set up Engine <Q> or <Esc> quits, <SPACE> cycles to next page.

T850/3.26

Student Proficiency Test
ANSWER SHEET

Instructions

1. Complete all of the information in the Student Information section of this sheet.
2. Read the questions and possible answers provided on the blue colored test sheets and record your answers on this sheet. Answer the questions based only on the information provided in the 801S EMS Self Study book.
3. When complete, fax or mail only the answer sheet to:

   Jaguar Cars Service Training Department
   ATTN: Service Training Administrator
   555 MacArthur Boulevard
   Mahwah, New Jersey 07430

   FAX: (201) 818-9074

Student Information

Name ______________________________ Date of birth ______________

Social Security # ☐ ☐ ☐ – ☐ ☐ – ☐ ☐ ☐ ☐

Dealer Name ______________________________ Dealer # ______________

Address ____

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801S Test Answers

Mark an X in the box adjacent to your answer for each question.

1.	☐ A	☐ B	☐ C	☐ D	16.	☐ A	☐ B	☐ C	☐ D
2.	☐ A	☐ B	☐ C	☐ D	17.	☐ A	☐ B	☐ C	☐ D
3.	☐ A	☐ B	☐ C	☐ D	18.	☐ A	☐ B	☐ C	☐ D
4.	☐ A	☐ B	☐ C	☐ D	19.	☐ A	☐ B	☐ C	☐ D
5.	☐ A	☐ B	☐ C	☐ D	20.	☐ A	☐ B	☐ C	☐ D
6.	☐ A	☐ B	☐ C	☐ D	21.	☐ A	☐ B	☐ C	☐ D
7.	☐ A	☐ B	☐ C	☐ D	22.	☐ A	☐ B	☐ C	☐ D
8.	☐ A	☐ B	☐ C	☐ D	23.	☐ A	☐ B	☐ C	☐ D
9.	☐ A	☐ B	☐ C	☐ D	24.	☐ A	☐ B	☐ C	☐ D
10.	☐ A	☐ B	☐ C	☐ D	25.	☐ A	☐ B	☐ C	☐ D
11.	☐ A	☐ B	☐ C	☐ D	26.	☐ A	☐ B	☐ C	☐ D
12.	☐ A	☐ B	☐ C	☐ D	27.	☐ A	☐ B	☐ C	☐ D
13.	☐ A	☐ B	☐ C	☐ D	28.	☐ A	☐ B	☐ C	☐ D
14.	☐ A	☐ B	☐ C	☐ D	29.	☐ A	☐ B	☐ C	☐ D
15.	☐ A	☐ B	☐ C	☐ D	30.	☐ A	☐ B	☐ C	☐ D