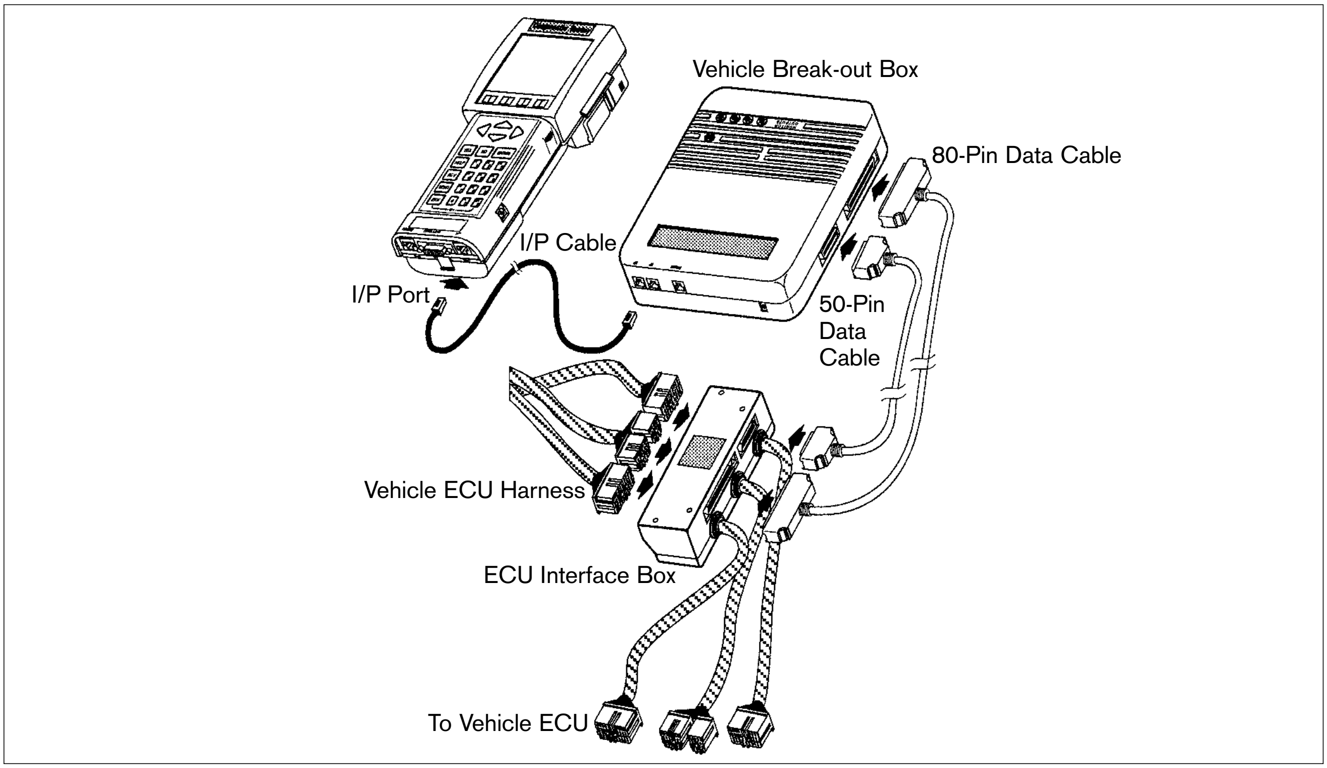
Section 1

Introduction to Engine Control System Processes and Diagnostic Tools



Learning Objectives:

1. Perform a general diagnostic process regardless of the type of customer concern on ECU controlled systems.
2. Utilize advanced diagnostic tools for greater accuracy and speed.
3. Lay out the troubleshooting steps and resources you will need to follow when diagnosing customer concerns.

Section 1

Introduction to Engine Control System Processes and Diagnostic Tools

Overview

The purpose of this section is to:

- help you understand the general diagnostic process that you will follow regardless of the type of customer concern you are troubleshooting.
- features of diagnostic tools that will help you with greater accuracy and speed.
- lay out the troubleshooting steps and resources you will need to follow when diagnosing customer concerns.

Diagnostic Tools and Resources

There are many troubleshooting "tools" that can be used to accurately identify and troubleshoot driveability problems. These include:

- Previous Troubleshooting Experience
- Use of the OBD self-diagnostic system
- Service Literature – Technical Information System (TIS), Repair Manuals, Electrical Wiring Diagrams, and Technical Service Bulletins
- Diagnostic Toolset
- TechView

There are also other resources at your disposal for those extraordinary situations where your best attempts fail to resolve the customer concerns:

- Technical Assistance hotline
- Area office assistance; STSs, FTSs, and FPEs

With these resources available to you, even the most difficult customer concerns can be resolved while maintaining high standards for customer satisfaction.

Previous Troubleshooting Experience

Your experience is one of the best resources you have. Depending on the symptom or customer description of the driveability concern, you can often eliminate many sub-systems from your diagnostic investigations. It is important to note, however, this does not mean that troubleshooting is performed in a random manner. In fact, you will always fix the car faster and with more accuracy when you follow a systematic diagnostic approach.

Use of the On-Board (Self) Diagnostic System

All ECMs are equipped with an on-board self-diagnostic system (OBD). This system is capable of detecting shorts and opens in most sensor electrical circuits and in some actuator circuits. Later models equipped with the OBD II system can also detect component and system performance.

These OBD systems are an integral part of your troubleshooting process and will weigh heavily in your diagnostic outcome.

Diagnostic Toolset

The Diagnostic Toolset consists of the Diagnostic Tester and the Vehicle Break-out Box (V-BoB). Depending on the vehicle you are working on and the nature of the customer concern, both of these tools are extremely valuable for gathering large quantities of diagnostic data in a relatively short period of time. For troubleshooting engine control system concerns, the Diagnostic Toolset allows you to quickly perform the following functions:

- Read and define Diagnostic Trouble Codes (DTCs)
- Display serial data stream containing sensor, actuator, and diagnostic information
- Display signal voltages on a fully adjustable laboratory oscilloscope
- Store and playback snapshot data.
- Test sensors and actuators dynamically using Active Tests
- All CARB OBD II functions

Diagnostic Toolset with TIS

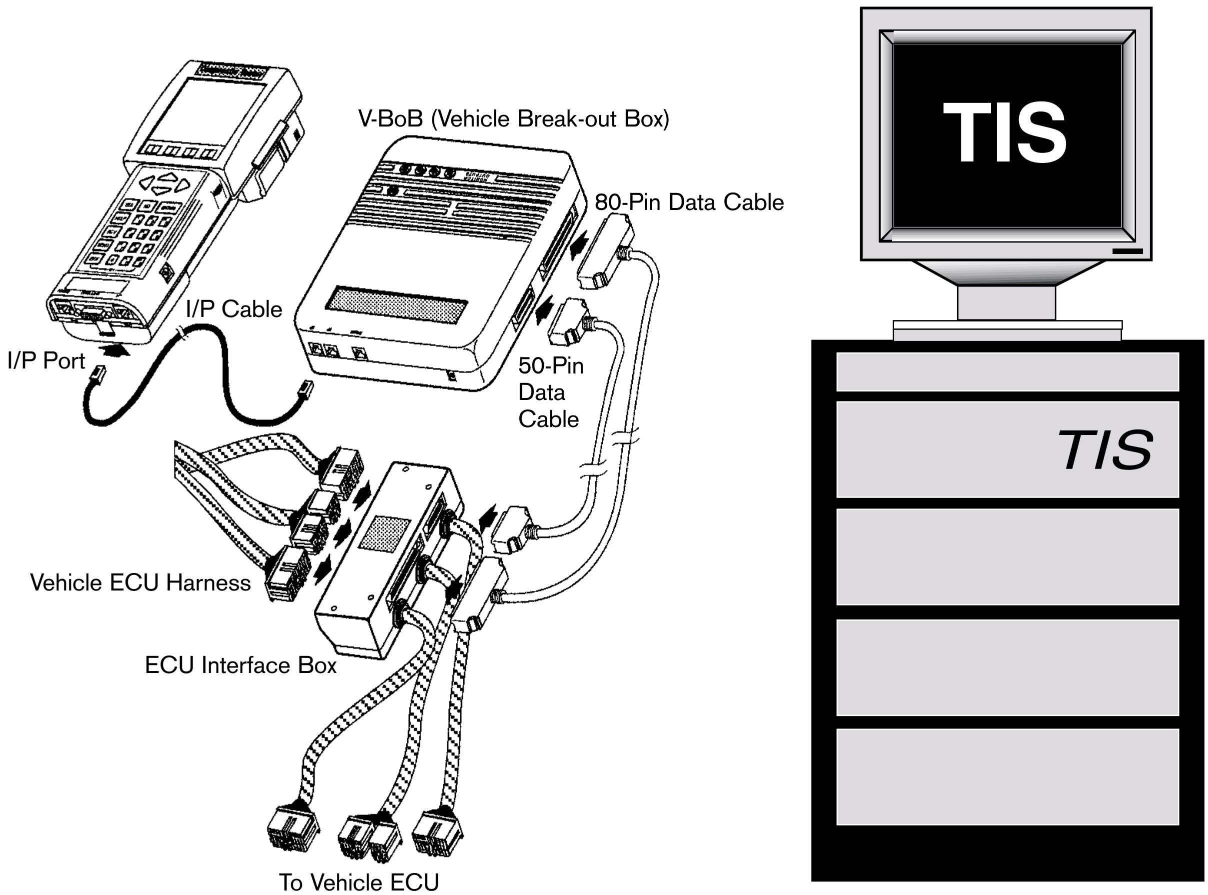


Fig. 1-1

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TechView

TechView is a computer-based program that works hand in hand with the Diagnostic Tester. This tool aids in collecting live data from the vehicle where the technician can view the data in a variety of formats (graphs, charts, lists) and store files for later viewing. Some of the TechView features include:

- Real Time Data List
- Tester Snapshot Data
- DTC Information
- OBD System Monitors
- Freeze Frame Data
- File Information

Each technician creates a user name where all of the vehicle information is stored and can be used again for future reference.

Before using the Diagnostic Tester, the Diagnostic Toolset Manual should be read thoroughly.

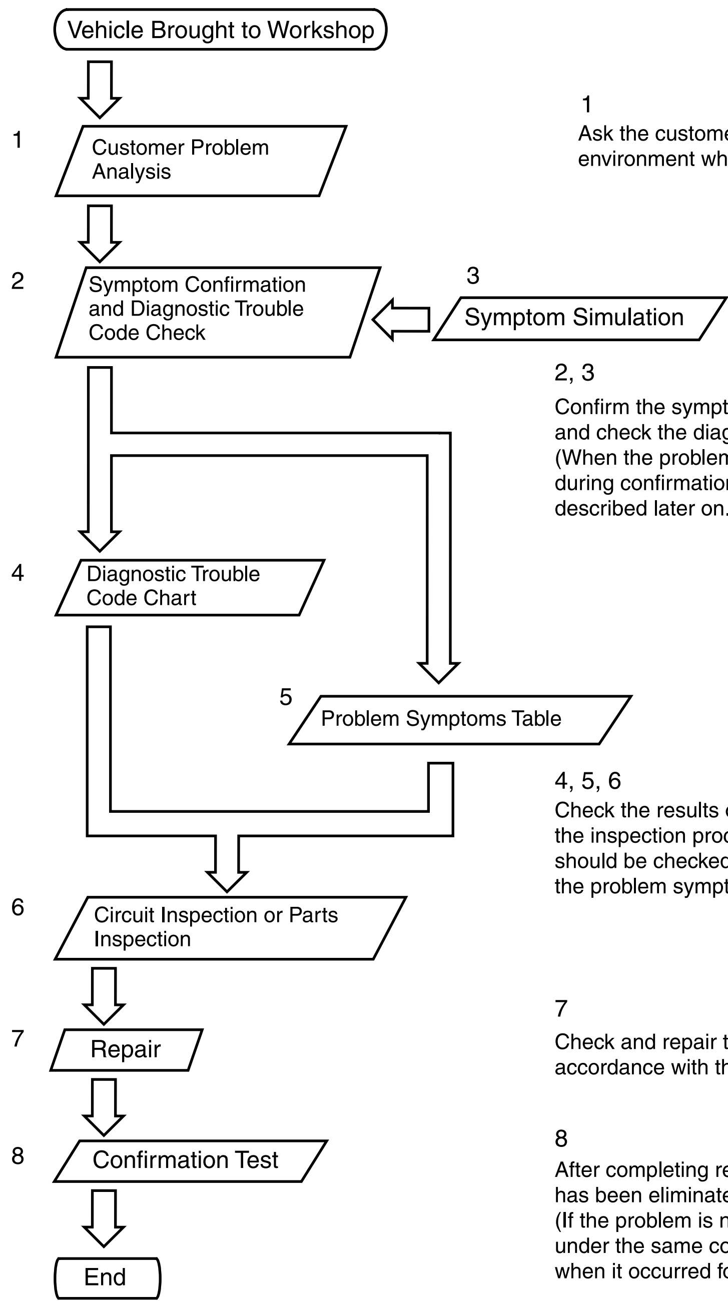
General OBD II Scan Tool or Diagnostic (Hand-held) Tester Procedure

If the Diagnsotic Tester cannot communicate with ECU controlled systems when connected to DLC3, the ignition switch is ON, and the Diagnostic Tester is on, there is a problem on the vehicle side or tool side.

(1)If communication is normal when the Diagnostic Tester is connected to another vehicle, inspect the diagnosis data link line (Bus≈line) or ECM (ECU) power circuit of the vehicle.

(2)If communication is still not possible when the Diagnostic Tester is connected to another vehicle, the problem is probably in the Diagnostic Tester itself, so perform the Self Test procedures outline in the Diagnostic Toolset Operator's Manual.

Customer Problem Analysis



1
Ask the customer about the conditions and the environment when the problem occurred

2, 3
Confirm the symptoms and the problem condition and check the diagnostic trouble codes.
(When the problem symptoms do not appear during confirmation, use the symptom simulation method described later on.)

4, 5, 6
Check the results obtained in Step 2, then confirm the inspection procedure for the system or the part which should be checked using the diagnostic trouble code chart or the problem symptoms table.

7
Check and repair the affected system or part in accordance with the instructions in Step 6.

8
After completing repairs, confirm that the problem has been eliminated.
(If the problem is not reproduced, perform the confirmation test under the same conditions and in the same environment as when it occurred for the first time.)

Fig. 1-2

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Customer Problem Analysis (1)

In troubleshooting, the problem symptoms must be confirmed accurately and all preconceptions must be cleared away to give an accurate judgment. To ascertain just what the problem symptoms are, it is extremely important to ask the customer about the problem and the conditions at the time it occurred.

Important Point in the Problem Analysis

The following five items are important points in the problem analysis. Past problems which are thought to be unrelated and the repair history, etc., may also help in some cases, so as much information as possible should be gathered and its relationship with the problem symptoms should be correctly ascertained for reference in troubleshooting. A customer problem analysis table is provided in the Diagnostics section for each system for your use.

The Five Major Questions

Important Points in the Customer Problem Analysis

- What?... Vehicle model, system name
- When?... Date, time, occurrence frequency
- Where?... Road conditions
- Under what conditions?... Running conditions, driving conditions, weather conditions
- How did it happen?... Problem symptoms

Fig. 1-3
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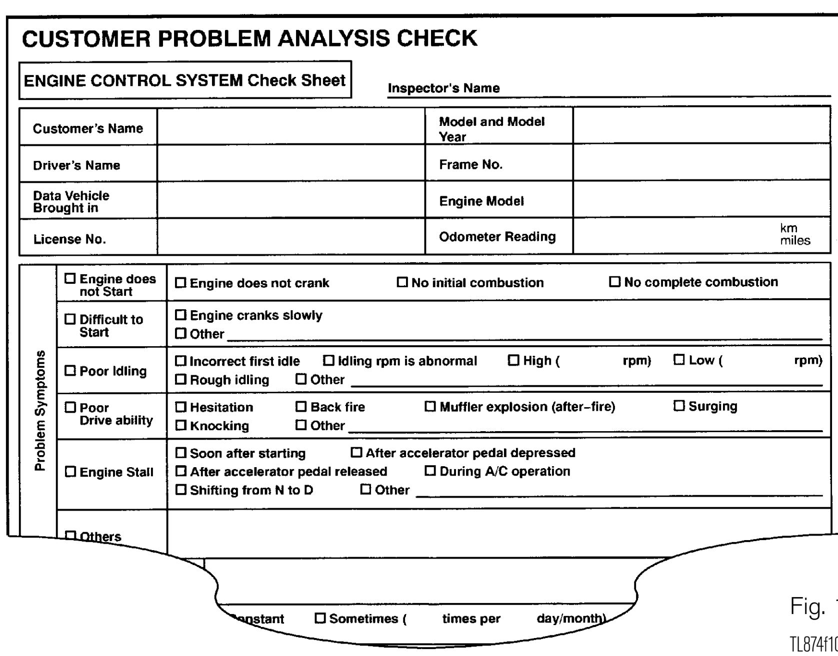
Customer Problem Analysis Check Sheet



CUSTOMER PROBLEM ANALYSIS CHECK

ENGINE CONTROL SYSTEM Check Sheet — Inspector's Name

Customer's Name		Model and Model Year	
Driver's Name		Frame No.	
Data Vehicle Brought in		Engine Model	
License No.		Odometer Reading	km miles

Problem Symptoms	☐ Engine does not Start	☐ Engine does not crank ☐ No initial combustion ☐ No complete combustion
	☐ Difficult to Start	☐ Engine cranks slowly ☐ Other
	☐ Poor Idling	☐ Incorrect first idle ☐ Idling rpm is abnormal ☐ High (rpm) ☐ Low (rpm) ☐ Rough idling ☐ Other
	☐ Poor Drive ability	☐ Hesitation ☐ Back fire ☐ Muffler explosion (after–fire) ☐ Surging ☐ Knocking ☐ Other
	☐ Engine Stall	☐ Soon after starting ☐ After accelerator pedal depressed ☐ After accelerator pedal released ☐ During A/C operation ☐ Shifting from N to D ☐ Other
	☐ Others	

...nstant ☐ Sometimes (times per day/month)

Fig. 1-4
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Symptom Confirmation and Diagnostic Trouble Code Check (2)

The diagnostic system fulfills various functions. The first function is the Diagnostic Trouble Code Check. A malfunction in the signal circuits to the ECM is stored in code in the ECM's memory at the time of occurrence. This DTC is retrieved by the technician during troubleshooting.

Another function is the Input Signal Check, which checks if the signals from various switches are sent to the ECM correctly. By using these check functions, the problem areas can be narrowed down quickly and troubleshooting can be performed effectively.

In diagnostic trouble code check, it is very important to determine if the problem indicated by the diagnostic trouble code is present or occurred in the past and returned to normal.

In addition, it must be checked in the problem symptom check whether the malfunction indicated by the diagnostic trouble code is directly related to the problem symptom or not. For these reasons, the diagnostic trouble codes should be checked before and after the symptom confirmation to determine the current conditions, as shown in the following figure.

If this is not done, it may, depending on the case, result in unnecessary troubleshooting for normally operating systems, thus making it more difficult to locate the problem, or in repairs not pertinent to the problem. Therefore, always follow the procedure in correct order and perform the diagnostic trouble code check.

DTC Check Procedure

DIAGNOSTIC TROUBLE CODE CHECK PROCEDURE

Diagnostic Trouble Code Check (Make a note of and then clear)	Confirmation of Symptoms	Diagnostic Trouble Code Check	Problem Condition
Diagnostic Trouble Code Display	Problem symptoms exist	Same diagnostic trouble code is displayed	Problem is still occuring in the diagnostic circuit
		Normal code is displayed	The problem is still occurring in a place other than in the diagnostic circuit (The diagnostic trouble code displayed first is either for a past problem or it is a secondary problem)
	No problem symptoms exist		The problem occurred in the diagnostic circuit in the past
Normal Code Display	Problem symptoms exist	Normal code is displayed	The problem is still occurring in a place other than in the diagnostic circuit
	No problem symptoms exist	Normal code is displayed	The problem occurred in a place other than in the diagnostic circuit in the past

Fig. 1-5

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DTC Check Procedure

Taking into account the points on the previous page, a flow chart showing how to proceed with troubleshooting using the diagnostic trouble code check is shown here. This flow chart shows how to utilize the diagnostic trouble code check effectively, then by carefully checking the results, indicates how to proceed either to diagnostic trouble code troubleshooting or to troubleshooting of problem symptoms table.

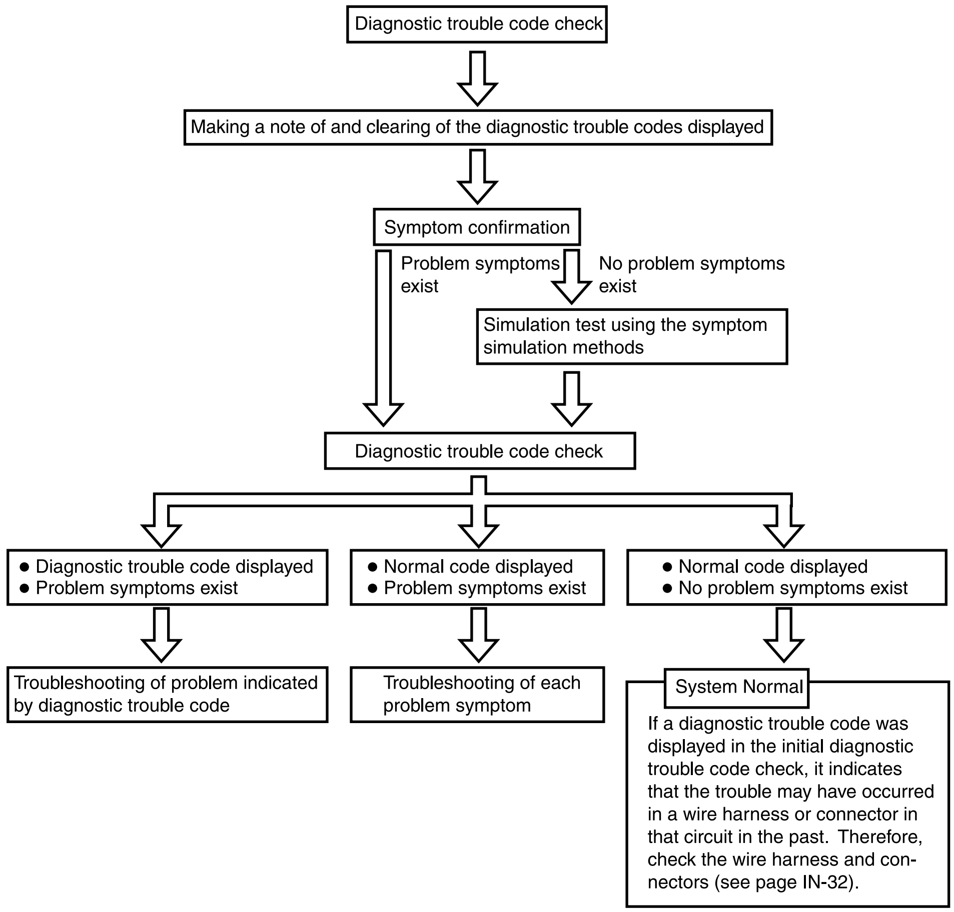

Fig. 1-6

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Symptom Simulation (3)

The most difficult cases to diagnose is when no problem symptoms are occurring. In such cases, a thorough customer problem analysis must be carried out, then simulate the same or similar conditions and environment in which the problem occurred in the customer's vehicle.

No matter how much experience or how skilled the technician is, to proceed to troubleshoot without confirming the problem symptoms will often result in wasted time and failure to resolve the customer concerns. For example, for a problem which only occurs when the engine is cold, the problem can never be determined so long as the symptoms are confirmed when the engine is hot.

Since vibration, heat or water penetration (moisture) are likely causes for problems that are difficult to reproduce, the symptom simulation tests introduced here are effective measures to apply to the vehicle.

Important Points in the Symptom Simulation Test:
In the symptom simulation test, the problem symptoms should of course be confirmed, but the problem area or parts must also be found out. To do this, narrow down the possible problem circuits according to the symptoms before starting this test and connect a tester beforehand. After that, carry out the symptom simulation test, judging whether the circuit being tested is defective or normal and also, confirming the problem symptoms at the same time.

Refer to the problem symptoms table for each system to narrow down the possible causes of the symptom.

Vibration Method

Do not do this until you have confirmed that the recorded DTC is not present.

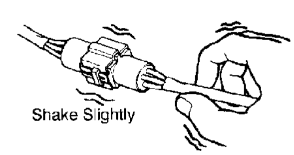
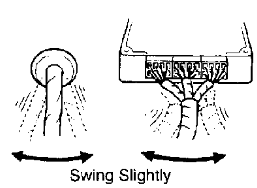
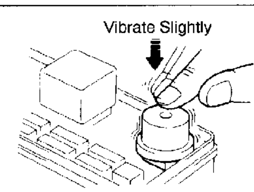
1	VIBRATION METHOD: When vibration seems to be the major cause.
CONNECTORS Slightly shake the connector vertically and horizontally.	
WIRE HARNESS Slightly shake the wire harness vertically and horizontally. The connector joint, fulcrum of the vibration, and body through portion are the major areas to be checked thoroughly.	
PARTS AND SENSOR Apply slight vibration with a finger to the part of the sensor considered to be the problem cause and check that the malfunction occurs. HINT: Applying strong vibration to relays may result in open relays.	

Fig. 1-7

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Other Methods for Simulating Conditions

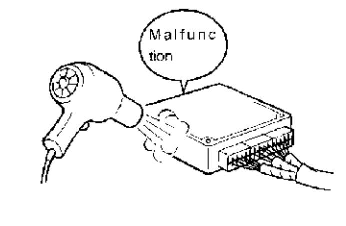
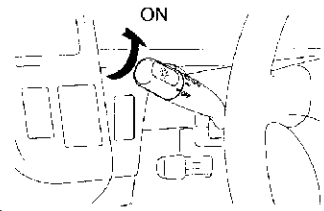
2	**HEAT METHOD: When the problem seems to occur when the suspect area is heated.**
Heat the component that is the likely cause of the malfunction with a hair dryer or similar object. Check to see if the malfunction occurs. NOTICE: **(1) Do not heat to more than 60 °C (140 °F). (Temperature is limited not to damage the components.)** **(2) Do not apply heat directly to parts in the ECU.**	 FI2334
3	**WATER SPRINKLING METHOD: When the malfunction seems to occur on a rainy day or in a high-humidity condition.**
Sprinkle water onto the vehicle and check to see if the malfunction occurs. NOTICE: **(1) Never sprinkle water directly into the engine compartment, but indirectly change the temperature and humidity by applying water spray onto the radiator front surface.** **(2) Never apply water directly onto the electronic components.** HINT: If a vehicle is subject to water leakage, the leaked water may contaminate the ECU. When testing a vehicle with a water leakage problem, special caution must be taken.	 FI6649
4	**OTHER: When a malfunction seems to occur when electrical load is excessive.**
Turn on all electrical loads including the heater blower, head lights, rear window defogger, etc. and check to see if the malfunction occurs.	 B02389

Fig. 1-8

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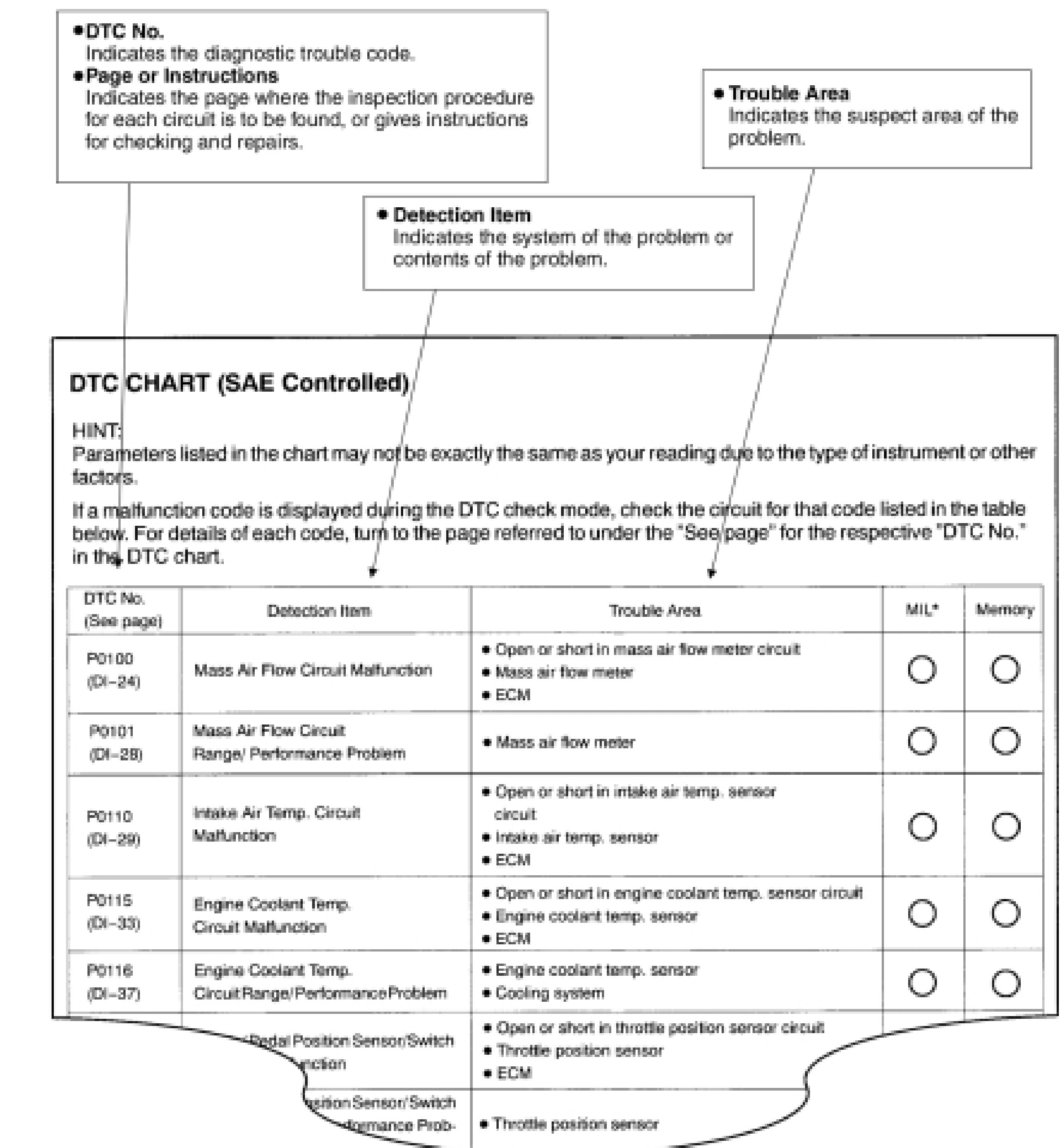
Diagnostic Troubleshooting Check (4)

The inspection procedure is shown in the following figure. This table permits efficient and accurate troubleshooting using the diagnostic trouble codes displayed in the diagnostic trouble code check. Proceed with troubleshooting in accordance with the inspection procedure given in the diagnostic chart corresponding to the diagnostic trouble codes displayed

DTC Chart



DTC CHART (SAE Controlled)

HINT:
Parameters listed in the chart may not be exactly the same as your reading due to the type of instrument or other factors.

If a malfunction code is displayed during the DTC check mode, check the circuit for that code listed in the table below. For details of each code, turn to the page referred to under the "See page" for the respective "DTC No." in the DTC chart.

DTC No. (See page)	Detection Item	Trouble Area	MIL*	Memory
P0100 (DI–24)	Mass Air Flow Circuit Malfunction	• Open or short in mass air flow meter circuit • Mass air flow meter • ECM	○	○
P0101 (DI–28)	Mass Air Flow Circuit Range/ Performance Problem	• Mass air flow meter	○	○
P0110 (DI–29)	Intake Air Temp. Circuit Malfunction	• Open or short in intake air temp. sensor circuit • Intake air temp. sensor • ECM	○	○
P0115 (DI–33)	Engine Coolant Temp. Circuit Malfunction	• Open or short in engine coolant temp. sensor circuit • Engine coolant temp. sensor • ECM	○	○
P0116 (DI–37)	Engine Coolant Temp. Circuit Range/Performance Problem	• Engine coolant temp. sensor • Cooling system	○	○
	...Pedal Position Sensor/Switch ...nction	• Open or short in throttle position sensor circuit • Throttle position sensor • ECM		
	...sition Sensor/Switch ...formance Prob-	• Throttle position sensor		

Fig. 1-9

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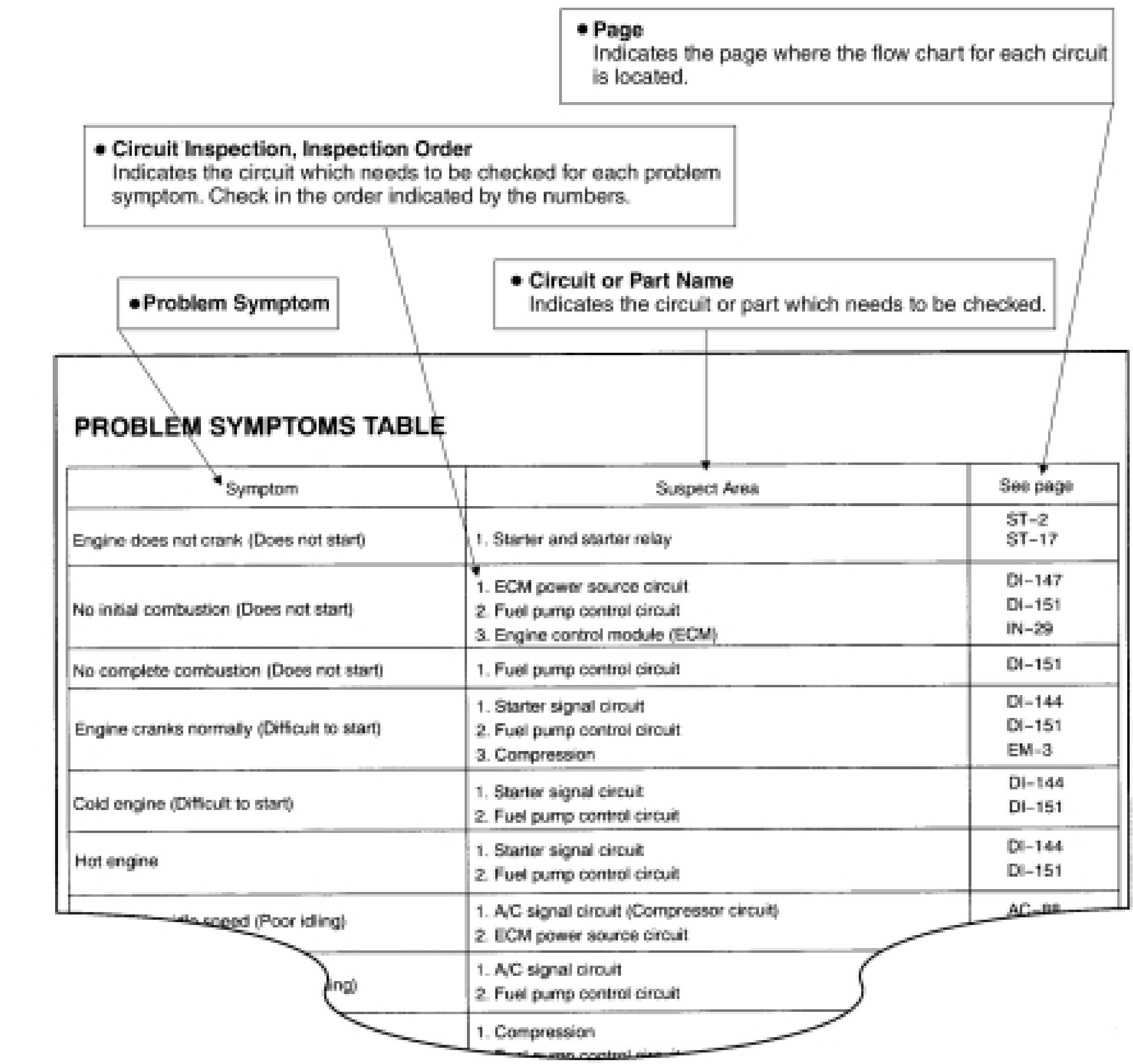
Problem Symptoms Table (5)

The suspected circuits or parts for each problem symptom are shown in the table below. Use this table to troubleshoot the problem when a "Normal" code is displayed in the diagnostic trouble code check but the problem is still occurring. Numbers in the table indicate the inspection order in which the circuits or parts should be checked.

When the problem is not detected by the diagnostic system even though the problem symptom is present, it is considered that the problem is occurring outside the detection range of the diagnostic system, or that the problem is occurring in a system other than the diagnostic system.

Problem Symptoms Table



Symptom	Suspect Area	See page
Engine does not crank (Does not start)	1. Starter and starter relay	ST-2 ST-17
No initial combustion (Does not start)	1. ECM power source circuit 2. Fuel pump control circuit 3. Engine control module (ECM)	DI-147 DI-151 IN-29
No complete combustion (Does not start)	1. Fuel pump control circuit	DI-151
Engine cranks normally (Difficult to start)	1. Starter signal circuit 2. Fuel pump control circuit 3. Compression	DI-144 DI-151 EM-3
Cold engine (Difficult to start)	1. Starter signal circuit 2. Fuel pump control circuit	DI-144 DI-151
Hot engine	1. Starter signal circuit 2. Fuel pump control circuit	DI-144 DI-151
...idle speed (Poor idling)	1. A/C signal circuit (Compressor circuit) 2. ECM power source circuit	AC-...
...ing)	1. A/C signal circuit 2. Fuel pump control circuit	
	1. Compression	

Fig. 1-10

TL874f110

Circuit Inspection (6)

How to read and use each page is shown in the following figures. This chart provides the procedure to diagnose a circuit or system. Often, you will use the Diagnostic Tester, DVOM, or oscilloscope to diagnose faults in a circuit.

Circuit Inspection

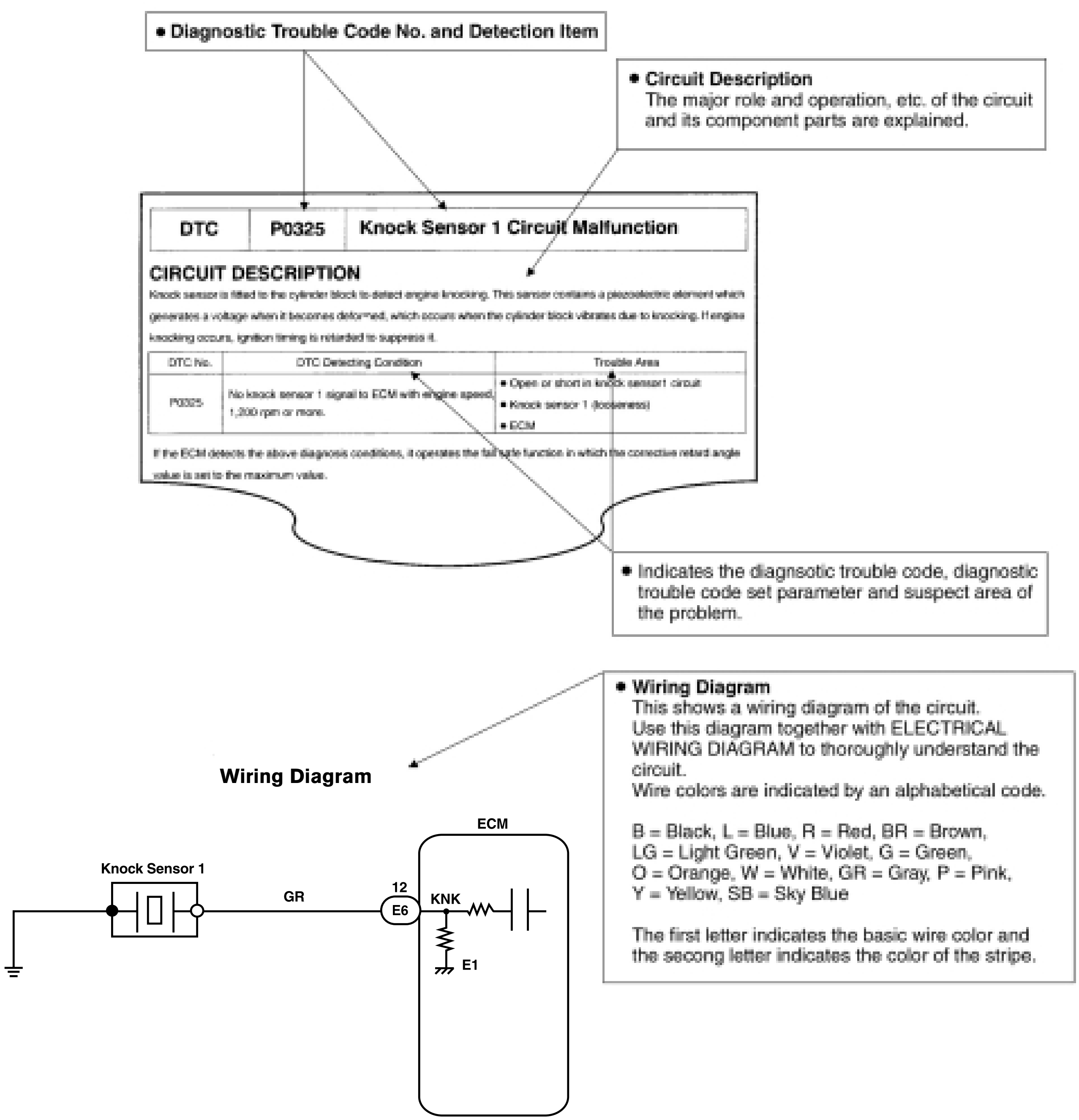


Fig. 1-11

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Inspection Procedure

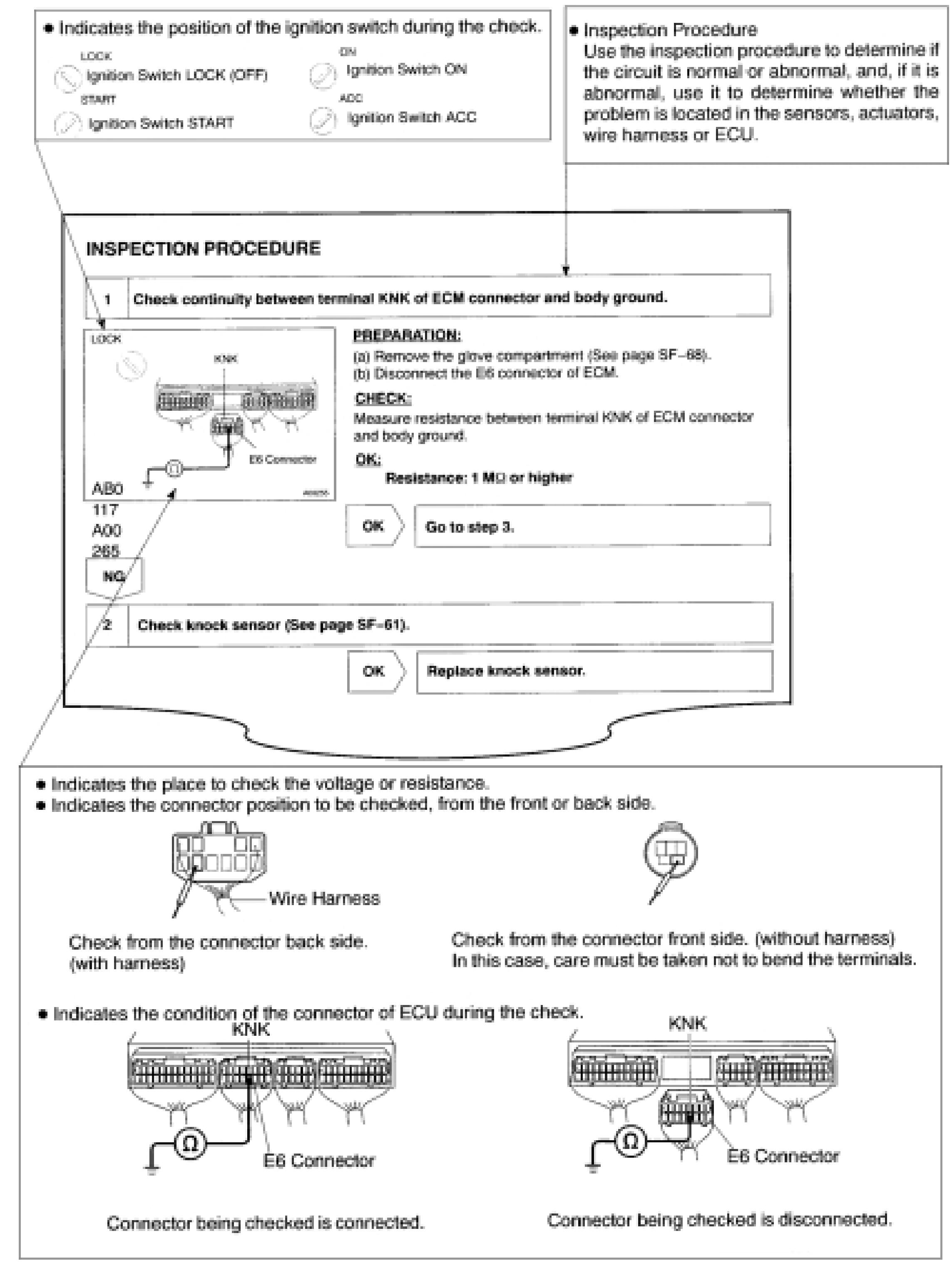

Fig. 1-12

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Repair the Problem (7)

In electrical/electronic diagnostics, you will frequently encounter situations where diagnosis consumes 90% of the actual repair time. By using this procedure to narrow down the number of tests you perform, you can reduce diagnostic time.

After successfully locating the faulty circuit and pinpointing the fault, repair is a relatively simple matter. It is important, however, to ensure customer satisfaction after the repair by performing one last step before releasing the vehicle.

On occasion, you will have to diagnose and repair vehicles with compound problems. To ensure that the vehicle is operating normally, and that the original symptom has been remedied, a quick quality control check of the vehicle is performed. This is accomplished during the Repair Confirmation step.

Repair Confirmation (8)

This is always the final step in diagnosis. Regardless of how you arrived at this step, there are always several items you want to confirm before releasing the vehicle to your customer. The items you will be looking for during this quality control quick check are:

- Satisfactory driveability under the problem conditions stated by the customer
- Repair Confirmation (Readiness Tests) where indicated completed
- All DTC(s) eliminated from ECM keep alive memory

These last two items can be confirmed using the Diagnostic Tester. Once confirmed, the vehicle can be returned to the customer. You can be confident that by following these procedures, in the order given, that you will repair the vehicle with a high rate of success in the shortest possible time.

Problems Which Cannot Be Duplicated

You cannot attempt to fix a problem that does not exist. Therefore, in cases where the problem cannot be duplicated, better communication with the owner, or outside assistance, may offer a solution.

Owner Perception: Sometimes an owner perceives a “normal” operating condition to be a problem. The best way to identify these cases is to accompany the owner on a “road test.” Let the customer drive and point out the problem condition during the road test.

WORKSHEET 1–1
General Diagnostic Tester Procedure

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

When troubleshooting using the Diagnostic Tester, there are general procedures that will aid in troubleshooting the vehicle. This worksheet will familiarize you with those procedures.

Section 1:

1. The primary purpose of the Customer Problem Analysis Check sheet is:

2. The DTC Check procedure is used to confirm if the problem is present or can be duplicated. What are three possible outcomes from this procedure?

3. What are the four methods for simulating conditions?

4. When is the Problem Symptoms Table used?

5. Name four items of information found in the Circuit Inspection.

6. Name three items that are checked during the Repair Confirmation.

WORKSHEET 1-2
Diagnostic Tester

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

Display data using a variety of Diagnostic Tester modes that will aid in troubleshooting and interpreting the results.

Tools and Equipment

- Vehicle
- Repair Manual, EWD, & NCF
- Diagnostic Tester & Manual
- Diagnostic Tester Printer
- Hand Tools, Fender Covers, Floor Mats, and Shop Towels

Section 1: Setup

1. On a vehicle selected by the instructor, warm up the vehicle and connect the Diagnostic Tester to the vehicle. Refer to the Diagnostic Tester Manual for specific setup instructions if needed.

Section 2: Data List

1. Select DATA LIST mode under ENHANCED OBD II.

2. Compare All DATA List to the EXTENDED DATA List. What is the major difference between these lists?

___

Section 3: LED/LIST Mode

1. Select LED/LIST mode

2. Observe DATA LIST. When would you use this mode?

___

3. Reorder LED/LIST parameters according to instructor's directions.

Section 4: Bar Graph Mode

1. Select BAR GRAPH mode

2. Observe Data List. When would you use this mode?

3. Reorder LED/LIST parameters according to instructor's directions.

Section 5: STRIP CHART Mode

1. Select STRIP CHART mode. Select and list 5 parameters as identified by the instructor.

2. Observe Data List. When would you use this mode?

Section 6: CUSTOM DATA Mode

1. Select CUSTOM DATA mode. Select and list below the 6 parameters as identified by the instructor.

2. Observe Data List. When would you use this mode?

Section 7: SNAPSHOT Mode

1. Select SNAPSHOT mode. Select and list below the 6 parameters as identified by the instructor.

______________________ ______________________

______________________ ______________________

______________________ ______________________

2. Prepare to create a fault as identified by your instructor. You will create the fault during a snapshot capture. Write below the type of fault, any terminal pin numbers used, and the intended DTC.

____

____

____

3. Create a snapshot with the fault recorded. Replay the captured snapshot and repeat if the fault was not recorded. Remove the fault when done and return vehicle to original condition.

4. What DTC(s) were recorded?

____

5. Clear DTC(s)

6. When would you use SNAPSHOT mode?

____

7. Switch to another team's SNAPSHOT file and diagnose the cause. What was the fault?

Vehicle: ______________ Fault: ______________________

Vehicle: ______________ Fault: ______________________

Vehicle: ______________ Fault: ______________________

Notes

Diagnostic Tester

Name: ______________________________ Date: ______________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Open Data List in CARB and ENHANCED OBD			
View data in LIST/LED format and describe the advantage of this mode			
View data in Strip Chart mode and describe the advantage of this mode			
Save and view a SnapShot and describe the advantage of this mode			
Interpret vehicle condition based on Data Lists			
Retrieve DTC(s), Freeze Frame and CARB Readiness data			

Notes

WORKSHEET 1-3
TechView Operation

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet, you will diagnose a vehicle by viewing the vehicle's Real Time Data. You will then practice saving and opening files.

Tools and Equipment

- Diagnostic Tester
- TIS with Tech View
- Hand Tool Set

NOTE: Follow the instructions and steps in the TechView Guide before proceeding.

Section 1: Problem Solving using TechView

1. Under the direction of the instructor, create a problem with the vehicle.

2. Save the DATA LIST only. Make sure the problem can be seen from the DATA LIST. Clear DTC(s) from the vehicle.

3. You will rotate through the other workstations. Write down the vehicle and the cause of the problem.

TechView Operation

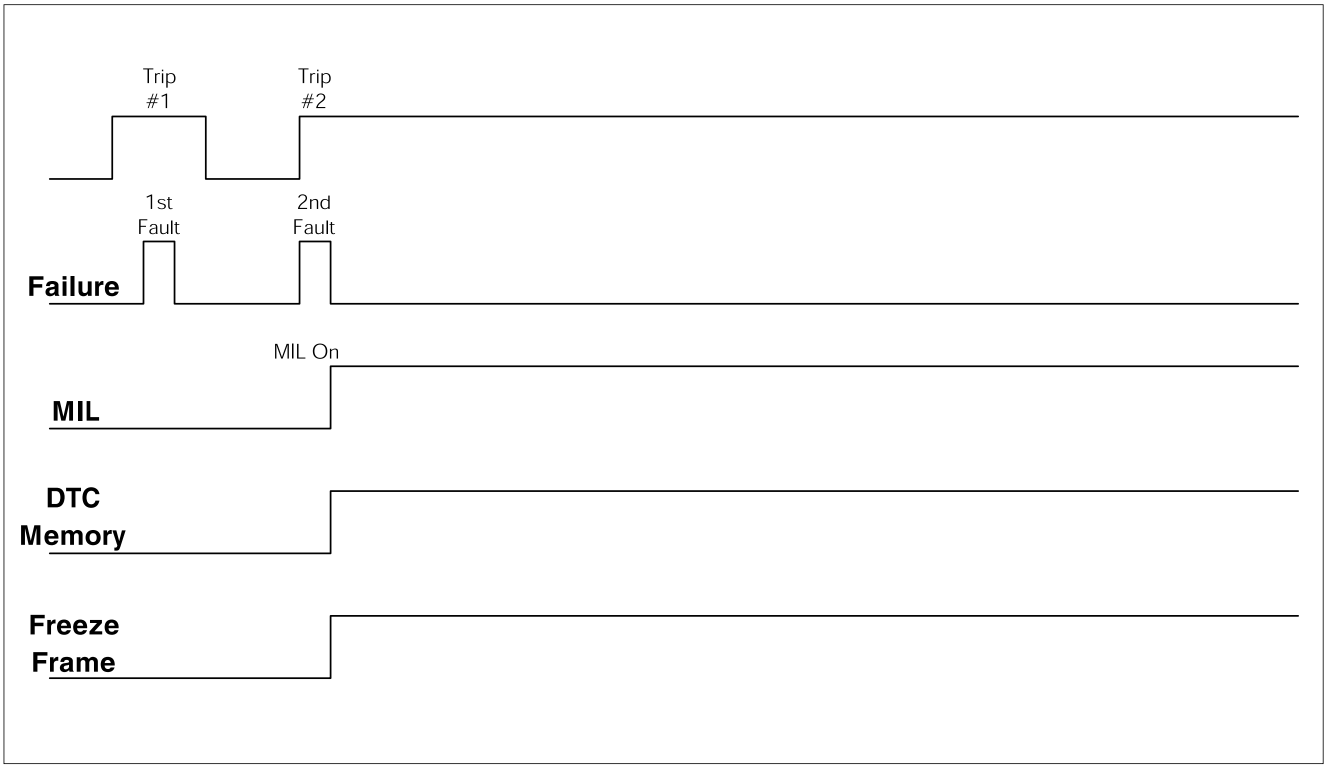
Name: ____ Date: ____________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Open a new file			
Save a file			
Open and resave an existing file			
Display data in all TechView formats and describe the advantage of each mode			
Save Data Lists in TechView			
Retrieve DTC(s), Freeze Frame and CARB Readiness data			
Retrieve SnapShot data			
Interpret data from TechView to diagnose the root cause of a problem			

Section 2

On-Board Diagnostic Systems



Learning Objectives:

1. Determine status of OBD II controlled systems based on MIL status.
2. Determine status of OBD II Readiness Tests Monitors using CARB mode.
3. Interpret OBD II SAE Powertrain DTC nomenclature.
4. Identify OBD II Scan Tool modes and apply these modes to a diagnostic routine.

Section 2

On-Board Diagnostic Systems

Overview

On-Board Diagnostic (OBD) systems use the vehicle's computer(s) to detect problems with components or systems and report these problems to driver and technician. Engine OBD systems are, in part, governed by regulations and divided into two major categories:

- OBD I
- OBD II (phased in beginning 1996 MY)

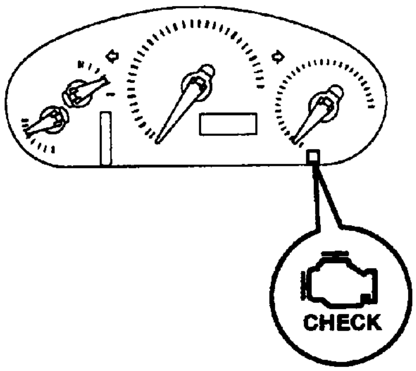
In 1988, the California Air Resources Board (CARB) set the requirement that all vehicles have a system that could identify faults in the emission and powertrain system. This is recognized as OBD I.

At the same time, CARB also set the requirements for OBD II. The Federal government adopted these requirements and they went into effect beginning in 1996. OBD II standards greatly enhanced the On-Board diagnostic system's capabilities and changed the way technicians troubleshoot engine and emission control systems.

In either case, the manufacturer can provide additional diagnostic capabilities. For the technician, understanding what the OBD system is capable of and its limitations will help in fixing vehicles right the first time.

OBD systems report data to the technician by a Malfunction Indicator Lamp (MIL) located in the instrument cluster and Diagnostic Tester.

OBD I Regulations



- Current related checks (open or short)
- Limited system monitoring (A/F & EGR)
- Minimal use of rationality checks
- Limited DTC(s)
- Limited use of Serial data
- System and component names not standardized
- DTC(s) not standardized

Fig. 2-1

TL874f201

OBD I (On-Board Diagnostic System, (Generation 1)

In April 1985, the California Air Resources Board (CARB) approved On-Board Diagnostic system regulations, referred to as OBD. Beginning in 1988, these regulations were phased in to include cars and light trucks marketed in the State of California. They required that the ECM monitor critical emission related components for proper operation and illuminate a malfunction indicator lamp (MIL) on the instrument panel when a malfunction was detected.

Although the OBD regulations initially apply to California emissions certified vehicles, some or all of the OBD system features are found on Federal emissions certified vehicles as well.

The OBD system uses Diagnostic Trouble Codes (DTC) and fault isolation logic charts in the Repair Manual, to assist technicians in determining the likely cause of engine control and emissions system malfunctions.

The basic objectives of this regulation are:

- To improve in-use emissions compliance by alerting the vehicle operator when a malfunction exists.
- To aid repair technicians in identifying and repairing malfunctioning circuits in the emissions control system.

OBD applies to systems that are considered most likely to cause a significant increase in exhaust emissions when a malfunction occurs. Commonly, this includes:

- All major engine sensors
- The fuel metering system
- Exhaust Gas Recirculation (EGR) function

Components and circuits are monitored for continuity, shorts, and in some cases, normal parameter range. OBD systems were normally limited to the detection of an open or short in a sensor circuit.

OBD Malfunction Indicator Lamp (MIL)

The MIL is required to serve as a visual alert to the driver of a malfunction in the system. When a malfunction occurs, the MIL remains illuminated as long as the fault is detected and goes off once normal conditions return, leaving a Diagnostic Trouble Code (DTC) stored in the ECM memory.

OBD Diagnostic Trouble Codes (DTC)

DTC(s) are generated by the on-board diagnostic system and stored in the ECM memory. They indicate the circuit in which a fault has been detected. DTC information remains stored in the ECM long-term memory regardless of whether a continuous (hard) fault or intermittent fault caused the code to set. OBD vehicles store a DTC in the ECM long-term memory until power is removed from the ECM. In most cases, the EFI fuse powers this long-term (keep alive) memory.

OBD II

- Circuit continuity and out of range values monitored
- System monitored
- Rationality checks used (logic)
- Expanded DTC(s)
- Freeze Frame Data stored with DTC
- Serial Data required
- Active Tests
- Standards established

Fig. 2-2

TL874f202

ODB II (On-Board Diagnostic System, Generation 2)

OBD II requires the ECM to monitor the effectiveness of the major emission control systems and to turn on the MIL when a malfunction is detected or when the performance of the emission system(s) has deteriorated to where the emission output will exceed the allowed emission levels.

All vehicles sold in the United States are certified through the Federal Test Procedure (FTP). It is the FTP that tests and sets maximum emission levels in accordance with government regulations. The MIL must light when a component or system will cause the vehicle's emission levels to exceed 1-1/2 times the FTP standard. This means that the OBD II system must test the performance of a system or component. For example, the ECM OBD system monitors catalytic converter efficiency. If catalytic converter efficiency is out of range, the MIL will illuminate and a DTC will set.

OBD II Standardization

OBD regulations and technical standards have been developed with the cooperation of the automotive industry and the Society of Automotive Engineers (SAE). These standards provide a common format for data, the Diagnostic Tester, diagnostic test modes, and diagnostic trouble codes regardless of the vehicle manufacturer.

A number of SAE J standards were developed to implement the OBD II system, and these standards are applicable to all vehicle and tool manufacturers. The following list is an example of the areas of standardization:

- **ISO 9141** - (International Standards Organization) Serial Data Protocol
- **J1850** - Serial Data Protocol
- **J1930** - Terms and Definitions
- **J1962** - Standard OBD II Diagnostic Connector
- **J1978** - Generic Scan Tool
- **J1979** - Diagnostic Test Mode and Basic Serial Data Stream
- **J2008** - Electronic Service Information Access and Data Format
- **J2012** - Diagnostic Codes and Messages
- **J2190** - Enhanced Diagnostic Test Modes and Serial Data Streams

What this means to you is:

- that there are common terms used by all manufacturers
- a standardized Data Link Connector (DLC) located under the driver's side of the instrument panel
- access to all OBD II data is acquired with an OBD II compatible scan tool
- common DTCs
- common diagnostic data streams

NOTE A glossary of SAE J1930 and Toyota terms and definitions can be found in the Introduction section of the Repair Manual.

OBD II Monitors

The goal of the OBD II regulation is to provide the vehicle with an on-board diagnostic system capable of continuously monitoring the efficiency of the emission control systems, and to improve diagnosis and repair efficiency when system failures occur.

On-board tests are performed by the ECM. Two types of on-board test monitoring are supported: Continuous and Non-Continuous.

Continuous monitors test components and systems many times, conditions permitting, when the engine is running. Continuous monitored systems/components are:

- Engine Misfire
- Fuel System (Trim)
- Comprehensive Components

Non-Continuous monitors test components and systems one time, conditions permitting, when the engine is running. Non-continuous monitored systems/components are:

- O2 & A/F Sensor
- O2 & A/F Sensor Heater
- EGR System
- Evaporative System
- Catalyst
- Secondary Air System
- Thermostat

Beginning with the 2000 model year, manufacturers were required to phase-in diagnostic strategies to monitor the thermostat operation on vehicles so equipped. In addition, beginning with the 2002 model year, manufacturers will phase-in diagnostic strategies to monitor the PCV system on vehicles so equipped, for system integrity.

Each of these monitors is covered in detail in the following sections.

Malfunction Indicator Lamp (MIL)

Also referred to as a Check Engine Lamp.

Fig. 2-3

TL874f203

OBD II Malfunction Indicator Lamp (MIL)

When a malfunction occurs and meets the criteria to set a DTC, the MIL illuminates and remains illuminated as long as the fault is detected. The MIL will be turned off after 3 warm-up cycles once normal conditions return. A Diagnostic Trouble Code (DTC) will be stored in the ECM memory.

OBD II Diagnostic Trouble Codes (DTC)

Unlike OBD Diagnostic Trouble Codes, OBD II codes have been standardized by SAE. They indicate the circuit or the system in which a fault has been detected.

Once the condition has been confirmed for normal operation, the DTC remains as an active code for 40 drive cycles. The code will automatically be erased after 40 drive cycles, but will remain in the ECM DTC history until cleared.

OBD

- Current related checks (open or short)
- Limited system monitoring (A/F & EGR)
- Minimal use of rationality checks
- Limited DTC(s)
- Limited use of Serial Data
- System and component names not standardized
- DTC(s) not standardized
- MIL will turn off if problem corrects itself
- DTC must be cleared from memory

OBD II

- Circuit continuity and out of range values monitored
- Systems monitored
- Rationality checks used for component and system performance (logic)
- Expanded DTC(s)
- Freeze Frame Data stored with DTC
- Serial Data required
- Active Tests
- Standards established
- MIL stays on until 3 consecutive trips have passed without the problem re-occurring
- DTC(s) erased after 40 warm-up cycles
- OBD II can detect malfunctions that do not effect driveability

Drive Patterns

Drive patterns are a designated set of parameters for the ECM to test components or systems. Many of these tests are based all or in part on the Los Angeles #4 (LA#4), Federal Test Procedure (FTP) driving pattern.

LA#4/FTP Drive Pattern

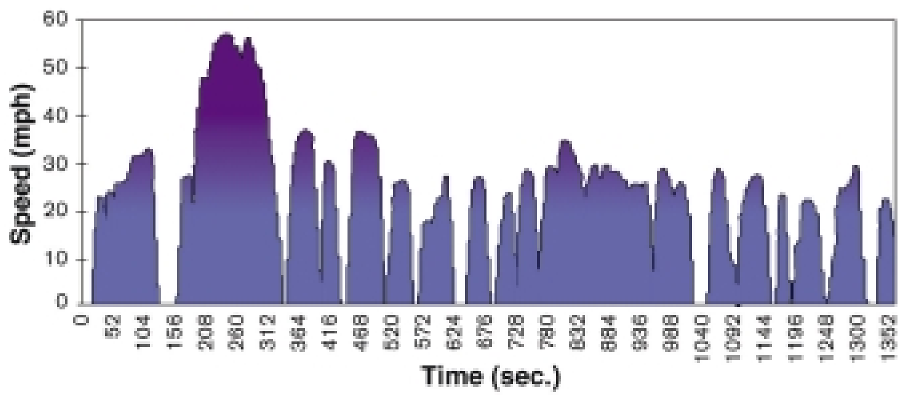


Fig. 2-4

TL874f204

LA#4 Drive Cycle

The Federal Test Procedure (FTP) drive cycle and the LA#4 drive cycle are the same. LA means Los Angeles and 4 means the 4th of the plans submitted to determine the optimum-driving pattern to measure exhaust gases. This pattern was determined while driving in Los Angeles during the morning commuting hours and includes both city and freeway driving.

FTP Drive Cycle

The FTP drive cycle, also known as LA#4, is a standardized drive pattern used for emissions certification. A system may only need a portion of the drive pattern to detect a fault or the pattern needs to be repeated for a two trip DTC fault.

The OBD II drive cycle is the basic set driving conditions for the diagnostic monitors to run. This does not mean that all monitors can be completed with this drive pattern because a warm-up cycle or other additional parameters may be required. Also a test may be interrupted by a fault in another related system.

If a fault is present, a DTC should appear if the driving pattern is completed along with any other operating condition noted in the Repair Manual.

OBD II Trip

The OBD II trip, or "trip", contrasted with the LA#4/FTP drive cycle, consists of an engine start following an engine off period, with enough vehicle travel to allow the OBD II monitoring sequences to complete their tests. The vehicle must be driven under a variety of operation conditions for all tests to be performed.

Trip

A trip is defined as an engine-operation drive cycle that contains all of the necessary conditions for a particular test to be performed. Some DTC(s) may require a warm-up cycle, while others require just a key off cycle.

Completing the trip correctly is necessary to verify a symptom or confirm a successful repair.

Warm-Up Cycle

OBD II standards define a warm-up cycle as a period of vehicle operation, after the engine was turned on, in which coolant temperature rises by at least 22°C (40°F) and reaches at least 88°C (160°F). The ECM determines a cold start by comparing the engine coolant temperature (ECT) and the intake air temperature (IAT).

Confirmation Driving Patterns

The Repair Manual lists special confirmation driving patterns specific to a particular DTC. The confirmation procedure listed may not actually require the vehicle to be driven. The confirmation procedure is designed to verify the operation of a component or system. The conditions listed in the Repair Manual must be strictly followed or the detection of the malfunction will not be possible.

NOTE The confirmation drive pattern may require the use of the Diagnostic Tester. In addition, the instructions may call for switching from normal to check mode.

NOTE The conditions outlined in this section are general and intended to serve as a guide only.

Malfunction Indicator Lamp and Diagnostic Trouble Codes

OBD II regulations require the ECM to light the Malfunction Indicator Lamp (MIL) when the ECM detects a malfunction in the emission control system/components or in the powertrain control components that affect vehicle emissions.

In addition to the MIL lighting when a malfunction is detected, the applicable Diagnostic Trouble Code (DTC) prescribed by SAE J2012 is recorded in the ECM Memory.

MIL ON

There are two basic reasons why the MIL will light and remain on: a failure of a component monitor, or a failure of a system monitor. When the MIL is turned on, a DTC is stored, as well as Freeze Frame data.

NOTE There is the possibility that two Freeze Frame data displays are stored from two DTCs. Refer to the section on Freeze Frame data in this handbook for additional details.

MIL ON One Trip

There are some DTCs that will set in one trip. A one trip DTC will store a code that can be observed in the DTC screen, set a Freeze Frame, and light the MIL.

MIL ON One Trip

In this illustration, the fault occurred during the first trip. The MIL came on when the basic parameters for the diagnostic test were met and the test completed, confirming the fault. Also the DTC and Freeze Frame were recorded in memory when the MIL came on.

Fig. 2-5

TL874f205

MIL ON Two Trip

When a two trip emissions-related fault is detected for the first time, a DTC related to that fault is stored as a pending code. This pending code can often be seen in the Mode 7 screen - Continuous Tests (if the ignition key is not turned off).

If the fault occurs again on the second drive cycle, then the DTC is stored as a current code (can be seen in the DTC screen), and the ECM will turn on the MIL.

The pending fault will be erased if the monitoring sequence does not detect a fault under the same conditions.

MIL ON Two Trip

In this illustration, the fault occurred during the first trip. The MIL came on during the second trip after the basic parameters for the diagnostic test were met and the test completed, confirming the fault. The DTC and Freeze Frame were recorded in memory when the MIL came on during the second trip.

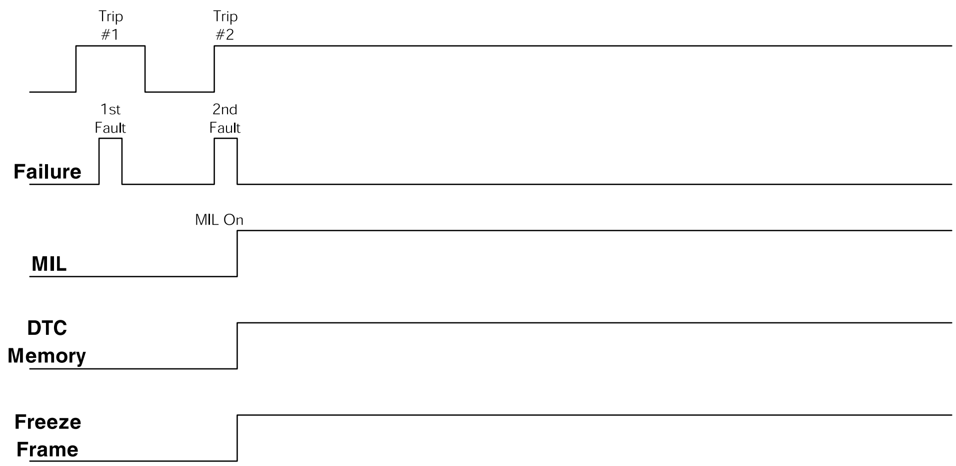


Fig. 2-6

TL874f206

MIL Blinking

The MIL will blink when a misfire occurs that will raise the temperature enough to damage the catalytic converter. The blinking may be intermittent, because of changes in engine load and the severity of engine misfire.

A misfire that will allow emissions to exceed regulations, but not damage the catalyst, will light the MIL but not blink the light. The MIL will light on the second trip if the misfire occurs under similar conditions. See Misfire Diagnosis for more details.

MIL Blinking

When a misfire occurs that is severe enough to damage the Catalytic Converter the MIL will blink during the first trip. If the condition reoccurs during the second trip, the MIL again blinks, the DTC and Freeze Frame are recorded in memory. The MIL will be on solid once the DTC is recorded if the misfire is no longer severe enough to damage the catalyst.

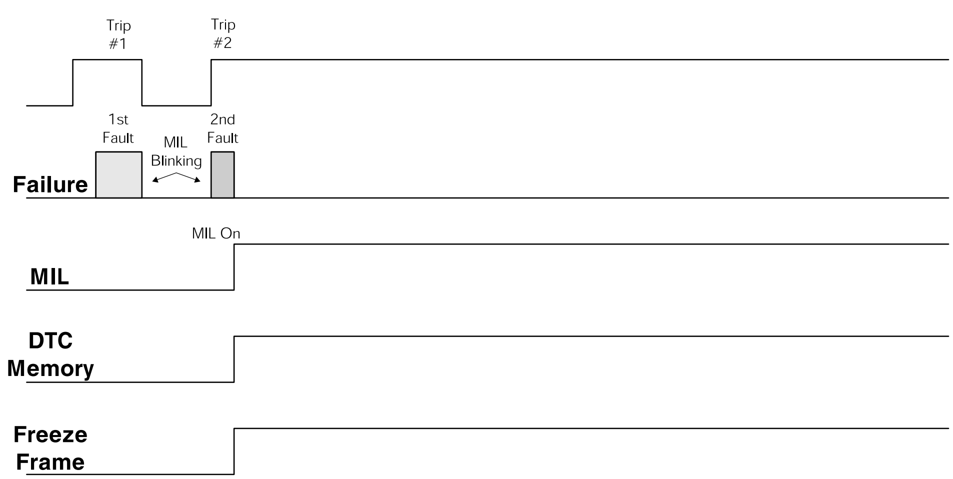


Fig. 2-7

TL874f207

MIL OFF, DTC and Freeze Frame Erased

When the ECM confirms that the fault is no longer present, the MIL is turned off after three trips where the basic parameters for the diagnostic test are met and the test completed without the fault being detected. After 40 warm-up cycles without the fault being detected, the DTC and Freeze Frame are erased from memory as current; however, the DTC and Freeze Frame will remain in DTC history as a history code and Freeze Frame until cleared.

NOTE A DTC found in history, but not related to a current condition is most likely the result of an intermittent condition or previous repair since the conditions that set the code have not recurred for at least 40 cycles.

MIL Off, DTC and Freeze Frame Erased

In this illustration, the fault did not recur after the MIL came on, therefore, the MIL was turned off after three trips without a fault being detected. After 40 successful trips without the fault being detected, the DTC and Freeze Frame were erased from memory. However, the DTC will remain in history until cleared.

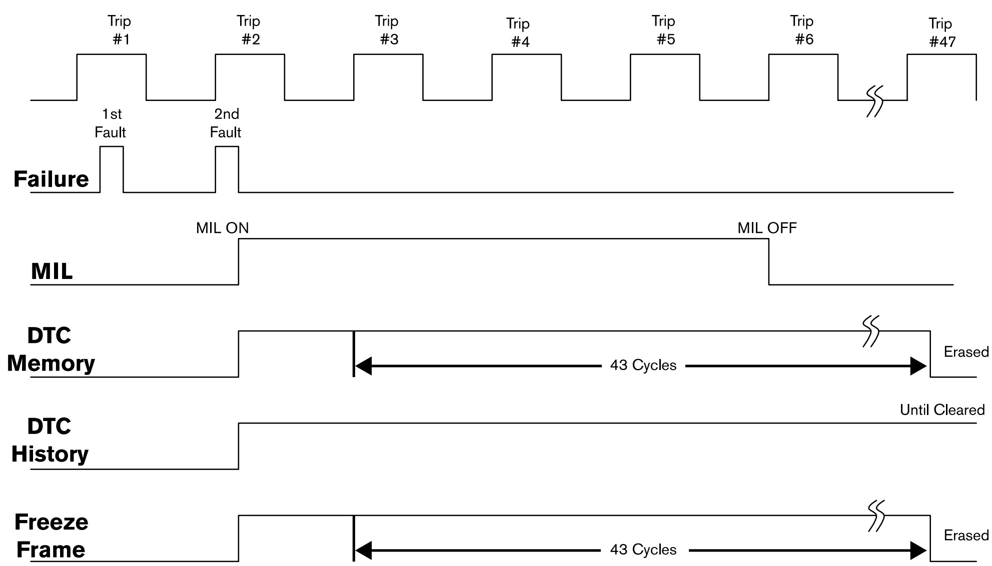


Fig. 2-8

TL874f208

Extinguishing the MIL

Once lit, the MIL will remain on until the vehicle has completed three consecutive good trips (three trips in which the effected diagnostic monitor runs and passes).

Should the MIL blink due to a misfire, the MIL will go off if the misfire is no longer detected. A misfire DTC will be stored if the misfire meets the criteria for storing in the ECM memory.

If the DTC has not been cleared since the MIL was turned off, the erased DTC will be stored in DTC history until the memory is cleared.

Summary of MIL and DTC Operation

Misfire detected severe enough to damage catalytic converter:

- **MIL Blinking** - One trip fault
- **MIL Illumination** - One and two trip faults
- **MIL Extinguished** - Three consecutive trips, fault not detected
- **DTC Memory Erasure** - 40 Warm-up cycles, fault not detected or when cleared with DT
- **DTC History** - DTC is held in history until cleared with DT
- **Freeze Frame Erasure** - 40 Warm-up cycles, fault not detected or when cleared with DT

OBD II Definition

Each DTC is assigned a number to indicate the circuit, component, or system area that was determined to be at fault. The numbers are organized such that different codes related to a particular sensor or system are grouped together.

OBD II Diagnostic Trouble Code Chart

First Digit	Second Digit	Third Digit	Fourth Digit	Fifth Digit
	Prefix Letter of DTC Indicates Component Group Area	SAE or Controlled	Powertrain DTC Subgroup	Area or Component involved
	P = Powertrain	0 = SAE	0 = Total System	
	B = Body	1 = Manufacturer	1 = Fuel and Air Metering	
	C = Chassis		2 = Fuel and Air Metering	
	U = Network Communication		3 = Ignition System or Misfire	
			4 = Auxiliary Emission Controls	
			5 = Speed, Idle, & Auxiliary Inputs	
			6 = ECM and Auxiliary Inputs	
			7 = Transmission	
Example			8 = Transmission	
Fuel Trim Malfunction	P	0	1	71

Manufacturer Enhanced OBD II

OBD II regulations allow the manufacturer to add additional information to the data stream and DTCs. A "1" in the second digit of the DTC code indicates it is a manufacturer specific DTC. Toyota has an enhanced data stream, which consists of 60 or more additional data words. As new systems are created, additional data is added to the data stream.

OBD II Scan Tool Features

When the decision was made to create a scan tool that could access all manufacturers vehicles, it also meant there had to be a standardized way of communicating information to the technician. Common Diagnostic Trouble Codes (DTC) is one aspect. The manufacturer of the vehicle or scan tool can add more data streams, report modes, and diagnostic tests.

The following is a list of modes that every OBD II compatible scan tool and vehicle must support.

CARB MODES	GENERIC TITLE	TOYOTA TITLE
Mode 1	Current Powertrain Diagnostic Data	DATA LIST and READINESS TESTS
Mode 2	Powertrain Freeze Frame Data	FREEZE DATA
Mode 3	Emission Related Powertrain DTCs	DTCs
Mode 4	Clear/Reset Emission Related Diagnostic Information	CLEAR DIAG INFO
Mode 5	O2 sensor Monitoring Test Results	O2S TEST RESULTS
Mode 6	On-Board Monitoring Test Results for Non-Continuously Monitoring Systems	NON-CONTINUOUS
Mode 7	On-Board Monitoring Test Results for Continuously Monitored Systems	CONTINUOUS
Mode 8	Request Control of On-Board System Test or Component	EVAP LEAK TEST
Mode 9	Request Vehicle Information	INFORMATION MENU

Mode 1: Current Powertrain Diagnostic Data

This mode provides access to current emission related data values such as inputs, outputs, and system status. All input values that are displayed are current values. No substitute values are permitted if there is a problem with the input sensor/circuit. This information is referred to as serial data and found under Data List.

Data List

```
CURRENT DATA

ENGINE SPD......... 2260RPM
COOLANT TEMP......... 190°F
VEHICLE SPD.......... 60MPH
IGN ADVANCE.......... 38.0°
CALC LOAD............ 37.2%
MAF.............. 1.21b/min
THROTTLE POS......... 10.1%
INTAKE AIR............ 93°F
FUEL SYS #1........ OLDRIVE
FUEL SYS #2........ OLDRIVE
SHORT FT #1........... 0.0%
LONG FT #1........... -1.5%
SHORT FT #2........... 0.0%
LONG FT #2........... -1.5%
O2S B1 S1........... 0.705V
O2FT B1 S1............ 0.0%
O2S B1 S2........... 0.120V
O2FT B1 S2.......... UNUSED
O2S B2 S1........... 0.660V
O2FT B2 S1............ 0.0%
MIL...................... ON
# CODES.................. 1
MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL........ INCMPL
EGR EVAL............. COMPL
OBD CERT............ OBD II
```

Fig. 2-9

TL874f209

NOTE **The READINESS TEST screen and MONITOR STATUS screen contain identical information. You can use either screen to confirm monitor operation.**

Readiness Test Status

The example to the right shows which monitors have completed and which monitors are available or not available (do not apply to this vehicle). The Non-Continuous monitors have all completed. The Continuous monitors are available and run continuously.

INCMPL stands for incomplete. Incomplete can mean the monitor did not complete, judgment is withheld pending further testing, the monitor did not operate, or the monitor operated and recorded a failure. Please see Modes 6 and 7 for additional details.

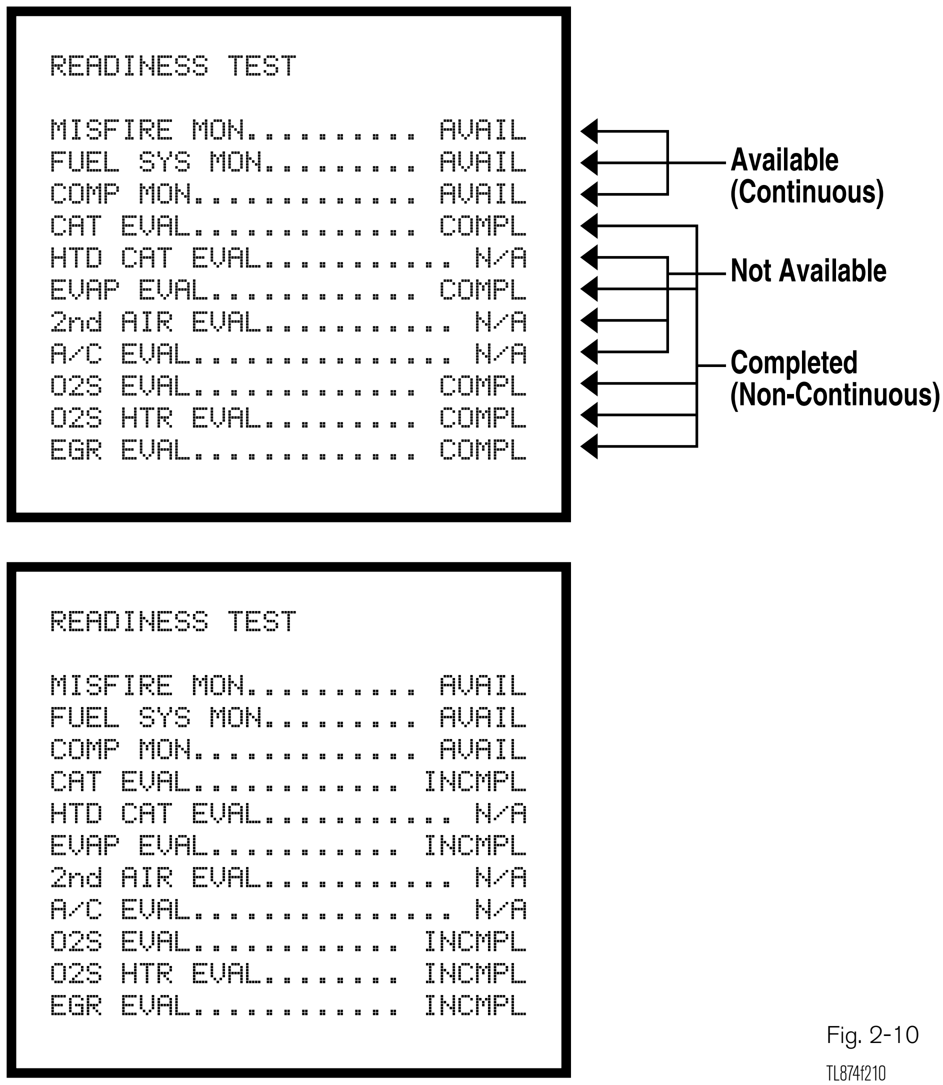


Fig. 2-10

TL874f210

Mode 2: Powertrain Freeze Frame Data

This mode displays emission related values that are stored when the ECM has determined there has been an emission related failure. The manufacturer can add more values beyond the emission related values. All values are actual readings, none are substituted values.

Manufacturers are free to add additional Freeze Frames.

If a fault is detected and recorded, that information is stored as a "Freeze Frame." The ECM uses this data for identification and comparison of similar operating conditions when they recur. The data is also available to the diagnostic technician for use in identifying what conditions were present when the DTC was set. This information can only be accessed with the Diagnostic Tester.

CARB Freeze Frame

```
FREEZE FRAME   0

TROUBLE CODE......... P0304
ENGINE SPD.......... 683RPM
COOLANT TEMP......... 190°F
VEHICLE SPD........... 0MPH
CALC LOAD............ 18.0%
FUEL SYS #1............. CL
FUEL SYS #2............. CL
SHORT FT #1........... 0.8%
LONG FT #1........... -5.4%
SHORT FT #2.......... -0.7%
LONG FT #2........... 12.5%
```

Fig. 2-11

TL874f211

Under CARB, only one Freeze Frame is stored with the required data. In Enhanced OBD II, two Freeze Frames are stored with additional data. The CARB Freeze Frame is listed under the CARB menu and accessed from there.

Freeze Frame Data

Freeze Frame information typically includes:

- DTC involved
- Engine RPM
- Engine load
- Fuel trim (short and long term)
- Engine Coolant Temperature
- Calculated load
- Operating mode (open or closed loop)
- Vehicle speed

Enhanced Freeze Frame Priority

Two Freeze Frames can be stored in the Enhanced OBD II mode in the ECM. The first is reserved for information related to misfire and fuel control, which have priority over other DTC(s). The second, if not occupied by one of the priority DTC(s), will store information for the first non-priority DTC that occurs. The Freeze Frame information updates if the condition recurs.

Enhanced Freeze Frame Priority

The first frame is reserved for misfire and fuel control DTC data only. The second frame will store the second misfire or fuel control DTC data first. If the second frame is not used for a priority DTC, the ECM can store data related to other DTC(s).

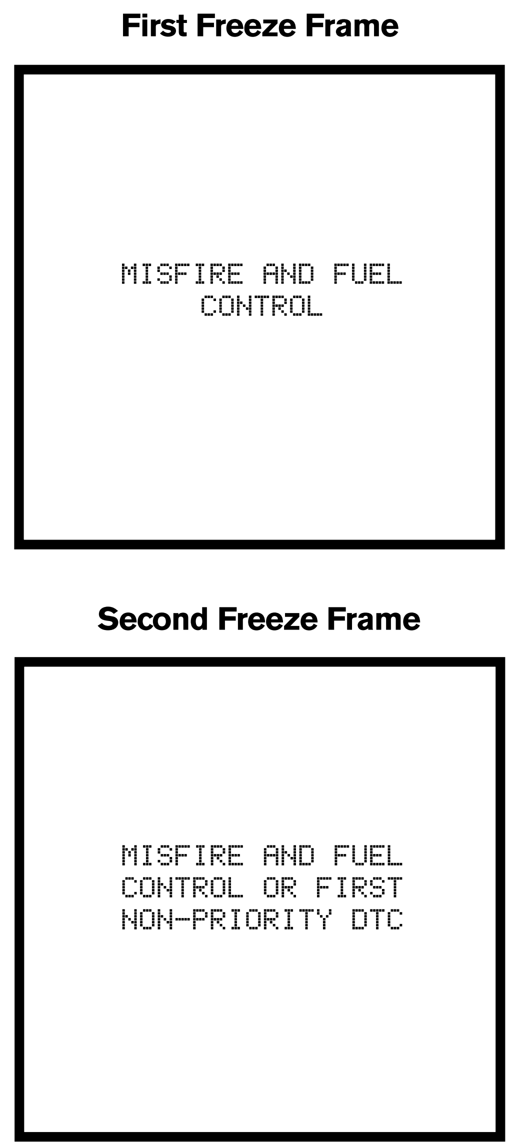


Fig. 2-12

TL874f212

Accessing Enhanced Freeze Frame Data

When using the Diagnostic Tester, an * (asterisk) next to the Trouble Code ID indicates there is Freeze Frame data associated with that DTC. If Freeze Frame data is available for the highlighted DTC, press Enter to display the data.

Accessing Enhanced Freeze Frame Data

The Diagnostic Tester screens show stored DTC(s), both priority and non-priority and the Freeze Frame Data stored for each of these DTC(s). The Freeze Frame Data is displayed in the same format for all DTC(s).

Trouble Codes

```
  ECU: $10 (Engine)
  Number of DTCs: 3

* P0304
  Cylinder 4 Misfire
  Detected

  P0100
  Mass or Volume Air
  Flow Circuit Malfunction

* P0110
  Intake Air Temperature
  Circuit Malfunction
```

Priority Freeze Frame

```
TROUBLE CODE......... P0304
CALC LOAD.............. 18%
ENGINE SPD.......... 683RPM
COOLANT TEMP....... 190.4°F
INTAKE TEMP........ 125.6°F
CTP SW.................. ON
VEHICLE SPD........... 0MPH
SHORT FT #1........... 0.7%
LONG FT #1........... -5.5%
SHORT FT #2.......... -0.9%
LONG FT #2........... 12.4%
FUEL SYS #1............. CL
FUEL SYS #2............. CL
FC IDL................. OFF
STARTER SIG............ OFF
A/C SIG................ OFF
PNP SW [NSW]............ ON
ELECT LOAD SIG......... OFF
STOP LIGHT SW.......... OFF
ENG RUN TIME............ 80
```

Non-Priority Freeze Frame

```
TROUBLE CODE......... P0110
CALC LOAD............... 0%
ENGINE SPD.......... 662RPM
COOLANT TEMP....... 192.2°F
INTAKE TEMP........ -40.0°F
CTP SW.................. ON
VEHICLE SPD........... 0MPH
SHORT FT #1........... 1.5%
LONG FT #1........... -5.5%
SHORT FT #2........... 1.5%
LONG FT #2........... 12.4%
FUEL SYS #1............. CL
FUEL SYS #2............. CL
FC IDL................. OFF
STARTER SIG............ OFF
A/C SIG................. ON
PNP SW [NSW]............ ON
ELECT LOAD SIG......... OFF
STOP LIGHT SW.......... OFF
ENG RUN TIME............. 0
```

Fig. 2-13

TL874f213

Using Freeze Frame Data for Diagnosis

The Freeze Frame data screen provides information of the conditions that were present at the time the DTC was recorded in memory. By recreating the vehicle speed, engine RPM, and engine load, as well as other conditions noted, the technician can verify the customer's concern.

Mode 3: Emission Related Powertrain DTCs

When in this mode, the Diagnostic Tester retrieves all stored emission related DTCs in the ECM. See MIL ON section for additional details.

Mode 4: Clear/Reset Emission Related Diagnostic Information

When this mode is activated by the Diagnostic Tester, all DTCs, Freeze Frame data, O2 sensor monitoring test results, status of monitoring system test (Readiness Tests) results, and on-board test results are cleared and reset. The Diagnostic Tester and ECM must be able to respond to this request with ignition key on and engine off.

OBD II DTC(s) are automatically erased after 40 warm-up cycles if the failure is not detected again. These 40 cycles begin only after the ECM turns off the MIL. The Freeze Frame data is cleared at the same time. A technician using the Diagnostic Tester can also clear the DTC(s) and freeze frame data, however, this will clear DTC history also.

O2 Sensor Monitoring Screens

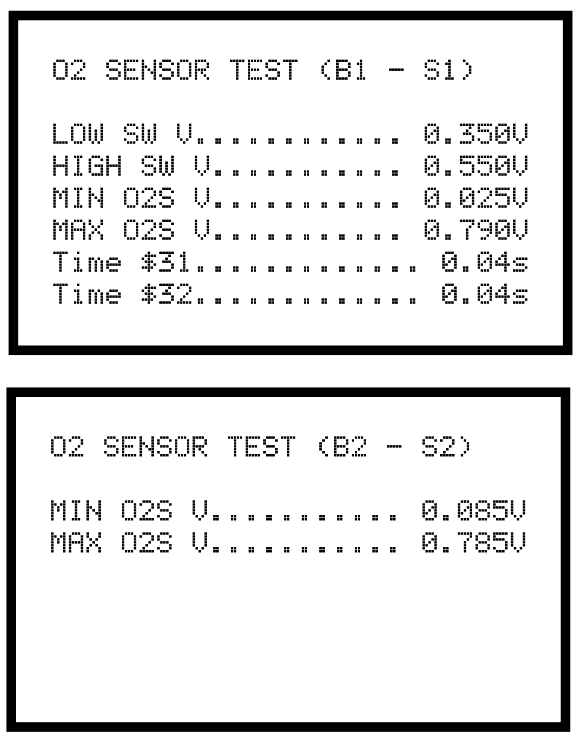


Fig. 2-14

TL874f214

Mode 5: O2 Sensor Monitoring Test Results

This mode displays the test results of the O2 sensor test monitor. This screen's data can be used as a report on the condition of the O2 sensor(s), and is found under O2S TEST RESULTS.

NOTE

These values are stored values, not current values that are found in Mode 1 (DATA LIST). These values are reported only if the O2 sensor monitor has run. This information is lost if the ignition key is turned off.

Not all test values are applicable to all manufacturers. The A/F sensor test values are not applicable and are not displayed in Mode 5. Some vehicles use Non-Continuous Test Results mode to report results. For more information see the section on O2 and A/F Sensor Diagnosis.

Mode 6: On-Board Monitoring Test Results for Non-Continuous Monitoring Systems

Two different screens showing Pass and Fail. Some vehicles will show TID in place of Time.

- (TID)Time$01 = Catalyst Deterioration
- (TID)Time$02 = Evaporative System Deterioration
- (TID)Time$03 = Not Supported
- (TID)Time$04 = O2 Sensor Heater
- (TID)Time$05 = EGR
- (TID)Time$06 = A/F Sensor
- (TID)Time$07 = A/F Sensor Heater
- (TID)Time$08 = Thermostat Monitor

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Fail
Time$02 CID$02........ Fail
Time$02 CID$03........ Fail
Time$02 CID$04........ Fail
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Fig. 2-15

TL874f215

Mode 6: On-Board Monitoring Test Results for Non-Continuous Monitoring Systems

This mode reports on the Non-Continuous monitors:

- Catalyst
- Evaporative System
- Secondary Air System
- O2 & A/F Sensor
- O2 & A/F Sensor Heater
- EGR System
- Thermostat

You can use this mode to identify potential problems in the Non-Continuous monitored systems.

The ECM compares the Non-Continuous monitor test data to the test limits and reports to the Diagnostic Tester a Pass or Fail indication for each monitored system/component. This mode will report results in one trip if the monitor runs and completes its testing. The results can be found in Non-Continuous Tests.

Mode 7: On-Board Monitoring Test Results for Continuous Monitoring Systems

This mode reports test results for emission related powertrain components that are Continuously and Non-Continuously monitored in one trip under normal driving conditions. It will report a failure as a DTC. This allows you to test the vehicle for problems and (after clearing DTCs) to check on a repair in one trip. This mode is found in Continuous Tests.

NOTE

The DTCs that are initially reported in Continuous Tests and Pending Codes are pending DTCs. If conditions persist, DTCs will be stored in the normal areas.

For a DTC to be reported, the monitor has to be operating, though the monitor may not go to completion. This is the first place a DTC will show up. A two trip DTC reported in this mode on the first trip may not be accurate and may change during monitoring. Another trip is needed to confirm that the reported DTC is valid. If a DTC is reported in this mode there is good reason to suspect that there is a problem with the vehicle and further checks are necessary before returning to the owner.

Please see the section on Continuous Monitors for more information.

Mode 7 Continuous Tests DTC Screen and Pending CodesScreen

```
CONTINUOUS TESTS
ECU:  $10 (Engine)
Number of Tests: 1

P0401
EGR Flow Insufficient
Detected
```

```
PENDING CODES
ECU:  ENGINE
Number of DTCs: 1

P0401
EGR Flow Insufficient
Detected
```

Fig. 2-16

TL874f216

Mode 8: Request Control of On-Board System Test or Component

This mode enables the Diagnostic Tester to control the ECM in order to test the system and related components. Currently, the EVAP leak test procedure is under this mode. When the EVAP leak test is enabled, it sets the conditions for leak testing but does not conduct a leak test.

Mode 8 EVAP Leak Test

Fig. 2-17

TL874f217

Mode 9: Request Vehicle Information

This mode reports the following if the ECM supports this function:

- Vehicle Identification Number
- Calibration Identification
- Calibration Verification

This mode is found in Information Menu.

Mode 9 Vehicle Information

```
VEHICLE ID

******************
JT2ST07N150015566
******************

Press [ENTER]
```

```
ECU $10, CAL ID:01
73309069

ECU $10, CAL ID:02
83309012

[ENTER]
```

```
ECU $10, CVN:4567
```

Fig. 2-18

TL874f218

How to Proceed with Troubleshooting OBD II Systems

The following steps provide a general outline with explanations for troubleshooting OBD II systems. There are slight variations in different years and with different models. Please review the procedure, General OBD II Scan Tool or Diagnostic (Hand-held) Tester Procedure in Section 1 before reading this section.

Troubleshooting OBD II systems involves a series of steps as listed in the figure 2-19 on the following page. The order will vary depending on symptoms.

OBD II Engine Troubleshooting Procedure

Each numbered step is explained in the following text.

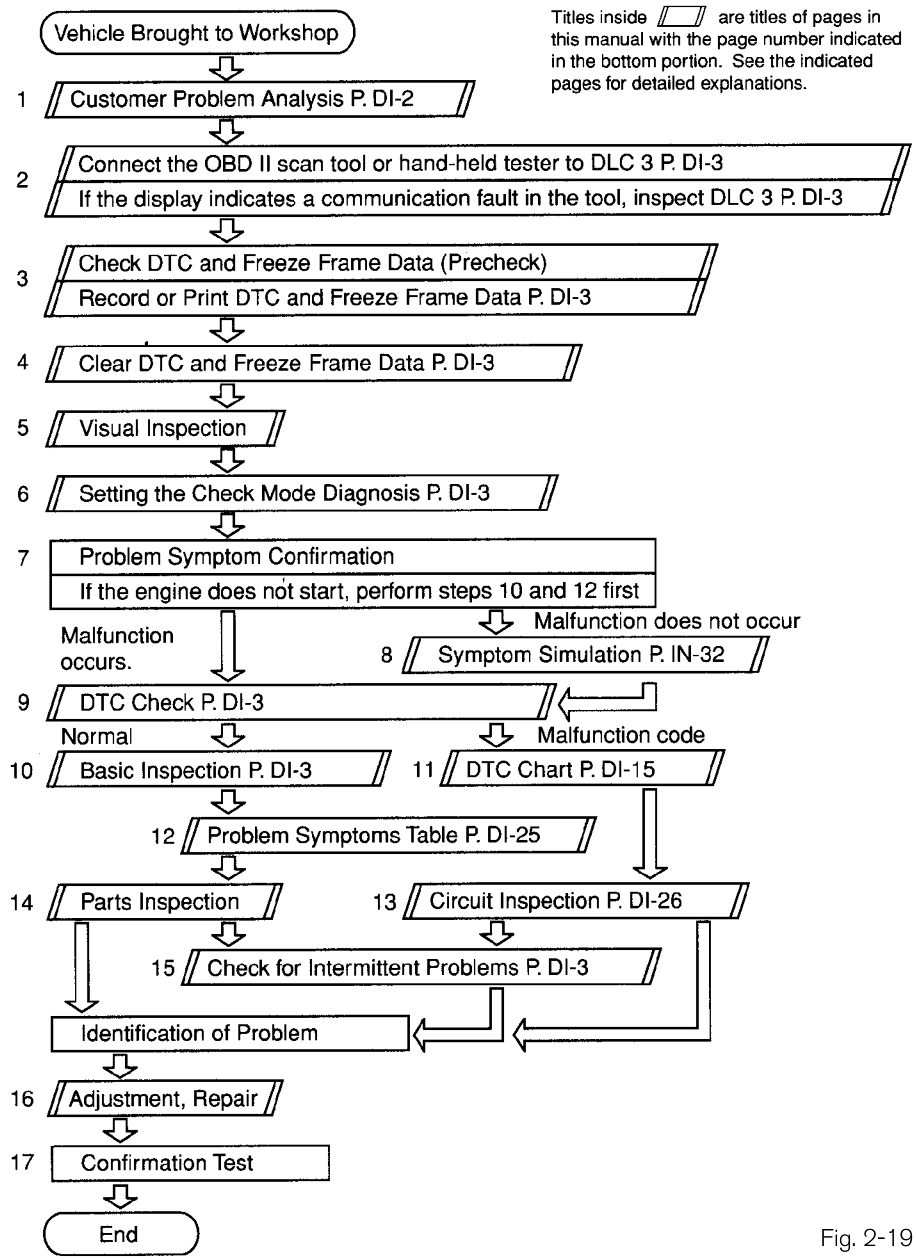


Fig. 2-19

TL874f219

Step 1: Customer Problem Analysis

Always begin with getting as much information about the conditions when the problems occur. Service managers and assistant service managers need to work with you to prevent wasted time and resources. The sophisticated systems you are working with require accurate, timely information. The Customer Problem Analysis Check Sheet needs to be familiar to all those who communicate with the customer.

Customer Problem Analysis Check

ENGINE CONTROL SYSTEM Check Sheet

Inspector's Name ____________________

Customer's Name		Model and Model Year	
Driver's Name		Frame No.	
Date Vehicle Brought in		Engine Model	
License No.		Odometer Reading	km miles

Problem Symptoms	☐ Engine does not Start	☐ Engine does not crank ☐ No initial combustion ☐ No complete combustion
	☐ Difficult to Start	☐ Engine cranks slowly ☐ Other ____
	☐ Poor Idling	☐ Incorrect first idle ☐ Idling rpm is abnormal ☐ High (rpm) ☐ Low (rpm) ☐ Rough idling ☐ Other ____
	☐ Poor Driveability	☐ Hesitation ☐ Back fire ☐ Muffler explosion (after-fire) ☐ Surging ☐ Knocking ☐ Other ____
	☐ Engine Stall	☐ Soon after starting ☐ After accelerator pedal depressed ☐ After accelerator pedal released ☐ During A/C operation ☐ Shifting from N to D ☐ Other ____
	☐ Others	

Dates Problem Occurred		
Problem Frequency		☐ Constant ☐ Sometimes (times per day/month) ☐ Once only ☐ Other ____
Condition When Problem Occurs	Weather	☐ Fine ☐ Cloudy ☐ Rainy ☐ Snowy ☐ Various/Other ____
	Outdoor Temperature	☐ Hot ☐ Warm ☐ Cool ☐ Cold (approx. ____ °F/____ °C)
	Place	☐ Highway ☐ Suburbs ☐ Inner city ☐ Uphill ☐ Downhill ☐ Rough road ☐ Other ____
	Engine Temp.	☐ Cold ☐ Warming up ☐ After warming up ☐ Any temp. ☐ Other ____
	Engine Operation	☐ Starting ☐ Just after starting (min.) ☐ Idling ☐ Racing ☐ Driving ☐ Constant speed ☐ Acceleration ☐ Deceleration ☐ A/C switch ON/OFF ☐ Other ____

Condition of MIL		☐ Remains on	☐ Sometimes lights up ☐ Does not light up
DTC Inspection	Normal Mode (Precheck)	☐ Normal	☐ Malfunction code(s) (code) ☐ Freezed frame data ( )
	Check Mode	☐ Normal	☐ Malfunction code(s) (code) ☐ Freezed frame data ( )

Fig. 2-20

TL874f220

Step 2: Connect Diagnostic Tester

When troubleshooting OBD II vehicles, you must use an OBD II scan tool complying with SAE J1978 or Diagnostic Tester, and interpret various data output from the vehicle's ECM.

OBD II regulations require that the vehicle's on-board computer turns on the Malfunction Indicator Lamp (MIL) on the instrument panel when the computer detects a malfunction in the emission control system/ components, in the powertrain control components that affect vehicle emissions, or a malfunction in the computer. In addition to the MIL lighting when a malfunction is detected, the applicable Diagnostic Trouble Codes (DTC(s)) prescribed by SAE J2012 are recorded in the ECM memory (See section on OBD Systems Overview).

If the malfunction does not occur in three trips the MIL goes off automatically but the DTC(s) remain recorded in the ECM memory.

Step 3: Check DTC(s) and Freeze Frame Data

To check the DTC(s), connect the Diagnostic Tester to the Data Link Connector 3 (DLC3) on the vehicle. The OBD II scan tool or Diagnostic Tester also enables you to erase the DTC(s) and check Freeze Frame data and various forms of engine data (For operating instructions, see the OBD II scan tool's instruction book). DTC(s) include SAE controlled codes and manufacturer controlled codes. SAE controlled codes must be set as prescribed by the SAE, while manufacturer controlled codes can be set freely by the manufacturer within the prescribed limits (See DTC chart in the Repair Manual).

The ECM diagnostic system operates in normal mode during normal vehicle use. It also has a check mode for technicians to simulate malfunction symptoms and troubleshooting. Most DTC(s) use two trip detection logic (see below) to prevent erroneous detection and ensure thorough malfunction detection. By switching the ECM to check mode when troubleshooting, the technician can cause the MIL to light up for a malfunction that is only detected once or momentarily (using the Diagnostic Tester and certain DTCs only) (See step 2).

Two trip detection logic:

- When a malfunction is first detected, the malfunction is temporarily stored in the ECM memory (first trip).

- If the same malfunction is detected again during the second drive test, this second detection causes the MIL to light up (second trip) (However, the ignition switch must be turned OFF between the first trip and second trip).

- Freeze Frame data records the engine condition when a misfire (DTC(s) P0300 - P0308) or fuel trim malfunction (DTCs P0171, P0172, P0174 and P0175) or other malfunction (first malfunction only), is detected. The Freeze Frame data records the engine conditions (fuel system, calculated load, engine coolant temperature, fuel trim, engine speed, vehicle speed, etc.) when a malfunction is detected.

When troubleshooting, it is useful for determining whether the vehicle was running or stopped, the engine was warmed up or not, the A/F ratio was lean or rich, etc., at the time of the malfunction.

Check Service History and Service Publications

At this point, checking TSBs or other service publications may have the necessary repair information.

Checking the service history can provide clues about cause of the problem. The condition may be related to a recent repair.

NOTE

Checking TSBs and service history is not specifically outlined in the Repair Manual diagnostic procedure.

Priorities for Troubleshooting

If troubleshooting priorities for multiple DTC(s) are given in the applicable DTC chart, those should be followed.

If no instructions are given, follow the order given in the beginning of the DI section. Below is a typical procedure to troubleshoot DTC(s) according to the following priorities:

(1) DTC(s) other than fuel trim malfunction (DTC(s) P0171, P0172, P0174 and P0175) and misfire (DTC(s) P0300 - P0308).

(2) Fuel trim malfunction (DTC(s) P0171, P0172, P0174 and P0175).

(3) Misfire (DTC(s) P0300 - P0308).

No Communication

If no communication, you will need to check the OBD II diagnostic circuit. An explanation of this procedure is in the section on ECM Diagnostics.

Step 4: Clear DTC and Freeze Frame Data

This procedure is used to verify if the fault is currently present. Doing this step will save you time.

INSPECT DIAGNOSIS (Normal Mode)

(a) Check the MIL.

(1) The MIL comes on when the ignition switch is turned ON and the engine is not running.

NOTE If the MIL does not light up, troubleshoot the combination meter.

(2) When the engine is started, the MIL should go off. If the lamp remains on, the diagnosis system has detected a malfunction or abnormality in the system.

(b) Check the DTC.

NOTE If there is no DTC in the normal mode, check to see if there are any DTC(s) (first trip DTC) by going to the Continuous Test Results function (Mode 7 for SAE J1979) or Pending Codes on the Diagnostic Tester. For some DTC(s) to set, the vehicle must be driven in a specified driving pattern. See Readiness Test Confirmation Strategy.

(1) Prepare the Diagnostic Tester.

(2) Connect the Diagnostic Tester to DLC3 at the lower left of the instrument panel.

(3) Turn the ignition switch ON and switch the Diagnostic Tester ON.

(4) Use the Diagnostic Tester to check the DTC(s) and Freeze Frame data. Print or write the information for future reference.

(5) See the DI section in the Repair Manual to confirm the details of the DTC(s).

NOTE When the diagnosis system (Diagnostic Tester only) is switched from the normal mode to the check mode, it erases all DTC(s) and Freeze Frame data recorded in the normal mode. So before switching modes, always check the DTC(s) and Freeze Frame data, and print or write them down.

NOTE When simulating symptoms with a generic OBD II scan tool, check the DTC(s) and use the normal mode. For codes on the DTC chart subject to "two trip detection logic", perform either of the following actions.

Turn the ignition switch OFF after the symptom is simulated the first time. Then repeat the simulation process again. When the problem has been simulated twice, the MIL lights up and the DTC(s) are recorded in the ECM.

Check the first trip DTC using Mode 7 (Continuous Test Results) or Pending Codes. See Readiness Test Confirmation Strategy.

(c) Clear the DTC.

The DTC(s) and Freeze Frame data will be erased by either action.

(1) Operate the Diagnostic Tester to erase the codes (See the Diagnostic Toolset Operator's Manual for instructions).

(2) Disconnecting the battery terminals or EFI and ETCS fuses.

NOTE If the Diagnostic Tester switches the ECM from the normal mode to the check mode or vice-versa, or if the ignition switch is turned from ON to ACC or OFF during the check mode, the DTC(s) and Freeze Frame data will be erased.

Fail-Safe Chart

For many DTCs, the ECM enters fail-safe mode. A chart in the DI section lists the action the ECM takes when a DTC is present.

Fail-Safe Chart

The Fail-Safe Chart is located in the DI section. If any of the listed DTCs are present, the ECM enters Fail-Safe mode. In most cases, this means the ECM substitutes a value so that the engine will continue to run.

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0100	Ignition timing fixed at 5° BTDC	Returned to normal condition
P0110	Intake air temperature is fixed at 20°C (68°F)	Returned to normal condition
P0115	Engine coolant temperature is fixed at 80°C (176°F)	Returned to normal condition
P0135 P0141 P0155 P0161	The heater circuit in which an abnormality is detected is turned off	Ignition switch OFF
P0325 P0330	Max. timing retardation	Ignition switch OFF
P1300	Fuel cut	Returned to normal condition

Fig. 2-21

TL874f221

Step 5: Visual Inspection

This is a quick check of the basics such as:

- Is there gasoline in the tank?
- All hoses and wires connected and routed correctly?
- Does the vehicle start? If not, go to steps 10 and 12 first.

NOTE

Do not wiggle or shake wires at this time. You will want to see if the fault is present. Shaking wires could temporarily fix the problem.

Step 6: Check Mode

Check Mode is an operation to speed up diagnosis. Compared to Normal Mode, Check Mode has an increased sensitivity to detect malfunctions. Furthermore, the same diagnostic items that are detected in Normal Mode can also be detected in Check Mode.

Check the DTC in the Repair Manual to see if Check Mode is used to verify the condition. Check Mode will not work for Evaporative System or misfire DTCs.

The MIL flashes when in Check Mode.

NOTE

If the Diagnostic Tester switches the ECM from Normal Mode to Check Mode or vice-versa, or if the ignition switch is turned from ON to ACC or OFF during Check Mode, the DTC(s) and Freeze Frame data will be erased.

Step 7: Problem Symptom Confirmation

Using conditions described by the owner, check vehicle operation. Once the problem is verified, proceed to step 9 to see if any DTCs were recorded. If no symptoms were exhibited by the vehicle, proceed to step 8.

Step 8: Symptom Simulation

In this mode, as described in Section 1, an action is taken based on the description in the customer analysis sheet. For example, the condition occurs only when hot. Heating the component simulates the condition and may produce the fault.

Step 9: DTC Check

If there is a DTC, proceed to step 11.

If no DTCs are present, go to step 10.

Step 10: Basic Inspection

When the malfunction code is not confirmed in the DTC check, troubleshooting should be performed to narrow down the possibilities. In many cases, by carrying out the basic engine check shown in the Repair Manual under Basic Inspection, the location causing the problem can be found quickly and efficiently. Therefore, use of this check is essential in engine troubleshooting.

Basic Inspection Procedure

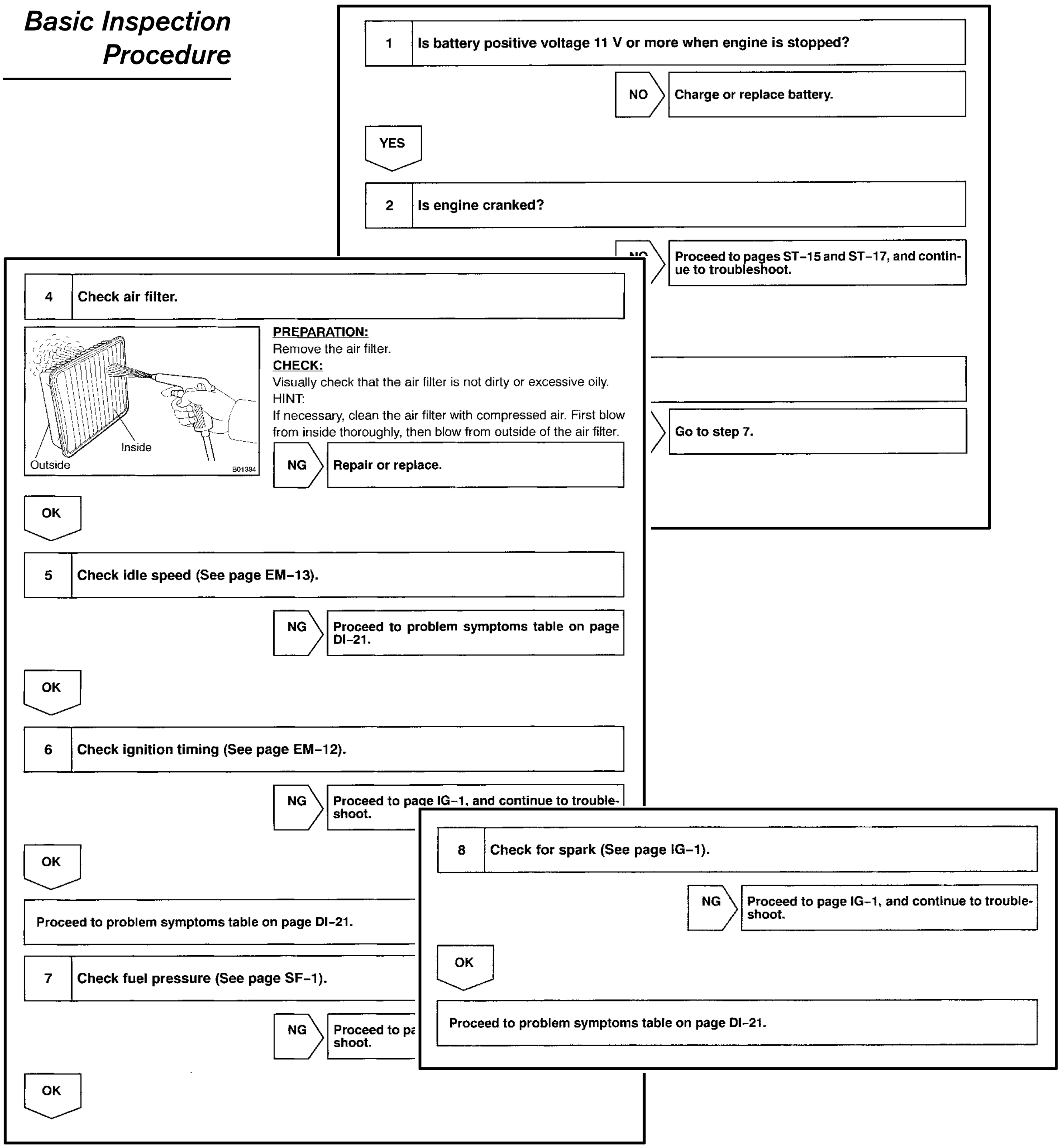


Fig. 2-22

TL874f222

Step 11: DTC Chart

The DTC chart lists DTC codes, what is detected, possible trouble areas, and what page to turn to in order to diagnose that DTC.

Step 12: Problem Symptoms Table

Use this table to troubleshoot the problem when a "NO" code is displayed in the diagnostic trouble code check but the problem is still occurring. Numbers in the table indicate the inspection order in which the circuits or parts should be checked.

Step 13: Circuit Inspection

Go to the circuit inspection for the DTC(s) listed and follow the procedure as outlined.

NOTE

Often overlooked by technicians are the Inspection Procedure, Hints and Circuit Descriptions. These areas contain valuable information on how the circuit operates, items to check, and the order to check these items.

Here is an example from the DTC P0440 section:

Inspection Procedure

Inspection Procedure:

HINT

- If DTC P0441, P0446, P0450 or P0451 is output after DTC P0440, first troubleshoot DTC P0441,P0446, P0450 or P0451. If no malfunction is detected, troubleshoot DTC P0440, next.
- Ask the customer whether, after the MIL came on, the customer found the fuel tank cap loose and tightened it. Also, ask the customer whether the fuel tank cap was loose when refueling. If the fuel tank cap was loose, it was the cause of the DTC. If the fuel tank cap was not loose or if the customer was not sure if it was loose, troubleshoot according to the following procedure.
- Read Freeze Frame data using the Diagnostic Tester, because Freeze Frame records the engine conditions when the malfunction is detected. When troubleshooting, it is useful for determining whether the vehicle was running or stopped, the engine was warmed up or not, or the A/F ratio was lean or rich, etc. at the time of the malfunction.
- When the ENGINE RUN TIME in the Freeze Frame data is less than 200 seconds, carefully check the vapor pressure sensor.

Step 14: Parts Inspection

The parts inspection procedures for engines and engine control system components are usually found in the following sections:

- Engine Mechanical
- Fuel (Sequential Fuel Injection)
- Emission Control
- Ignition
- Engine Control System

Usually, the circuit inspection diagnosis routine will direct you to one of these sections.

The DI section has a Parts Location drawing showing the location of major engine control system components.

Step 15: Check for Intermittent Problems

Intermittent problems are often the most frustrating to solve. Aids to help you are:

- Using V-BoB
- Observing Mode 7 Continuous Tests or Pending Codes

By putting the vehicle's ECM in the check mode, one trip detection logic is possible instead of two trip detection logic; and sensitivity to detect open circuits is increased. This makes it easier to detect intermittent problems.

(1) Clear the DTC(s).

(2) Set the check mode.

(3) Perform a simulation test.

(4) Check the connector and terminal.

(5) Handle the connector.

NOTE Check mode does not work for EVAP DTCs.

Step 16: Adjustment/ Repair

At this point perform any adjustment or repairs.

Step 17: Confirmation Test

After repairing a problem involving many DTCs, the Repair Manual will outline a confirmation test procedure. It is very similar to using Check Mode. An alternative method is to use the Readiness Test Procedure using Mode 7.

Engine Operation Conditions Serial Data

In the DI section under ENGINE OPERATING CONDITION, there is a list that displays diagnostic tester abbreviations, the item measured, and what is a normal condition.

While not part of a specific routine, the listed items can provide important clues to engine operation and components and circuits operation.

If the measured item is not within the values given under normal condition, make a note but do not condemn the component or circuit. Always follow the troubleshooting procedure.

Engine Conditions - Serial Data

The values given for "Normal Condition" are representative values, so a vehicle may still be normal even if its value differs from those listed here. Do not decide whether a part is faulty according to the "Normal Condition" here.

hand-held tester display	Measurement Item	Normal Condition*
FUEL SYS #1	Fuel System Bank 1 OPEN: Air-fuel ratio feedback stopped CLOSED: Air-fuel ratio feedback operating	Idling after warming up: CLOSED
FUEL SYS #2	Fuel System Bank 2 OPEN: Air-fuel ratio feedback stopped CLOSED: Air-fuel ratio feedback operating	Idling after warming up: CLOSED
CALC LOAD	Calculator Load: Current intake air volume as a proportion of max. intake air volume	Idling: 15.6 – 22.2 % Racing without load (2,500 rpm): 16.6 – 23.9 %
COOLANT TEMP	Engine Coolant Temp. Sensor Value	After warming up: 80 – 95°C (176 – 203°F)
SHORT FT #1	Short-term Fuel Trim Bank 1	0 ± 20 %
LONG FT #1	Long-term Fuel Trim Bank 1	0 ± 20 %
SHORT FT #2	Short-term Fuel Trim Bank 2	0 ± 20 %
LONG FT #2	Long-term Fuel Trim Bank 2	0 ± 20 %
ENGINE SPD	Engine Speed	Idling: 650 – 750 rpm
VEHICLE SPD	Vehicle Speed	Vehicle stopped: 0 km/h (0 mph)
IGN ADVANCE	Ignition Advance: Ignition Timing of Cylinder No.1	Idling: BTDC 6 – 16°
INTAKE AIR	Intake Air Temp. Sensor Value	Equivalent to ambient temp.
MAF	Air Flow Rate Through Mass Air Flow Meter	Idling: 3.5 – 5.0 gm/sec. Racing without load (2,500 rpm): 12.5 – 17.9 gm/sec.
THROTTLE POS	Voltage Output of Throttle Position Sensor Calculated as a percentage: 0 V → 0 %, 5 V → 100 %	Throttle fully closed: 8 – 20 % Throttle fully open: 64 – 96 %
O2S B1 S1	Voltage Output of Oxygen Sensor Bank 1 Sensor 1	Idling: 0 – 1.0 V
O2S B1 S2	Voltage Output of Oxygen Sensor Bank 1 Sensor 2	Driving (50 km/h, 31 mph): 0 – 1.0 V
O2S B2 S1	Voltage Output of Oxygen Sensor Bank 2 Sensor 1	Idling: 0 – 1.0 V
O2S B2 S2	Voltage Output of Oxygen Sensor Bank 2 Sensor 2	Driving (50 km/h, 31 mph): 0 – 1.0 V
O2FT B1 S1	Oxygen Sensor Fuel Trim Bank 1 Sensor 1 (Same as SHORT FT #1)	0 ± 20 %
O2FT B2 S1	Oxygen Sensor Fuel Trim Bank 2 Sensor 1 (Same as SHORT FT #2)	0 ± 20 %

Fig. 2-23

TL874f223

Limitations of the Self-Diagnostic System

As advanced as the OBD and OBD II self diagnostic systems are, there are still certain limitations you must keep in mind when troubleshooting engine control system faults:

Not all engine control system circuits are monitored. Therefore, not all problems will activate the Malfunction Indicator Lamp (MIL) or store a DTC in ECM memory.

A DTC only indicates that a problem exists somewhere in the sensor/actuator circuit. You must determine where the fault exists. For example; a sensor, related wiring, or ECM. Some intermittent problems can go undetected because the diagnostic programming is unable to detect the fault. In these cases, it is best to use the problem symptoms, Basic Inspection, and get live measurements by using a DVOM or V-BoB.

Even though the engine control system passes the Diagnostic Circuit Inspection, it does not always indicate a problem free system.

Readiness Test Confirmation Strategy

This procedure uses the modes under CARB to detect problems with monitored systems. This procedure will guide you on how to use and interpret Readiness Confirmation Test status for diagnosis.

The Repair Manual often provides a confirmation driving pattern to test the vehicle, for certain types of repairs (O2 sensor, A/F sensor, EGR system, catalytic converter). The Repair Manual may direct you to use Check Mode. Check mode is NOT to be used. This procedure is a general procedure designed for all Non-Continuous monitors.

The following must be observed for the EVAP monitor to run and it must be within the following parameters:

- Vehicle must be cold, ambient temperature approximately between 10°C - 35°C (50°F - 95°F). (This is done for earlier completion.)

- Fuel level between 1/4 to 3/4 (this is done for earlier completion).

- Intake Air Temperature (IAT) and Engine Coolant Temperature (ECT) sensors within 6.5°C (12°F) of each other.

TID CID Screen and TIME$0 Screen

Two different screens showing Pass and Fail. Some vehicles will show TID in place of Time. To see the test results of the O2 sensor monitor, go to Mode 5 O2S Test Results.

- (TID)Time$01 = Catalyst Deterioration
- (TID)Time$02 = Evaporative System Deterioration
- (TID)Time$03 = Not Supported
- (TID)Time$04 = O2 Sensor Heater
- (TID)Time$05 = EGR
- (TID)Time$06 = A/F Sensor
- (TID)Time$07 = A/F Sensor Heater
- (TID)Time$08 = Thermostat Monitor

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Fail
Time$02 CID$02........ Fail
Time$02 CID$03........ Fail
Time$02 CID$04........ Fail
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Fig. 2-24

TL874f215

First Trip Procedure

Clear DTCs. Under CARB OBD II, Readiness Tests will show INCMPL. Turn ignition key off, wait 5 seconds, then start the engine.

NOTE **The READINESS TEST screen and MONITOR STATUS screen contain identical information. You can use either screen to confirm monitor operation.**

First Trip Procedure - DTCs Cleared

All Non-Continuous Readiness Tests evaluations show INCMPL (incomplete) when DTCs are cleared. Monitor status will show the same monitors..

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............ INCMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL........ INCMPL
EGR EVAL............ INCMPL
```

Fig. 2-25

TL874f225

Drive the vehicle in the following manner: Allow the engine to warm up. Moderately accelerate from 0 mph to 40 mph, hold at 40 mph for at least 30 seconds, then decelerate to idle with an idle time of approximately 30 seconds. Repeat this pattern at least three times. Next, drive the vehicle at a relatively constant speed between 40 mph to 65 mph. Avoid rough terrain and sharp turns. Note the state of Readiness Tests. They will change to **COMPL** as the evaluation monitors operate and if the system passes. This procedure may take approximately 20 minutes or more. **Do not shut off the engine – the results will be invalid.**

The following will explain the possible results of this test. The Diagnostic Tester will display either COMPL (complete) or INCMPL (incomplete). Read the following two conditions, **Pass Condition** or **Fail Condition** to determine the state of the monitor.

Pass Condition - No Problem Found by the ECM

If the evaluation monitor(s) shows **COMPL**, go to the NON-CONTINUOUS TESTS screen. To get there, go to ADVANCED OBD II, ON-BOARD TESTS, NON-CONTINUOUS TESTS. For the O2 sensor monitor, go to O2S TEST RESULTS.

NOTE Do not turn the engine off – the results will be invalid.

If the Time$0x tests show **Pass**, the evaluation monitor(s) **has operated and no problem was detected**.

Pass Condition

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL............ COMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Fig. 2-26

TL874f226

No Determination Condition

If a Readiness Test shows **INCMPL**, go to NON-CONTINUOUS TESTS screen. For the O2 sensor monitor, go to O2S TEST RESULTS.

1.If the tests show **Pass**, the following may have occurred:

- the evaluation monitor did not operate
- the evaluation monitor did not finish
- the ECM withheld judgement

No Determination Condition

From the data on these two screens, the ECM has not determined if the EVAP system is good or if there is a problem. Further driving may be needd.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Fig. 2-27

TL874f227

NOTE When a Readiness Test monitor shows INCMPL and Pass, it is unknown if the system monitor is good or if it has a problem. Further testing and/or driving is recommended to confirm system monitor operation.

Fail Condition - Problem Detected by the ECM

1. If one or more of the tests in the Time$0x... category show **Fail**, the evaluation monitor(s) did operate and the ECM detected a problem.

TID Screen

- (TID)Time$01 = Catalyst Deterioration
- (TID)Time$02 = Evaporative System Deterioration
- (TID)Time$03 = Not Supported
- (TID)Time$04 = O2 Sensor Heater
- (TID)Time$05 = EGR
- (TID)Time$06 = A/F Sensor
- (TID)Time$07 = A/F Sensor Heater
- (TID)Time$08 = Thermostat Monitor

Fig. 2-28

Fail Condition

Here, the ECM has detected a problem in the EVAP system. Since this happened on the first trip, the DTC(s) can be found in Continuous Tests (Mode 7) or Pending Codes. These are pending DTC(s).

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Fail
Time$02 CID$02........ Fail
Time$02 CID$03........ Fail
Time$02 CID$04........ Fail
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Fig. 2-29

TL874f229

NOTE

Go to CONTINUOUS TESTS (Mode 7) screen or PENDING CODES screen.

Pending DTCs

The Continuous Tests or Pending Codes showed the DTCs. These DTCs do not show up anywhere else. These DTCs may not be valid, but indicates a possible problem. A second trip is needed to confirm.

```
CONTINUOUS TESTS
ECU: $10 (Engine)
Number of Tests: 3

P0440
EVAP Control System
Malfunction

P0441
EVAP Control System
Incorrect Purge Flow

P0446
EVAP Control System Vent
Control Circuit Malfunction
```

```
PENDING CODES
ECU: ENGINE
Number of DTCs: 3

P0440
EVAP Control System
Malfunction

P0441
EVAP Control System
Incorrect Purge Flow

P0446
EVAP Control System Vent
Control Circuit Malfunction
```

Fig. 2-30

TL874f230

Second Trip Procedure

The DTC listed may not be valid. A second trip is needed to confirm the DTC.

1. Vehicle must be cold, ambient temperature approximately between 10°C - 35°C (50°F - 95°F).

2. Fuel level between 1/4 to 3/4.

3. Intake Air Temperature (IAT) and Engine Coolant Temperature (ECT) sensors within 6.5°C (12°F) of each other.

4. **DO NOT CLEAR CODES!**

5. Go to Readiness Test screen.

6. Drive the vehicle according to the same pattern as outlined earlier. Note the state of evaluation monitor(s). This procedure may take approximately 20 minutes or more. **Do not shut off the engine – the results will be invalid.**

If a Readiness Test changes to **COMPL**, the evaluation monitor has operated. Check for any stored DTCs.

- If a DTC has stored, the problem has been detected and confirmed by the ECM.
- If no DTC was found, the monitor operated but no problem was detected.

There are situations where the Readiness Test may stay **INCMPL**, but the MIL will illuminate on the second trip (if two trip DTC). In this case, a fault has been detected and you should troubleshoot the displayed DTC(s).

Second Trip Procedure

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
P0440
EVAP Control System
Malfunction

P0441
EVAP Control System
Incorrect Purge Flow

P0446
EVAP Control System Vent
Control Circuit Malfunction
```

Fig. 2-31

TL874f231

Summary of Readiness Test Results

NO problem detected if the monitor shows COMPL on the first trip, and if Non-Continuous test screen shows Pass.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL............ COMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

The monitor did not operate/did not complete/withheld judgement -If monitor shows INCMPL on the first trip, and Non-Continuous Tests shows Pass.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

Problem detected if the monitor operated and a fault was detected if the monitor shows INCMPL on the first trip, and Non-Continuous shows Fail. Go to Continuous Tests or Pending Codes for DTC(s).

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Fail
Time$02 CID$02........ Fail
Time$02 CID$03........ Fail
Time$02 CID$04........ Fail
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

```
CONTINUOUS TESTS
ECU: $10 (Engine)
Number of Tests: 3

P0440
EVAP Control System
Malfunction

P0441
EVAP Control System
Incorrect Purge Flow

P0446
EVAP Control System Vent
Control Circuit Malfunction
```

Fig. 2-32

TL874f232

Check Mode Procedure

(1) Initial conditions:

- Battery positive voltage 11V or more
- Throttle valve fully closed
- Transmission in P or N position
- A/C switched OFF

(2) Turn the ignition switch OFF.

(3) Prepare the Diagnostic Tester.

(4) Connect the Diagnostic Tester to the DLC3.

(5) Turn the ignition switch ON and push the Diagnostic Tester switch ON.

(6) Switch the Diagnostic Tester from the normal mode to the check mode (Check that the MIL flashes.)

NOTE If the Diagnostic Tester switches the ECM from the normal mode to the check mode or vice-versa, or if the ignition switch is turned from ON to ACC or OFF during the check mode, the DTC(s) and Freeze Frame data will be erased.

(7) Start the engine (The MIL goes out after engine start.)

(8) Simulate the conditions of the malfunction described by the customer.

NOTE Leave the ignition switch ON until you have checked the DTC(s), etc.

(9) After simulating the malfunction conditions, use the Diagnostic Tester diagnosis selector to check the DTC(s) and Freeze Frame data, etc.

NOTE Take care not to turn the ignition switch OFF. Turning the ignition switch OFF switches the diagnosis system from check mode to normal mode, so all DTC(s), etc., are erased.

(10) After checking the DTC, inspect the applicable circuit.

Notes

WORKSHEET 2-1
Diagnostic Tester Modes

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

For troubleshooting OBD II concerns with the Diagnostic Tester, there are two major areas with information, Enhanced OBD II and CARB OBD II. In this worksheet, you will use the Diagnostic Tester to obtain relevant information, and observe the advantages different screens posses to the diagnosis of OBD II related concerns.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

Section 1: Features of Enhanced OBD II and CARB OBD II

1. On the list below, note if the listed item is located in the ENHANCED OBD II or CARB OBD II section. Write a very brief comment on the use/advantage of the following modes (if any).

SCREEN TITLE	ENHANCED OBD II	CARB OBD II
DATA LIST		
NORMAL MODE		
CHECK MODE		
REPAIR CONFIRMATION		
DTCs		

SCREEN TITLE	ENHANCED OBD II	CARB OBD II
SNAP SHOT		
FREEZE DATA		
CLEAR DIAG INFO		
O2S TEST RESULTS		
O2S/RPM CHECK		
READINESS TESTS		
ACTIVE TESTS		
ADVANCED OBD II FUNCTIONS		
NON-CONTINUOUS		
CONTINUOUS		
UNIT CONVERSION		
PENDING CODES		

Diagnostic Tester Modes

Name: ____ Date: ___________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate Enhanced and CARB OBD II functions on the Diagnostic Tester			

Notes

WORKSHEET 2-2
Readiness Non-Continuous Test Modes

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

To accurately diagnose the condition of the vehicle based on Readiness Tests and Non-Continuous Test modes.

CASE 1

DTCs were cleared and the vehicle was driven with the DT connected. Based on the following screen shots, determine the status of the Readiness Tests (monitors) and determine if there is a problem

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL............ COMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............. COMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

READINESS TEST MON	Operate?	Status?
MISFIRE MON		
FUEL SYS MON		
COMP MON		
CAT EVAL		
EVAP EVAL		
O2S EVAL		
O2S HTR EVAL		
EGR EVAL		

Notes:

CASE 2

DTCs were cleared and the vehicle was driven with the DT connected. Based on the following screen shots, determine the status of the Readiness Tests monitors and determine if there is a problem.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL........... INCMPL
HTD CAT EVAL........... N/A
EVAP EVAL.......... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............... N/A
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

READINESS TEST MON	Operate?	Status?
MISFIRE MON		
FUEL SYS MON		
COMP MON		
CAT EVAL		
EVAP EVAL		
O2S EVAL		
O2S HTR EVAL		
EGR EVAL		

Notes:

CASE 3

DTCs were cleared and the vehicle was driven with the DT connected. Based on the following screen shots, determine the status of the Readiness Tests monitors and determine if there is a problem.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............. COMPL
O2S HTR EVAL......... COMPL
EGR EVAL............... N/A
```

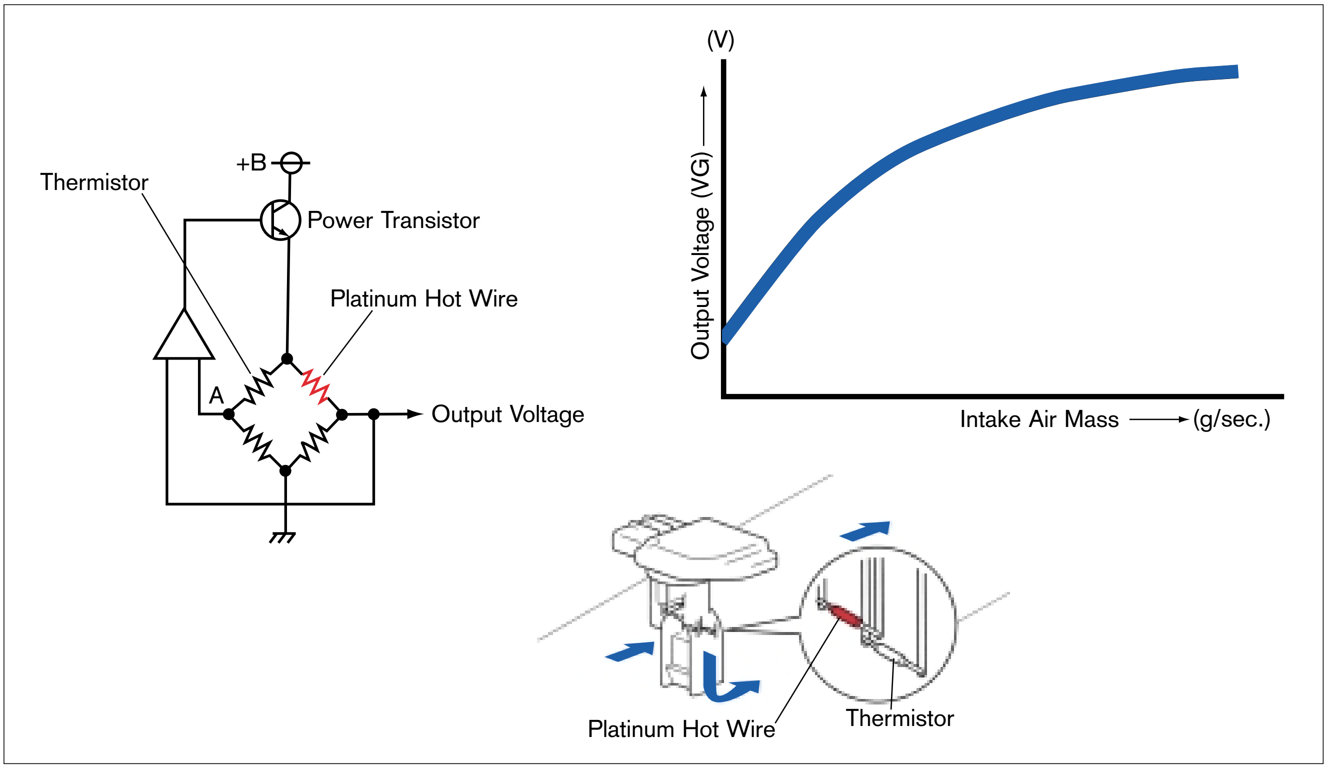
```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Fail
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$00........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$06 CID$01........ Pass
Time$07 CID$01........ Pass
```

READINESS TEST MON	Operate?	Status?
MISFIRE MON		
FUEL SYS MON		
COMP MON		
CAT EVAL		
EVAP EVAL		
O2S EVAL		
O2S HTR EVAL		
EGR EVAL		

Notes:

Section 3

Comprehensive Component Monitor Diagnosis



Learning Objectives:

1. Determine engine systems operation and identify faulty comprehensive components based on Data List information.
2. Explain the basic enable strategies and detecting conditions used for assessing comprehensive components and circuits.

Section 3

Comprehensive Component Monitor Diagnosis

Overview

The comprehensive component monitor is used to monitor individual component operation. In many ways this is similar to the OBD systems. The comprehensive component monitor, like OBD, monitors for opens or shorts in the component or its circuit, however it also has the ability to determine the performance of a component/circuit. The ECM does this by determining if the signal is rational. For example, a MAF voltage signal of 3.0 volts with the throttle closed is not rational.

If it affects vehicle emissions, but is not part of the other monitored systems, it is a comprehensive component.

Many comprehensive components have two types of DTCs. An open, a short, or no response is a one trip DTC. A performance problem is usually a two trip DTC.

NOTE

The best source of this code setting parameter information is the Repair Manual specific to that vehicle. Some parameters may not be outlined but should be assumed, i.e. engine at operating temperature. Carefully study the information given to determine what must occur before DTC will be recorded. Remember the DTC may be the result of an out-of-spec system monitor, not a component that has failed.

ECM Detection Range Example

This graph displays the detection range for the ECT sensor. OBD II tests for these conditions and for ECT sensor performance.

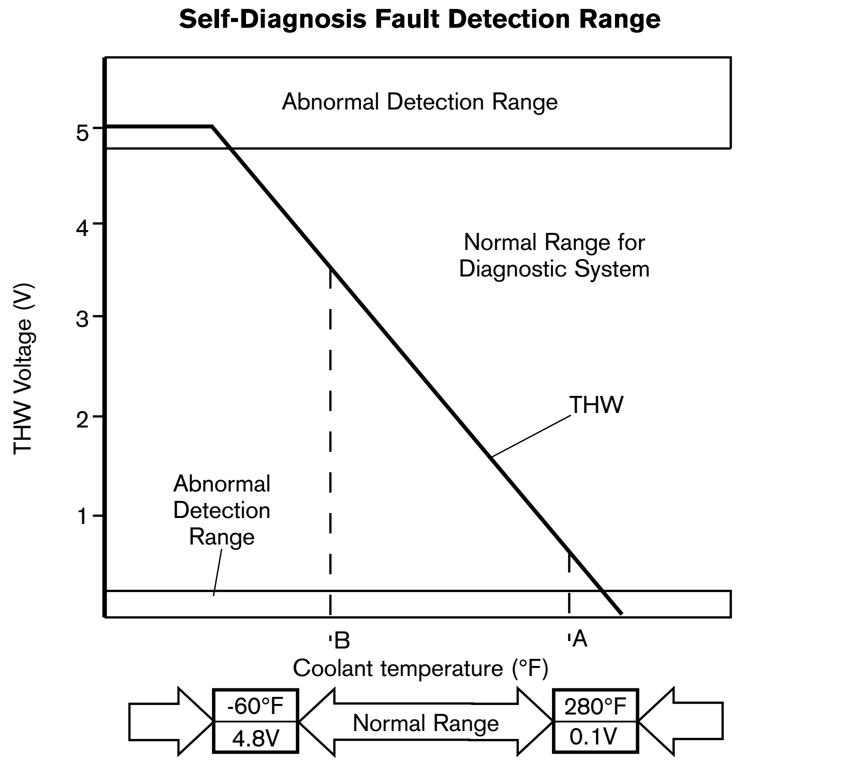


Fig. 3-1

TL874f301

MAF Sensor Circuit

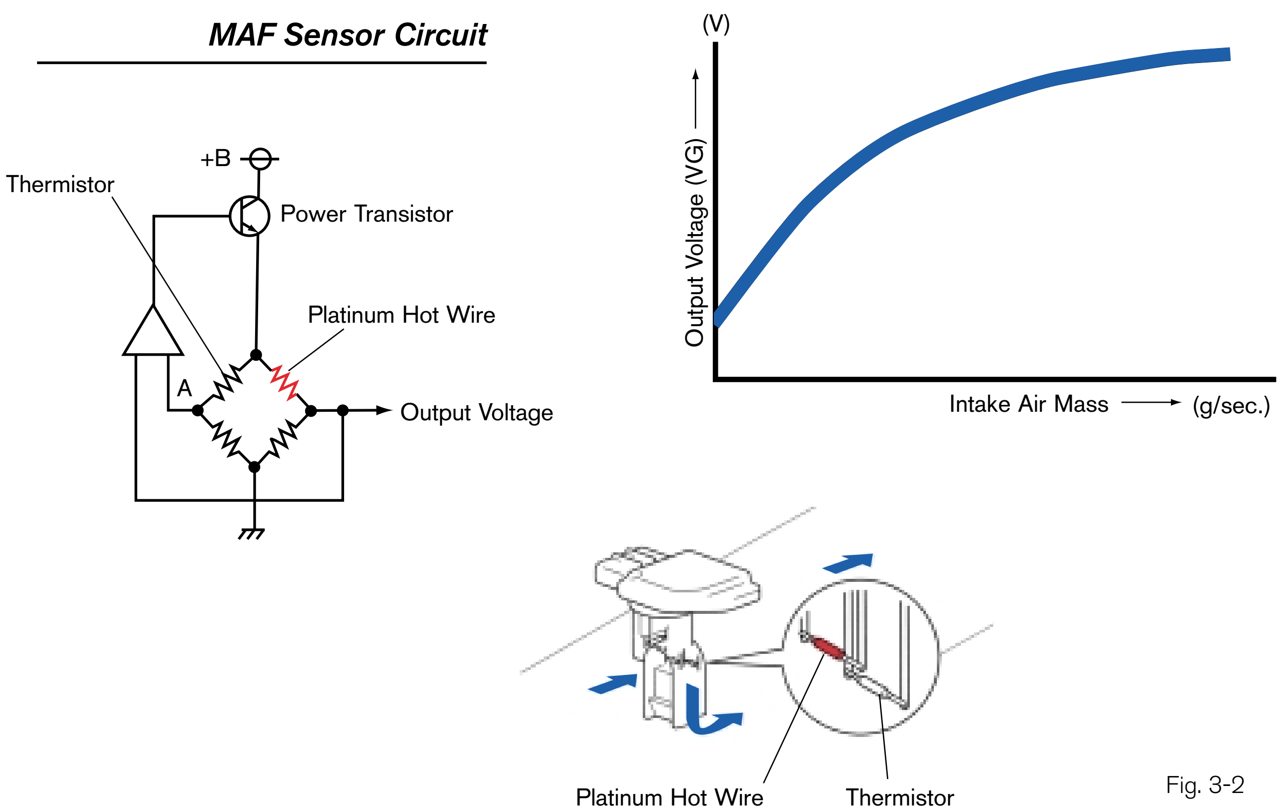


Fig. 3-2

TL874f302

Mass Air Flow (MAF) Sensor Circuit

There are two DTCs directly applicable to the MAF circuit. DTC P0100 is set when an open or short occurs in the MAF circuit. It is a one trip DTC and has Fail-Safe strategy. The Fail-Safe Strategy fixes the ignition timing and the on time of the fuel injectors according to engine conditions.

DTC P0101 has three different conditions to detect MAF sensor/circuit failure. ECM is comparing the MAF signal against the expected MAF signal when compared to throttle position and engine speed.

***P0100** Mass Air Flow Sensor Circuit*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Time $>$ 3 sec. Engine Speed $\geq$ 4000 rpm	0.0 gm.sec or 271 gm/sec	1	Fail-Safe Mode Ignition timing fixed Injection on time fixed

***P0101** Mass Air Flow Circuit Range/Performance*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine warmed up Throttle Valve fully closed Engine Speed $\geq$ 1000 rpm Time $\geq$ 10 sec.	MAF output $>$ 2.2V	2	
Engine Speed $\geq$ 2000 rpm Time $\geq$ 6 sec. VTA $\geq$ 0.64V	MAF output $<$ 1.0V	2	

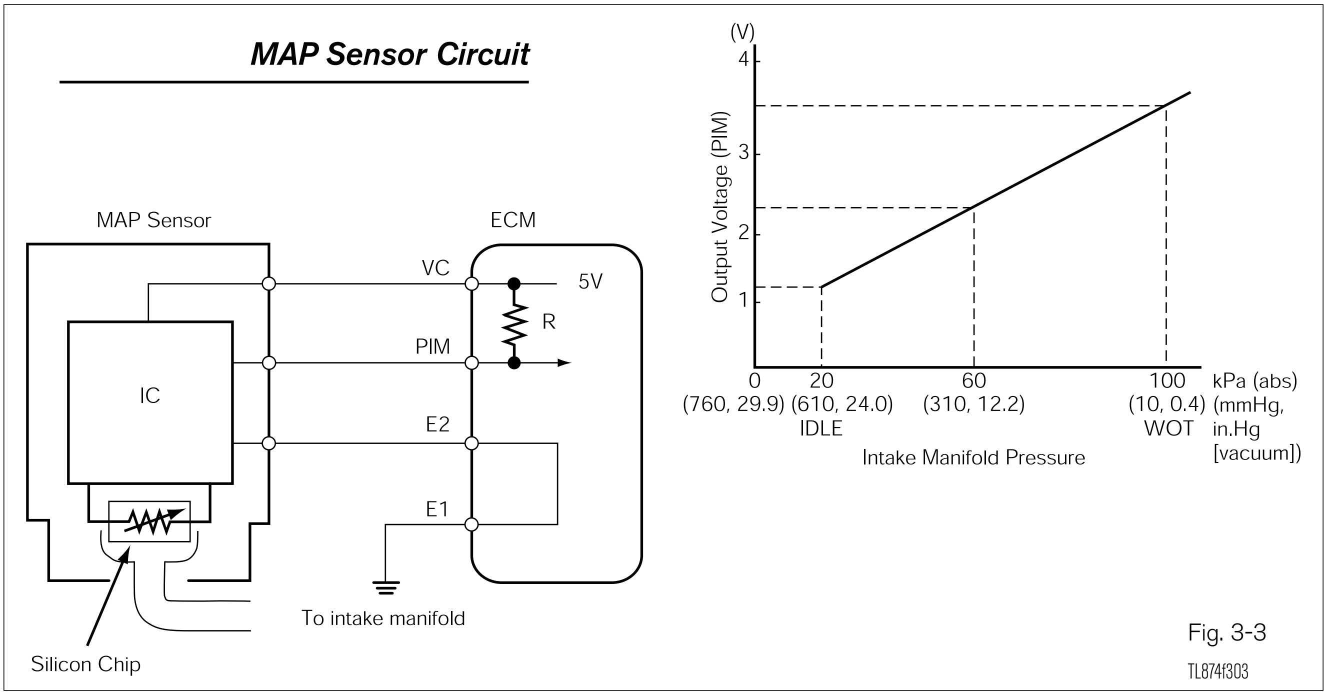


Fig. 3-3

Manifold Absolute Pressure (MAP) Sensor Circuit

The ECM will set DTC P0105 when there is an open or short in the circuit. There is a Fail-Safe strategy when this condition is detected. DTC P0106 is a performance condition based on logic. ECM is comparing the MAP signal against the expected MAP signal when compared to throttle position and engine speed.

***P0105** Manifold Absolute Pressure/Barometric Pressure Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	MAP 0kPa or > 130kPa	1	Fail-Safe Mode Ignition timing fixed (5° BTDC)

***P0106** Manifold Absolute Pressure Circuit Range/Performance Problem*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine warmed up Throttle Valve fully closed Engine speed 400-1000 rpm Time ≥ 10 sec.	MAP output > 3.0V	2	
Engine Speed 2500 rpm Time ≥ 5 sec. VTA ≥ 1.85V	MAP output < 1.0V	2	

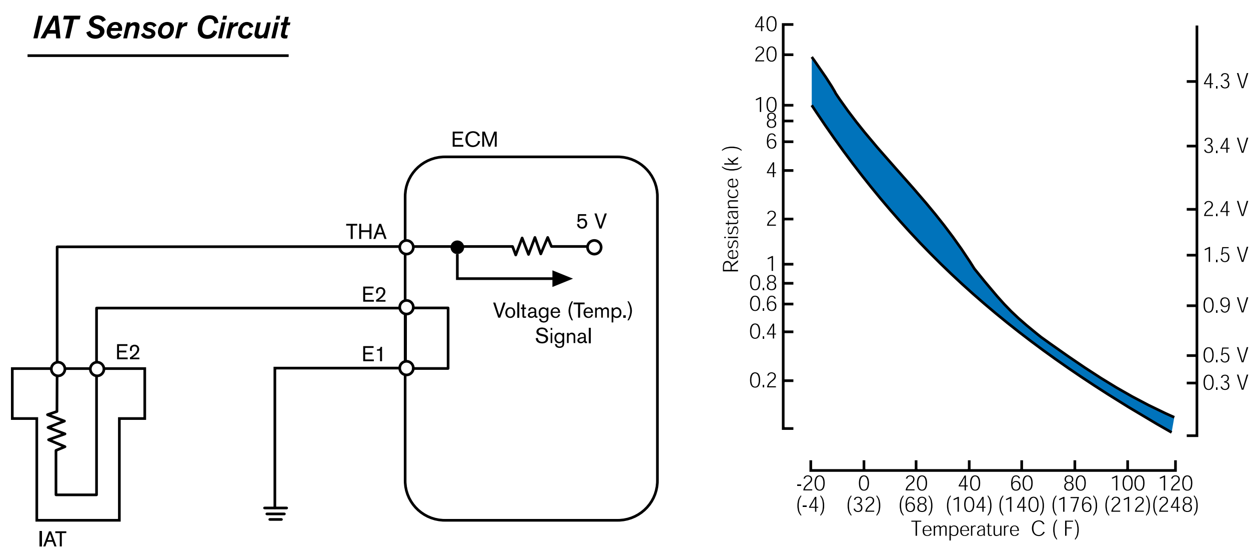


Fig. 3-4

TL874f304

Intake Air Temperature (IAT) Sensor Circuit

The ECM detects an open or short in the IAT circuit. This is a one trip DTC with a Fail-Safe function.

***P0110** Intake Air Temperature Sensor Circuit*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	Temperature -40°C (40°F) or ≥ 140°C (284°F)	1	Fail-Safe Mode ECT is fixed @ 20°C (68°F)

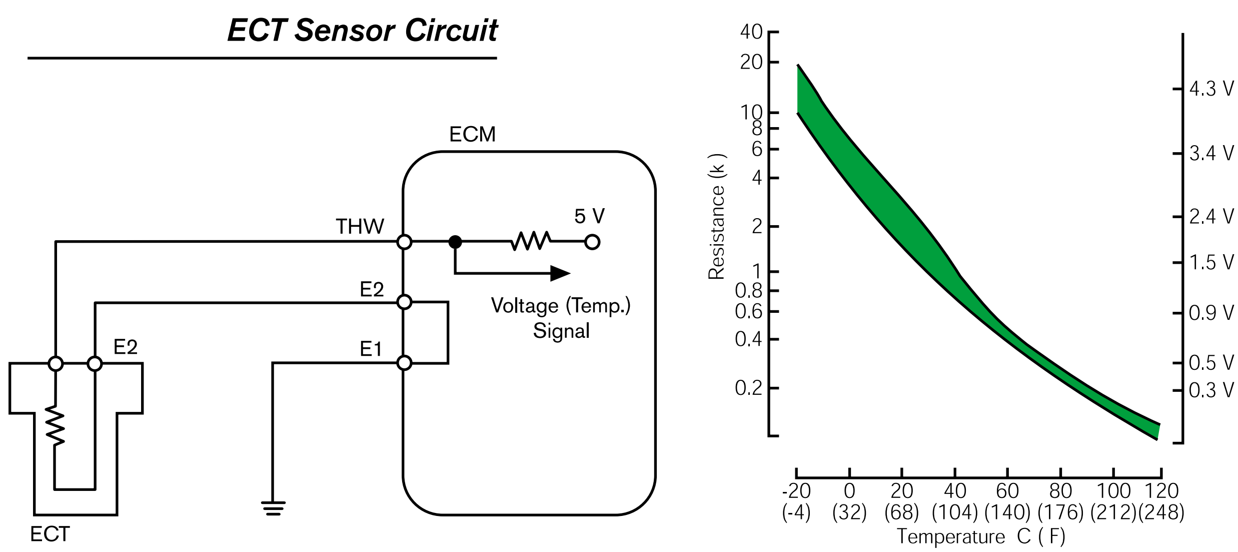


Fig. 3-5

TL874f305

Engine Coolant Temperature (ECT) Sensor Circuit

There are two DTCs that can set for the ECT sensor circuit. The first DTC P0115 is for an open or short in the circuit. Note that this is a one trip DTC and that the ECM strategy is to go to Fail-Safe Mode and substitute a value.

***P0110** Engine Coolant Temperature Sensor Circuit*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	Temperature -40°C (40°F) or ≥ 140°C (284°F)	1	Fail-Safe Mode ECT is fixed @ 80°C (176°F)

The second DTC is set when the ECT sensor does not change its signal according to the ECM logic. The ECM has been programmed to measure how quickly the ECT sensor changes as the engine warms up. This is a two trip DTC. Note the different temperature ranges the ECM uses to see if the ECT circuit is functioning correctly.

***P0116** Engine Coolant Temperature Circuit Range/Performance Problem*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
If THW < -7°C (19.4°F) or THA < -7°C (19.4°F) @ Engine Start Time ≥ 20 min.	ECT Sensor is: ≤ 30°C (86°F) Non CA ≤ 20°C (68°F) CA	2	
If THW ≥ -7°C (19.4°F) and < 10°C (50°F) @ Engine Start Time ≥ 5 min. OR THA ≥ 10°C (50°F)@ Engine Start Time ≥ 2 min.	ECT Sensor is: ≤ 30°C (86°F) Non CA ≤ 20°C (68°F) CA	2	
When THW ≥ 35°C (95°F) and 60°C (140°F), THA ≥ -7°C (19.4°F) @ Engine Start	Vehicle speed not stable ECT temp change lower 3°C (37.4°F) than when engine started	2	

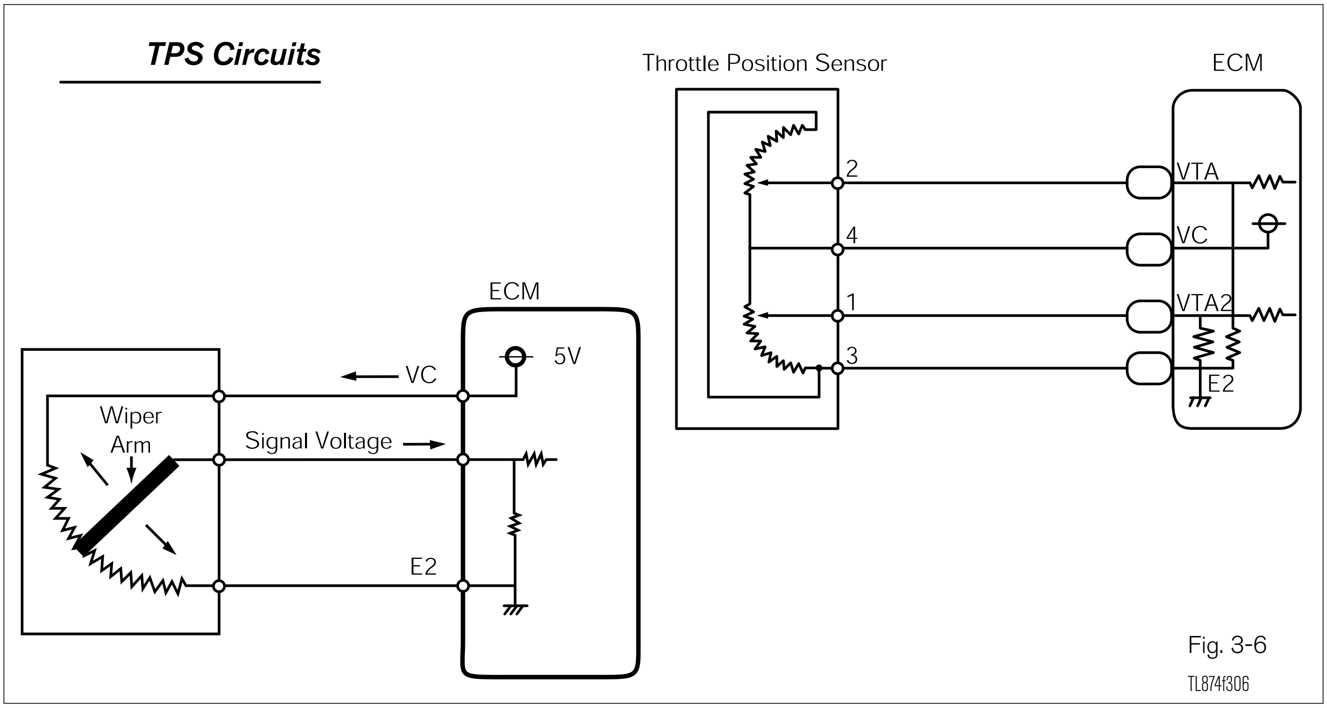


Fig. 3-6

TL874f306

Throttle Position Sensor (TPS) Circuit

DTC P0120 is a one trip DTC that sets when the TPS circuit shows either open circuit voltage or closed circuit voltage.

For DTC P0121, the ECM looks at the VTA voltage from the TPS as the vehicle decelerates from 19 mph to 0 mph. The ECM compares the VTA voltage to its preprogrammed specifications to determine if the TPS is out of range. This is a one trip DTC.

***P0120** Throttle/Pedal Position Sensor/Switch "A" Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON Time ≤ 5 sec.	VTA < 0.1V or VTA > 4.9V	1	Fail-Safe Mode VTA is fixed at 0 degrees

NOTE Throttle valve either fully closed (approx. 0%) or fully opened (approx. 100%)

***P0121** Throttle/Pedal Position Sensor/Switch "A" Circuit Range/Performance Problem*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Vehicle speed has exceeded 19 mph (30 (km/h). Vehicle speed drops from 19 mph (30 km/h) or more to 0 mph (0 km/h), output value of the TPS is out of applicable range	VTA voltage out of range VTA < 0.7V or ≥ 5.2V	1	

NOTE These DTCs are covered in detail with the approproate system monitor.

P0125 *Insufficient Coolant Temp. for Closed Loop Fuel Control*

P0130/P0150 *Heated O2 Sensor Circuit Malfunction (B1,S1/B2,S1)*

P0133/P0153 *Heated O2 Sensor Circuit Slow Response (B1,S2/B2,S2)*

P0135/P0141/P0155/P0161 *Heated O2 Sensor Heater Malfunction (B1,S1/B1,S2/B2,S1/B2/S2)*

P0136/P0156 *Heated O2 Sensor Circuit Malfunction (B1,S2/B2,S2)*
See O2 and A/F Sensor Diagnostics section

P0171, P0174 *System Too Lean (Fuel Trim)*
See Fuel System Diagnostics section

P0172, P0175 *System Too Rich (Fuel Trim)*
See Fuel System Diagnostic section

P0300/P0301/P0302/P0303/P0304/P0305/P0306/P0307/P0308 *Cylinders Misfire Detected*
See Engine Misfire Diagnostic section

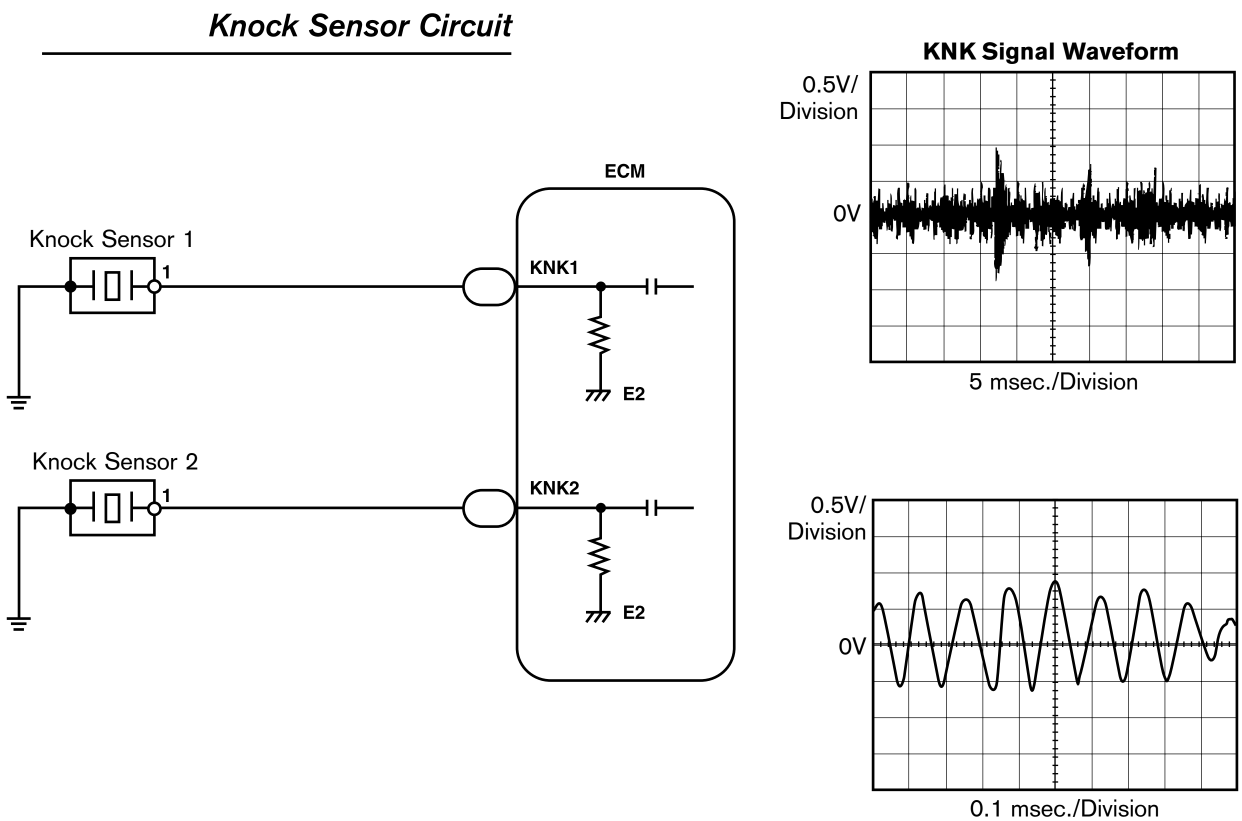


Fig. 3.7

TL874f307

Knock Sensor Circuit

The ECM looks for a signal from the knock sensor when the engine is operating under certain conditions. If the signal is not present, the ECM will retard the timing and the driver may notice a loss of power. The MIL will come on during the first trip.

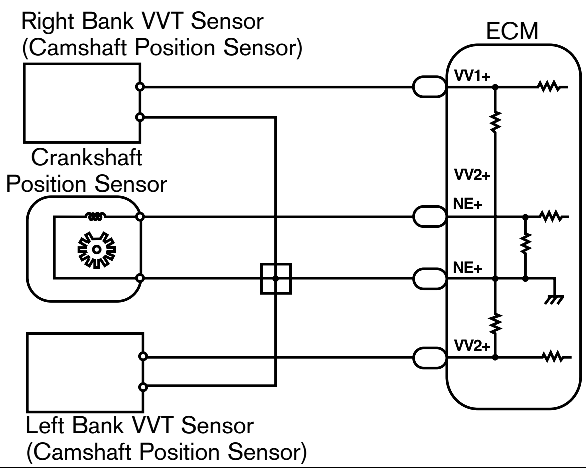
***P0325** Knock Sensor 1 Circuit*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine Speed 2000-5600 rpm	No Knock Sensor signal at the ECM	1	Fail-Safe Mode MIL ON Steady Max Timing retarded

***P0330** Knock Sensor 2Circuit*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine Speed 2000-5600 rpm	No Knock Sensor signal at the ECM	1	Fail-Safe Mode MIL ON Steady Max Timing retarded

Camshaft and Crankshaft Position Sensor Circuits



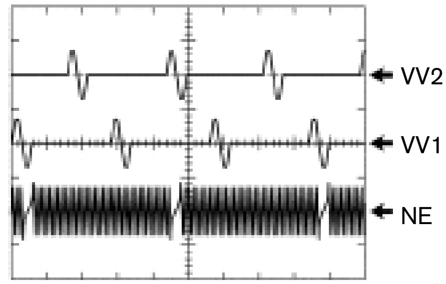


Fig. 3-8

TL874f308

Crankshaft Position Sensor Circuit

The ECM has two modes for detecting a fault in the crankshaft position sensor circuit and they both set the same DTC.

***P0335** Crankshaft Position Sensor "A" Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine Cranking	No Crankshaft Position Sensor signal received by ECM	2	
Engine Speed ≥ 600 rpm	No Crankshaft Position Sensor signal received by ECM	2	

Camshaft Position Sensor Circuit

The ECM has two modes for detecting a fault in the camshaft position sensor circuit and they both set the same DTC.

***P0340** Camshaft Position Sensor Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine Cranking	No Camshaft Position Sensor signal received by ECM	2	
Engine Speed ≥ 600 rpm	No Camshaft Position Sensor signal received by ECM	2	

P0420/P0430 *Catalyst System Efficiency Below Threshold (B1/B2)*
See Catalytic Converter Diagnosis section

P0440 *Evaporative Emission Control System Malfunction*

P0441 *Evaporative Emission Control System Incorrect Purge Flow*

P0446 *Evaporative Emission Control System/Vent Control System Malfunction*

See Evaporative System Diagnostic section

NOTE These DTCs are the results of System Monitors.

Vehicle Speed Sensor Circuits

There are many styles of speed sensor circuits. When diagnosing a vehicle speed sensor DTC, also refer to other relevant sections such as combination meter or ABS.

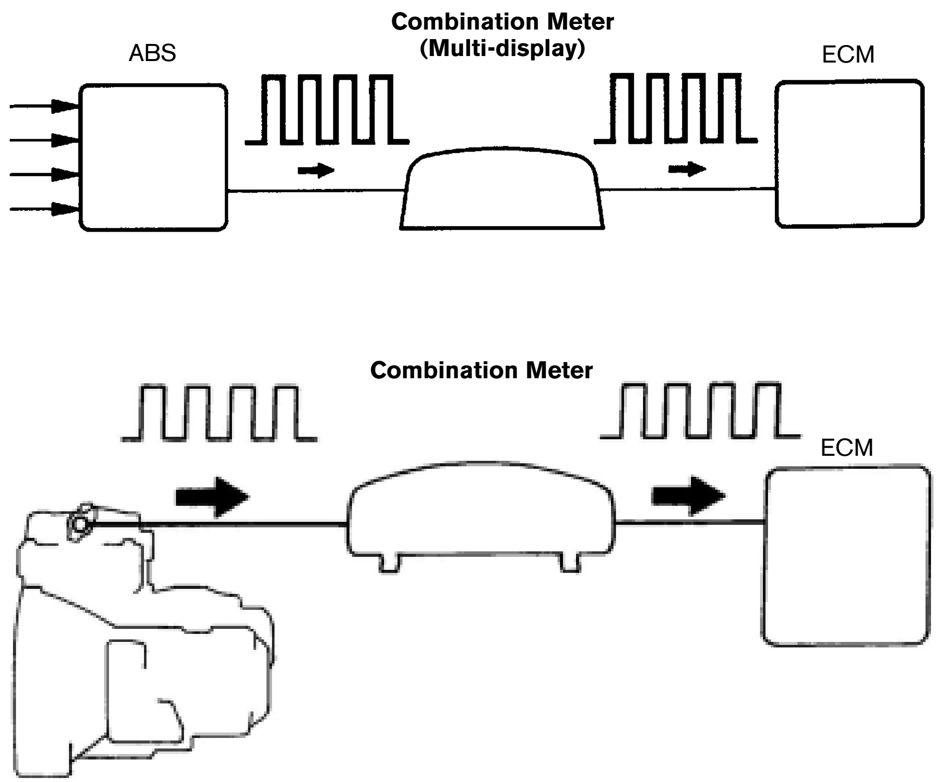


Fig. 3-9

TL874f309

Vehicle Speed Sensor Circuit

The ECM determines the vehicle speed based on the frequency of the pulse signals from the speed sensor. The speed sensor signal can come from the transmission/transaxle or ABS ECU.

***P0500** Vehicle Speed Sensor Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Park/Neutral switch is OFF Vehicle is being driven	No vehicle speed signal to ECM	2	

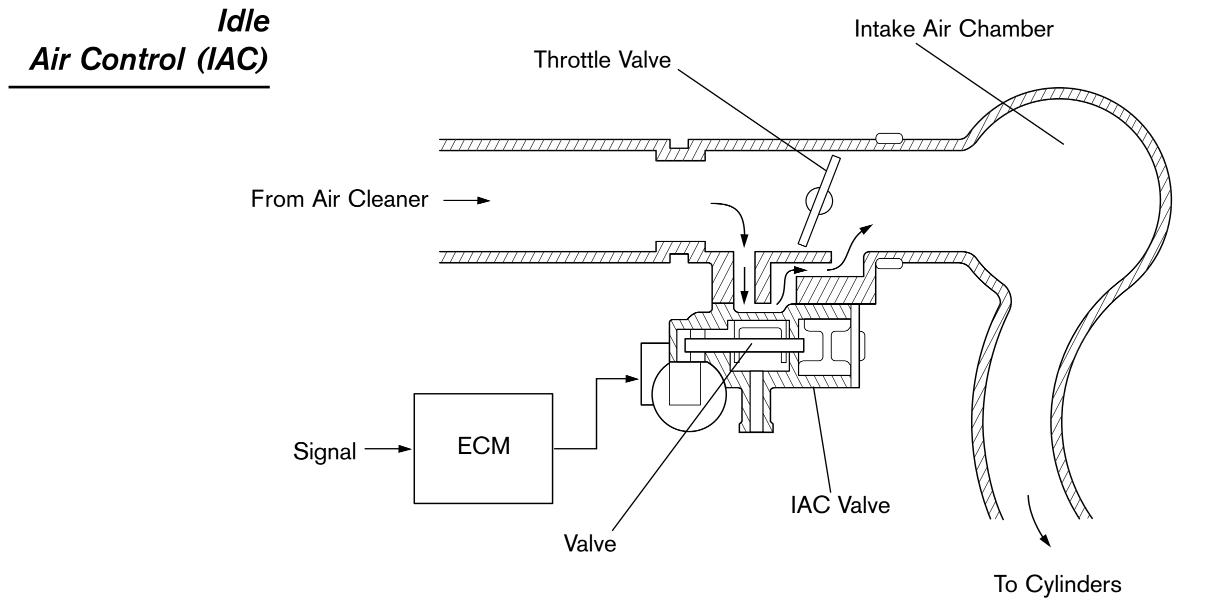


Fig. 3-10

Idle Air Control (IAC)

The ECM compares the actual engine idle speed to its target idle speed. If it is out of range, as determined by the ECM, the DTC will set, and the MIL will light on the second trip.

***P0505** Idle Air Control Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine running @ idle	Idle Speed varies greatly from Target Idle	2	

Accelerator Pedal Position Sensor Circuit

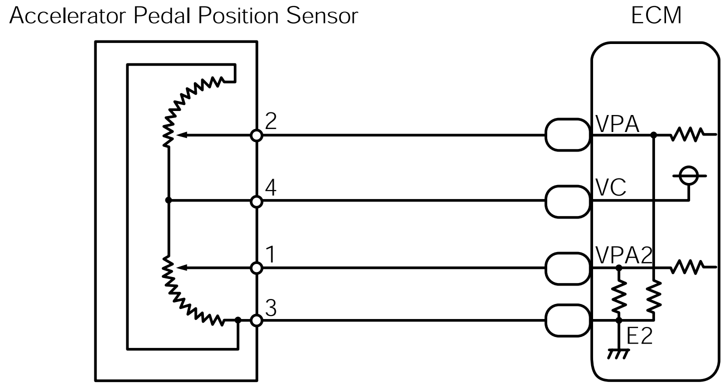


Fig. 3-11
TL874f311

Acceleration Pedal Position Sensor Circuit

DTC P1120 is a one trip DTC that sets when the accelerator pedal position sensor either shows an open or short in the circuit.

DTC P1121, the ECM calculates the output voltages between VPA and VPA2 and compares with its preprogrammed specifications to determine if the sensors are out of range.

P1120 Accelerator Pedal Position Sensor Circuit Malfunction

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	VPA ≤ 0.2V VPA2 ≤ 0.5V VPA ≥ 4.8V VPA ≥ 0.2V and ≤ 1.8V, and VPA2 ≥ 4.97V Time ≥ 2 sec. OR VPA ≤ 0.2V and VPA2 ≤ 1.5V VPA-VPA2 ≤ 0.02V Time ≥ 0.4 sec.	1	Fail-Safe Mode

P1121 Accelerator Pedal Position Sensor Range/Performace Problem

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	Difference between VPA and VPA2 is out of threshold	1	Fail-Safe Mode

Throttle Control Motor Circuit

DTC P1125, ECM judges the throttle motor current value to determine if there is an open or short in the circuit. This is a one trip DTC.

P1125 *Throttle Control Motor Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine running	Throttle Control Motor output duty ≥ 80% Throttle Control Motor current ≤ 0.5V Time = 0.5 sec. OR Throttle Control Motor current ≥ 16A OR Throttle Control Motor current ≥ 7A Time = 0.6 sec.	1	Fail-Safe Mode

Electro-magnetic Clutch Circuit

DTC P1126, ECM judges the current value to determine if there is an open or short in the circuit. This is a one trip DTC.

P1126 *Electromagnetic Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	Magnetic clutch current ≥ 1.4A or ≤ 0.4A Time = 0.8 sec. OR Magnetic clutch current ≥ 1.0A or ≤ 0.8A Time = 1.5 sec.	1	Fail-Safe Mode

ETCS Actuator Power Source Circuit

DTC P1127 is set when there is no current supplied to the ECM from the ETCS switch. This is a one trip DTC.

P1127 *ETCS Actuator Power Source Circuit Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	No current supplied to +BM terminal of ECM	1	Fail-Safe Mode

Throttle Control Motor Lock

DTC P1128 is set when signal from TPS indicates that the throttle valve-opening angle is not in response with the driving condition.

P1128 *Throttle Control Motor Lock Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Engine running	Locked throttle control motor during throttle control motor mode.	1	Fail-Safe Mode

Electronic Throttle Control System

DTC P1129 sets when the ETCS either electrically or mechanically malfunctions.

P1129 *Electronic Throttle Control System Lock Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Key ON	Throttle opening angle varies greatly in comparison to the target throttle opening angle	1	Fail-Safe Mode

NOTE P1120, P1121, P1125, P1126, P1127, P1128, P1129 DTCs are found in vehicles equipped with Electronic Throttle Control System (ETCS). Always refer to Repair Manual for further information.

P1130/P1150 *A/F Sensor Circuit Range/Performance Malfunction (B1,S1/B2,S1)*

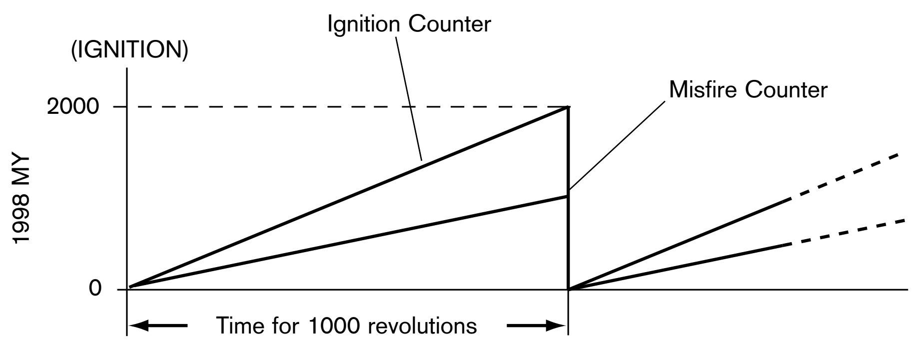
P1133/P1153 *A/F Sensor Circuit Response Malfunction (B1,S1/B2,S1)*

P1135/P1155 *A/F Sensor Heater Circuit Malfunction (B1,S1/B2,S1)*
See O2 and A/F Sensor Diagnosis section

NOTE These DTCs are the results of System Monitors. Refer to the appropriate section for more information.

Section 4

Engine Misfire Diagnosis



Learning Objectives:

1. Determine engine cylinder misfire through Enhanced Data, CARB Data and engine symptoms.

Section 4

Engine Misfire Diagnosis

Overview

It used to be that engine misfire was primarily diagnosed with a variety of test equipment and a logical troubleshooting procedure using a process of elimination to determine the cause. With OBD II, an engine misfire monitor detection is part of the ECM's diagnostic program and the cylinder that is misfiring is reported on a scan tool. However, not all misfires can be detected in this manner. The misfire detection program is keyed towards engine emissions, not a smooth running engine.

Included in this section is an overview of engine diagnosis. This area provides explanations on no start and other engine conditions.

Misfire Monitor

The misfire monitor serves two purposes. The first reason for the monitor is to determine if a misfire is severe enough to damage the catalytic converter. The second reason is to monitor for any misfire that would raise emission levels above the standard. The misfire monitor is a continuous monitor.

The ECM measures crankshaft acceleration via the crankshaft position sensor. The crankshaft will briefly accelerate each time a cylinder is on the power stroke. When the cylinder misfires, the crankshaft slows down instead of speeding up. The ECM detects the change in frequency in the crankshaft position sensor signal (NE). The ECM is able to identify the cylinder on the power stroke from the camshaft position sensor signal (G). Severe rough road conditions may temporarily suspend misfire monitor operation.

Misfire Detection

When the ignition counter is cycling, the misfire monitor is operating. A percentage above zero indicates the cylinder(s) that is misfiring.

```
INJECTOR............. 2.9ms
IGN ADVANCE......... 7.0deg
CALC LOAD.............. 17%
ENGINE SPD.......... 715rpm
COOLANT TEMP....... 190.4°F
CTP SW.................. ON
VEHICLE SPD........... 0MPH
STARTER SIG............ OFF
A/C SIG................ OFF
PNP SW [NSW]............ ON
ELECT LOAD SIG......... OFF
STOP LIGHT SW.......... OFF
IGNITION.............. 1697   — Ignition Counter
CYL #1.................. 0%
CYL #2.................. 0%
CYL #3.................. 0%
CYL #4.................. 5%   — Misfire Percentage
CYL #5.................. 0%
CYL #6.................. 0%
CYL #7.................. 0%
CYL #8.................. 0%
MISFIRE RPM......... 775rpm
MISFIRE LOAD..... 0.90g/rev
# CODES.................. 1
CHECK MODE............. OFF
MISFORE TEST......... COMPL
```

Fig. 4-1

TL874f401

The Diagnostic Tester will display the cylinder and the percentage of misfire. As you will you see, misfire monitor operation varies with the model year and operating conditions.

Misfire Type A (One Trip)

The Type A misfire is a misfire severe enough to damage the catalytic converter. The MIL will blink if the misfire would result in catalyst temperatures of 1000°C (1832°F) or more.

The catalyst temperature is calculated by the ECM based on driving conditions and the percentage of misfire. The higher the percentage of misfire and engine load, the more likely the ECM will cause the MIL to blink.

The blinking MIL will warn the driver of pending catalyst damage and is the only condition that will cause the MIL to blink. The blinking will continue only when the misfire is severe enough to cause catalytic converter damage.

NOTE A pending misfire DTC can be observed in CARB, Mode 7, Continuous Test screen or Pending Codes.

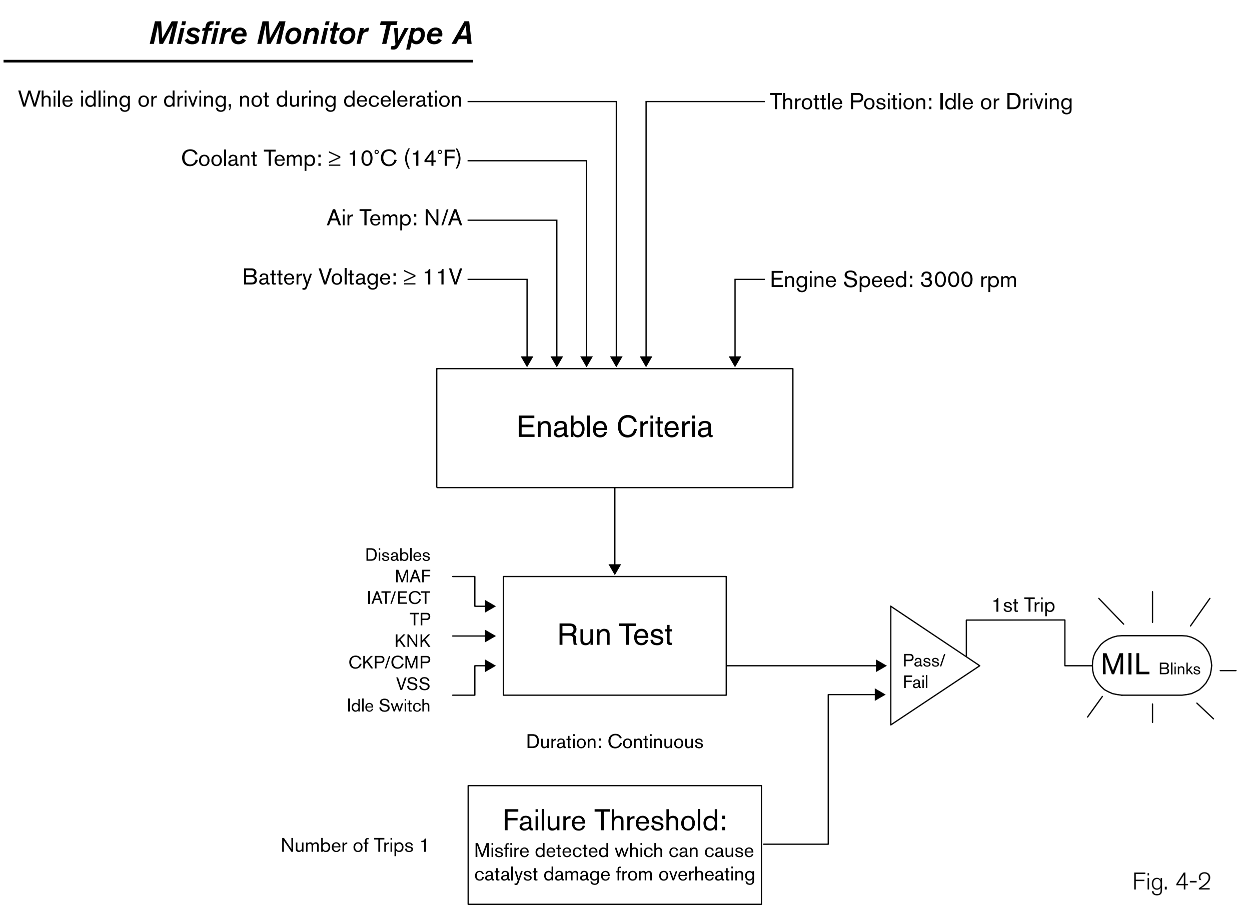


Fig. 4-2

TL874f402

Misfire Type B (Two Trip)

The type B misfire is less severe. It will increase emissions above standards, but will not damage the catalytic converter. This type of misfire is determined by the percentage of misfire compared to ECM emission specifications. If the percentage misfire causes the emissions to increase beyond a specified level, a DTC will set on the second trip. Type B misfire is a two trip monitor.

The MIL does not blink for these DTCs.

NOTE A pending misfire DTC can be observed in CARB, Mode 7, Continuous Test screen or Pending Codes.

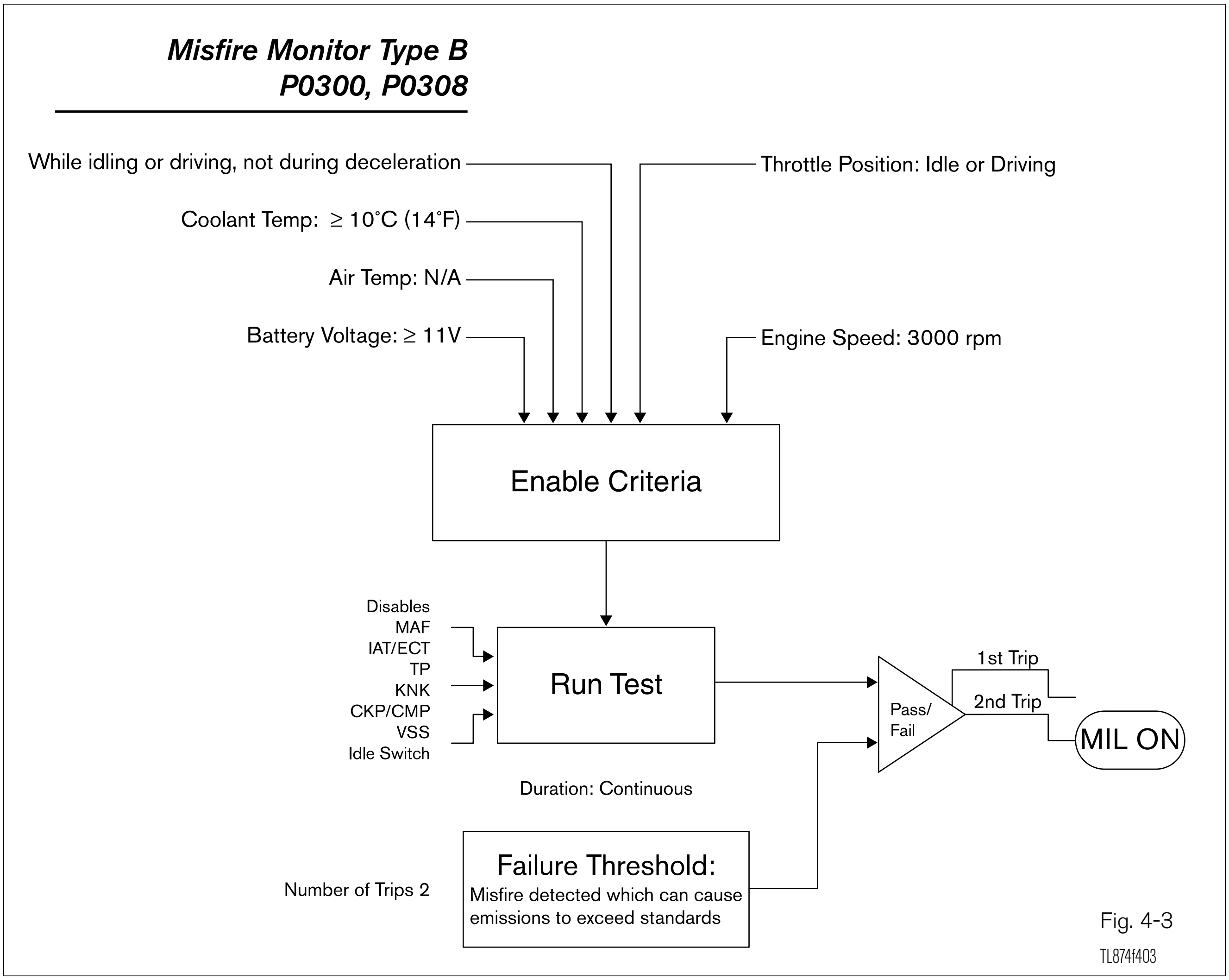


Fig. 4-3

Time Period to Duplicate Misfire Conditions

The Repair Manual provides a chart similar to the one shown. Use this chart along with the Freeze Frame data to reproduce misfire conditions.

Engine Speed	Time
Idling	3 minutes 30 seconds or more
1000 rpm	3 minutes or more
2000 rpm	1 minute 30 seconds or more
3000 rpm	1 minute or more

Fig. 4-4

TL874f404

Ignition Counter (1000 Revolutions)

1994 ~ 1998 and some 1999 MY OBD II vehicles: The Diagnostic Tester displays an Ignition Count that reflects the number of firing events that take place in 1000 engine revolutions. Each cylinder fires every other revolution, thus each cylinder will fire 500 times in 1000 revolutions.

Ignition Count vs. Number of Firing Cycles per Cylinder

The Diagnostic Tester display will show the Ignition Counter recycling at a different count based on the number of cylinders.

Number of Cylinders		Number of Firing Events per Cylinder in 1000 Revolutions		Ignition Count
4	x	500	=	2000
6	x	500	=	3000
8	x	500	=	4000

Fig. 4-5

TL874f405

1000 Revolutions

Misfire counter repeats each 1000 revolutions or 2000 ignitions for a 4 cylinder engine shown here.

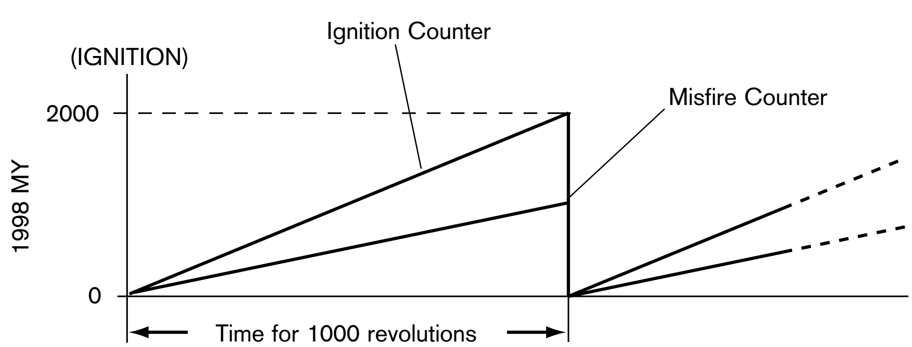


Fig. 4-6

TL874f406

Ignition Counter (200 Revolutions)

Some 1999 and newer MY OBD II vehicles: The Diagnostic Tester displays an Ignition Count that reflects the number of firing events that take place in 200 engine revolutions. Each cylinder fires every other revolution, thus each cylinder will fire 100 times in 200 revolutions.

Ignition Count Based on 200 Revolutions

1999 and newer vehicles will display the Ignition Count based on 200 revolutions.

Number of Cylinders		Number of Firing Events per Cylinder in 200 Revolutions		Ignition Count
4	x	100	=	400
6	x	100	=	600
8	x	100	=	800

Fig. 4-7

TL874f407

200 Revolutions

Misfire counter repeats each 200 revolutions or 400 ignitions for a 4 cylinder engine shown here.

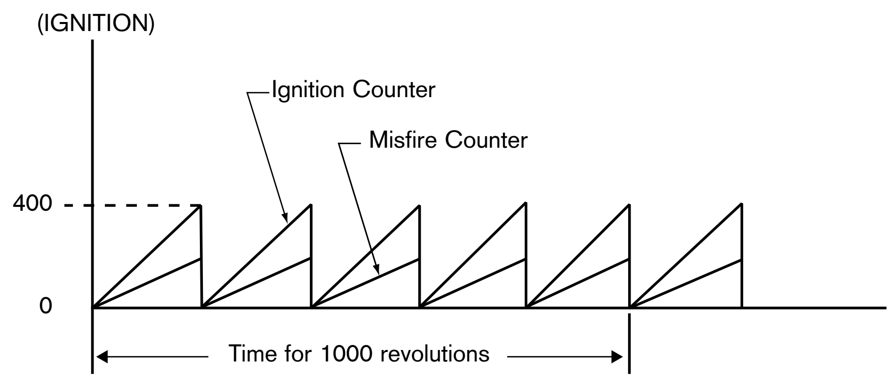


Fig. 4-8

TL874f408

Although the Diagnostic Tester only displays the 200 revolution ignition counter, the ECM monitors five multiples of the 200 counter to total 1000 revolutions for a misfire that would increase emissions above standards. Thus the internal logic uses 200 revolutions for a misfire that would damage the catalytic converter and 1000 revolution counter for an increase in emissions.

Misfire Monitor Screens

CARB Screens

```
CONTINUOUS TESTS
ECU:  $10 (Engine)
Number of Tests: 1

P0304
Cylinder 4 Misfire
Detected
```

```
FREEZE FRAME   0

TROUBLE CODE......... P0304
ENGINE SPD.......... 683RPM
COOLANT TEMP......... 190°F
VEHICLE SPD........... 0MPH
CALC LOAD............ 18.0%
FUEL SYS #1............. CL
FUEL SYS #2............. CL
SHORT FT #1........... 0.8%
LONG FT #1........... -5.4%
SHORT FT #2.......... -0.7%
LONG FT #2........... 12.5%
```

Enhanced OBD II Screens

```
ECU:  $10 (Engine)
Number of DTCs: 1
MIL ON

P0304
Cylinder 4 Misfire
Detected
```

```
TROUBLE CODE......... P0304
CALC LOAD.............. 18%
ENGINE SPD.......... 683RPM
COOLANT TEMP....... 190.4°F
INTAKE TEMP........ 125.6°F
CTP SW.................. ON
VEHICLE SPD........... 0MPH
SHORT FT #1........... 0.7%
LONG FT #1........... -5.5%
SHORT FT #2.......... -0.9%
LONG FT #2........... 12.4%
FUEL SYS #1............. CL
FUEL SYS #2............. CL
FC IDL................. OFF
STARTER SIG............ OFF
A/C SIG................ OFF
PNP SW [NSW]............ ON
ELECT LOAD SIG......... OFF
STOP LIGHT SW.......... OFF
ENG RUN TIME............ 80
```

Fig. 4-9

TL874f409

Misfire DTC(s)

P0300: Random/ Multiple Cylinder Misfire Detected

Misfiring of random cylinders is detected during any particular 200 or 1000 revolutions (two trip detection logic). This code can be set from multiple cylinders randomly misfiring.

P0301: Cylinder 1 Misfire Detected

Cylinder 1 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0302: Cylinder 2 Misfire Detected

Cylinder 2 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0303: Cylinder 3 Misfire Detected

Cylinder 3 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0304: Cylinder 4 Misfire Detected

Cylinder 4 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0305: Cylinder 5 Misfire Detected

Cylinder 5 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0306: Cylinder 6 Misfire Detected

Cylinder 6 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0307: Cylinder 7 Misfire Detected

Cylinder 7 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

P0308: Cylinder 8 Misfire Detected

Cylinder 8 misfire detected during any particular 200 or 1000 revolutions which can cause catalyst overheating or deterioration in emissions (two trip detection logic).

Causes of Engine Misfire

Troubleshooting

This type of diagnosis requires an understanding of engine basics and a working knowledge of the subsystems involved in getting the engine to start and keeping it running. The Basic Inspection and Problem Symptoms chart should be followed to locate the problem.

Fundamentally, there are four conditions that must be satisfied to prevent engine misfire:

- Engine compression - this procedure is found in the beginning of the EM section
- Fuel delivery – this procedure is found in the beginning of the SF section
- Ignition spark - this procedure is found in the beginning of the IN section
- Free breathing intake and exhaust system

Perform a preliminary inspection before any pinpoint troubleshooting takes place. Perform a Diagnostic Circuit Inspection, to narrow down the scope of your investigation. The Diagnostic Circuit Inspection includes:

Malfunction Indicator Lamp (MIL) Check:

- By confirming MIL operation, you eliminate power distribution and a grounded Vc circuit from your investigation

Diagnostic Code Check:

- If codes are stored, they could very possibly be the cause of the misfire condition.

Another important quick check to perform is an inspection of critical data parameters using the Diagnostic Tester. Abnormalities in any of the following signals may have an impact on engine misfire:

- Engine RPM (NE)
- Engine cranking signal (STA)
- Engine Coolant Temperature (ECT/THW)
- Injection duration
- Ignition timing (spark advance)

NOTE Injection duration and ignition spark parameters may display normal values on serial data even when injection pulse or ignition trigger are not present. Use a DVOM or V-BoB oscilloscope to display real circuit voltage signals if pinpoint tests are necessary in these areas.

A specific series of events must occur in several engine control sub-systems for proper combustion. The following will address these sub-systems, their normal function, and specific checks to verify normal operation.

Basic Mechanical Functions - the following must be satisfactory:

- the engine must develop at least 80% of normal compression
- the air/fuel mixture must be in the correct proportion
- the intake and exhaust systems must be free of any abnormal restrictions
- the ignition secondary system must be in good condition without leakage to ground
- engine mechanical components must be in good condition and in the proper relationship to each other. For example, the crankshaft timing pulley must be in the correct location on the crankshaft and correctly timed to the camshaft timing pulleys

It is important to realize that the ratio of air to fuel needs to vary to meet engine operating conditions. A stoichiometric A/F Ratio is needed for efficient catalytic converter operation. During starting, acceleration, and under heavy load, the mixture needs more fuel. During light cruise and decel, less fuel is needed.

Engine symptoms can provide important clues. An extremely rich mixture fouls spark plugs. A mixture too lean typically causes a backfire (usually during cold weather). See Fuel System Diagnosis for more information.

Primary Ignition Circuit (ESA)

When the engine is running, current flows to the ignition coil primary circuit and to the igniter +B terminal (to power the igniter electronics). As the crankshaft rotates, the crankshaft speed and position signals (NE and G) are sensed at the ECM supplying information necessary to calculate the Ignition Timing Signal (IGT). The ECM sends the IGT signal to the igniter firing the coil.

When the igniter detects the primary coil circuit current rise and fall, the igniter triggers an IGF signal (see Engine Control Systems I). When the ECM does not detect the IGF signal, the ECM goes into fail-safe mode. With no IGF signal, the ECM will store the P1300 series DTCs, depending on model year and number of cylinders affected. There are different fail-safe modes depending on type of ignition system, cylinder displacement and model year. The following is a general summary.

- If there is no IGF signal on engines before 1998 model year, the ECM will enter fuel fail-safe and turn off all the fuel injectors.

- Beginning with the 1998 model year, V-6 and V-8 engines equipped with direct ignition system with integrated ignition coil/igniter (1 ignition coil/igniter per cylinder), the engine will still run without the IGF signal, but the MIL will be ON.

- Beginning with the 2001 model year on 1 ignition coil/igniter per cylinder engines, the ECM fail-safe will turn off the fuel injector if there is no IGF signal for that cylinder and if engine conditions (such as load and temperature) are sufficient to damage the catalytic converter. If the IGF signal returns to normal while the engine is running, the injector may remain off until the next engine start.

NOTE

Regardless of the type of IGF fail-safe mode, the IGF DTCs must be diagnosed before attempting to diagnose a fuel system/injection problem. The IGF DTCs (P1300 series) are one trip DTCs.

Quick checks using a noid light on one of the injectors confirms if the ECM is pulsing the injector(s).

Check for spark as outlined in the Basic Inspection section of the Repair Manual. IG section of the Repair Manual contains more information on ignition system diagnosis.

Circuit Inspection using a DVOM or V-BoB: Inspect the following signals for behavior as indicated above; NE, G, IGT, IGF. Refer to the appropriate Repair Manual circuit inspection charts and to the Engine Control System schematic in the EWD for troubleshooting details.

WORKSHEET 4-1
Misfire Detection Monitor

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

Accurately interpret cylinder misfire data.

Tools and Equipment

- Vehicle
- Vehicle Repair Manual, EWD, & NCF
- Diagnostic Tester
- TIS Access
- Hand Tools, Fender Covers, Floor Mats, and Shop Towels

Section 1

1. Connect Diagnostic Tester to vehicle.

2. Disconnect a fuel injector connector.

3. Start the engine. Observe the MISFIRE DATA LIST under ENHANCED OBD II.

4. What cylinder is misfiring? _____________

5. If the MIL is blinking, check CARB OBD, CONTINUOUS TESTS or PENDING CODES.

   What DTC is displayed? ________

6. What do the following Data List parameters represent?

MAF	
CALC LOAD	
MISFIRE RPM	
IGNITION	

Section 2

1. Why didn't a DTC set on the first trip? ____

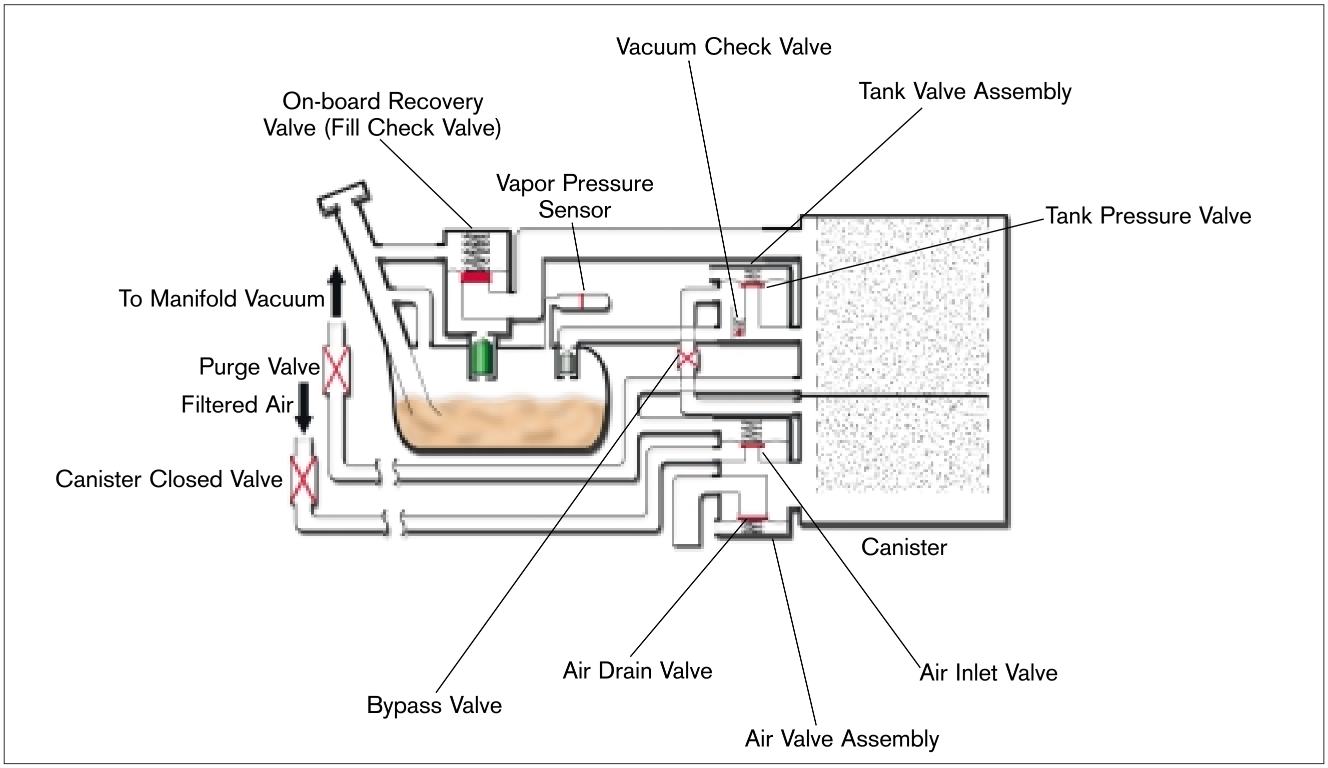
2. Shut off the engine, wait 30 seconds, and restart. Wait approximately 3.5 mins. or until the MIL illuminates.

3. Is there a DTC and Freeze Frame? _______ Why? ____

4. Connect the fuel injector. Check for normal engine operation.

Section 5

Evaporative Systems Diagnosis



Learning Objectives:

1. Determine the condition of the EVAP system operation based on engine data and the EVAP pressure tester.
2. Determine the condition of the vapor pressure sensor.
3. Determine EVAP monitor status using Readiness Tests and CARB modes.

Section 5

Evaporative System Diagnosis

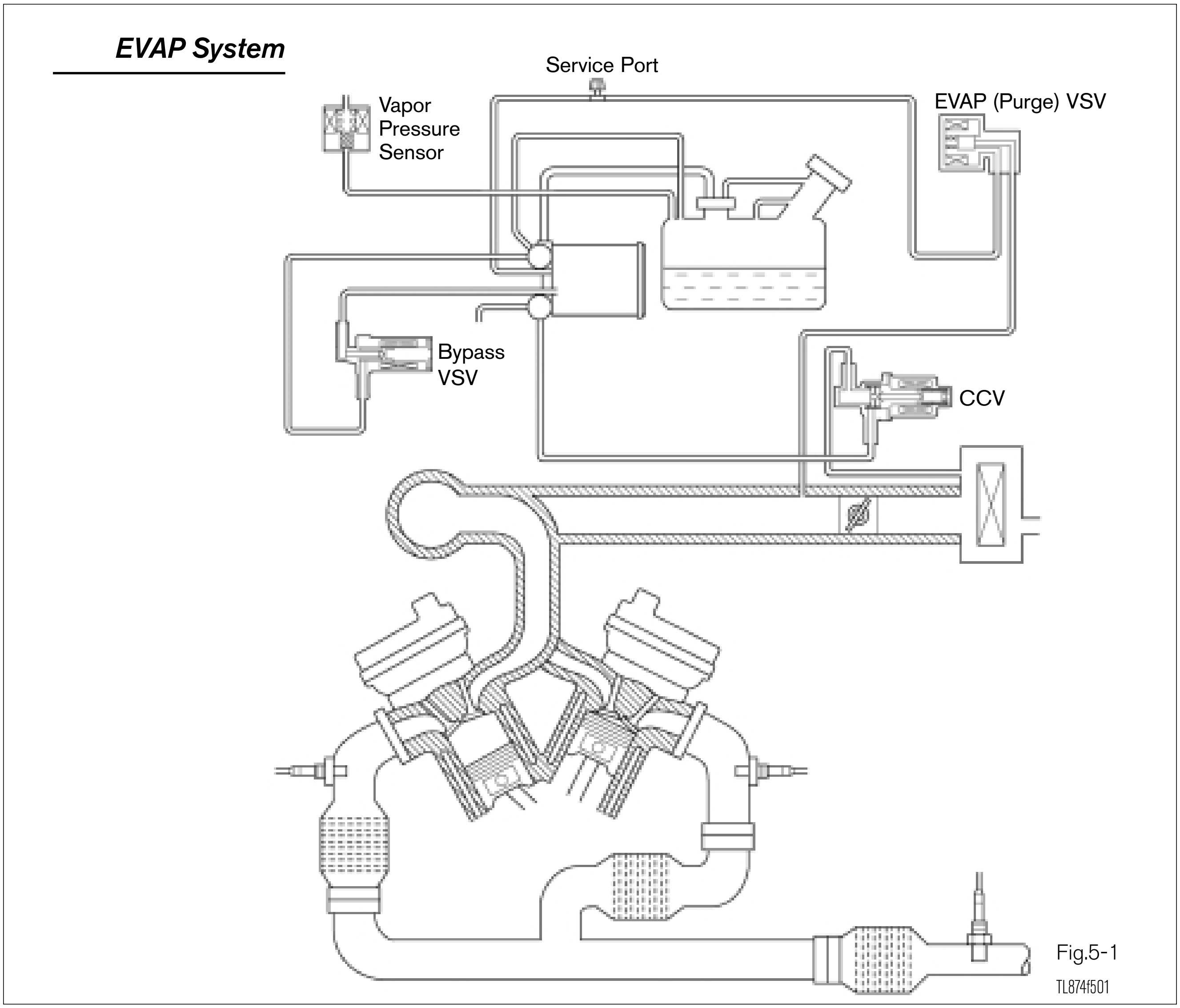


Fig.5-1

Overview

There are a variety of EVAP systems in use with different monitoring strategies. It is essential that the EVAP system be correctly identified before beginning diagnosis (the Repair Manual is the best source). The following information covers the different systems.

Usually, the customer is unaware of an EVAP system problem until the MIL illuminates. The customer needs to be aware that they must correctly install the fuel cap after refueling.

Check mode does not work for EVAP codes. Use the Readiness Test Confirmation procedure.

A common failure is a leak in the system, but restrictions will also set EVAP related DTCs.

EVAP System with ORVR

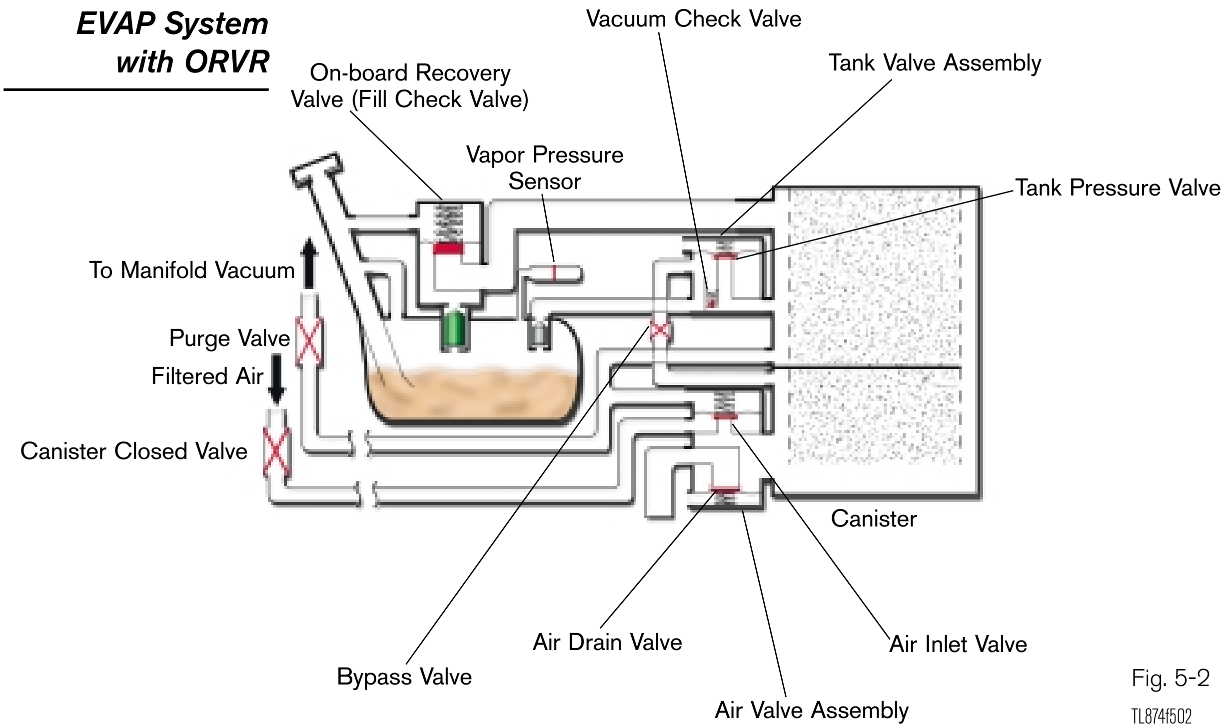


Fig. 5-2
TL874f502

Condition	Purge Port	Air Inlet Port	Tank Vacuum Ball Check	Tank Pressure Valve	ORVR Valve	Air Drain
VSV Purge Valve ON	OPEN (V)	OPEN (V)	CLOSED	CLOSED	CLOSED	CLOSED
VSV Purge Valve OFF	CLOSED (NV)	CLOSED (NV)	CLOSED	CLOSED	CLOSED	CLOSED
Pressure in Tank	CLOSED	CLOSED	CLOSED	OPEN	CLOSED	CLOSED
Vacuum in Tank			OPEN	CLOSED	CLOSED	CLOSED
Refill			CLOSED	CLOSED	OPEN	OPEN

Late Type EVAP Pressure in Fuel Tank

Fuel vapor pressure is vented into the charcoal canister when vapor pressure forces the tank pressure control valve open.

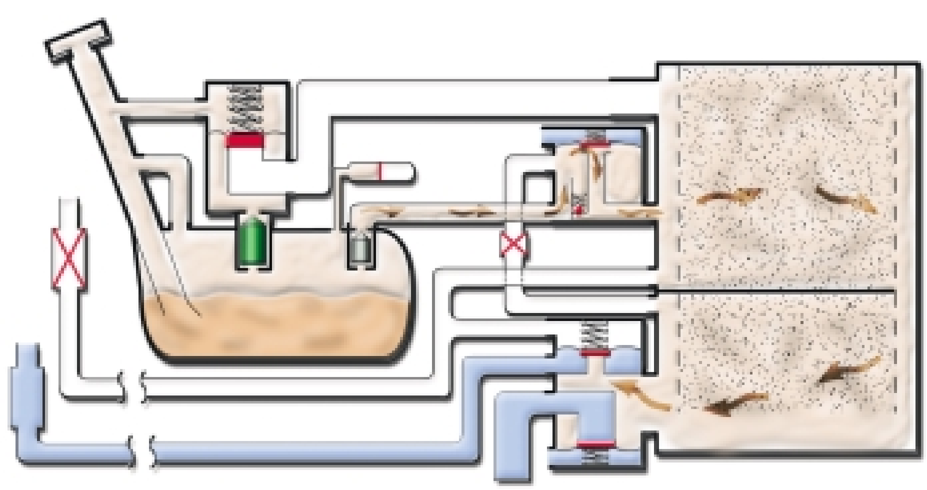


Fig. 5-3
TL874f503

Late Type EVAP Vacuum in Fuel Tank

Vacuum in the tank can be relieved by allowing air to enter through the charcoal canister or fuel tank cap.

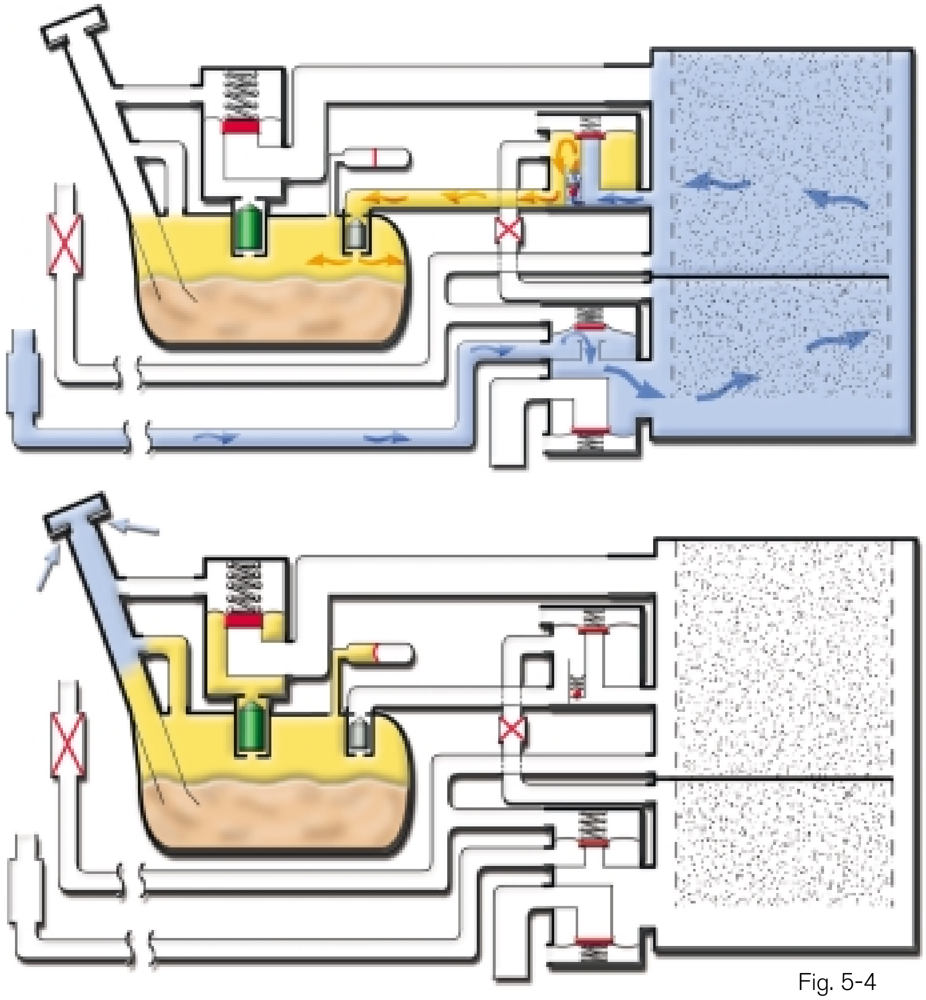


Fig. 5-4

TL874f504

Late Type EVAP Purge Mode

During purge, vapors are drawn out of the canister and burned in the engine.

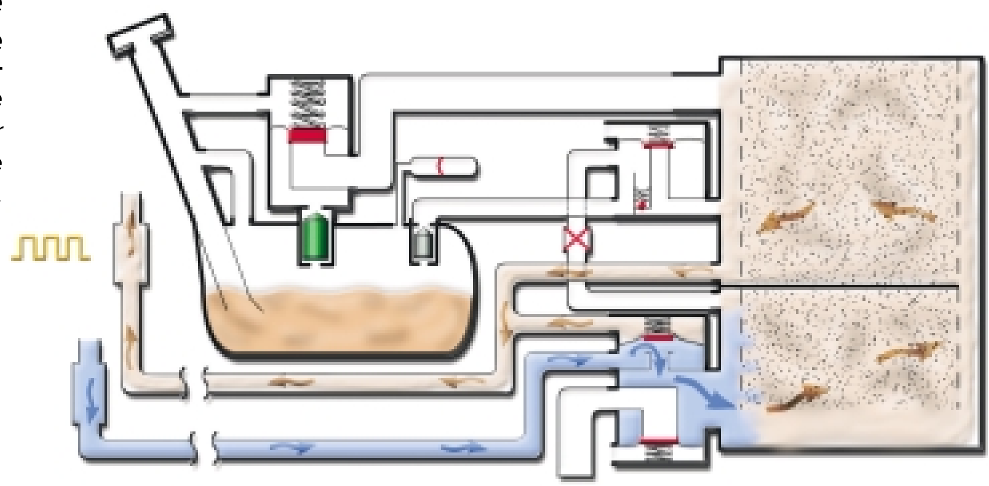
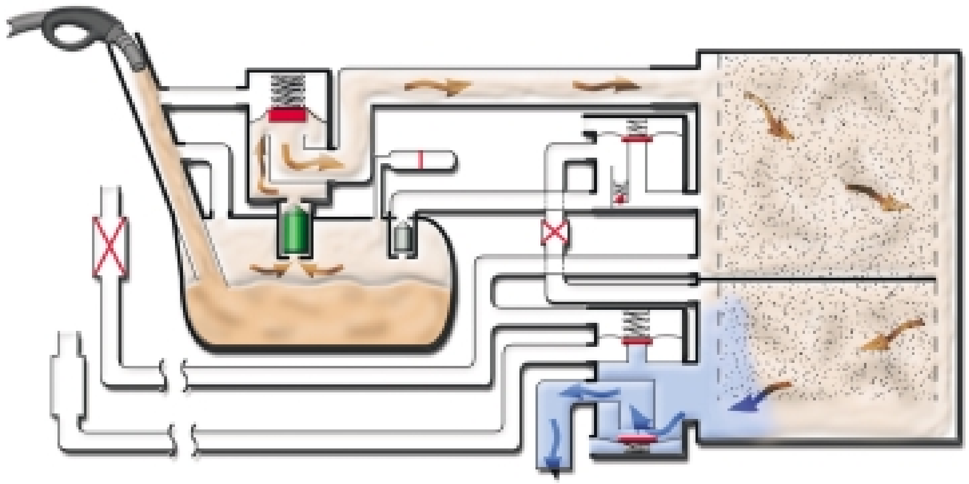


Fig. 5-5

TL874f505



Late Type EVAP ORVR Operation

During refueling, the differential pressure valve and air drain valve are open. Fuel vapors are absorbed by the charcoal canister and excess air is vented to the atmosphere.

Fig. 5-6

TL874f506

Evaporative Systems Monitoring

Regulations require that the EVAP system be monitored for system performance and leak detection. Leaks, restrictions, and many components are checked by measuring the pressure of the EVAP system at various stages.

Early EVAP systems had to detect a 1mm (0.040 in.) hole and greater. It is often called the early type or non-intrusive system.

Beginning with 2000 model year, a new EVAP monitor system was implemented to meet the new, mandated standard of detecting a hole down to .5mm (0.020 in.). This new system is referred to as the Late Type or Intrusive Type. The intrusive system is being phased in.

In addition, the EVAP monitor has to monitor vapor purge and component performance. All EVAP monitor DTCs require two trips.

Early-Type (Non-Intrusive) Pressure Detection

The ECM relies on the VP sensor signal to accurately measure pressure in the EVAP system and the purge side of the charcoal canister. The changes in the pressures being measured are very small, often 15.5 mmHg (0.3 psi) or less. For the VP sensor to measure tank pressure and canister pressure, a three-way VSV is connected to the VP sensor, fuel tank and lines, and charcoal canister. When there is no power to the three-way VSV VP sensor, the VP sensor measures canister purge pressure. When the ECM turns on the VSV, the VP sensor measures fuel tank pressure.

Early Type EVAP Components

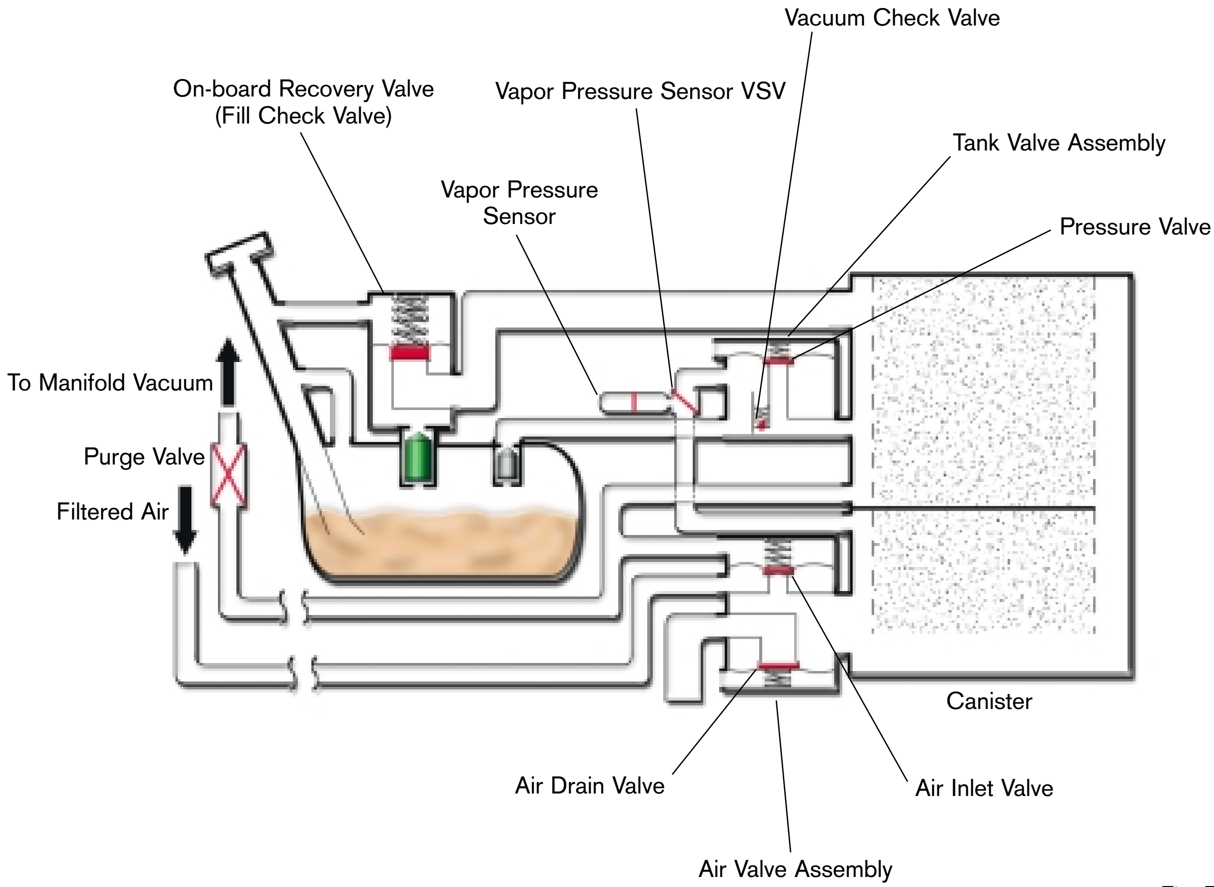


Fig. 5-7
TL874f507

EVAP Pressure Monitoring

The ECM tests for leaks by measuring EVAP system pressure in the lines, charcoal canister, and fuel tank. When the EVAP pressure is higher or lower than atmospheric pressure, the ECM concludes that no leaks are present. EVAP pressure is measured by the VP sensor. If either the tank or canister purge side is at atmospheric pressure under specific conditions, the ECM determines there is a leak.

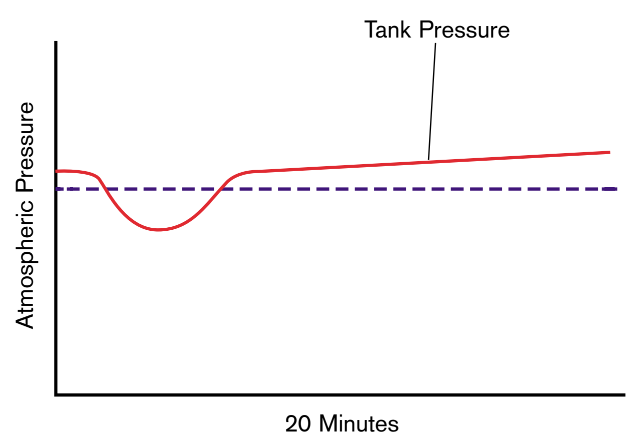


Fig. 5-8
TL874f508

HC Leak Detection - P0440, P0441, P0446

A leak can generate multiple DTCs depending on component and location. Refer to the Repair Manual for the proper sequence for diagnosing these DTCs.

The ECM tests for leaks by measuring EVAP system pressure in the lines, charcoal canister, and fuel tank. When the EVAP pressure is higher or lower than atmospheric pressure, the ECM concludes that no leaks are present. EVAP pressure is measured by the VP sensor. If either the tank or canister purge side is at atmospheric pressure under specific conditions, the ECM determines there is a leak.

The leak could be a filler cap not properly tightened, a hole in the lines, charcoal canister, or fuel tank. A visual inspection of the EVAP is performed for most EVAP diagnostic procedures. Inspection begins with the filler cap, hoses and tank.

The number of times the leak detection test is performed is determined by the regulations for that model year and test conditions. The monitor runs depending on engine temperature and vehicle operating conditions. If a leak is detected on two consecutive trips (providing the monitor ran and completed on each trip), the MIL is illuminated and a DTC is stored. **(For details for DTC(s) see P0440, P0441, & P0446)**

P0440: Evaporative Emission System Malfunction

If DTC P0440 is present, the leak is on the fuel tank side of the EVAP system. This also includes the lines between the fuel tank and part of the canister. When the VP sensor is measuring tank pressure, the ECM is observing changes in pressure and comparing tank pressure to atmospheric pressure. No difference in pressure indicates a leak. The ECM may take 20 minutes or more to complete testing the fuel tank side.

Evaporative Monitor P0440

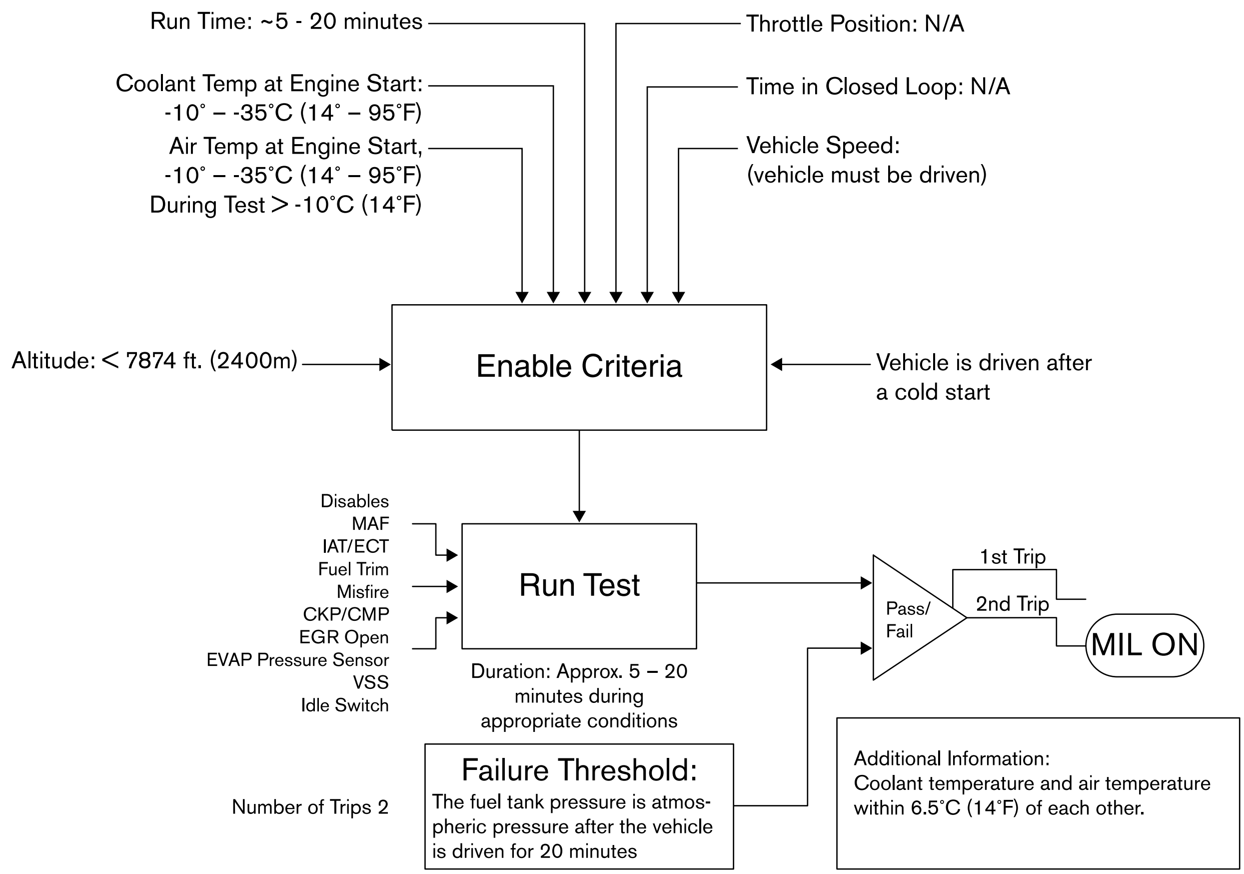


Fig. 5-9

TL874f509

Early Type EVAP Tank Side

If a leak is suspected, the shaded areas should be checked.

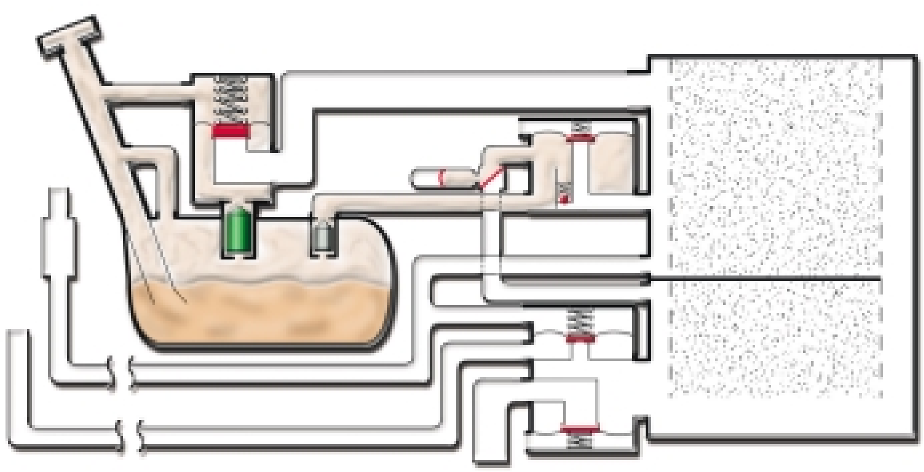


Fig. 5-10

TL874f510

P0441: Vapor Purge Flow Detection

The EVAP monitor is designed to detect:

- restricted vapor purge flow when the purge VSV is open
- inappropriate vapor purge flow when the purge VSV is closed
- under normal purge conditions, pressure pulsations generated by the cycling of the purge VSV are present in the canister and detected by the VP sensor

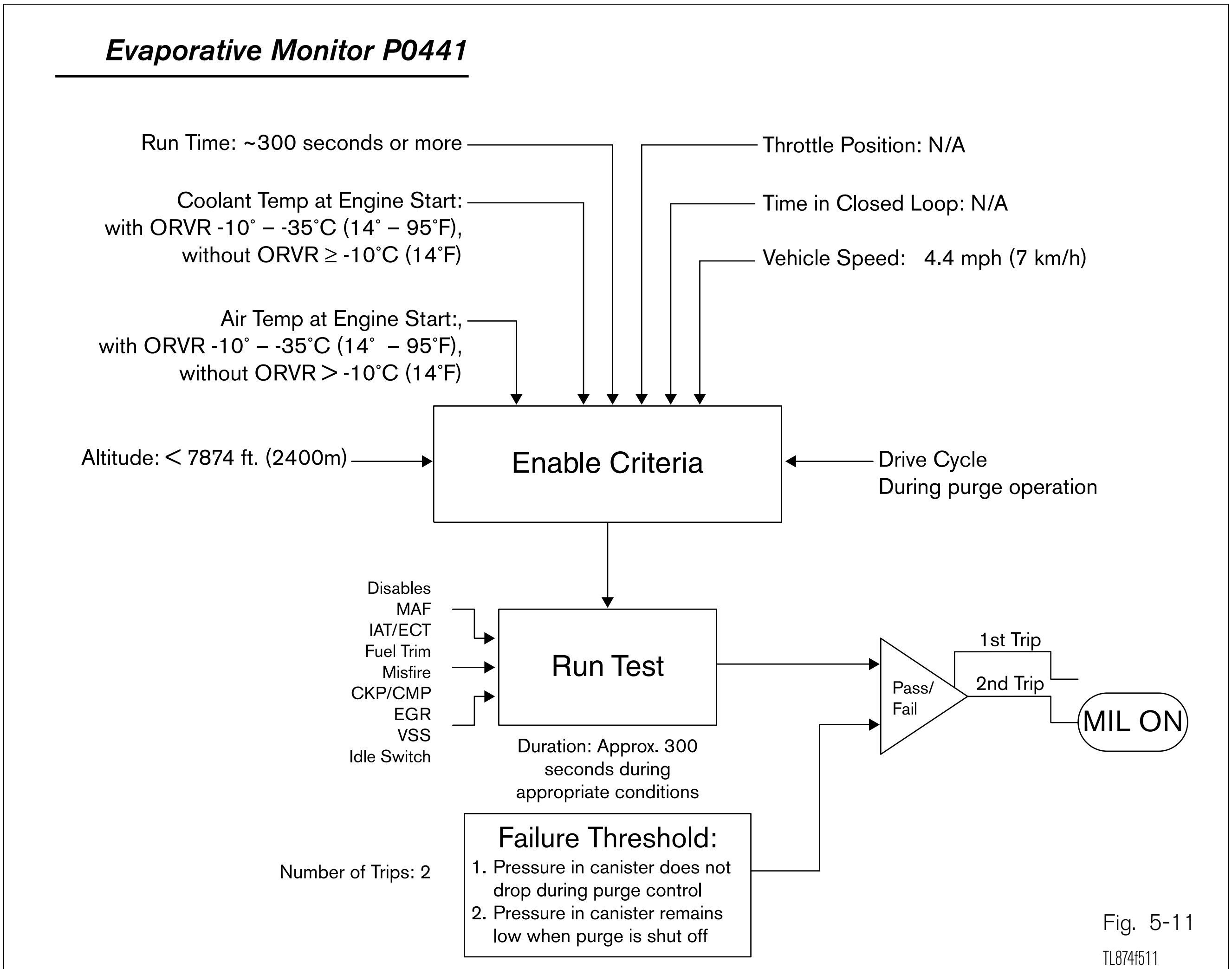


Fig. 5-11

Restricted Vapor Purge Flow

During purging under normal conditions, pressure pulsations are generated by the cycling of the purge VSV and canister pressure drops. If the VP sensor does NOT detect these pulsations and pressure drop in the canister, the ECM determines the EVAP system is not working. Possible causes are, the purge VSV is stuck closed, a restricted purge line, a hole or disconnected purge line.

Inappropriate Vapor Purge Flow

If during starting the canister internal pressure is at atmospheric pressure, and immediately after starting the canister internal pressure drops to nearly intake manifold pressure (vacuum), the purge VSV is open when it should be closed.

Both vapor purge flow conditions set DTC P0441 and the technician must diagnose the system to find which condition is present.

NOTE

DTC P0441 may indicate a leak. If the VP sensor does NOT detect a pressure drop when the purge control is turned on, a leak may be a possible cause; for example, a disconnected purge hose.

Early Type EVAP Vapor Purge Flow Detection

If a purge flow problem is suspected, check the shaded areas. The purge VSV should also be checked.

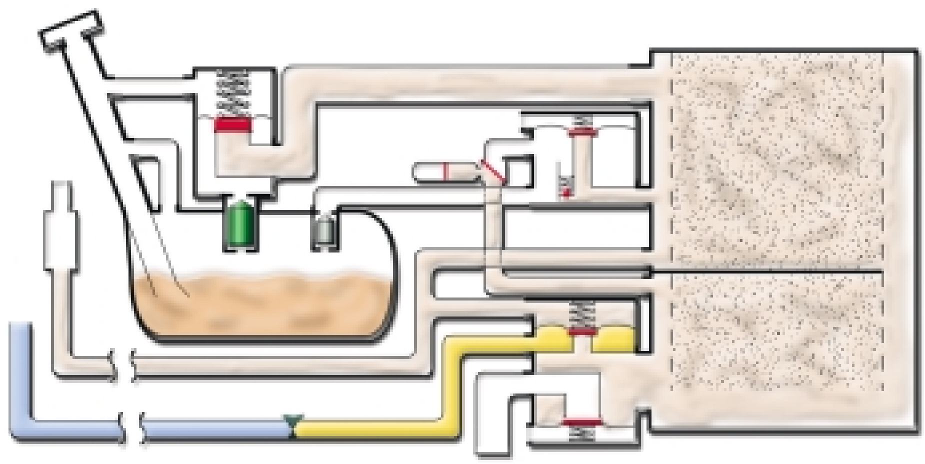


Fig. 5-12

TL874f512

P0446: Three-Way VSV

If DTC P0446 is present, a leak present on the canister purge side may set this code.

NOTE

This code can also be set by a malfunctioning three-way VSV. If there is atmospheric pressure in the canister after the purge VSV is shut off, the ECM concludes there is a problem with the system.

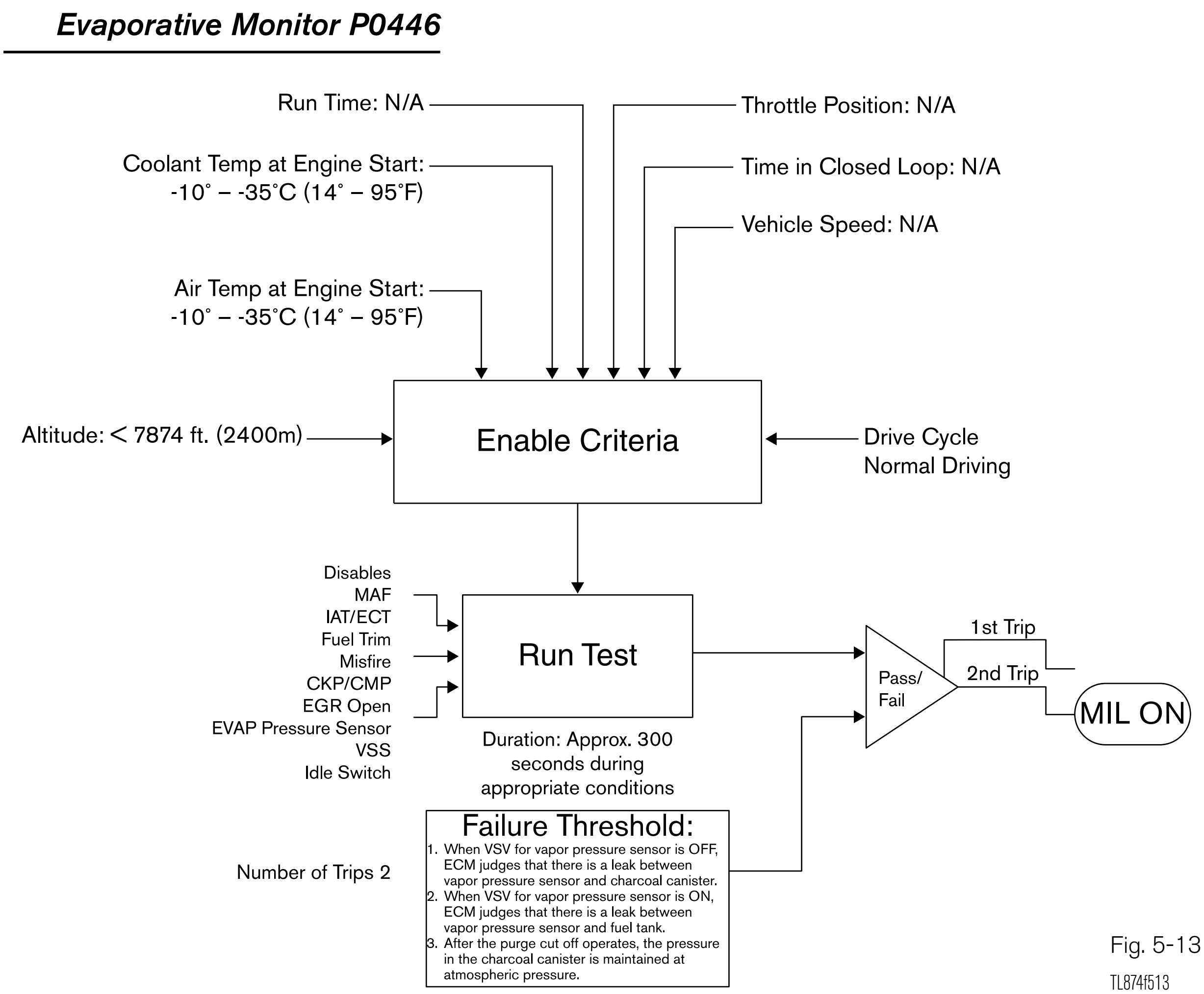


Fig. 5-13

Early Type EVAP Canister Leak Detection

If a leak is suspected in the canister, check the shaded areas.

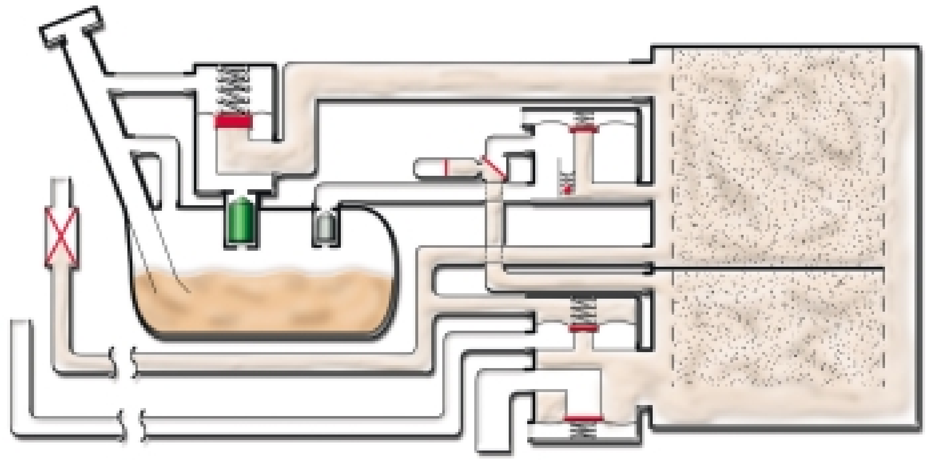


Fig. 5-14

TL874f514

The three-way VSV is connected to the VP sensor, canister, and fuel tank. This VSV allows the VP sensor to detect either canister or tank pressure.

There are two modes the ECM can use to determine if the three-way VSV is malfunctioning. The three-way VSV is judged to be normal if there is pressure difference between the tank and canister when the three-way VSV is switched.

If there isn't any pressure difference between the tank and canister, the ECM looks for the following conditions:

During purging, if pressure pulsations generated by the purge VSV are not present in the canister as detected by the VP sensor, the three-way VSV is judged to be defective.

If there are pressure pulsations detected by the VP sensor present in the fuel tank, the three-way VSV is judged to be defective.

The logic is that during purging, the VP sensor is supposed to be monitoring pressure pulsations in the canister. Because the VP sensor did not see pulsations in the canister but, in the tank during purging, the ECM concludes the three-way VSV did not switch.

Summary of Early Type Evaporative System DTC(s)

P0440: Evaporative Emission Control System Malfunction

The fuel tank pressure is atmospheric pressure after the vehicle is driven for 20 minutes. (two trip detection logic)

P0441: Evaporative Emission Control System Incorrect Purge Flow

The pressure in the charcoal canister does not drop during purge control. (two trip detection logic)

During purge cut-off, the pressure in the charcoal canister is very low compared with atmospheric pressure. (two trip detection logic)

P0446: Evaporative Emission Control System Vent Control Malfunction

When VSV for vapor pressure sensor is OFF, the ECM judges that there is a leak between the vapor pressure sensor and charcoal canister. (two trip detection logic)

When VSV for vapor pressure sensor is ON, ECM judges that there is a leak between the pressure sensor and fuel tank. (two trip detection logic)

After the purge cut off operates, the pressure in the charcoal canister is maintained at atmospheric pressure. (two trip detection logic)

NOTE

When diagnosing a P0446 DTC, check the Freeze Frame data. If the DTC sets at 0 mph, check for a hole in the canister. If a vehicle speed is recorded, check the 3-way VSV.

Late Type EVAP Components

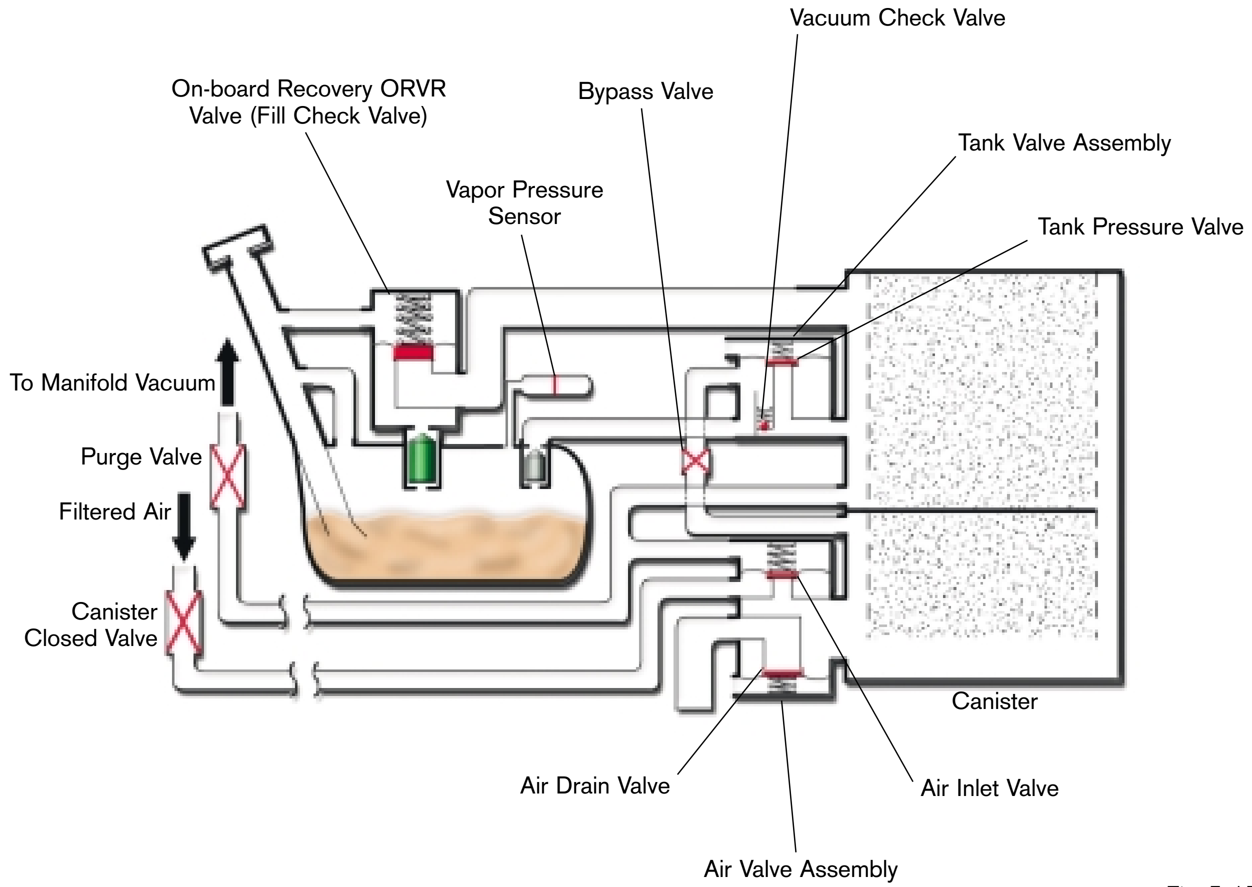


Fig. 5-15

TL874f515

Late Type (Intrusive) Monitor System

The late type, also known as intrusive type, was developed to meet the very stringent, mandated standard of detecting a hole 5mm (0.020″). This system uses many of the same components as the early type. Purge, vacuum relief, pressure relief, and ORVR operations are identical to the early type. However, the following items have been changed:

The vapor pressure sensor is connected to the tank and is not switched to the canister.

The three-way VSV has been replaced with a bypass VSV which connects the canister and tank during monitor operation.

A closed canister valve (CCV) has been added on the air inlet line allowing the system to be sealed.

The monitoring for leak detection is different. This system applies a very small vacuum to the EVAP system. The ECM determines if there is a problem in the system based on the vapor pressure sensor signal. All EVAP DTCs require two trips.

The following is a general overview of this monitoring system operation:

- The monitor sequence begins with a cold engine start. The IAT and ECT sensors must have approximately the same temperature reading.
- The ECM is constantly monitoring fuel tank pressure. As the temperature of the fuel increases, pressure slowly rises.
- The ECM will purge the charcoal canister at the appropriate time. With the bypass VSV closed, pressure will continue to rise in fuel tank.

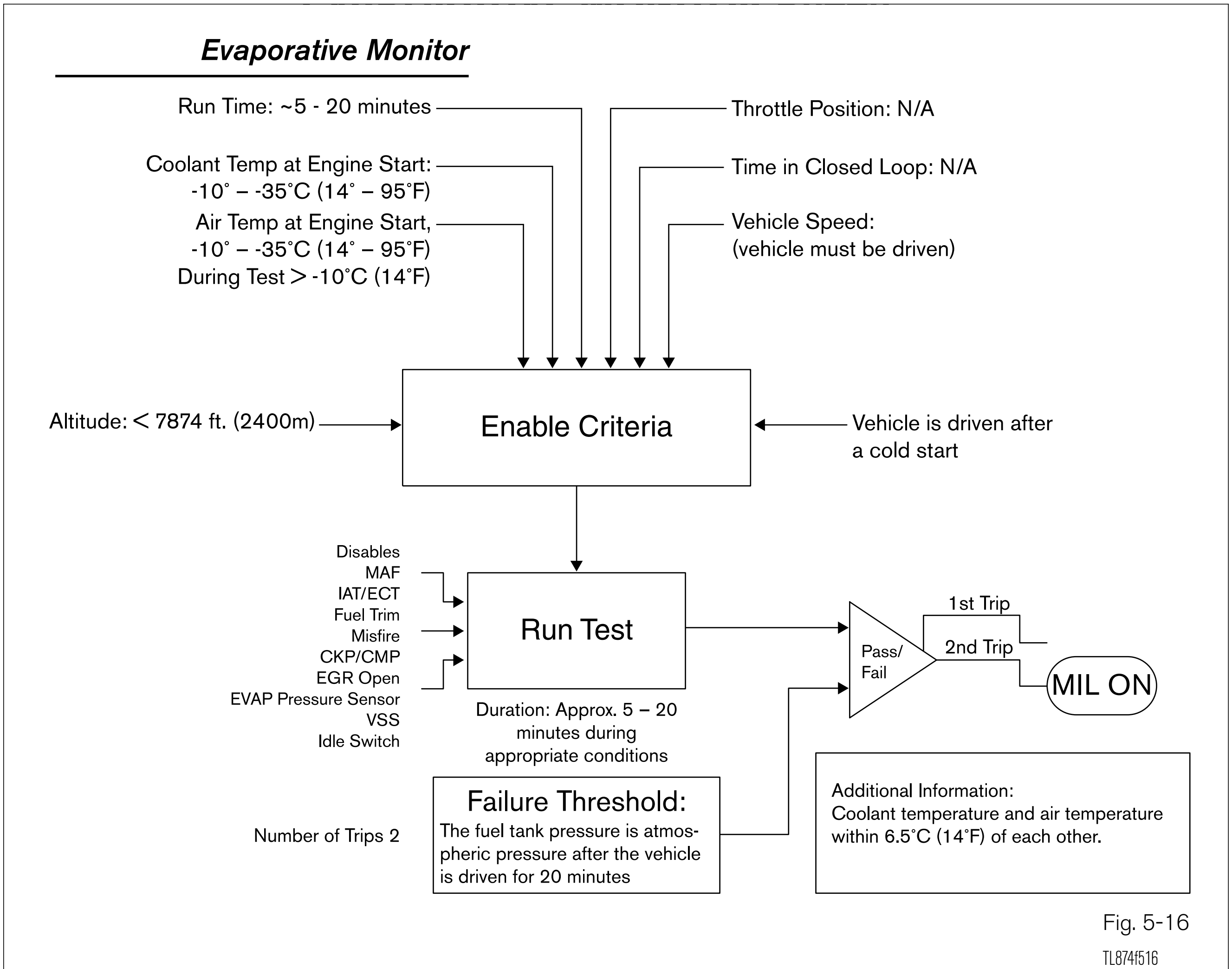


Fig. 5-16

Late Type EVAP Monitor Beginning Stages

After a period of driving, 5-20 minutes, the ECM cycles the purge VSV.

Next, the ECM will close the CCV and open the bypass VSV while continuing to operate the purge VSV. This will lower the pressure in the EVAP system.

When the pressure reaches a predetermined point, the purge VSV is turned off and the valve is closed. At this point the ECM will begin to monitor for a leak by measuring the rate of pressure increase.

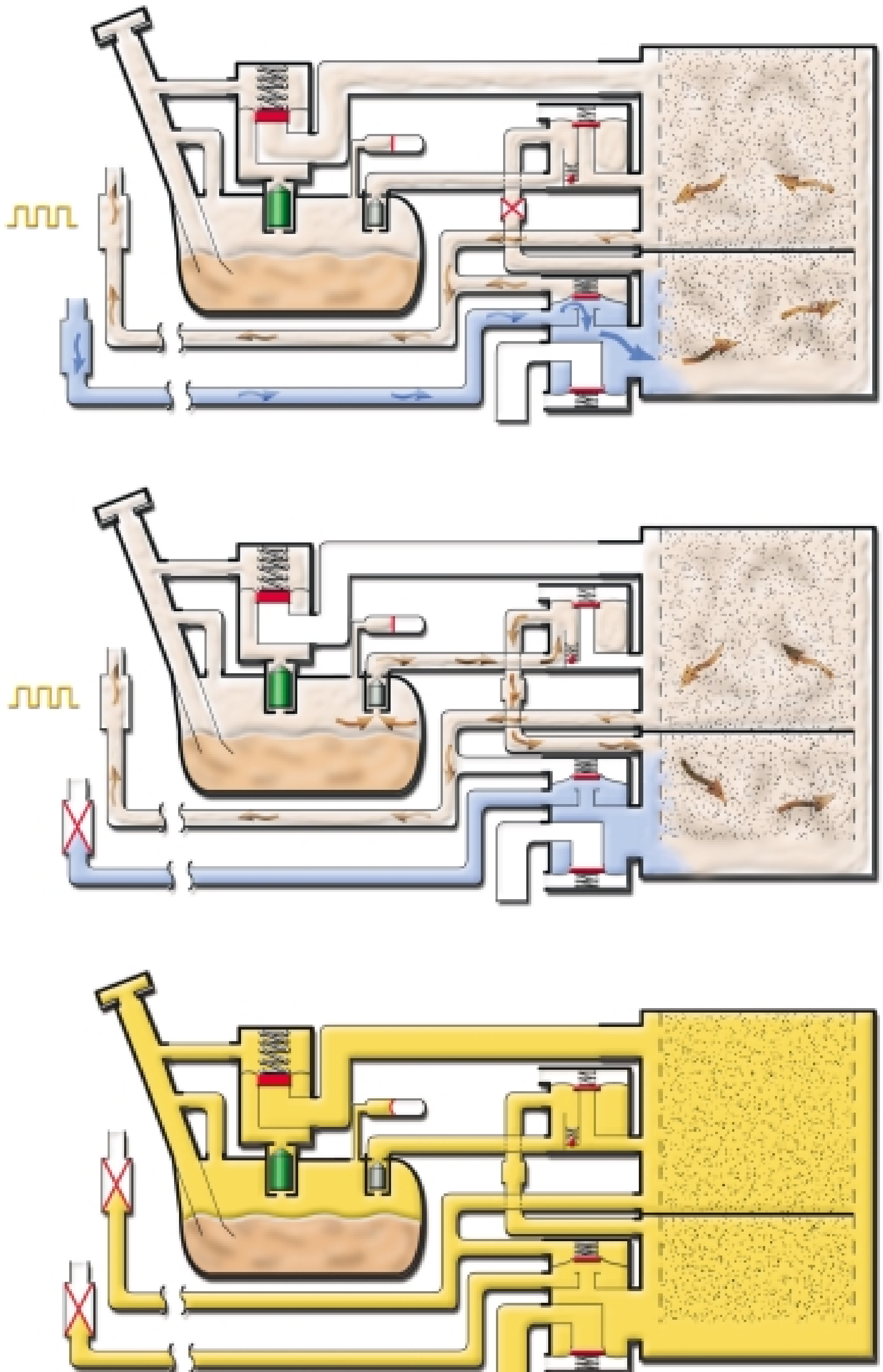


Fig. 5-17

TL874f517

P0441: Purge VSV Operation

At a predetermined point, the ECM closes the CCV and opens the bypass VSV causing a pressure drop in the entire EVAP system.

The ECM continues to operate the purge valve until the pressure is lowered to a specified point at which time the ECM closes the purge valve.

If the pressure did not drop, or if the drop in pressure decreased beyond the specified limit, the ECM judges the purge VSV and related components to be faulty.

P0440 & P0442: HC Leak Detection

The rate of pressure increase, as detected by the vapor pressure signal, indicates if there is a leak and if it is a large or small leak.

After purge valve operation, the purge VSV is turned off sealing the vacuum in the system and the ECM begins to monitor the pressure increase. Some increase in pressure is normal. A very rapid, sharp increase in pressure indicates a leak in the EVAP system and sets the DTC P0440.

This monitoring method is also able to distinguish what is called the small leak detection. A pressure rise just above normal indicates a very small hole.

CCV Operation

The CCV is commanded open by the ECM. The vapor pressure sensor will measure a rapid pressure increase.

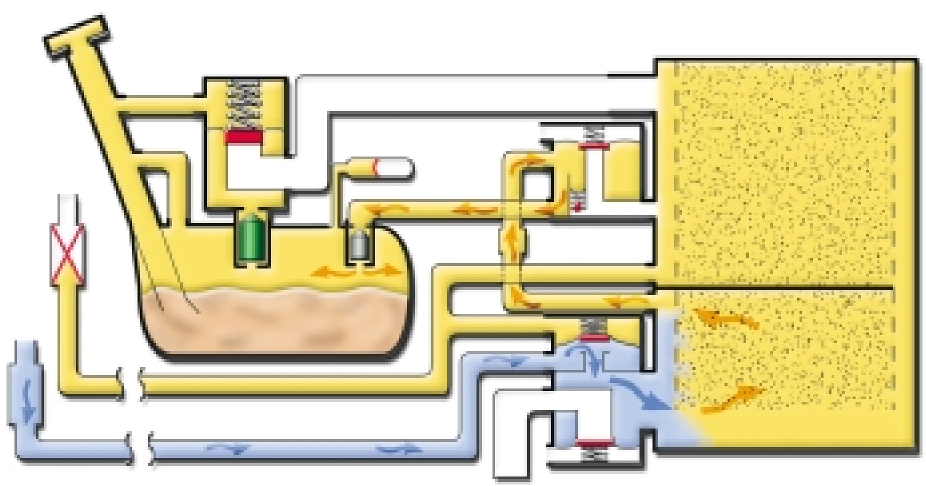


Fig. 5-18

TL874f518

P0446: Vent Control, CCV Operation and Bypass VSV Operation

This stage checks the CCV and vent (air inlet side) operation. When the vapor pressure rises to a specified point, the ECM opens the CCV. Pressure will increase rapidly because of the air allowed into the system. No increase or an increase below specified rate of pressure increase indicates a restriction on the air inlet side.

In the next stage, the ECM closes the bypass VSV. This action blocks air entering the tank side of the system. The pressure rise is no longer as great. If there was no change in pressure, the ECM will conclude the bypass VSV did not close.

Late Type (Intrusive) EVAP Monitor Sequence

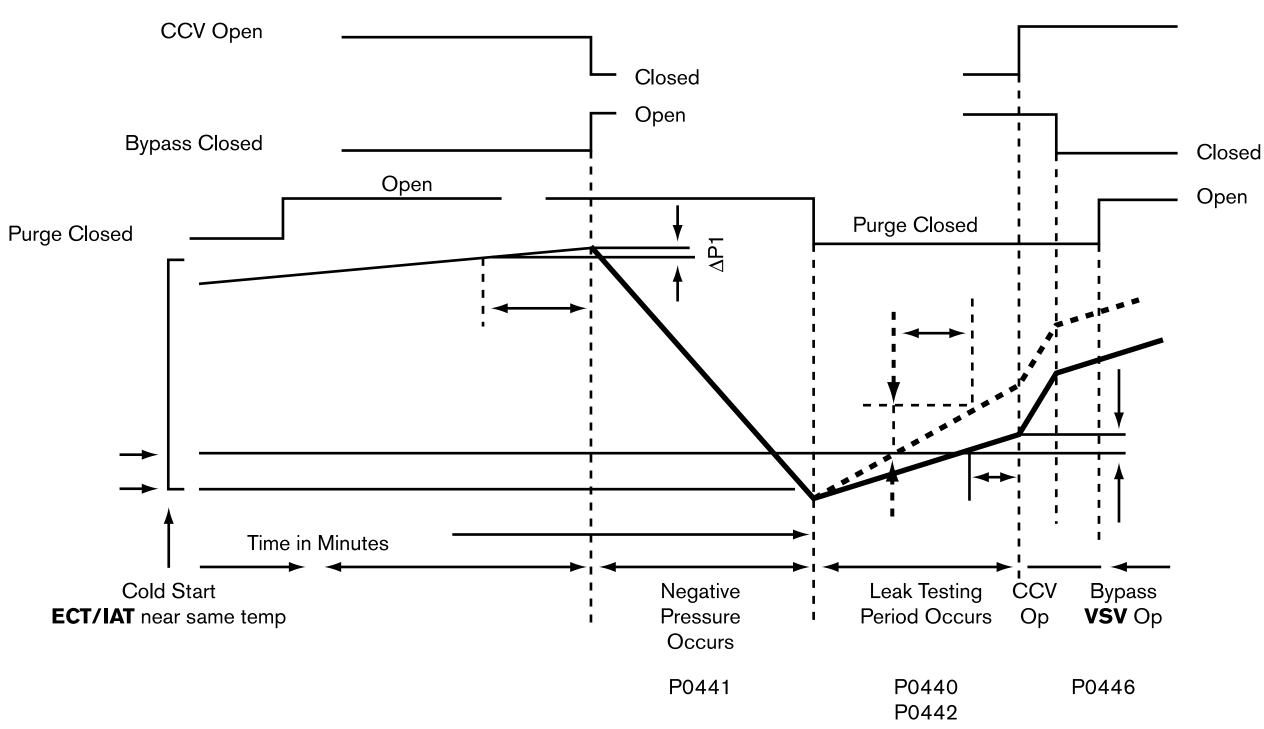


Fig. 5-19

TL874f519

P0450 & P0451: VP Sensor

These two DTCs indicate a faulty VP sensor or circuit on Early and Late type EVAP systems. These DTCs are not set instantly, for the ECM measures VP sensor signal under a variety of conditions and may require the EVAP monitor to complete. Both DTCs require two trips.

To set DTC P0450, after starting, the ECM monitors the VP sensor for 10 seconds. If the VP sensor measures over 4.5V or under 0.5V for at least 7 seconds of the 10 seconds after starting in both the canister and tank, the VP sensor is judged to have failed.

For DTC P0451, after 10 seconds, the voltage criteria is 4.9V and 0.10V. If the VP sensor exceeds these specifications for over 7 seconds, the VP sensor is judged as faulty. Within a 10 seconds period, between 5 to 15 seconds after stopping the vehicle, the tank pressure is monitored. If the VP sensor output fluctuates beyond the programmed specifications, the VP sensor is judged to have failed. For example, 3.83V (+5 mmHg) and 2.77V (-5 mmHg) have occurred more than 7 times within the 10 seconds period.

Vapor Pressure Sensor Circuit

Though there are different styles of vapor pressure sensors, they use the same style circuit.

The Vapor Pressure Sensor (VPS) measures the vapor pressure in the evaporative emission control system. The vapor pressure sensor may be located on the fuel tank, near the charcoal canister assembly or in a remote location.

Vapor Pressure Sensor Operation

The pressure inside the reference chamber changes with atmospheric pressure. The reference chamber pressure uses a small flexible diaphragm exposed to atmospheric pressure. This causes the reference pressure to increase with an increase in atmospheric pressure. Using this method allows the vapor pressure reading to be calibrated with atmospheric pressure.

The VPS is extremely sensitive to changes in pressure.

1.0 psi = 51.7 mmHg

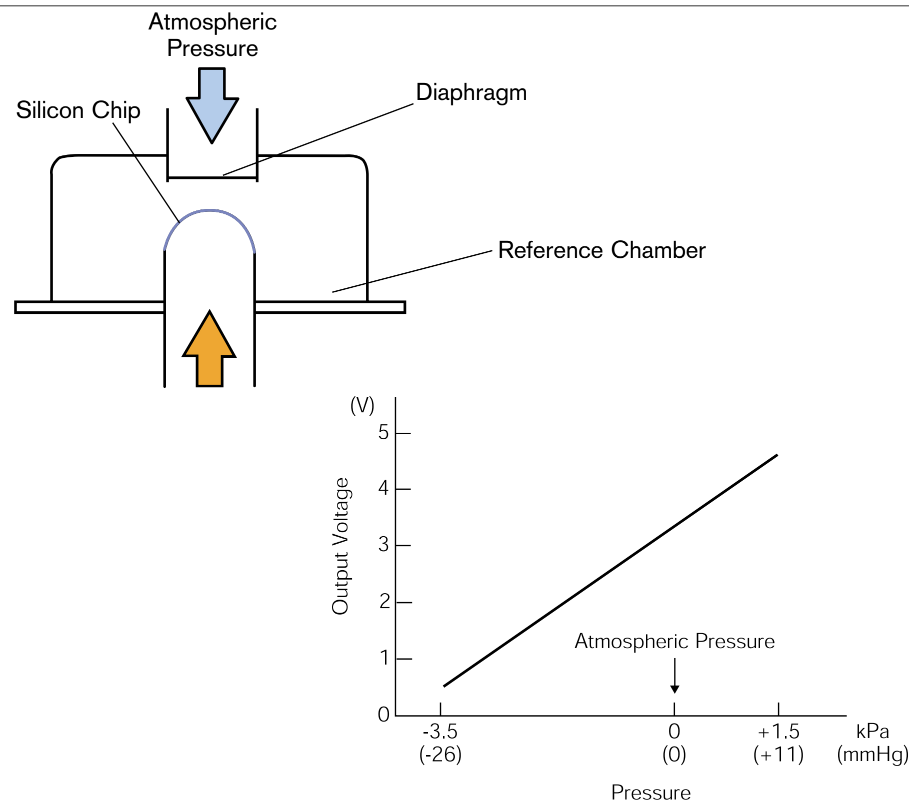


Fig. 5-20

TL874f520

This sensor uses a silicon chip with a calibrated reference pressure on one side of the chip. The other side of the chip is exposed to vapor pressure. Changes in vapor pressure cause the chip to flex and vary the voltage signal to the ECM. The voltage signal out depends on the difference between atmospheric pressure and vapor pressure. As vapor pressure increases, the voltage signal increases. This sensor is sensitive to very small pressure changes (1.0 psi = 51.7 mmHg).

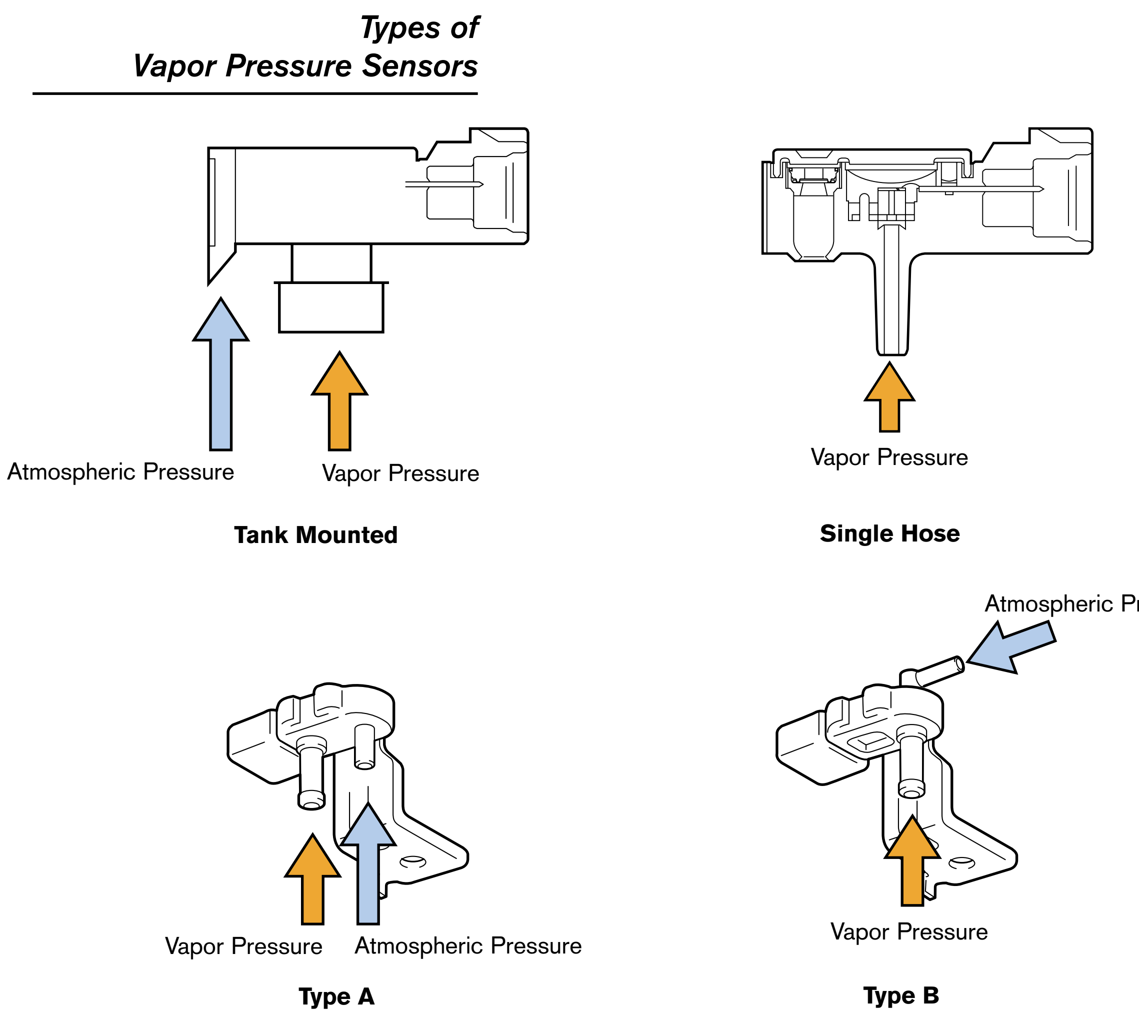


Fig. 5-21

TL874f521

Vapor Pressure Sensors come in a variety of configurations. When the VPS is mounted directly on the fuel pump assembly, no hoses are required. For remote locations, there may be one or two hoses connected to the VPS. If the VPS uses one hose, the hose is connected to vapor pressure. In the two hose configuration, one hose is connected to vapor pressure, the other hose to atmospheric pressure. It is important that these hoses are connected to the proper port. If they are reversed, DTCs will set.

VPS Electrical Circuit

The ECM receives this voltage signal at the PTNK terminal. This sensor receives 5 volts from the ECM on the VC line. The ground for the sensor is through a ground wire to the ECM (usually terminal E2).

The PTNK signal will be 5 volts if the PTNK wire is disconnected.

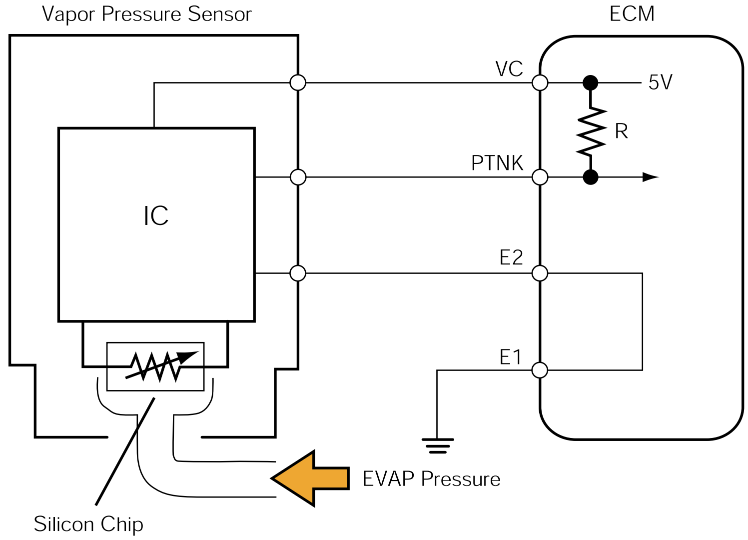


Fig. 5-22

TL874f502

VPS Diagnosis

Check all hoses for proper connection, restrictions, and leaks. Check the VC and E2 voltages. Apply the specified pressure and read sensor voltage output. The vapor pressure sensor is calibrated for the pressures found in the EVAP system, so apply only the specified amount to prevent damaging the sensor.

NOTE

Check the Freeze Frame data. Typically, when ENGINE RUN TIME is less than 200 seconds, carefully check the Vapor Pressure Sensor.

***P0450** Evaporative Emission Control System Pressure Sensor Malfunction*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Up to 10 sec. after engine has started	Vapor Pressure Sensor > -3.5kPa (-26 mmHg, -1.0 in. Hg) for 7 sec. or more OR Vapor Pressure Sensor ≥ 2.0kPa (15 mmHg, 0.6 in. Hg) for 7 sec. or more	2	

***P0451** Evaporative Emission Control System Pressure Sensor Range Performance*

ENABLING STRATEGY	DETECTING CONDITION	TRIP(S)	ECM STRATEGY
Vehicle Speed 0 mph (0 km/h) Engine Speed Idling VSV for Vapor Pressure Sensor is ON	Vapor Pressure Sensor output changes extremely	2	
10 sec. or more after the engine has started	Vapor Pressure Sensor > -4.0kPa (-30 mmHg, -1.2 in. Hg) for 7 sec. or more OR Vapor Pressure Sensor ≥ 2.0kPa (15 mmHg, 0.6 in. Hg) for 7 sec. or more	2	

EVAP Diagnostic Tools and Procedures

The common tools for diagnosis are the Diagnostic Tester and Pressure tool. Procedures will vary with application. The worksheet attached to this section will provide you with a general procedure.

The nature of the EVAP system makes it difficult to confirm the repair. Please refer to the Readiness Confirmation Test.

It is recommended that during a visual inspection, do not wiggle hoses or tighten fittings and caps until the system has been pressurized.

NOTE

When the Intrusive EVAP system is pressurized through the service port, the EVAP system is pressurized EXCEPT for the fresh air intake line between the CCV and canister. The CCV and intake line must be pressurized separately to check for a leak.

Notes

WORKSHEET 5-1
EVAP Leak Test Confirmation - Intrusive Test

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

This worksheet will guide you in testing and confirming if there is a leak in the Intrusive EVAP system. It will also show you how to isolate the canister side from the tank side.

Tools and Equipment

- Vehicle
- Vehicle Repair Manual, EWD, & NCF
- Diagnostic Tester
- Hand Tools, Fender Covers, Floor Mats, and Shop Towels
- DVOM
- Test leads

Section 1: Setup and Test

1. On a vehicle selected by the instructor, connect the Diagnostic Tester to the vehicle.

2. DIAGNOSTIC TESTER SETUP: Go to setup menu on the tester and select UNIT CONVERSION.

3. Under VAPOR PRESSURE, select ABS for absolute pressure, and mmHg for millimeters of mercury. This is to match RM specs.

4. Go back to FUNCTION SELECT and select ENHANCED OBD II.

5. Turn the ignition key to ON.

6. Using a test lead, ground the Closed Canister Valve (CCV) at the ECM and listen for a clicking sound at the CCV.

   Did the CCV "click"? ____________________

   DO NOT REMOVE the test lead.

7. Using a test lead, ground the Bypass (Pressure Switching Valve) VSV (TBP) at the ECM and listen for a clicking sound at Bypass VSV.

   Did the Bypass VSV "click"? ____________________

   DO NOT REMOVE the test lead.

8. What will grounding the CCV and Bypass VSV do to these valves and what does it verify?

   ____

   ____

9. Connect the + lead of a DVOM to the Vapor Pressure Sensor pin at the ECM, the - lead to ground E2.

10. Start the engine, activate the EVAP (Purge) VSV. Observe the vapor pressure reading and DVOM. Pressure should drop to approximately 740mmHg or 1.2 volts (this will vary with altitude and condition of system). Turn OFF or disconnect EVAP (Purge) VSV.

11. Observe the Vapor Pressure Sensor and DVOM. How long should the EVAP system maintain a vacuum?

    ____

12. What is the condition of the system?

    ____

13. Create a small leak by opening the gas cap, or at another point as directed by the instructor. Observe DT and DVOM.

14. What happened to the DT Vapor Pressure Sensor reading and DVOM readings? Which reacted faster?

    ____

15. Is the vacuum test more useful for locating a leak or verifying a leak exists?

    ____

16. What DTC(s) are likely to be reported if there is a leak?

    ____

17. Restore vehicle to normal condition.

EVAP Leak Test Confirmation - Intrusive Test

Name: ____ Date: ____________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Set the conditions for the test			
Determine if the EVAP system is leaking			

Notes

WORKSHEET 5-2
EVAP System Test - Intrusive Type

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet, you will use the Diagnostic Tester and EVAP Pressure Tester (Miller) to test system integrity and determine the condition of the EVAP system and components. When finished, you will know how to diagnose the EVAP system and components.

Tools and Equipment

- Repair Manual
- Vehicle EWD
- EVAP Pressure Tester
- Diagnostic Tester
- DVOM
- Hand Tool Set

Note: Fuel Level should be 1/4 to 3/4 of the tank.

SECTION 1: DIAGNOSTIC TESTER SETUP

1. Go to setup menu on the Diagnostic Tester and select UNIT CONVERSION.
2. Under VAPOR PRESSURE, select ABS for absolute pressure, and mmHg for millimeters of mercury. This is to match RM specs.
3. Go back to FUNCTION SELECT and select ENHANCED OBD II.

SECTION 2: EVAP SYSTEM

1. Setup the Diagnostic Tester as outlined above.
2. With the **key on and engine off**, record Tank Vapor Pressure reading ______________mmHg. What does a reading above or below atmospheric pressure **(762 mmHg)** indicate?

   ____

Note: DO NOT TIGHTEN or REMOVE the FUEL CAP!

Test EVAP Purge Line/Check Purge VSV

This procedure tests for purge flow restrictions, and checks the purge VSV and EVAP purge line connections. This is done to confirm the operation of these components.

1. Connect EVAP System Pressure Pump to EVAP service port.
   - Set pump hold switch to CLOSE.
   - Set vent switch to CLOSE.

2. Using the Diagnostic Tester, go to ACTIVE TEST, EVAP (Purge) VSV test.

3. Start the engine. With engine warm @ idle, activate EVAP VSV.

4. Pump gauge should read between - 9 mmHg to - 499 mmHg (-5" H_2O to -268" H_2O) with the needle fluctuating. Name two causes for the needle not to fluctuate.

   ____

   ____

5. What DTC(s) are possible if the Purge VSV does not operate correctly? (HINT: See monitor sequence)

   ____

6. From air cleaner side, temporarily plug the air inlet line. Pressure should decrease by -10mmHg (- 5" H_2O) or more.

7. If pressure did not decrease, list two causes.

   ____

   ____

Note: When both gauge valves are in the CLOSE position, the pump cannot pressurize the system. The gauge measures the pressure in the EVAP system.

Pressurize System (System Integrity Check)

This test checks for leaks in the canister and fuel tank sides by pressurizing the system. When the system is pressurized, it allows you to locate the source of a leak. The CCV and Air Inlet Line are checked separately.

Procedeuce	Resutls
1. Clamp air drain hose with supplied hose pliers.	**Condition 1. Pump gauge and vapor pressure above atmospheric pressure.** This indicates:
2. Locate the Vapor Pressure Sensor. **If the sensor has two hoses connected to it**, disconnect the hose between the air drain and the sensor and plug the air drain hose. See Figure 1.	**2. Pump pressure gauge zero, vapor pressure above atmospheric pressure (above 762 mmHg).** This indicates:
3. Pressurize EVAP system. Turn off the pump and seal system (see pump directions).	**3. Pump pressure gauge is above atmospheric pressure (above zero), vapor pressure is at 762 mmHg.** This indicates:
4. Note pump pressure reading and Vapor Pressure Sensor reading.	**4. Pump pressure gauge at zero, vapor pressure is at 762 mmHg**. This indicates:
5. Compare your readings to one of the four results listed in the right column. Your vehicle had result number ________________.	
6. Next, in the right column, list a probable reason or area that can cause each result.	

What DTC(s) are likely to set if there is a leak?

After completing the steps above proceed to checking the CCV and air inlet line. This must be done because this section is not pressurized when the pump pressurizes the system through the service port.

Check CCV and Air Inlet Line

This test checks for leaks and restrictions between the canister and CCV; tests CCV operation.

1. Disconnect the air inlet line at the canister.
2. Connect pump to line.
3. Go to ACTIVE TEST, turn on the CCV.
4. Pressurize line, turn pump off. Pressure should hold. If not, check line and CCV.
5. Turn off the CCV, pressure should decrease.
6. Reconnect line.
7. What DTC(s) are possible if the CCV fails?

Check Bypass (Pressure Switching Valve) VSV Operation

This tests the Bypass VSV for operation and restrictions.

1. Disconnect Bypass VSV lines from canister.
2. Connect pump to one Bypass VSV line.
3. Go to ACTIVE TEST BYPASS VSV.
4. Pressurize Bypass VSV, Turn Pump off.
5. Pressure should hold at this point. If not, what needs to be checked?
6. Turn Bypass VSV on, pressure should drop. If not, what component should be checked first?
7. Reconnect lines.
8. What DTC(s) are possible if the Bypass VSV fails?

Return Vehicle to Service

1. After repairs, pressurize the EVAP system to be sure the system does not leak.

2. Remove clamp from air drain. Remove the plug and connect the Vapor Pressure Sensor hose.

3. Enable EVAP monitor according to Readiness Test Confirmation procedure.

Vapor pressure sensor with two hoses - preparation for leak testing

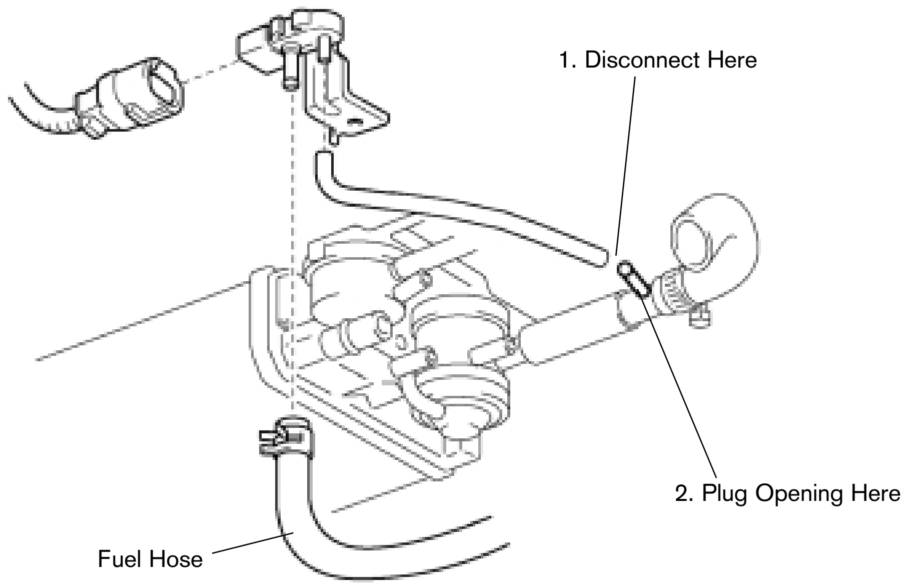


Figure 1

Areas to Check for Leaks

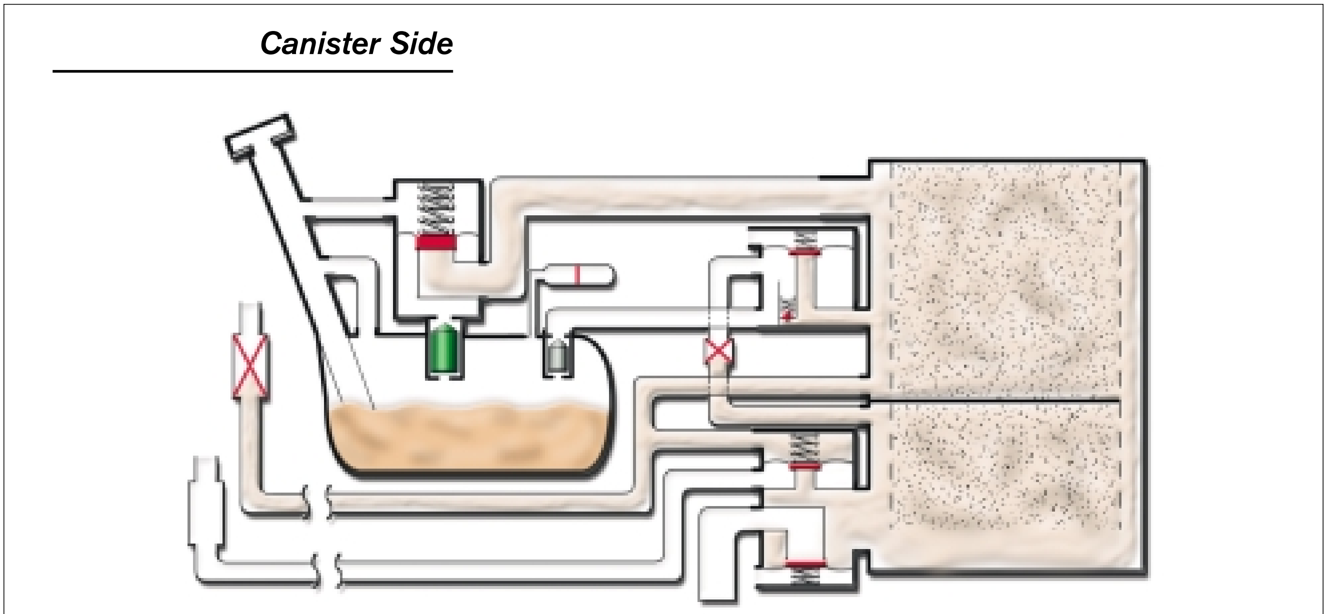


Figure 2

1. Check shaded areas for leaks (soapy water detection).

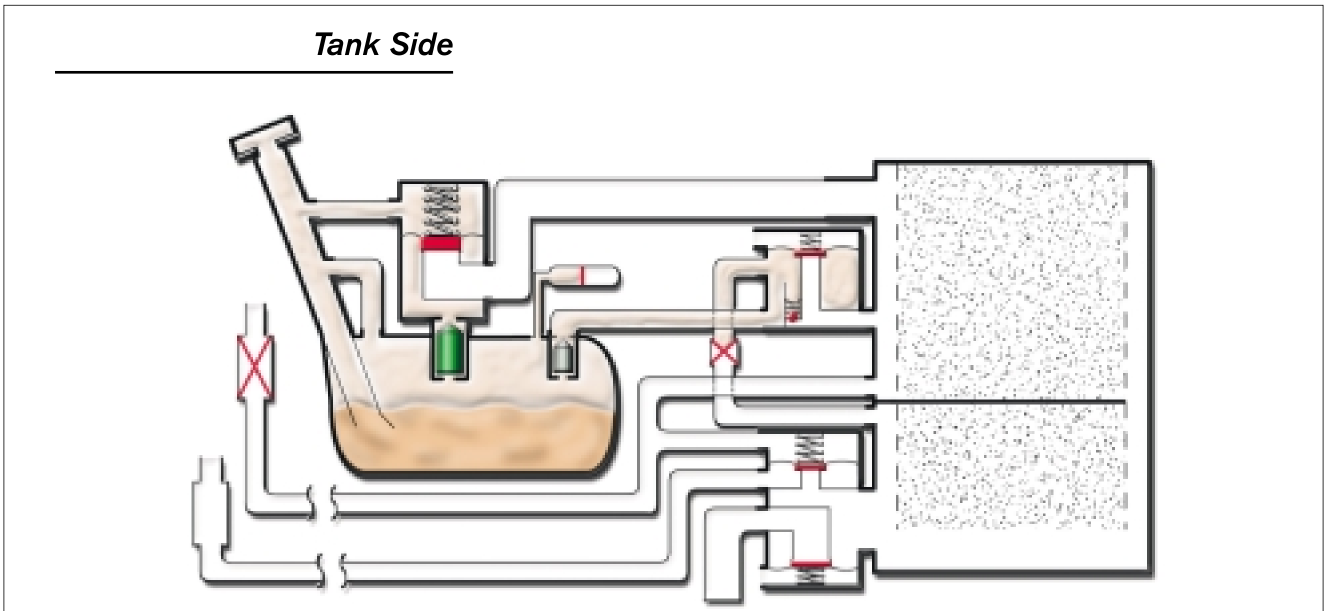


Figure 3

1. Disconnect the EVAP hose from the charcoal canister side and then pressurize the fuel tank to 30 mmHg (4 kPa/0.58psi).

2. Check that the internal pressure of the tank can hold for 1 minute. Check shaded areas for leaks (soapy water detection). If it does, check the canister side.

3. With system pressurized, check shaded areas for leaks (soapy water detection). Inspect fuel tank cap for leaks and if it is OEM.

EVAP System Test - Intrusive Type

Name: ______________________________ Date: ______________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	*I have questions*	*I know I can*	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Set the conditions for the test			
Determine if the EVAP system is leaking			
Set the conditions for the test and operate the EVAP pressure tester			
Determine if EVAP system purge operation is normal			
Locate the source of the leak and determine the cause			
Visually inspect tank, fuel cap, lines, canister			
Activate purge VSV with Active Test			
Test purge VSV and compare to specs. to determine condition			
Test Vapor Pressure Sensor			

Notes

WORKSHEET 5-3
EVAP System Test - Non-Intrusive Type

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet, you will use the Diagnostic Tester and EVAP Pressure Tester (Miller) to test system integrity and determine the condition of the EVAP system and components.

Tools and Equipment

- Repair Manual
- Vehicle EWD
- EVAP Pressure Tester
- Diagnostic Tester
- DVOM
- Hand Tool Set

Note: Fuel Level should be 1/4 to 3/4 of the tank.

SECTION 1: DIAGNOSTIC TESTER SETUP

1. Go to setup menu on the Diagnostic Tester and select UNIT CONVERSION.
2. Under VAPOR PRESSURE, select ABS for absolute pressure, and mmHg for millimeters of mercury. This is to match RM specs.
3. Go back to FUNCTION SELECT and select ENHANCED OBD II.

SECTION 2: EVAP SYSTEM

The following procedures are designed to test the operation of the EVAP system with a service port.

1. Setup the Diagnostic Tester as outlined above.
2. With the key on and engine off, record Tank Vapor Pressure reading _______________mmHg. What does a reading above or below atmospheric pressure indicate?

____

Note: DO NOT TIGHTEN or REMOVE the FUEL CAP!

Test EVAP Purge Line/Check Purge VSV

This procedure tests for purge flow restrictions, and checks the purge VSV and EVAP purge line connections. This is done to confirm the operation of these components.

1. Connect EVAP System Pressure Pump to EVAP service port
   - Set pump hold switch to CLOSE
   - Set vent switch to CLOSE

2. Using the Diagnostic Tester, go to ACTIVE TEST, EVAP (Purge) VSV test

3. Start the engine. With engine warm @ idle, activate EVAP VSV

4. Pump gauge should read between - 9 mmHg to - 499 mmHg (-5" H2O to -268" H2O) with the needle fluctuating. Name two causes for the needle not to fluctuate.

   ____

   ____

5. What DTC(s) are possible if the Purge VSV does not operate correctly? (HINT: See monitor sequence)

   ____

6. From air cleaner side, temporarily plug the air inlet line. Pressure should decrease by -10mmHg (- 5" H2O) or more.

7. If pressure did not decrease, list two causes.

   ____

   ____

Note: When both gauge valves are in the CLOSE position, the pump cannot pressurize the system. The gauge measures the pressure in the EVAP system.

Pressurize System (System Integrity Check)

This test checks for leaks in the canister and fuel tank sides by pressurizing the system. When the system is pressurized, it allows you to locate the source of a leak.

Procedcue	Resutls
1. Clamp air drain line with supplied hose pliers. ⇩ 2. Pressurize EVAP system. Turn off the pump and seal system (see pump directions). ⇩ 3. Note pump pressure reading and Vapor Pressure Sensor reading for the fuel tank. ⇩ 4. Note pump pressure reading and Vapor Pressure Sensor reading. ⇩ 5. Compare your readings to one of the four results listed in the right column. Your vehicle had result number ________________. 6. Next, in the right column, list a probable reason or area that can cause each result.	**Condition 1. Pump gauge and vapor pressure above atmospheric pressure.** This indicates: **2. Pump pressure gauge zero, vapor pressure above atmospheric pressure (above 762 mmHg).** This indicates: **3. Pump pressure gauge is above atmospheric pressure (above zero), vapor pressure is at 762 mmHg.** This indicates: **4. Pump pressure gauge at zero, vapor pressure is at 762 mmHg**. This indicates:

What DTC(s) are likely to set if there is a leak?

Return Vehicle to Service

1. After repairs, pressurize the EVAP system to be sure the system does not leak.
2. Remove clamp from air drain. Remove the plug and connect the Vapor Pressure Sensor hose.
3. Enable EVAP monitor according to Readiness Test Confirmation procedure.

Areas to Check for Leaks

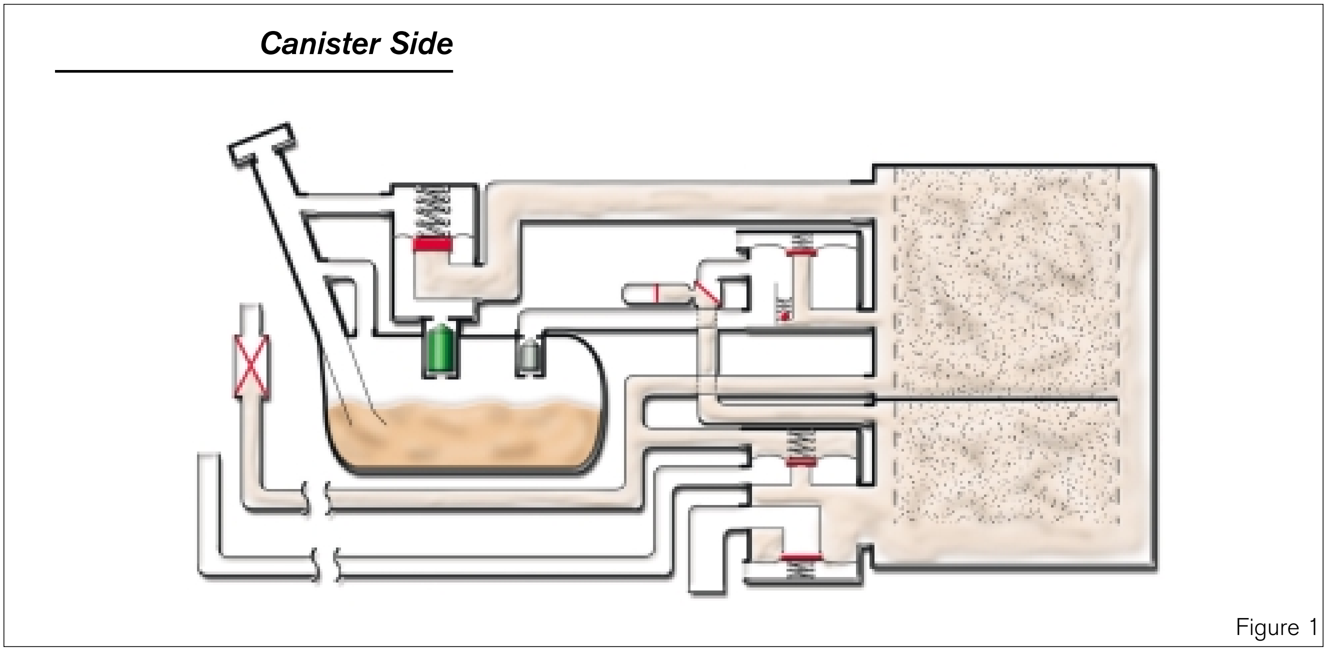


Figure 1

1. With the system pressurized, check shaded areas for leaks (soapy water detection).

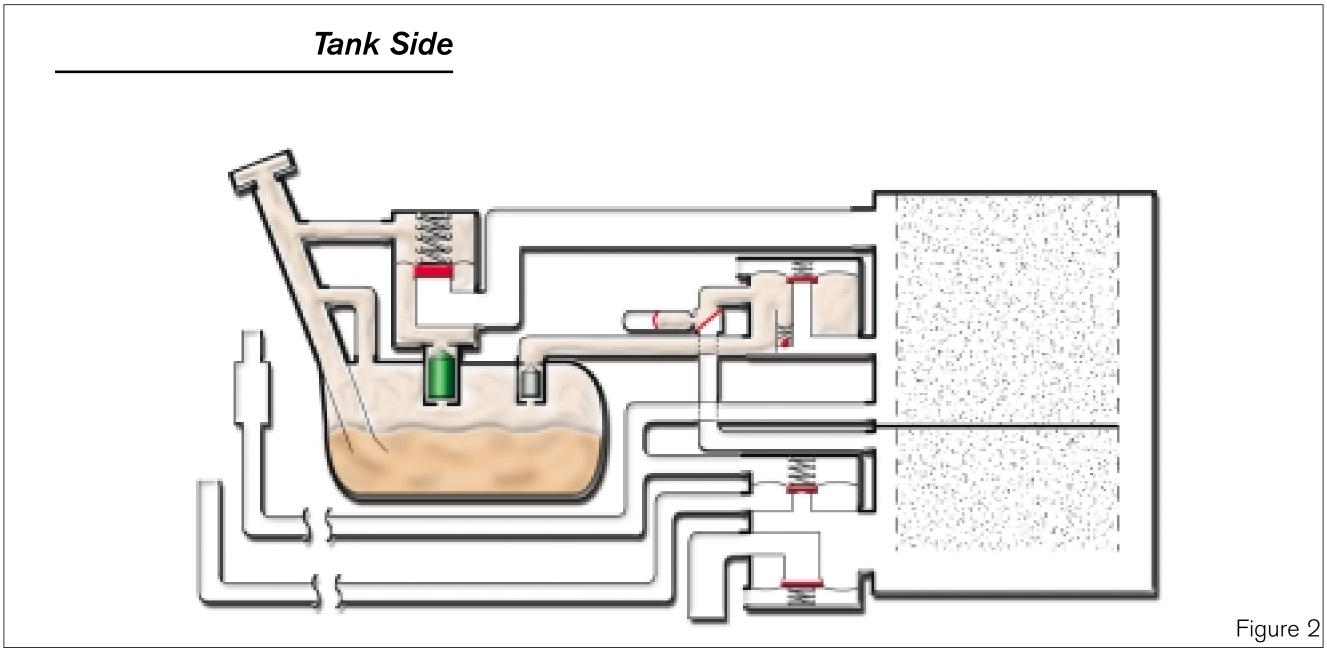


Figure 2

1. Inpect fuel tank cap for leaks and see if it is OEM.

2. Check shaded areas for leaks (soapy water detection).

EVAP System Test - Non-Intrusive Type

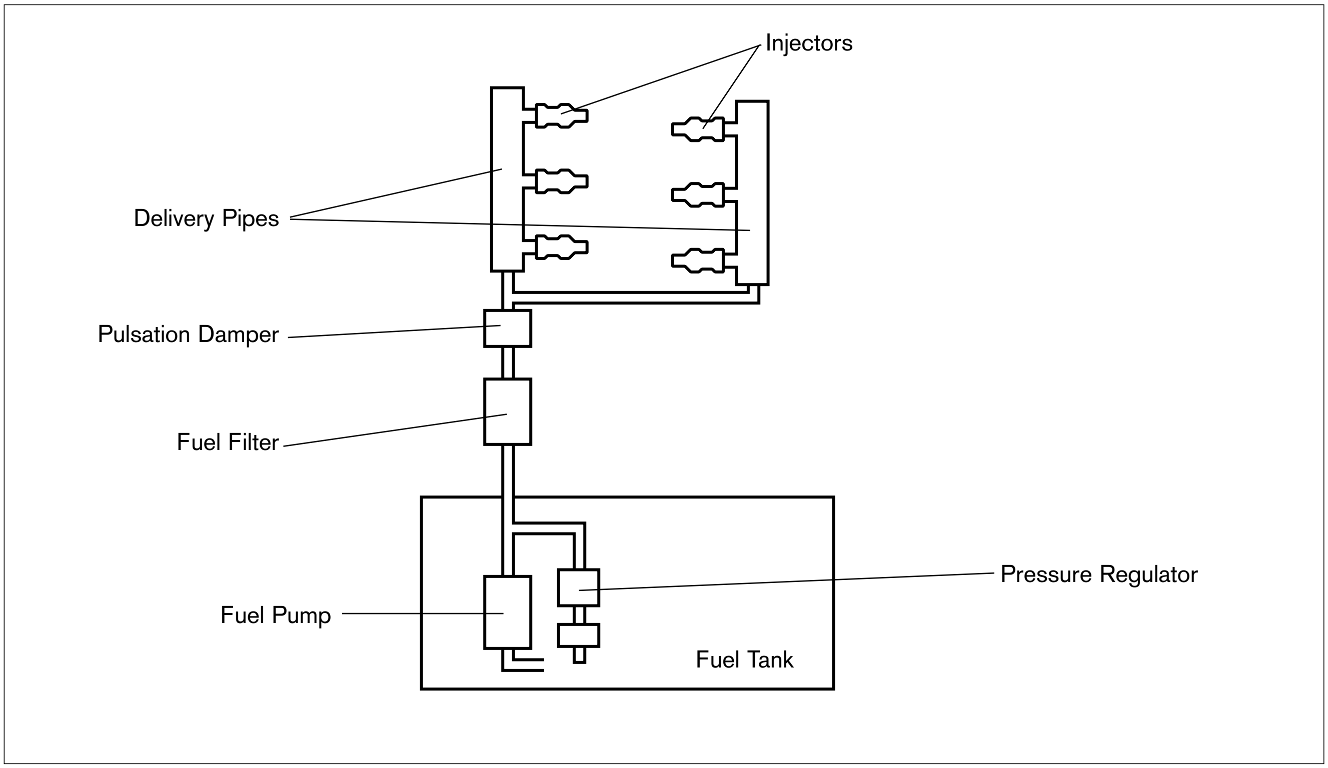
Name: ____ Date: ____________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Set the conditions for the test			
Determine if the EVAP system is leaking			
Set the conditions for the test and operate the EVAP pressure tester			
Determine if EVAP system purge operation is normal			
Locate the source of the leak and determine the cause			
Visually inspect tank, fuel cap, lines, and canister			
Activate purge VSV with Active Test			
Test purge VSV and compare to specs. to determine condition			
Test Vapor Pressure Sensor			

Section 6

Fuel System Diagnosis



Learning Objectives:

1. Determine fuel system response and corrective actions.
2. Determine the causes of a rich fuel trim condition.
3. Determine the causes of a lean fuel trim condition.

Fuel System Diagnosis

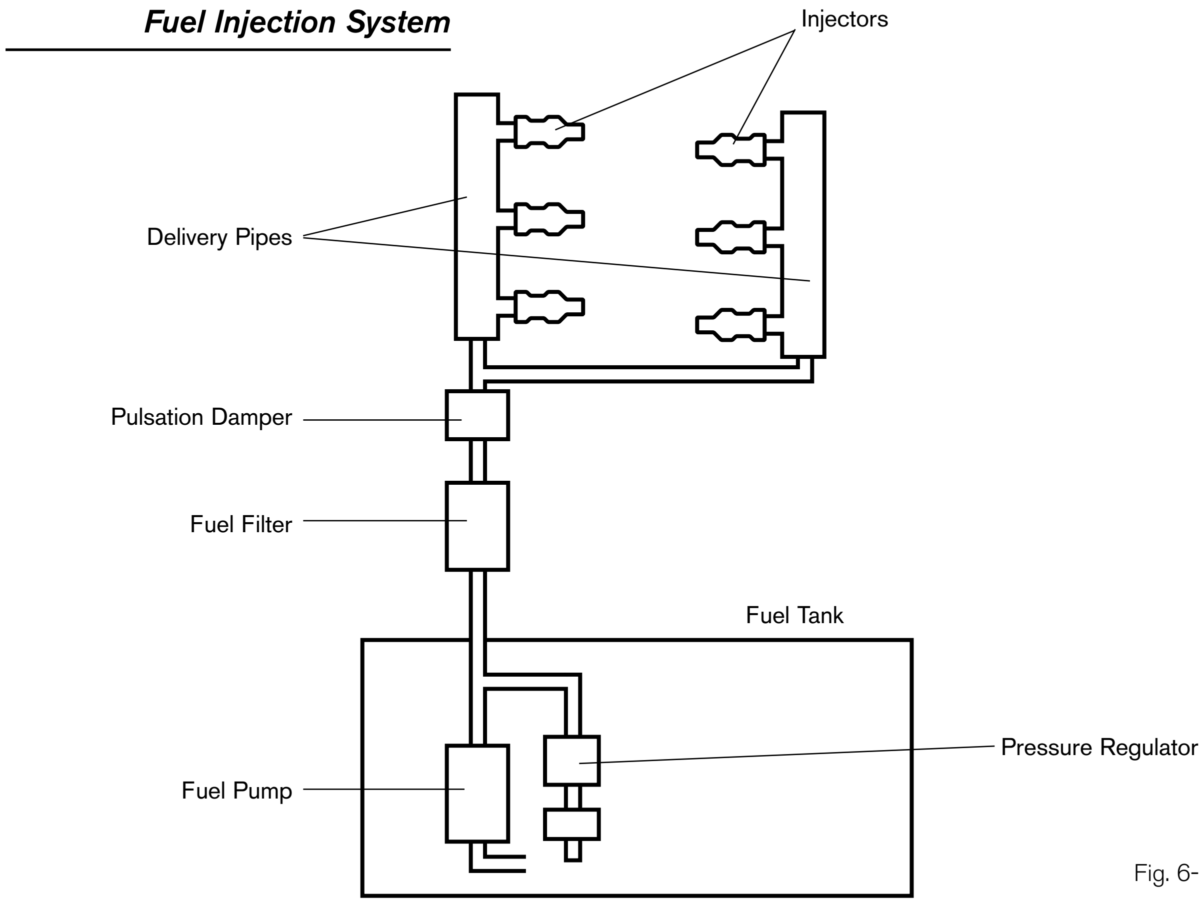


Fig. 6-1

Overview

The ECM adjusts the amount of fuel injected into the cylinder to meet a variety of operating conditions. The fuel system's purpose is to deliver and inject the proper amount of fuel at the correct time. The ECM can provide a limited correction for variances in the fuel system. The fuel system monitor reports the amount of the correction.

Fuel system problems are usually no fuel or an inadequate amount of fuel.

Fuel System Monitor

Fuel trim refers to the feedback compensation value compared against the basic injection time. Fuel trim includes short-term and long-term fuel trim. The ECM monitors its ability to control fuel trim.

The ECM fuel system monitor looks at the total or sum of both the short term and long term fuel trim to monitor its ability to control the A/F mixture. Should the ECM be forced to take both short term and long term fuel trim to the extreme rich or lean limit of control, a fault is recorded and a DTC will be set on the next trip if the condition is still present. The fuel trim monitor is a continuous monitor.

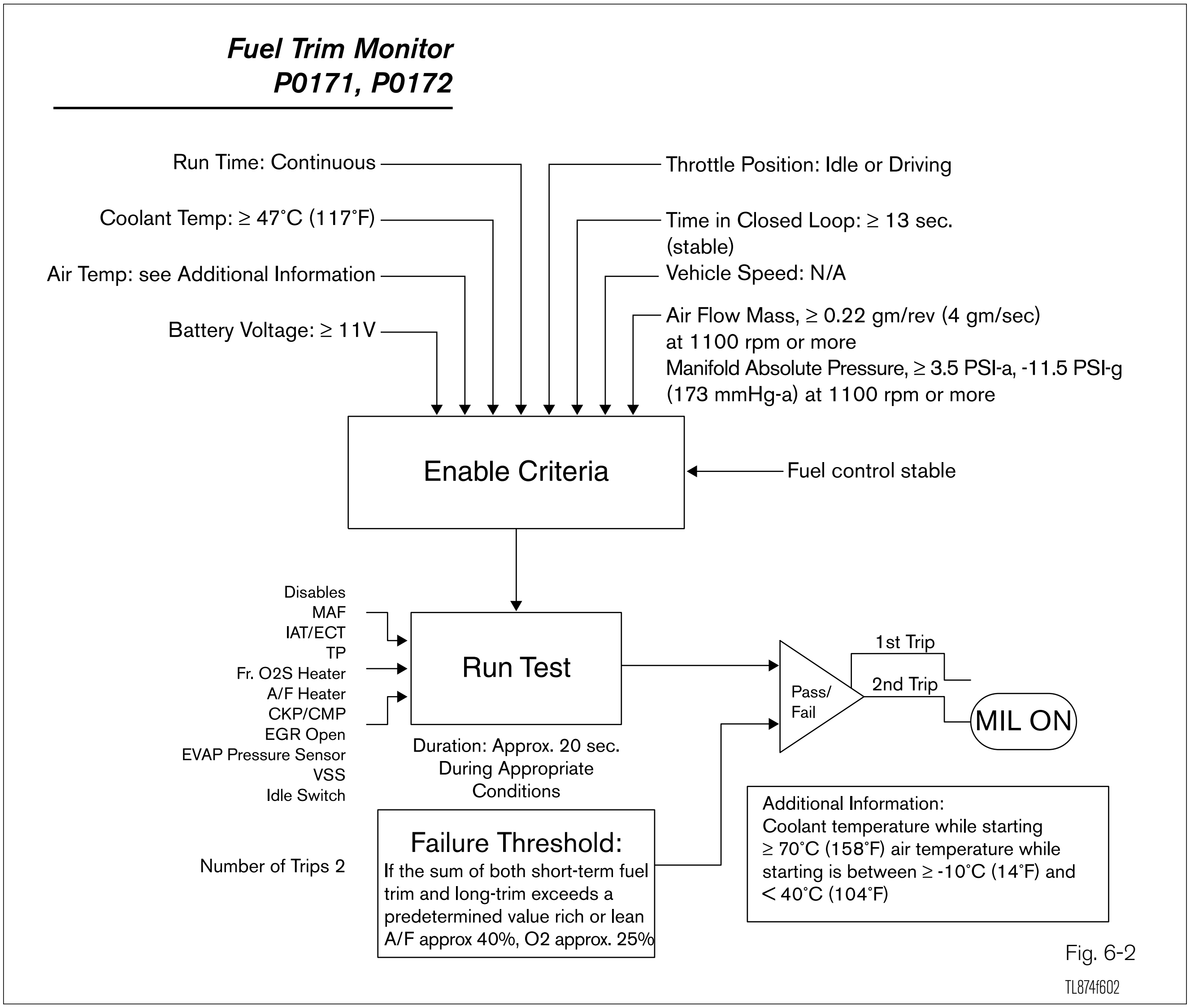


Fig. 6-2

Fuel Trim DTC(s)

P0171, P0174: System Too Lean When the A/F Ratio feedback is stable after the engine is at operating temperature and the fuel trim has reached its limit of correction to the rich side. (two trip logic)

P0172, P0175: System Too Rich When the A/F Ratio feedback is stable after the engine is at operating temperature and the fuel trim has reached its limit of correction to the lean side. (two trip logic)

Exhaust Oxygen Content	Fuel Trim Correction	If Correction Exceeds Failure Threshold
High →	**Fuel Trim percentage increases (adds fuel)** →	**P0171, P0174**
Low →	**Fuel Trim percentage decreases (subtracts fuel)** →	**P0172, P0175**

Feedback from the O2 or A/F sensor influences short-term fuel trim and short-term fuel trim influences long trim fuel trim. Short-term values are temporary and not stored when the ignition key is turned off. Long-term values are stored in memory because they are part of the basic injection duration. Long term values affect injection duration in closed and open loop because they are used to calculate basic injection duration. It is important to remember that the actual fuel trim will be the opposite of the DTC. A system too lean, DTC P0171 will mean the ECM is making a + or rich correction.

Fuel Trim

In this screen, P0171 was set when the Long Term Fuel Trim reached 35%.

```
TROUBLE CODE......... P0171
CALC LOAD.............. 45%
MAP................ 46KPa-a
ENGINE SPD.......... 647rpm
COOLANT TEMP....... 197.6°F
INTAKE AIR.......... 77.0°F
CTP SW.................. ON
VEHICLE SPD........... 0MPH
SHORT FT #1........... 0.7%
LONG FT #1........... 35.8%
FUEL SYS #1............. CL
FUEL SYS #2......... UNUSED
FC IDL................. OFF
STARTER SIG............ OFF
A/C SIG................ OFF
PNP SW [NSW]........... OFF
ELECT LOAD SIG......... OFF
STOP LIGHT SW........... ON
PS OIL PRESS SW........ OFF
PS SIGNAL............... ON
ENG RUN TIME............ 92
```

Fig. 6-3

TL874f603

Fuel System Checks

A fuel system monitor DTC does not mean the fuel system itself is at fault, but that there is a condition that is driving the fuel trim out of range. For example, excessively high fuel system pressure could cause the fuel trim to decrease beyond the parameter stored in the ECM. A misfiring cylinder may cause the fuel trim to go rich.

Checking Fuel Pressure

A pressure gauge is used to obtain accurate fuel pressure readings. If the pressure is too high, it is typically the fuel pressure regulator. If too low, the fuel hoses, fuel pump, filter and pressure regulator needs to be checked.

Residual fuel pressure is also checked. After the engine is shut off, there needs to be a residual pressure in the system. After the engine has been off for a period of time (usually five minutes), the pressure is checked. If pressure is not as specified, the fuel pump, connectors, hoses, regulator and injectors need to be checked.

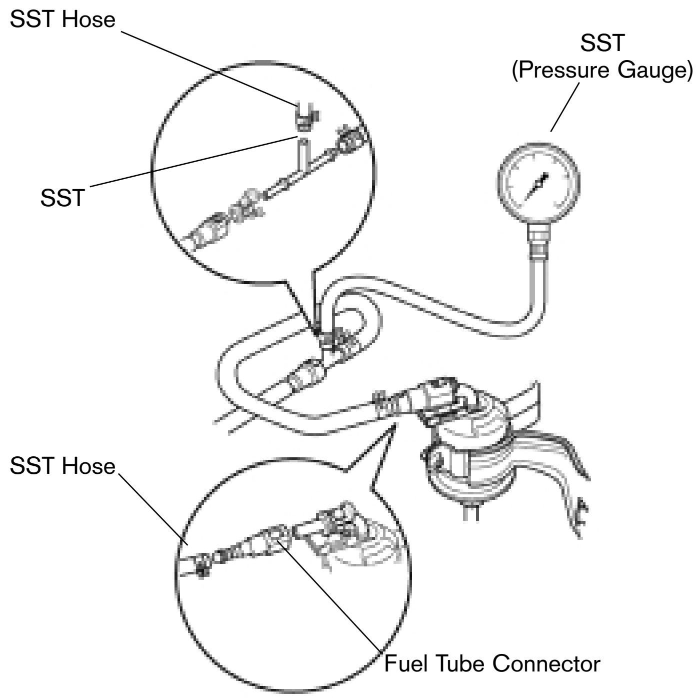


Fig. 6-4

TL874f604

Fuel Delivery System Inspection

Use a fuel pressure gauge or observe pulsation damper bolt head to confirm adequate pressure (see Course 852). Normal pressure confirms fuel pump operation and the electrical circuit between relay and pump.

Circuit Inspection Using V-BoB: Inspect the following signals for behavior as indicated above; STA, Fc (where applicable), +B, NE. Refer to the appropriate Repair Manual circuit inspection charts and to the Engine Control System schematic in the EWD for troubleshooting details.

Applicable Active Tests (OBD II only): Fuel Pump test, performed with ignition ON, will confirm circuit opening relay, all related wiring, and ECM control functions.

For NE signal inspection, use oscilloscope display.

Fuel Injector Drive System

When the engine is cranked, the injectors are pulsed by the ECM to supply the desired cranking A/F Ratio. Injection pulse width is based on inputs from the crankshaft speed sensor (NE), crankshaft position sensor [G], and engine coolant temperature (THW). The ECM also monitors the IGF signal for fuel injection Fail-Safe control in the event that adequate ignition is not maintained.

The ECM pulses the fuel injectors either simultaneously, in groups, or sequentially, depending on application and operating conditions. The injector driver circuits energize the injectors by providing a ground path for current flow.

Strategy

As the engine is cranked, the ECM looks for the STA signal, which indicates that the engine is cranking. Basic injection is calculated using the Engine Coolant Temperature (ECT) sensor as primary input.

Next the ECM looks for a crankshaft position signal to determine injector sequence and the crankshaft speed signal to determine pulse frequency.

Finally, the ECM compares the ignition confirmation (IGF) signal with the ignition trigger (IGT) signal to confirm that ignition events are taking place. If these signals are all present, the ECM will pulse the fuel injectors (#10, #20....#etc.) based on a starting enrichment program.

Inspection

Quick Checks:

- To determine if injector(s) are being pulsed, connect an injector test light (noid light) across an injector wire harness. A blinking light indicates normal driver circuit operation.

- Do not rely on an injection pulse signal from serial data stream for this test. During IGF fuel cut Fail-Safe, serial data may display an injection pulse even though the injector drivers are not operating. Repair any IGF problems before troubleshooting the injectors.

- To determine if fuel delivery is taking place – after cranking, remove a spark plug and check for fuel.

- Using Diagnostic Tester serial data, observe the STA and ENGINE SPD signals while cranking the engine.

- Circuit Inspection Using a DVOM or V-BoB: Inspect the following signals for behavior as indicated above; STA, (THW), NE, G, IGF, IGT, #10, #20...#etc. Refer to the appropriate Repair Manual circuit inspection charts and to the Engine Control System schematic in the EWD for troubleshooting details.

- For inspection of NE, G, IGF, and IGT signals, use oscilloscope display or a DVOM.

Fuel Injector Testing

Using SSTs, the fuel injector is tested for volume and leakage. Both specifications are given in the Reapir Manual.

The volume is a measurement of how much fuel comes out of the injector in a given time period.

The leakage test checks for leaks and a loss of pressure in a given time period.

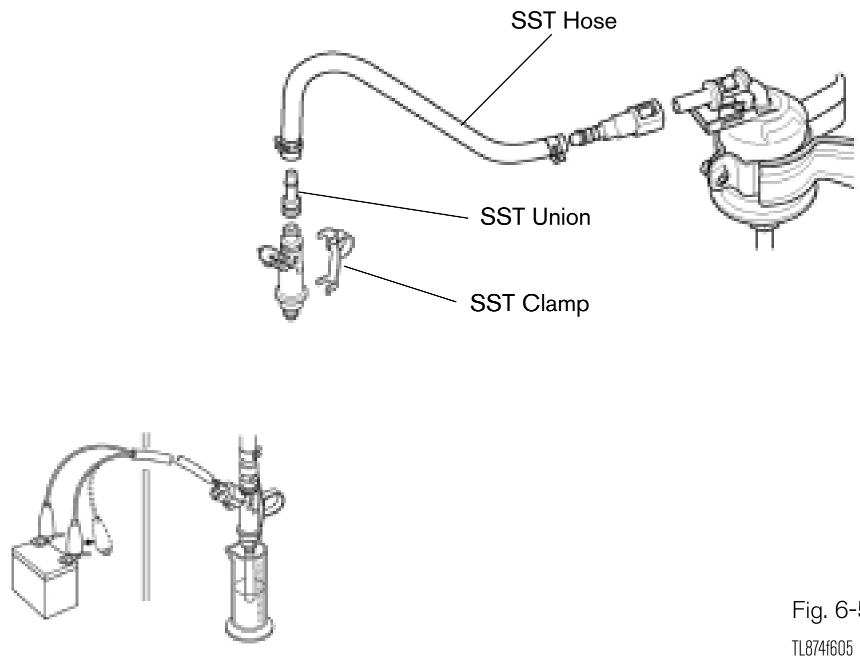


Fig. 6-5

TL874f605

Other Checks

There are other systems and components that can cause the fuel trim to go out of range. The following is a general list. Always consult the Repair Manual for specific procedures.

- **Air Induction System:** Check that all components are in place and properly sealed. Inspect hoses for damage. Inspect the air filter.

- **PCV System:** Inspect hose and system.

- **Inspect the Engine Coolant Temperature Sensor:** The ECT sensor circuit with abnormal resistance can cause the fuel trim to go out of range. ECT readings should match engine temperature.

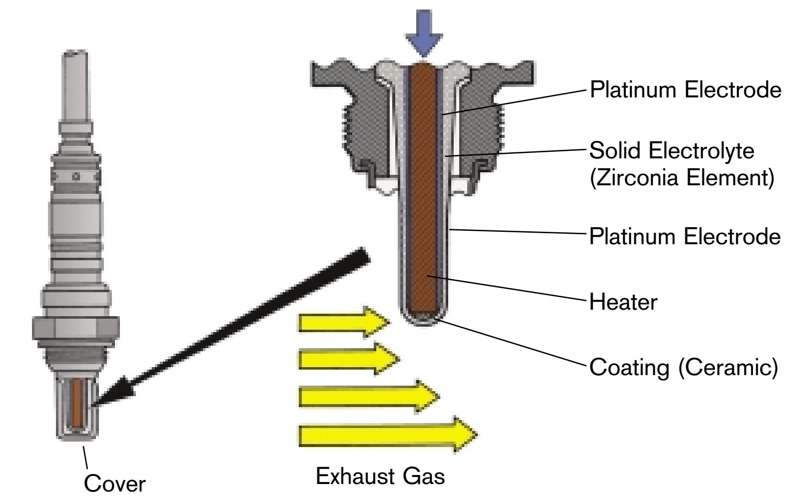
- **Ignition System:** Cylinder misfire can drive the fuel trim out of range.

- **Exhaust System Leak:** A leaking exhaust system can change the oxygen or A/F sensor signal. Inspect and repair any leaks.

- **Check O2 Sensor or A/F Sensor Response:** Do this after confirming all other systems are good.

Section 7

O2 and A/F Sensor Diagnosis



Learning Objectives:

1. Determine the condition of an O2 sensor, A/F sensor and heater based on data and engine symptoms and determine appropriate repair.
2. Use Modes 5, 6, and 7 to determine monitored O2 sensor results.
3. Accurately measure and interpret oxygen content of the exhaust gases based on sensor signal data.
4. Describe the primary difference between the O2 sensor and the A/F sensor.
5. Use Modes 6 and 7 to determine monitored A/F sensor results.

O2 & A/F Sensor Diagnosis

O2 Sensor Locations

S1 designates the oxygen sensor is before the catalytic converter, S2 after the catalytic converter. B1 indicates the sensor is on the bank with cylinder No. 1.

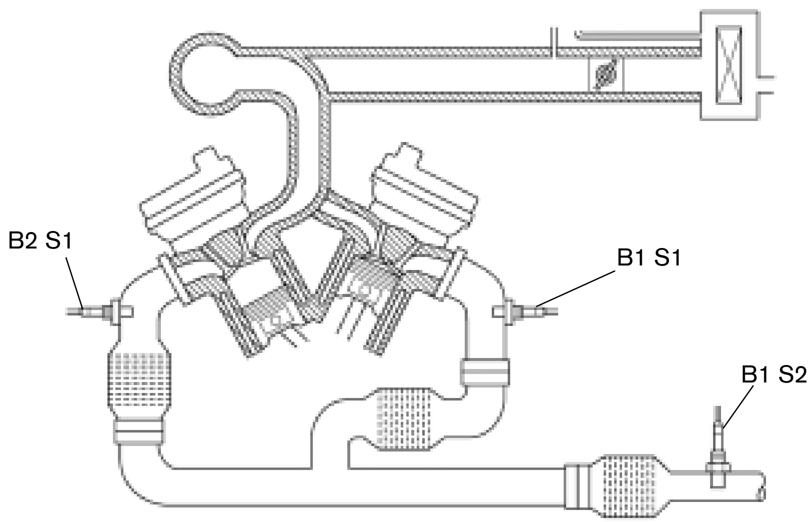


Fig. 7-1

TL874f701

Overview

The ECM uses an O2 sensor to ensure the A/F Ratio is correct for the catalytic converter. Based on the oxygen sensor signal, the ECM's fuel control program adjusts the amount of fuel injected into the cylinder. This program varies based on the type of O2 sensor.

There are different types of O2 sensors, but two of the more common types are the:

- narrow range O2 sensor, the oldest style, simply called the O2 sensor.

- wide range O2 sensor, the newest style, called the A/F sensor.

OBD II vehicles require two O2 sensors: one before and one after the catalytic converter. The O2 sensor, or A/F sensor before the catalytic converter is used by the ECM to adjust the A/F Ratio. The O2 sensor after the catalytic converter is primarily used for catalytic converter efficiency control and monitoring. (See Section 8 Overview)

O2 Sensor Monitor

The O2 sensor monitor checks for sensor circuit malfunctions, slow response rate, and for a malfunction of the sensor's heater circuit. There is a DTC for each condition for each sensor. The sub-sensor(S2) is not monitored for response rate. O2 sensors are required to be monitored once per trip, however, the ECM continuously monitors O2 sensor operation.

When the ECM sees the right conditions, the ECM will test the O2 sensors for performance by measuring the signal response as the fuel injected into the cylinder is varied. The faster the O2 sensor responds, the better the sensor. Mode 5 will report the results of this monitor test.

The repair confirmation drive pattern in the Repair Manual provides the driving conditions for the ECM to operate the O2 sensor monitor.

P0125 for O2 Sensor

DTC P0125 is stored when there is little or no signal response from the O2 sensor. Although the description in the Repair Manual states "insufficient coolant temp for closed loop fuel control" for this code, this can be one cause for no signal output from the O2 sensor. The sensor is monitored for a rise in voltage to (0.45V) when:

- Engine speed is 1,500 rpm or more
- Vehicle speed is 25 – 62 mph (40 – 100 km/hr)
- TPS does not register idle
- The condition continues for at least 90 sec.
- 140 seconds or more must have passed since the engine was started

This DTC is a one trip code, and will also set as a result of a problem due to any of the following items:

- Air induction system
- EGR system
- Fuel pressure
- Fuel injection
- Gas leakage on exhaust system
- Other related parts failure

NOTE This DTC will set when a sensor output has very little or no activity.

HINT A lean condition or an inoperative sensor will have very little activity.

If the vehicle runs out of fuel, the A/F Ratio is lean and DTC P0125 may be recorded. This DTC will also set if no signal is received by the ECM; for example, an open circuit (broken wire).

P0130, P0150: O2 Sensor Output Voltage

This portion of the monitor is concerned with sensor voltage output. These DTC(s) set if the output voltage stays high or low during the test period.

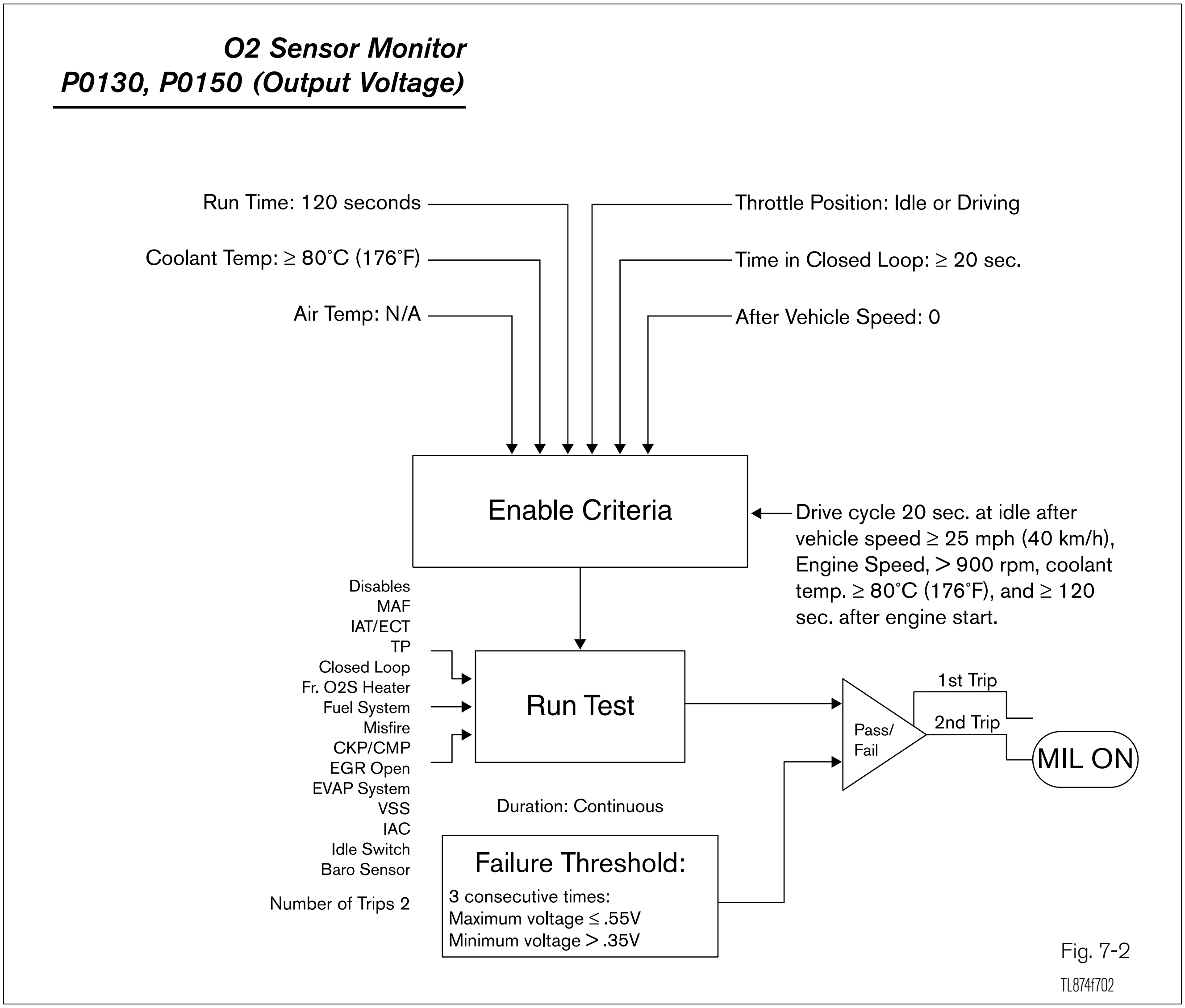


Fig. 7-2

P0133, P0153: O2 Sensor Response Rate

The ECM monitors the response of the O2 sensor.

This part of the monitor is concerned with the time the O2 sensor takes to switch from .35V and .55V.

NOTE

The failure threshold for switching can be as much as 1.1 seconds (max).

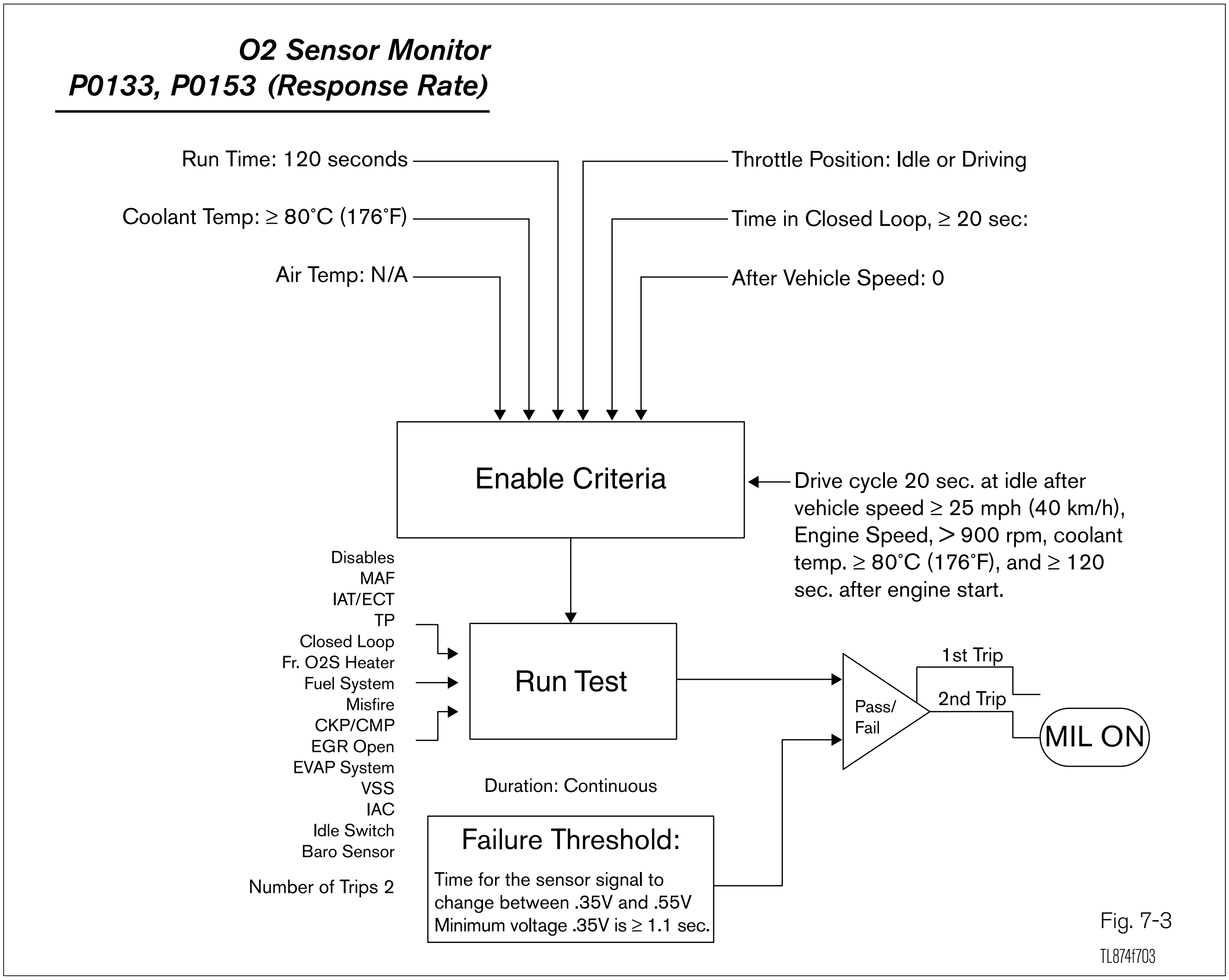


Fig. 7-3

O2 Sensor Detection Driving Pattern

The detection driving pattern shown will provide the conditions necessary for the O2 Sensor to show a response. If the sensor output remains within the failure threshold a DTC will set when all test parameters are met.

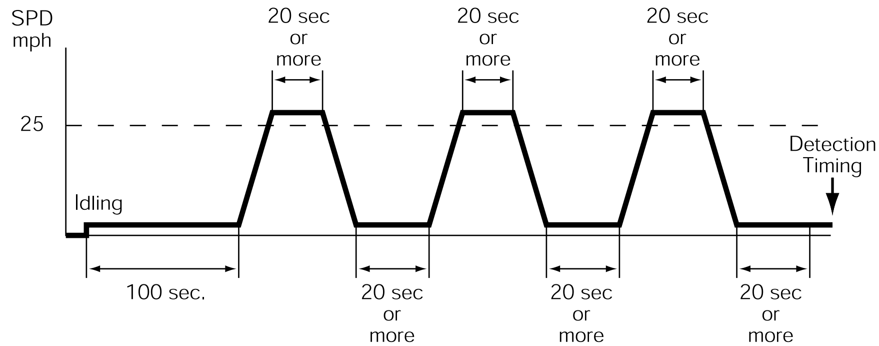


Fig. 7-4

TL874f704

Mode 5 O2 Sensor Monitoring Test Results

This mode displays the test results of the O2 sensor test monitor. These values are stored values, not current values that are found in Mode 1 (DATA LIST). Not all test values are applicable to all manufacturers. The A/F sensor test values are not applicable and are not displayed in Mode 5. Some vehicles use Non-Continuous Test Results mode to report results.

The following is a definition for the displayed terms under Mode 5, O2S Test Results:

- **R>>L O2S V** Rich to lean threshold voltage – voltage used by the ECM to determine the boundary line when going from rich to lean
  L>>R O2S V Lean to rich threshold voltage – voltage used by the ECM to determine the boundary line when going from lean to rich

- **LOW SW V** Low sensor voltage point for switch time calculation – value used by the ECM for switch time calculation
  HIGH SW V High sensor voltage point for switch time calculation – value used by the ECM for switch time calculation

- **R>>L SW TIM** Rich to lean switch time – time in seconds it takes to switch from Rich to Lean based on high to low switch voltages
  L>>R SW TIM Lean to rich switch time – time in seconds it takes to switch from Rich to Lean based on low to high switch voltages

- **MIN O2S V** Minimum sensor voltage during the test cycle
  MAX O2S V Maximum sensor voltage during the test cycle

- **O2S TRANS T** Time between sensor transitions – time between the rich to lean and lean to rich threshold voltages

- **TID $30** – The amount of time, used as a reference for the number (counts) each time the O2 sensor signal crosses the low and high sensor voltage points
  TID $70 – The number of counts, determined by the number of times the signal crossed the low and high sensor voltage points

This screens data can be used as a report on the condition of the O2 sensor. A malfunctioning sensor will switch slowly or not at all. Please keep in mind that other factors can affect O2 sensor performance.

O2 Sensor Monitoring Screens - Mode 5

These screens are found under the CARB section, O2S Test results.

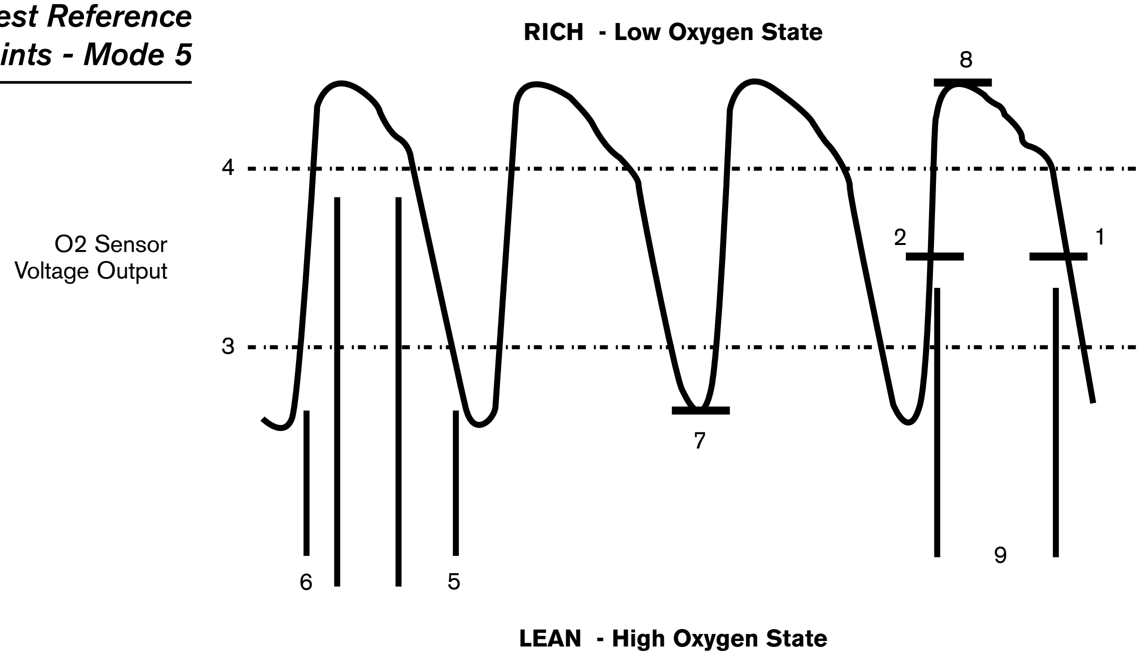
```
O2 SENSOR TEST (B1 - S1)

LOW SW V............ 0.350V
HIGH SW V........... 0.550V
MIN O2S V........... 0.025V
MAX O2S V........... 0.790V
Time $31............. 0.04s
Time $32............. 0.04s
```

```
O2 SENSOR TEST (B2 - S2)

MIN O2S V........... 0.085V
MAX O2S V........... 0.785V
```

Fig. 7-5

TL874f705

O2 Sensor Test Reference Points - Mode 5



1) R>>L O2S V Rich to lean threshold voltage

2) L>>R O2S V Lean to rich threshold voltage

3) LOW SW V Low sensor voltage for switch time calculation

4) HIGH SW V High sensor voltage for switch time calculation

5) R>>L SW TIM Rich to lean switch time

6) L>>R SW TIM Lean to rich switch time

7) MIN O2S V Minimum sensor voltage during the test cycle

8) MAX O2S V Maximum sensor voltage during the test cycle

9) O2S TRANS T Time between sensor transitions

Fig. 7-6

TL874f706

O2 Sensor Counts

The ECM provides the number of counts in a given time period. A count is when the voltage signal first crosses the high or low sensor voltage point.

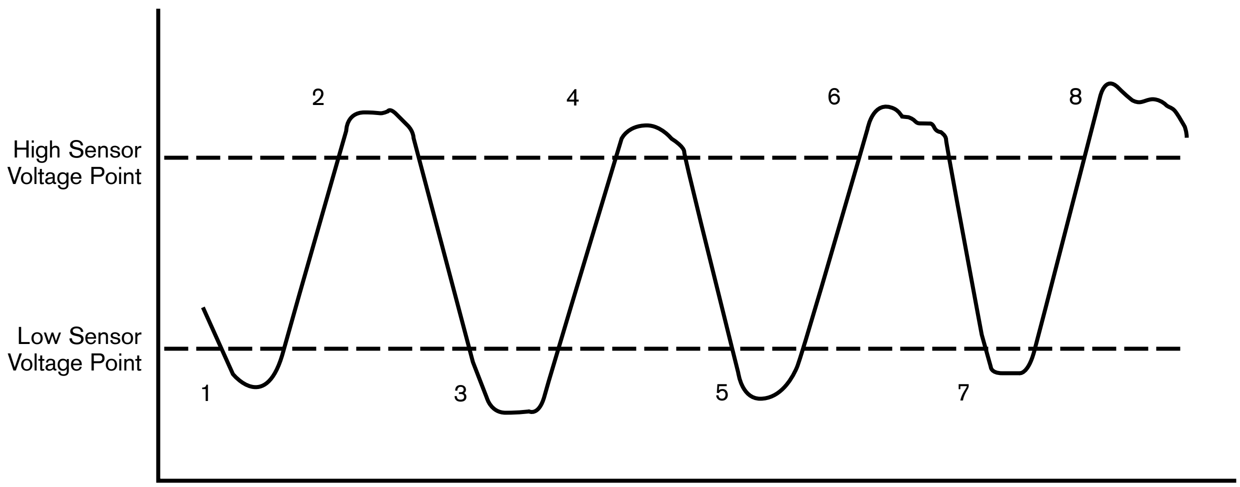


Fig. 7-7

TL874f707

Poor O2 Sensor Response

Poor O2 Sensor response as seen on an oscilloscope.

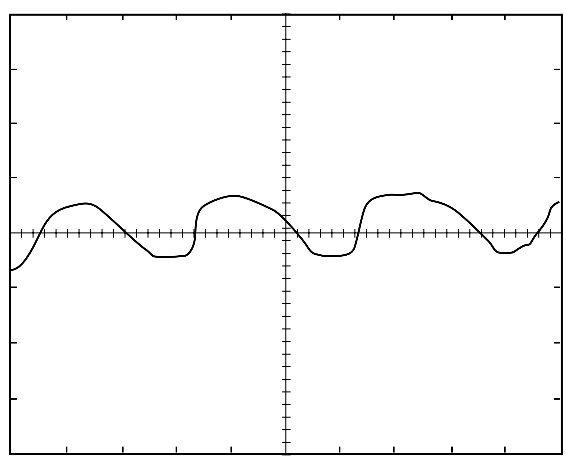


Fig. 7-8

TL874f708

P0136, P0156: Sub O2 Sensor Output Voltage The ECM monitors the output voltage of the O2 sensor. A DTC will set if output voltage remains high or low during the test period. See Mode 5, O2S Test Results.

Sub O2 Sensor Test Results

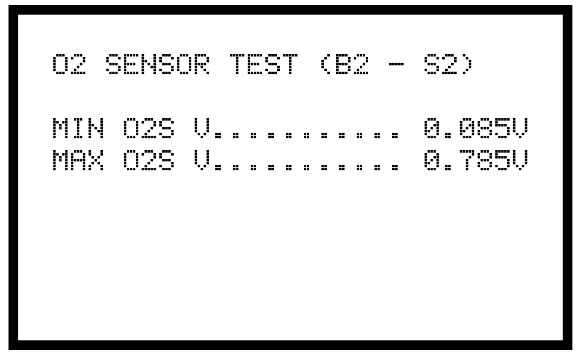


Fig. 7-9

TL874f709

Sub O2 Sensor Monitor P0136, P0156

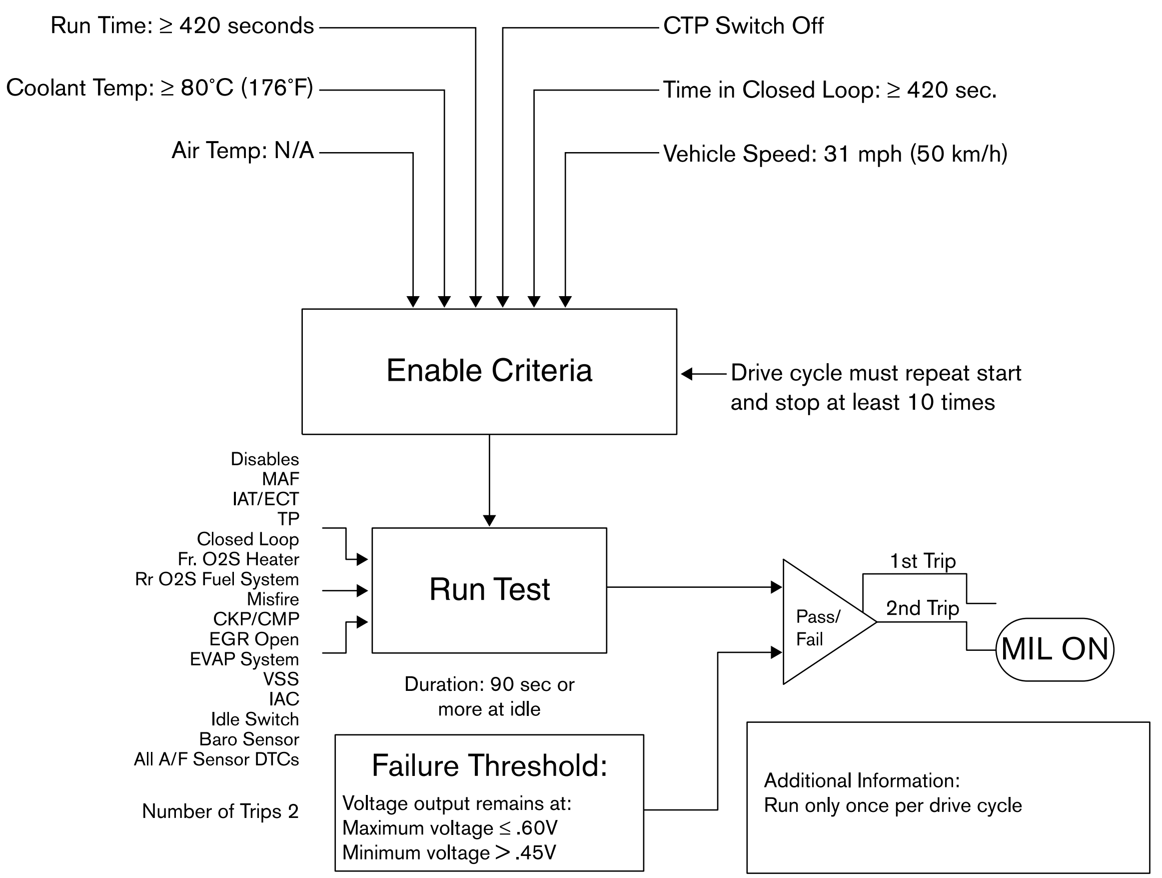


Fig. 7-10

TL874f403710

Sub O2 Sensor Detection Driving Pattern

The detection driving pattern shown will provide the conditions necessary for the Sub or rear O2 Sensor to show a response. If the sensor output remains within the failure threshold a DTC will set when all test parameters are met.

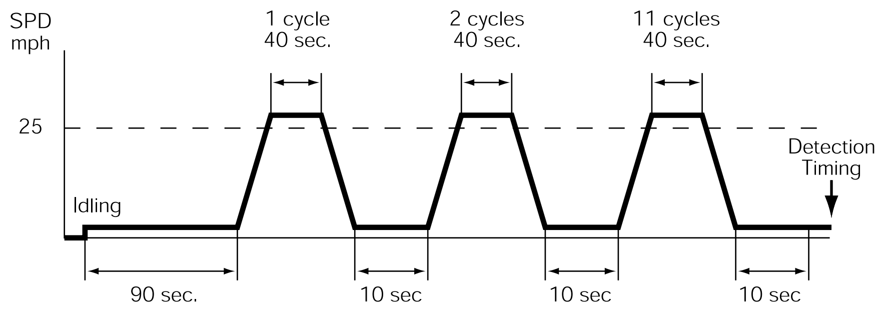


Fig. 7-11
TL874f711

P0135, P0141, P0155, P0161: O2 Sensor Heater Monitor

All heated O2 sensors are monitored for abnormal heater condition. The ECM checks the amount of current required for the sensor heater. If the current is too high or too low a DTC will be set.

O2 Sensor Heater Monitor P0135, P0141, P0155 (Circuit Current)

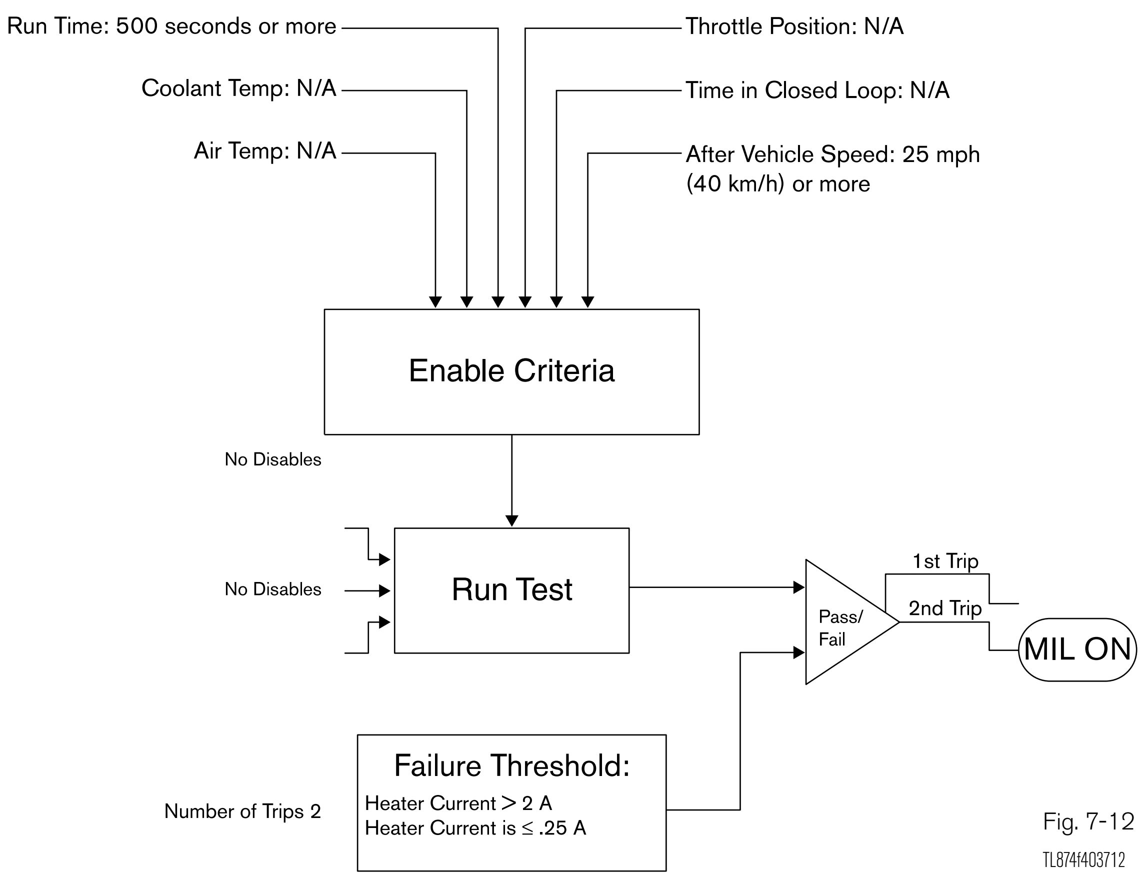


Fig. 7-12
TL874f403712

O2 Sensor DTC(s)

P0125: Coolant Temperature Insufficient for Closed Loop Operation (Bank 1 or 2 Sensor 1)

After the engine is warmed up, heated O2 sensor output does not indicate RICH even when conditions (a), (b), (c) and (d) continue for at least 1.5 min.:

a. Engine speed: 1,500 rpm or more

b. Vehicle speed: 25 - 62 mph (40 - 100 km/h)

c. Throttle valve does not fully close

d. 140 sec. or more after starting engine

This DTC can be set due to other related parts failure.

P0130: Heated O2 Sensor Circuit Malfunction (Bank 1 Sensor 1)

Voltage output of heated O2 sensor remains at 0.40V or more, or 0.55V or less, during idling after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0133: Heated O2 Sensor Circuit Slow Response (Bank 1 Sensor 1)

Response time for the heated O2 sensor's voltage output to change from rich to lean, or from lean to rich, is 1.1 sec. or more during idling after the engine is warmed up.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0135: Heated O2 Sensor Heater Circuit Malfunction (Bank 1 Sensor 1)

Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0136: Heated O2 Sensor Circuit Malfunction (Bank 1 Sensor 2)

Voltage output of the heated O2 sensor (bank 1 sensor 2, bank 2 sensor 2) remains at 0.4V or more or 0.5V or less when the vehicle is driven at 19 mph (30 km/h) or more after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0141: Heated O2 Sensor Heater Circuit Malfunction (Bank 1 Sensor 2)

Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0150: Heated O2 Sensor Circuit Malfunction (Bank 2 Sensor 1)

Voltage output of heated O2 sensor remains at 0.40V or more, or 0.55V or less, during idling after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0153: Heated O2 Sensor Circuit Slow Response (Bank 2 Sensor 1)

Response time for the heated O2 sensor's voltage output to change from rich to lean, or from lean to rich, is 1.1 sec. or more during idling after the engine is warmed up.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0155: Heated O2 Sensor Heater Circuit Malfunction (Bank 2 Sensor 1)

Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0156: Heated O2 Sensor Circuit Malfunction (Bank 2 Sensor 2)

Voltage output of the heated O2 sensor (bank 1 sensor 2, bank 2 sensor 2) remains at 0.4V or more or 0.5V or less when the vehicle is driven at 19 mph (30 km/h) or more after the engine is warmed up.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P0141: Heated O2 Sensor Heater Circuit Malfunction (Bank 2 Sensor 2)

Heater current exceeds 2A or heater current of 0.2A or less when the heater operates.

(two trip detection logic)

This DTC can be set due to other related parts failure.

O2 Sensor Monitor Diagnosis

When an O2 sensor DTC is found, it is important to look at each DTC description carefully before proceeding with diagnosis. In addition to P0125, each main O2 sensor has three DTC(s), one for a sensor circuit malfunction, one for slow response, and one for the sensor's heater circuit malfunction.

The sub O2 sensors have two DTC(s), one for a sensor circuit malfunction and one for the sub-sensor's heater circuit malfunction. The sub-sensor does not have a DTC for slow response because a sub-sensor shows very little activity during normal operation. Each DTC requires a different approach to diagnosis. Refer to the Repair Manual for the proper diagnostic procedure to follow for each DTC.

The CARB section of the diagnostic tester and the Readiness Test Confirmation procedure can be very useful for O2 sensor diagnosis, particularly Modes 5, 6, and 7. The following screen flows are guides. Varying conditions will have an effect on the outcome.

O2 Sensor Case

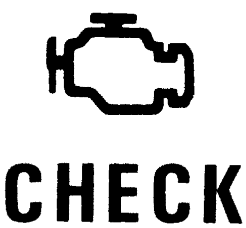
The screens shown here demonstrate the importance of checking the CARB screens.

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$04 CID$01........ Fail
Time$04 CID$02........ Pass
```

Driving the vehicle after the DTCs were cleared, TIME$04 showed FAIL, O2 Sensor Heater.

```
CONTINUOUS TESTS
ECU:  $10 (Engine)
Number of Tests: 1

P0135
O2 Sensor Heater Circuit
Malfunction (Bank 1,
Sensor 1)
```

Pending Codes or Mode 7 reported DTC P0135.




```
ECU:  $10 (Engine)
Number of DTCs: 1
MIL ON

P0125
Insufficient Coolant
Temperature for Closed
Loop Fuel Control
```

Further driving on the same trip produced DTC P0125, and the MIL turned on.

```
FREEZE FRAME   0

TROUBLE CODE......... P0125
ENGINE SPD......... 2415RPM
COOLANT TEMP......... 185°F
VEHICLE SPD.......... 55MPH
CALC LOAD............ 40.3%
FUEL SYS #1............. OL
FUEL SYS #2......... UNUSED
SHORT FT #1........... 0.0%
LONG FT #1............ 2.3%
```

The Freeze Frame recorded P0125.

Mode 6 and 7 displayed the reason for P0125, an O2 Sensor Heater not functioning.

Fig. 7-13

TL874f713

A/F Sensor Monitor

The A/F sensor monitor is similar to the O2 sensor monitor; however, the A/F sensor has different characteristics. Therefore, the operating parameters of the monitor also differ.

The A/F sensor monitor checks for sensor circuit malfunction, slow response rate, and for a malfunction of the sensor's heater circuit. There is a DTC for each condition for each sensor. A/F sensors are required to be monitored once per trip; however, the ECM does continuously monitor A/F sensor operation.

When the ECM sees the right conditions, the ECM will test the A/F sensors for performance by measuring the signal response as the fuel injected into the cylinder is varied. The faster the A/F sensor responds, the better the sensor. The results of this monitor test are NOT reported in Mode 5. Mode 6, Non-Continuous Test Results is used to determine if the A/F sensor passed or failed.

The repair confirmation drive pattern in the Repair Manual provides the driving conditions for the ECM to operate the A/F sensor monitor.

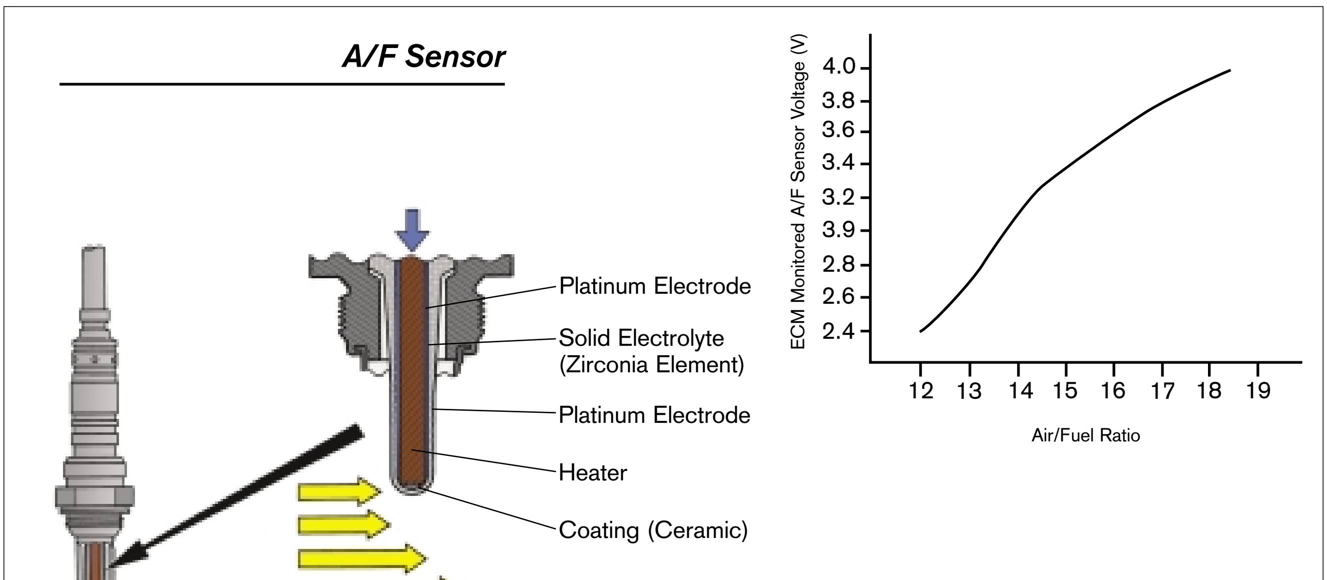


Fig. 7-14

TL874f714

A/F Sensor

The A/F sensor is similar to the O2 sensor. It appears similar to the O2 sensor, but it is constructed differently and has different operating characteristics.

The A/F sensor is also referred to as a wide range or wide ratio sensor because of its ability to detect A/F Ratios over a wide range.

The advantage of using the A/F sensor is that the ECM can more accurately meter the fuel reducing emissions.

To accomplish this, the A/F sensor:

- operates at approximately 650°C (1200°F), much hotter than the O2 sensors which operate at 400°C (750°F)
- changes its current (amperage) output in relation to the amount of oxygen in the exhaust stream

A/F Sensor Detecting Circuit

The detection circuit, located inside the ECM, is needed for the A/F Sensor to operate. The A/F Sensor output cannot be detected externally. A Diagnostic Tester is needed to read A/F Sensor signal output.

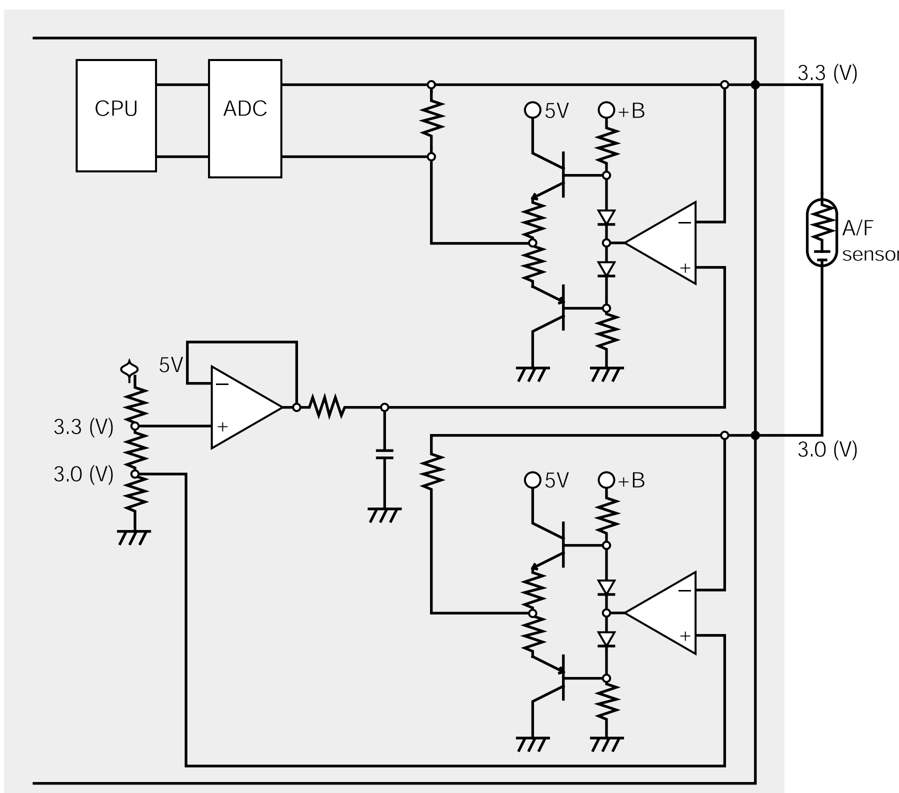


Fig. 7-15

TL874f715

Operation

A detection circuit in the ECM detects the change and strength of current flow and puts out a voltage signal relatively proportional to exhaust oxygen content.

NOTE

This voltage signal can only be measured by using the Diagnostic Tester or OBD II compatible scan tool. The A/F sensor current output cannot be accurately measured directly. If a Diagnostic Tester or OBD II compatible scan tool is used refer to the Repair Manual for conversion, for the output signal is different.

The A/F sensor is designed so that at stoichiometry, there is no current flow and the voltage put out by the detection circuit is 3.3 volts. A rich mixture, which leaves very little oxygen in the exhaust stream, produces a negative current flow. The detection circuit will produce a voltage below 3.3 volts. A lean mixture, which has more oxygen in the exhaust stream, produces a positive current flow. The detection circuit will now produce a voltage signal above 3.3 volts.

Exhaust Oxygen Content	Current Flow	Voltage Signal	Air/Fuel Mixture Judged to be:
Low oxygen content ⇨	– direction ⇨	Below 3.3 volts ⇨	Rich
Stoichiometry ⇨	0 ⇨	3.3 volts ⇨	14.7:1
High oxygen content ⇨	+ direction ⇨	Above 3.3 volts ⇨	Lean

NOTE

The A/F sensor voltage output is the opposite of what happens in the narrow range O2 sensor. Voltage output through the detection circuit increases as the mixture gets leaner.

A/F Sensor Signal Pattern

The A/F sensor responds to changes in exhaust oxygen. Note that the signal changes with engine RPM and does not move in cycles like the O2 densor.

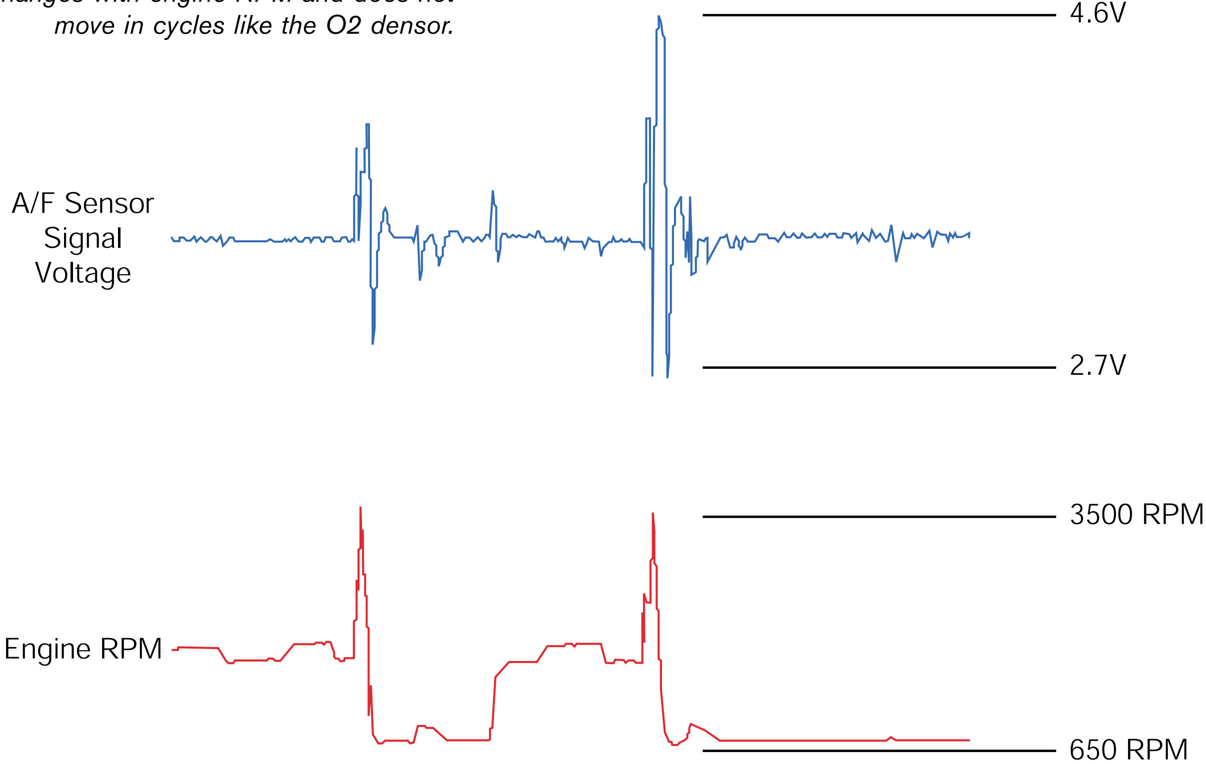


Fig. 7-16

TL874f716

The A/F sensor voltage signal is proportional to the change in the air/fuel mixture. This allows the ECM to more accurately judge the exact A/F Ratio under a wide variety of conditions and quickly adjust the amount of fuel to the stoichiometric point. This type of rapid correction is not possible with the narrow range O2 sensor. With an A/F sensor, the ECM does not follow a rich lean cycle.

P0125 for A/F Sensor

DTC P0125 is related to voltage output, although the description states insufficient coolant temp for closed loop fuel control. The A/F sensor is monitored for activity (voltage change) when:

- Engine speed is 1,500 rpm or more
- Vehicle speed is 25 – 62 mph (40 – 100 kph)
- TPS does not register idle
- The condition continues for at least 90 seconds.
- 140 seconds or more must have passed since the engine was started

This DTC will set when a sensor output has very little or no activity.

HINT A lean condition or an inoperative sensor will have very little activity.

This DTC is a one trip code, and will also set as a result of a problem due to any of the following items:

- Air induction system
- EGR system
- Fuel pressure
- Fuel injection
- Gas leakage on exhaust system
- Other related parts failure

P1130, P1150: A/F Sensor Output Voltage

This monitor is concerned with A/F sensor voltage output. These DTC(s) are found if the output voltage remains fixed for a predetermined period.

NOTE Voltage output changes take place inside the ECM. The Diagnostic Tester must be used for diagnosis.

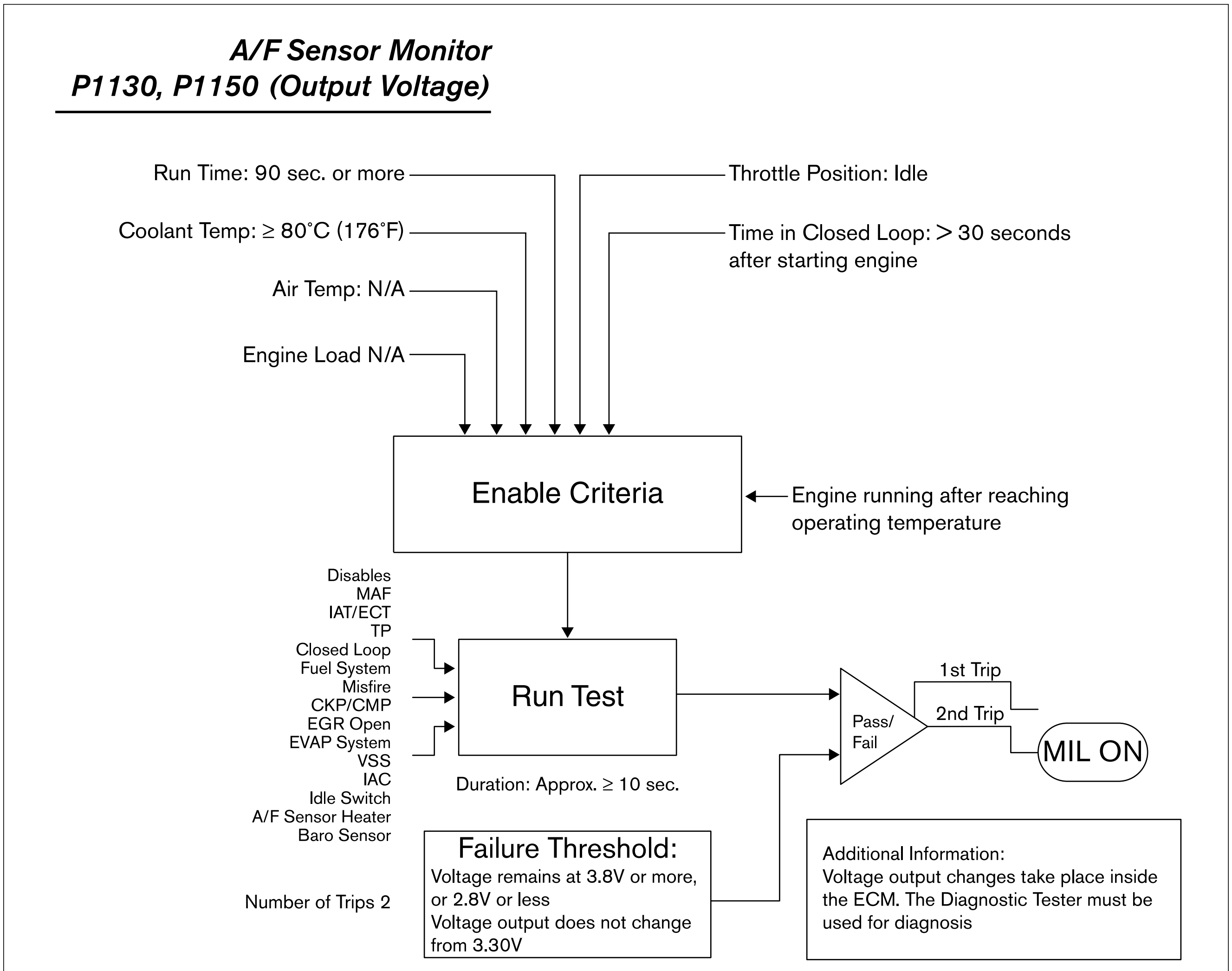


Fig. 7-17

HINT If output voltage of A/F sensor remains at 3.30V, the sensor circuit may be open. If output voltage of the A/F sensor remains 3.8V or more or 2.8V or less, the sensor circuit may be shorted.

P1133, P1153: A/F Sensor Response Rate

The ECM monitors the A/F sensors response characteristics. If the sensor response rate deteriorates, a fault will be recorded. The response rate cannot be confirmed by tests performed at the sensor. The response rate calculation is a function of the ECM only. The ECM compares the A/F sensor's response to the specifications stored in the ECM's programming.

HINT

In addition to Repair Manual procedures, the sensor's operation can be verified using the injector volume active test. This test is done while monitoring the A/F sensors output with the Diagnostic Tester.

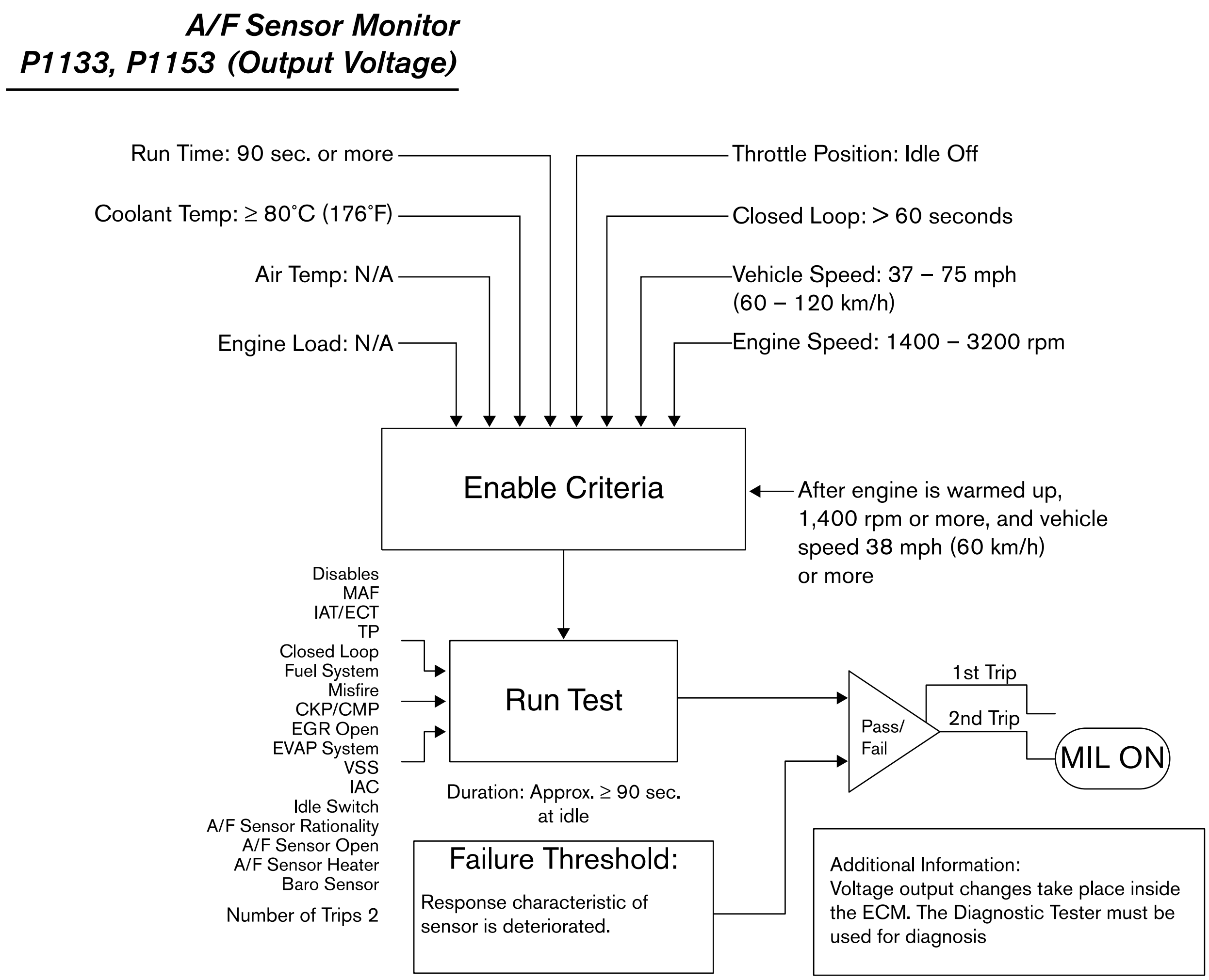


Fig. 7-18

TL874f718

A/F Sensor Detection Driving Pattern

The detection driving pattern shown will provide the conditions necessary for the A/F Sensor to show a response (voltage change). If the sensor output remains within the failure threshold, a DTC will set when all test parameters are met.

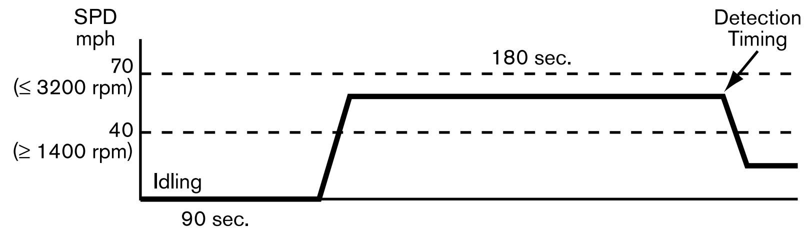


Fig. 7-19

TL874f719

P1135, P1155: A/F Sensor Heater Monitor

All A/F sensors are monitored for abnormal heater condition. The ECM checks the amount of current required for the sensor heater. If the current is too high or too low, a DTC will be set. If the current level detected is too high, the ECM will shut off the heater. When this happens, a P0125 can set.

The ECM provides a pulse width modulated control circuit to adjust current through the heater. On engines with two A/F sensors, the A/F sensor Heater circuit uses a relay on the B+ side of the circuit. In early models, heater DTCs are two trip detection. Beginning with 2001 models, a phased change to one trip DTC detection began.

A/F Sensor Heater Monitoring P1135, P1155 (Circuit Current)

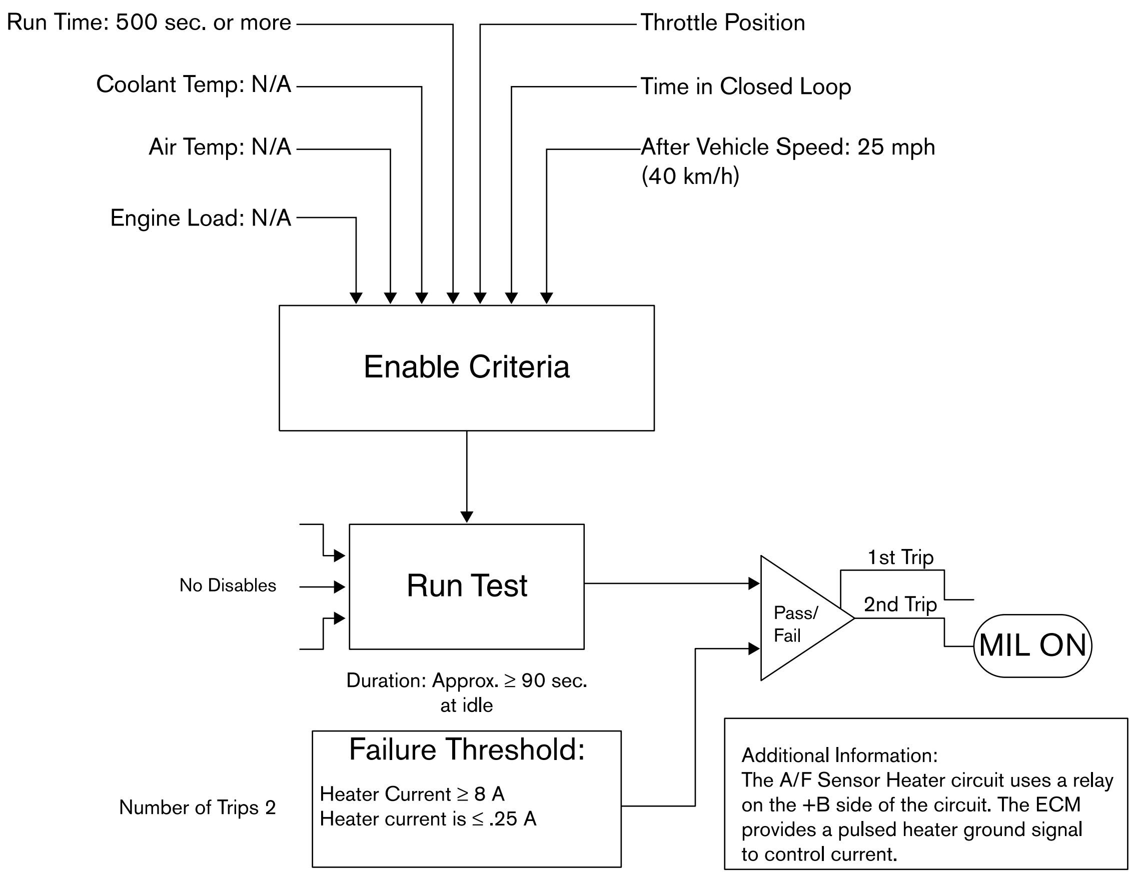


Fig. 7-20

TL874f720

A/F Sensor DTC(s)

P0125: Coolant Temperature Insufficient for Closed Loop Operation (Bank 1 or 2 Sensor 1)

After the engine is warmed up, A/F sensor Output* does not change when conditions (a), (b), (c), and (d) continue for at least 1.5 min.:

a. Engine speed: 1,500 rpm or more

b. Vehicle speed: 25 – 62 mph (40 –100 km/h)

c. Throttle valve is not fully closed

d. 140 seconds or more after starting engine

This DTC can be set due to other related parts failure.

P1130: Circuit Range/ Performance Malfunction (Bank 1 Sensor 1)

DTC P1130 will set from one of the following conditions:

- Voltage output of A/F sensor remains at 3.8V or more, or 2.8V or less, with engine running after the engine is warmed up
- Voltage output of A/F sensor does not change from 3.30V, with engine running after the engine is warmed up
- Open or short in A/F sensor circuit

(two trip detection logic)

This DTC can be set due to other related parts failure.

P1133: Circuit Response Malfuntion (Bank 1 Sensor 1)

After the engine reaches operating temperature, engine speed is 1,400 rpm or more, vehicle speed 38 mph (60 km/h) or more, and if the A/F sensor signal response is weaker than normal, DTC P1133 sets.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P1135: Heater Circuit Malfunction (Bank 1 Sensor 1)

When the heater operates, heater current exceeds 8A or heater current is 0.25A or less. Please confirm heater resistance specification in the vehicle Repair Manual.

(two trip detection logic, early models; phased change to one trip detection beginning 2001 model.)

This DTC can be set due to other related parts failure.

P1150: Circuit Range/ Performance Malfunction (Bank 2 Sensor 1)

DTC P1150 will set from one of the following conditions:

- Voltage output of A/F sensor remains at 3.8V or more, or 2.8V or less, during engine running after the engine is warmed up
- Voltage output of A/F sensor does not change from 3.30V, during engine running after the engine is warmed up
- Open or short in A/F sensor circuit

(two trip detection logic)

This DTC can be set due to other related parts failure.

P1153: Circuit Response Malfunction (Bank 2 Sensor 1)

After the engine reaches operating temperature, engine speed is 1,400 rpm or more, vehicle speed 38 mph (60 km/h) or more, and if the A/F sensor signal response is weaker than normal, DTC P1133 sets.

(two trip detection logic)

This DTC can be set due to other related parts failure.

P1155: Heater Circuit Malfunction (Bank 2 Sensor 1)

When the heater operates, heater current exceeds 8A or heater current is 0.25A or less. Please confirm heater resistance specification in vehicle Repair Manual.

(two trip detection logic, early models; phased change to one trip detection beginning 2001 model.)

This DTC can be set due to other related parts failure.

NOTE

When an A/F sensor DTC is found, it is important to look at each DTC description carefully before proceeding with diagnosis. In addition to P0125, the A/F sensors each have three DTC(s), one for a sensor range/performance malfunction, one for response malfunction, and one for the sensor’s heater circuit malfunction. Each DTC requires a different approach to diagnosis. Refer to the Repair Manual for the proper diagnostic procedure to follow for each DTC.

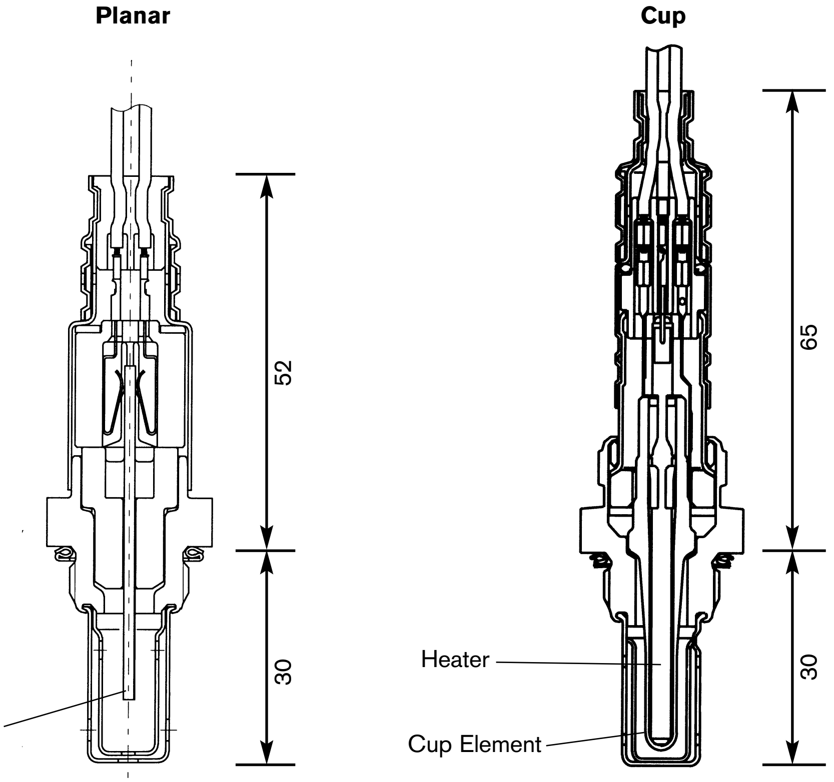


Fig. 7-21

Planar A/F Sensor

The newer planar A/F sensor can be identified by its shorter body.

The planar has the heater integrated into the sensing element. This sensor has the same detecting range as the previous, cup type A/F sensor.

Planar A/F Sensor Operation

A second generation A/F sensor (referred to here as the planar A/F sensor) was developed to meet more stringent emission regulations. This A/F sensor reaches operating temperature faster than the previous (referred to here as the cup element) A/F sensor. This allows the ECM to go into closed loop fuel control faster when the engine is cold reducing cold start emissions.

The planar A/F sensor has the same detecting range and signal characteristics as the previous cup element A/F sensor. The major differences are:

- goes into closed loop fuel control faster.
- heater element has a higher resistance.
- heater DTCs set in one trip.

NOTE This A/F sensor is not interchangeable with the older, cup element A/F sensor.

Planar Element

Like previous O2 and A/F sensors, the planar A/F sensor has ambient air on one side of the ZrO2 and exhaust gases on the other side.

The aluminum oxide layer conducts heat directly to the ZrO2 element providing a rapid warm up.

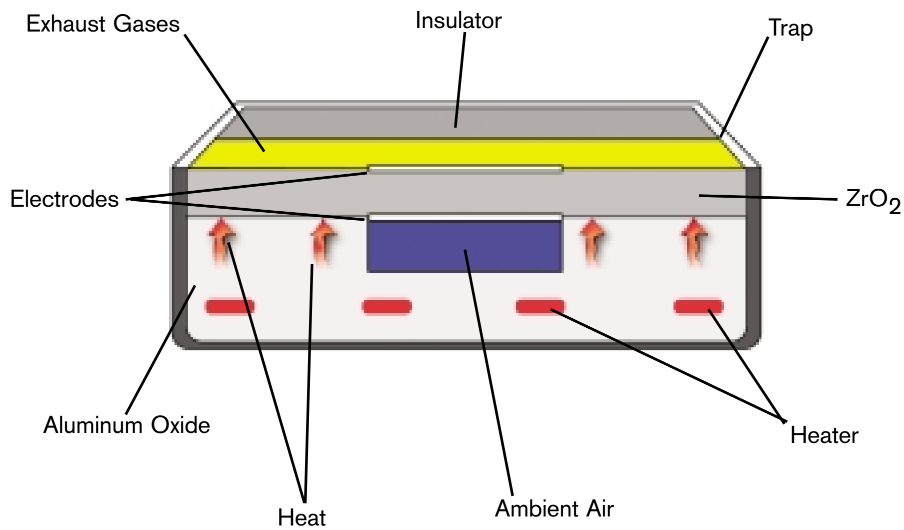


Fig. 7-22

TL874f722

The heater is imbedded into the aluminum oxide. When the heater is on, the aluminum oxide conducts heat directly to the zirconium dioxide layer bring the A/F sensor to operating temperature quickly.

Aluminum oxide is also an excellent electrical insulator. This prevents any voltage from the heater affecting signal output. Cracks or element contamination can alter signal output.

Signal Characteristics

The generated voltage output signal is identical to the previous A/F sensor. A high exhaust gas oxygen content (lean) produces a higher voltage signal. Stoichiometry is at 3.30 volts.

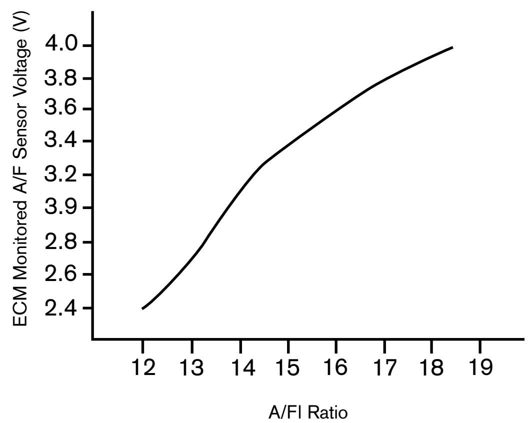


Fig. 7-23

TL874f723

Planar A/F Sensor Signal Detection DTCs

The detection logic for the planar A/F sensor is the same as the cup element A/F sensor EXCEPT for heater related DTCS. Please see the information on A/F sensor signal output DTCs P0125, P1130, P1133, P1150, and P1153 in this section.

Planar A/F Sensor Heater Detection DTCs

The heater circuit and operation is similar to the cup element, though amperage specifications are different. The heater monitor continuously detects over current or under current conditions and will set DTC in one trip. Therefore, heater related DTCs (such as P1135, P1155) will be set on the first trip when a malfunction is detected.

The heater resistance for the planar AF sensor is slightly higher than the cup element A/F sensor. Heater resistance is checked with a DVOM.

HEATER TEMPERATURE	PLANAR A/F SENSOR	CUP ELEMENT A/F SENSOR	O2 SENSOR
20°C (68°F)	1.8 - 3.4Ω	0.8 - 1.4Ω	11 - 16Ω

A characteristic of this AF sensor is that when it fails it can drive the A/F signal output high or low causing a rich or lean condition.

A/F Sensor Diagnosis Case Using CARB

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$05 CID$02........ Pass
Time$06 CID$01........ Pass
Time$06 CID$10........ Pass
Time$07 CID$01........ Pass
Time$07 CID$10........ Fail
```

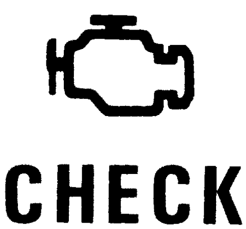
Driving the vehicle after the DTCs were cleared, TIME$07 showed FAIL, A/F Sensor Heater.

⇩

```
CONTINUOUS TESTS
ECU:  $10 (Engine)
Number of Tests: 1

P1150
Manufacturer Controlled
Fuel and Air Metering
```

Pending codes or Mode 7 reported DTC P1150

⇩




```
ECU:  $10 (Engine)
Number of DTCs: 1
MIL ON

P0125
Insufficient Coolant
Temperature for Closed
Loop Fuel Control
```

Further driving on the same trip produced DTC P0125, and the MIL turned on.

⇩

```
FREEZE FRAME   0

TROUBLE CODE......... P0125
ENGINE SPD......... 1833RPM
COOLANT TEMP......... 187°F
VEHICLE SPD.......... 37MPH
CALC LOAD............ 49.8%
FUEL SYS #1........ OLDRIVE
FUEL SYS #2........ OLDRIVE
SHORT FT #1........... 0.0%
LONG FT #1........... -1.5%
SHORT FT #2.......... -0.0%
LONG FT #2............ 3.9%
```

The Freeze Frame recorded P0125.

Conclusion: Mode 6 and 7 displayed the reason for P0125, an A/F Sensor Heater not functioning.

Fig. 7-24

TL874f724

Notes

WORKSHEET 7-1
A/F Sensor Tests

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet, you will use the Diagnostic Tester to test A/F sensor performance and compare to specifications to determine condition.

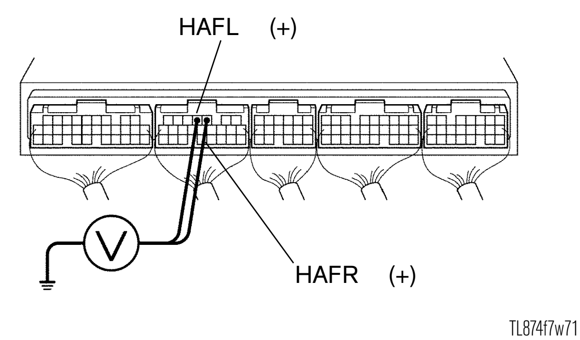
Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

Section 1: A/F Sensor

1. With the key on and engine off, measure voltage between ECM terminals HAFR and HAFL and body ground.

A/F Sensor Circuit Test



2. Use the EWD to trace the A/F Sensor Heater circuit.

   This test confirms the operation of which components and continuity of which circuits?

   ____

   ____

3. Using the repair manual(s), compare the resistance of an O2 sensor heater to the A/F sensor heater.

4. What is the major difference between the two sensors?

   ____

Section 2: A/F Sensor Response

Connect the Diagnostic Tester. With the engine at operating temperature, go to DATA LIST, USER DATA and select one of the A/F sensors, SHORT TERM FUEL TRIM, and select ENTER. Select F4. With a set of jumper leads, connect a Fluke 87 (or comparable) DVOM in series with the A/F signal wire. Make sure, the + lead is in the milliamp socket.

1. Record A/F sensor engine idling. Briefly, snap the throttle wide open and release. What happened?

   ____

2. Disconnect a vacuum hose. Was there a change to A/F voltage signal and Short Term Fuel Trim?

   ____

3. Reconnect vacuum hose.

4. **Predict** what **will** happen to A/F signal voltage and amperage if more fuel is added?

   ____

5. Go to INJECTOR VOLUME ACTIVE TEST. Increase injector duration. What happened to A/F sensor voltage and amperage signal?

   ____

6. Decrease injector duration. What happened to A/F sensor signal voltage amperage?

   ____

Test or confirm repair method using CARB OBD II Readiness Tests.

1. Access READINESS TEST Mode under CARB OBD II. What does it report?

   ____

Case 1

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. Answer the following questions using the listed screen prints.

READINESS TEST	
MISFIRE MON..........	AVAIL
FUEL SYS MON.........	AVAIL
COMP MON.............	AVAIL
CAT EVAL.............	COMPL
HTD CAT EVAL...........	N/A
EVAP EVAL...........	INCMPL
2nd AIR EVAL...........	N/A
A/C EVAL...............	N/A
O2S EVAL............	INCMPL
O2S HTR EVAL........	INCMPL
EGR EVAL.............	COMPL

NON-CONTINUOUS TESTS	
Time$01 CID$01........	Pass
Time$02 CID$01........	Pass
Time$02 CID$02........	Pass
Time$02 CID$03........	Pass
Time$02 CID$04........	Pass
Time$04 CID$02........	Pass
Time$05 CID$01........	Pass
Time$05 CID$02........	Pass
Time$06 CID$01........	Pass
Time$06 CID$10........	Pass
Time$07 CID$01........	Pass
Time$07 CID$10........	Pass

TL874f7w71

2. Do the screens indicate a problem with the vehicle?

3. What area(s) is affected?

4. Will there be DTC(s) and Freeze Frame?

Case 2

An A/F sensor equipped vehicle was driven after DTCs were cleared. Answer the questions from the following screens.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............ INCMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL........ INCMPL
EGR EVAL............ INCMPL
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$05 CID$02........ Pass
Time$06 CID$01........ Pass
Time$06 CID$10........ Pass
Time$07 CID$01........ Pass
Time$07 CID$10........ Fail
```

TL874f7w71

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

Case 3

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. Answer the following questions using the listed screen prints.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............. COMPL
HTD CAT EVAL........... N/A
EVAP EVAL............ COMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL......... COMPL
EGR EVAL............... N/A
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$02........ Pass
Time$06 CID$01........ Fail
Time$06 CID$10........ Pass
Time$07 CID$01........ Pass
Time$07 CID$10........ Pass
Time$08 CID$01........ Pass
```

TL874f7w71

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

Case 4

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. The MIL illuminated. Answer the following questions using the listed screen prints.

```
FREEZE FRAME 0

TROUBLE CODE......... P0125
ENGINE SPD......... 1833RPM
COOLANT TEMP......... 187°F
VEHICLE SPD.......... 37MPH
CALC LOAD............ 49.8%
FUEL SYS #1........ OLDRIVE
FUEL SYS #2........ OLDRIVE
SHORT FT #1........... 0.0%
LONG FT #1........... -1.5%
SHORT FT #2........... 0.0%
LONG FT #2............ 3.9%
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$02........ Pass
Time$05 CID$01........ Pass
Time$05 CID$02........ Pass
Time$06 CID$01........ Pass
Time$06 CID$10........ Pass
Time$07 CID$01........ Pass
Time$07 CID$10........ Fail
```

TL874f7w71

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be more DTC(s) on the second trip if driven according to the drive pattern?

A/F Sensor Tests

Name: ____ Date: ____________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Check condition of heater circuit with DVOM			
Accurately measure & interpret; oxygen content of the exhaust gases based on sensor signal data			
Describe the primary difference between the O2 sensor and the A/F sensor			
Use Modes 6 and 7 to determine monitored A/F sensor results			
Measure A/F sensor signal with DVOM and determine engine operating conditions			

Notes

WORKSHEET 7-2
O2 Sensor Test

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet, you will use the Diagnostic Tester and to check and test O2 sensor monitor performance and determine needed action.

Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

Case 1

Answer the following from the screen shots. The O2 sensor equipped vehicle was driven after clearing DTCs.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............ INCMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL........ INCMPL
EGR EVAL............... N/A
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$01 CID$02........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$01........ Pass
Time$04 CID$02........ Pass
Time$04 CID$10........ Pass
Time$04 CID$20........ Pass
```

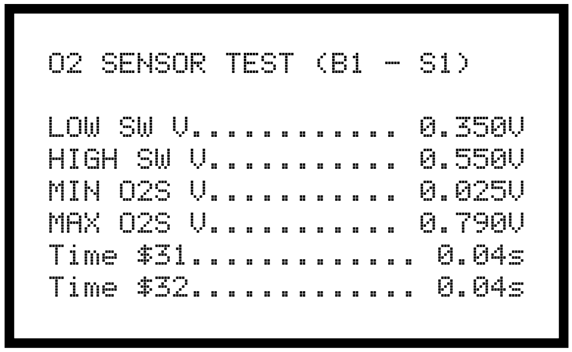
TL874f7w72

1. What is the status of the O2S monitor and O2S HTR heater monitor?

2. What does the Readiness Test indicate?

Case 2

Answer the following questions from the screen shot.



TL874f7w72

Low SW V	
High SW V	
Min O2S V	
Max O2S V	
Time $31	
Time $32	

1. What information is given in this mode?

2. What does Low/High SW mean and how is this information useful?

3. What does Min/Max O2S mean and how is this information useful?

4. What does Time $31/32 mean and how is this information useful?

5. Is the above O2 sensor good or bad?

Case 3

An O2 sensor equipped vehicle was driven after DTCs were cleared. Answer the questions from the following screens.

```
READINESS TEST

MISFIRE MON.......... AVAIL
FUEL SYS MON......... AVAIL
COMP MON............. AVAIL
CAT EVAL............ INCMPL
HTD CAT EVAL........... N/A
EVAP EVAL........... INCMPL
2nd AIR EVAL........... N/A
A/C EVAL............... N/A
O2S EVAL............ INCMPL
O2S HTR EVAL........ INCMPL
EGR EVAL............... N/A
```

```
NON-CONTINUOUS TESTS

Time$01 CID$01........ Pass
Time$01 CID$02........ Pass
Time$02 CID$01........ Pass
Time$02 CID$02........ Pass
Time$02 CID$03........ Pass
Time$02 CID$04........ Pass
Time$04 CID$01........ Fail
Time$04 CID$02........ Pass
Time$04 CID$10........ Pass
Time$04 CID$20........ Pass
```

```
O2 SENSOR TEST (B1 - S1)

LOW SW V........... 0.350V
HIGH SW V.......... 0.550V
MIN O2S V.......... 0.378V
MAX O2S V.......... 0.545V
Time $31............ 1.15s
Time $32............ 1.15s
```

TL874f7w72

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

Section 4: O2 Sensor Response

1. With the engine at operating temperature, go to Data List and note the O2 sensor voltage signal and Fuel Trim. Disconnect a vacuum hose. Was there a change to oxygen voltage signal and Short Term Fuel Trim?

2. Reconnect vacuum hose.

3. **Predict** what **will** happen to O2 sensor signal voltage if more fuel is added?

4. Go to Injector Volume Active test. Add fuel using the Active Test to increase injector duration. What happened to O2 sensor voltage signal?

5. Decrease injector duration. What happened to O2 sensor signal voltage?

O2 Sensor Tests

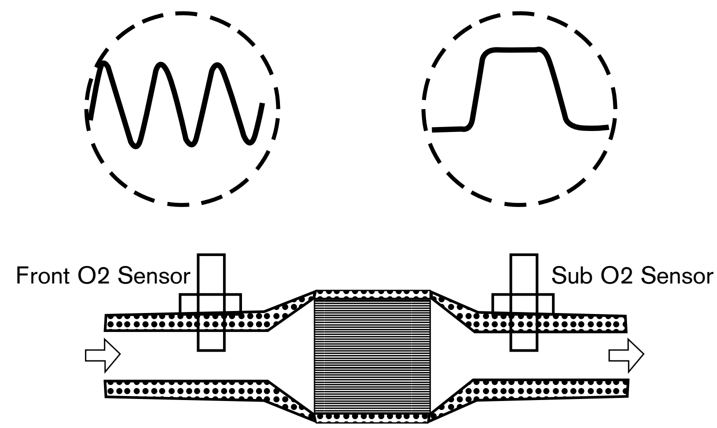
Name: ______________________________ Date: ______________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Check condition of heater circuit with DVOM			
Accurately measure & interpret; oxygen content of the exhaust gases based on sensor signal data			
Describe the primary difference between the O2 sensor and the A/F sensor			
Use Modes 6 and 7 to determine monitored O2 sensor results			

Section 8

Catalytic Converter Diagnosis



O2 Sensor waveform with ordinary catalyst

Learning Objectives:

1. Determine the condition of the catalytic converter based on data and engine symptoms, and determine appropriate repair.

Catalytic Converter Diagnosis

Catalytic Converter System

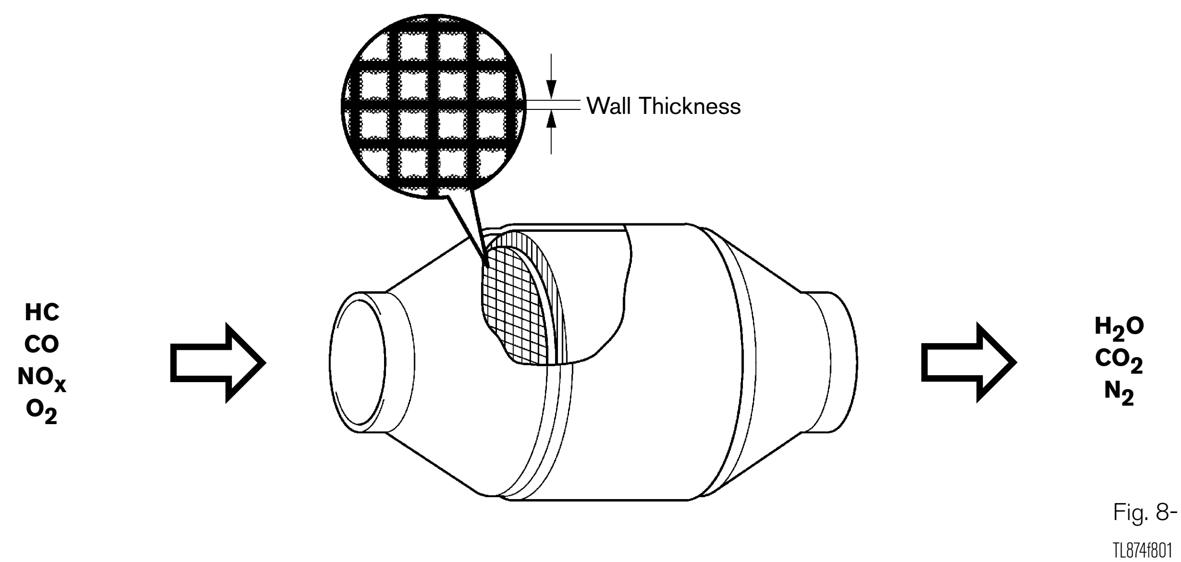


Fig. 8-1

Overview

Catalytic converter failures generally fall in the category of physical damage or catalyst failure. Physical damage usually can be visually identified-cracks, dents, etc. Internally, the structure can be cracked, broken, or melted. Where high heat may have lead to catalyst failure, the engine and related systems need to be thoroughly checked.

Catalyst performance before OBD II was determined differently in many states by test equipment. OBD II systems can determine catalyst performance. Performance deteriorates in many cases when the catalyst becomes coated with foreign materials. Contaminated fuel, sealants, or coolant can all affect catalyst performance.

The sub (S2) O2 sensor is used to adjust the oxygen level in the catalytic converter to achieve the best catalytic converter efficiency possible. As a catalytic converter deteriorates, its ability to store oxygen is also reduced. During conversion, the stored oxygen is rapidly depleted. The sub O2 sensor detects this and, within a very limited range, the ECM will reduce the amount of fuel injected providing more oxygen to converter. Oxygen levels build up, driving the O2 signal downward. At a predetermined point, fuel control will return to stoichiometric A/F Ratio. When this happens, oxygen again will be depleted driving the sub O2 signal upward, and the cycle will repeat itself. The rate at which this cycle repeats depends on how much of the catalyst has deteriorated, engine load, and the amount of correction as determined by the ECM's fuel control programming.

NOTE

- Fuel control by the sub O2 sensor is a very fine adjustment. Its affect on fuel trim and driveability is extremely limited.
- The cycling of the sub O2 sensor signal is NOT to produce an averaging of exhaust gases to achieve stoichiometry.
- The affect on the A/F sensor is practically impossible to see on the Diagnostic Tester because of the slow data rate, and the speed of fuel correction. The sub O2 response is slower because of the catalytic action and the fact it is an O2 sensor.
- The ECM on an A/F sensor equipped engine does try hold the A/F sensor signal at a constant level, but with these sensors there is hysteresis taking place. In other words there is some variation in the signal. This should not be confused with the cycling action found with fuel control programs used with O2 sensor equipped engines.
- The specification for the sub O2 sensor signal frequency to set a DTC is going to vary with the certification level of the vehicle- LEV, ULEV, SULEV.

It is important to determine why the catalytic converter failed before replacing it.

NOTE

Catalyst deterioration is determined by monitoring the amount of oxygen in the exhaust stream after the catalytic converter. The actual level of emission gases in the tailpipe is not monitored.

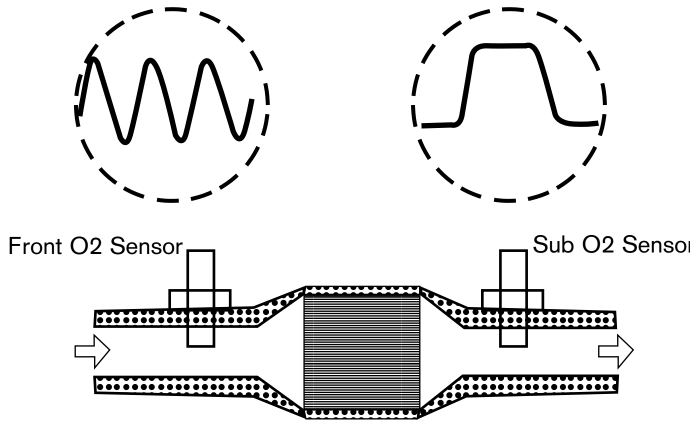
Catalytic Converter Monitor

The diagnostic system measures the oxygen storage capacity of the catalyst. This is based on the correlation between catalyst conversion efficiency and oxygen storage capacity. Catalyst efficiency is monitored by comparing the pre-catalyst O2 or A/F sensor output signal with the signal received from the post-catalyst O2 sensor. The ECM uses voltage variations between these sensors to measure the catalyst performance.

When the converter is operating properly, the post-catalyst sensor is significantly less active than the pre-catalyst sensor. This is because the converter stores and releases oxygen as needed during its reduction and oxidation processes, thus the post-catalyst sensor is exposed to exhaust gases with very little variation in oxygen levels.

O2 Waveform Normal Operation

Catalyst efficiency is monitored by comparing the pre-catalyst O2 or A/F sensor output signal with the signal received from the post-catalyst O2 sensor.



O2 Sensor waveform with ordinary catalyst

Fig. 8-2

TL874f802

Main O2 vs. Sub O2 Signal

The sub-sensor signal will make slow transitions in voltage, however, they occur over long periods of time (several seconds). The sub-sensor signal from a catalytic converter that is not functioning properly will have a pattern with a frequency and amplitude similar to the main O2 sensor.

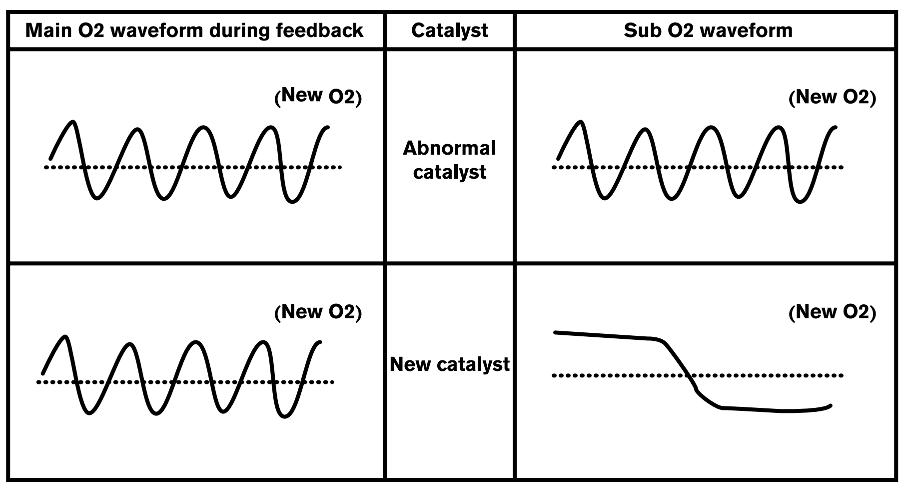


Fig. 8-3

TL874f803

A/F Sensor vs. Sub O2 Signal

Catalyst efficiency is monitored by comparing the pre-catalyst A/F sensor output signal with the signal received from the post-catalyst O2 sensor. The A/F sensor signal does not switch in the same manner as the O2 sensor, therefore the signal will reflect less activity. When the vehicle is accelerated under load with a bad catalytic converter, there will be excess oxygen passing through the converter lowering the sub O2 sensor signal.

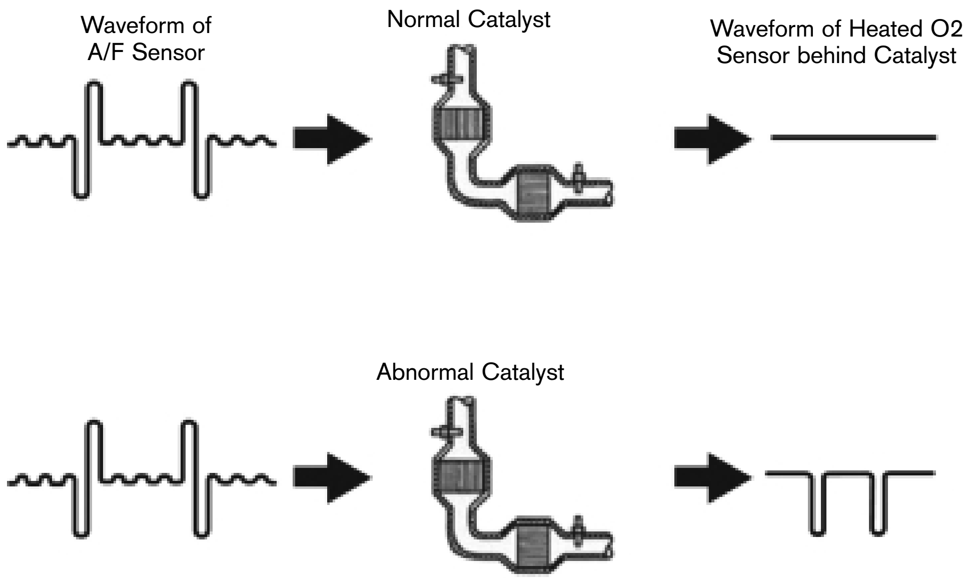
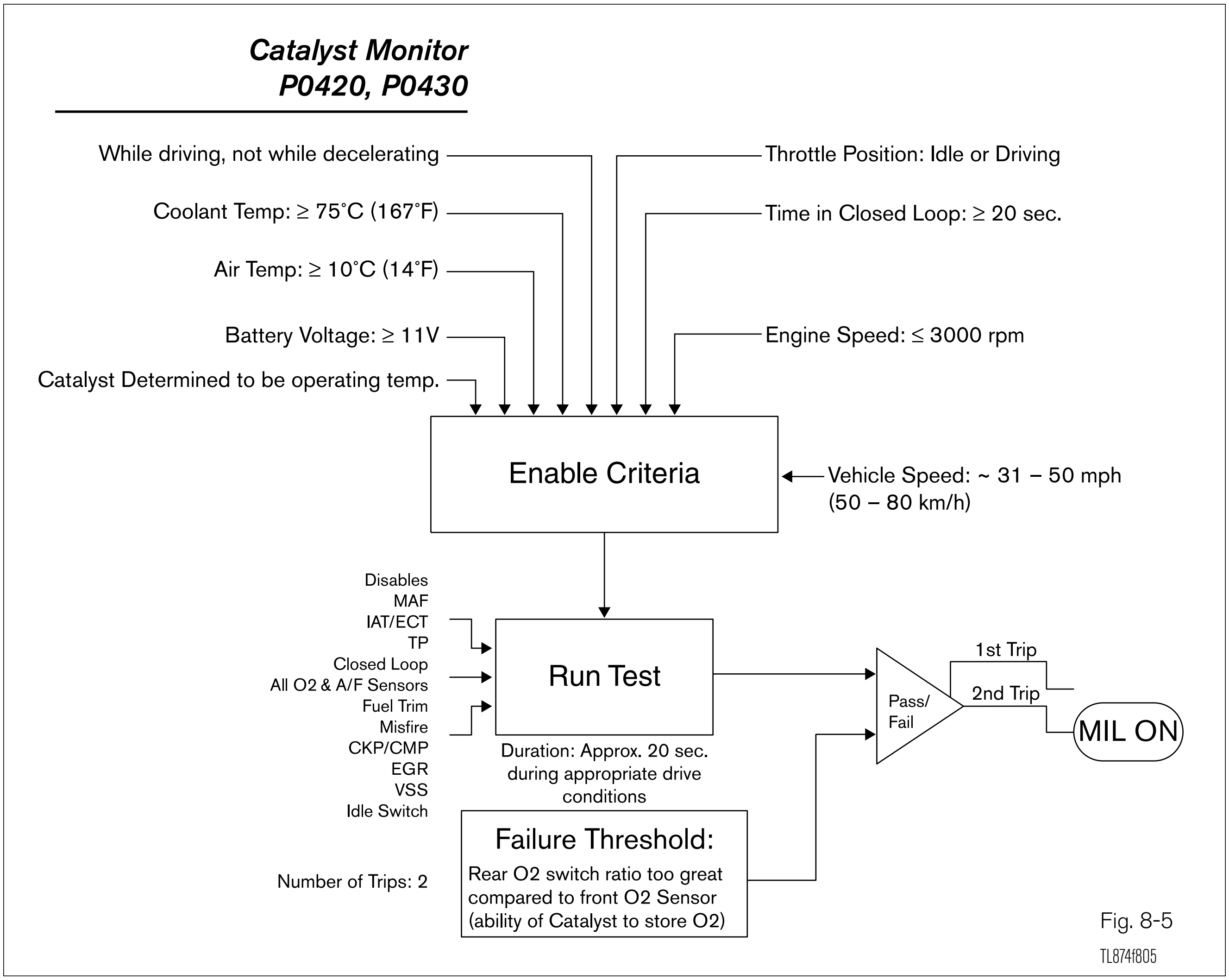


Fig. 8-4
TL874f804

NOTE After the engine and catalyst are warmed up and the conditions listed are met, the ECM will run the catalyst monitor. Catalyst warm-up is determined by a calculation in the ECM's internal programming. Engine load, engine coolant temperature, and time are the primary factors used to determine catalyst temperature.


Catalyst Monitor
P0420, P0430
While driving, not while decelerating
Coolant Temp: ≥ 75°C (167°F)
Air Temp: ≥ 10°C (14°F)
Battery Voltage: ≥ 11V
Catalyst Determined to be operating temp.
Throttle Position: Idle or Driving
Time in Closed Loop: ≥ 20 sec.
Engine Speed: ≤ 3000 rpm
Enable Criteria
Vehicle Speed: ~ 31 – 50 mph (50 – 80 km/h)
Disables
MAF
IAT/ECT
TP
Closed Loop
All O2 & A/F Sensors
Fuel Trim
Misfire
CKP/CMP
EGR
VSS
Idle Switch
Run Test
Duration: Approx. 20 sec. during appropriate drive conditions
Pass/ Fail
1st Trip
2nd Trip
MIL ON
Failure Threshold:
Rear O2 switch ratio too great compared to front O2 Sensor (ability of Catalyst to store O2)
Number of Trips: 2
TL874f805
Fig. 8-5

Confirmation Engine Racing Pattern

The Repair Manual provides special driving or engine racing patterns to confirm the operation of a sensor or system. The Repair Manual lists a pattern to be used for an O2 sensor equipped vehicle and another for an A/F sensor equipped vehicle. Use of these patterns may not complete a monitor. The monitor must complete to assure that no malfunctions are present.

Confirmation Engine Racing Pattern for O2 Sensor Equipped Vehicles

This pattern can be used to confirm catalyst operation, but does not complete the monitor. The monitor must complete to assure no malfunctions are present.

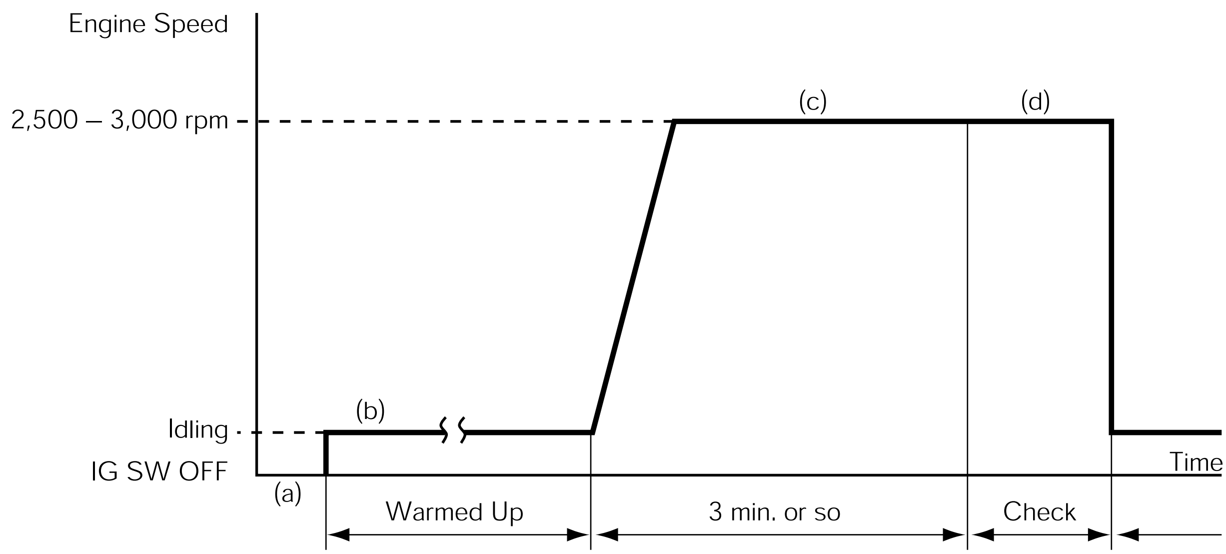


Fig. 8-6

TL874f806

Confirmation Engine Racing Pattern for A/F Sensor Equipped Vehicles

This pattern can be used to confirm catalyst operation, but does not complete the monitor. The monitor must complete to assure no malfunctions are present.

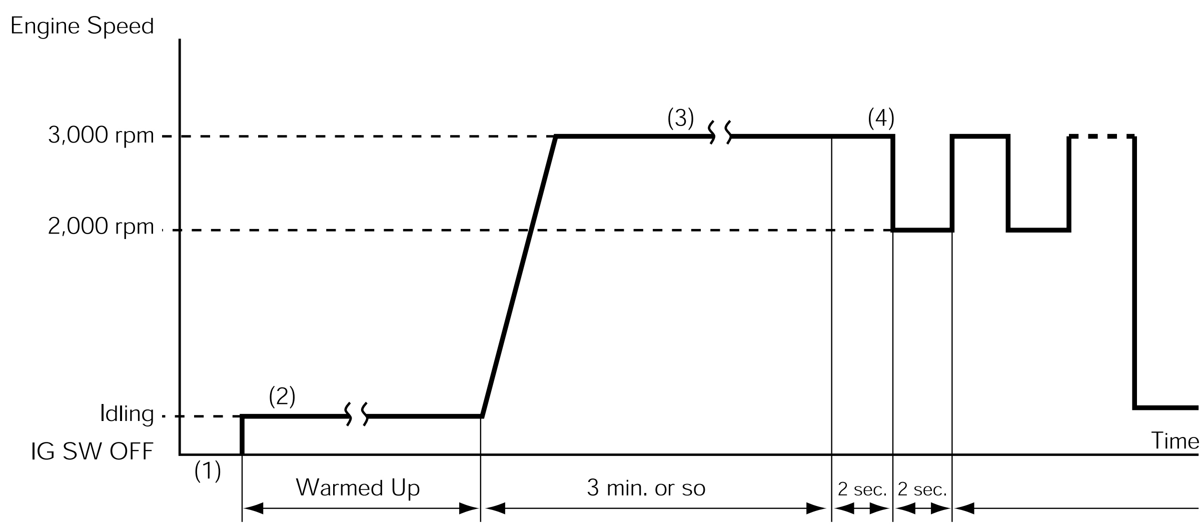


Fig. 8-7

TL874f807

Catalyst Efficiency DTC

P0420: Catalyst System Efficiency Below Threshold

After the engine and catalyst are warmed up, and while vehicle is being driven within set vehicle and engine speed range, the waveform of the heated O2 sensor (bank 1 sensor 2) alternates in a like frequency with the (bank 1 sensor 1).

Notes

WORKSHEET 8-1
Catalytic Converter Monitor

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

Determine the condition of the catalytic converter based on data and engine symptoms and determine appropriate repair.

Tools and Equipment

- Vehicle
- Vehicle Repair Manual, EWD, & NCF
- Diagnostic Tester
- Hand Tools, Fender Covers, Floor Mats, and Shop Towels

SECTION 1: Front O2/Sub O2 Equipped Vehicles

1. Connect Diagnostic Tester, go to DATA LIST and select O2 B1S1, O2 B2S1, O2 B1S2, O2 B2S2 sensors.

2. Start the engine, and with the engine warmed up and in closed loop observe O2 B1S1, O2 B2S1, O2 B1S2, O2 B2S2 sensors. Use the graphing function.

3. What is the frequency of the front O2 S1 sensor(s) compared with sub O2 S2 sensor(s)?

___

4. Momentarily perform a stall test. What happened to both sensors? Is it normal?

___

5. Would the sub O2 voltage signal go high or low with a misfiring cylinder?

___

6. Disconnect an injector. Note the result of the sub O2 sensor signal.

___

7. Would the sub O2 voltage signal go high or low with a rich mixture?

___

8. Go to INJECTOR VOL ACTIVE TEST and richen the mixture. Note the result of the sub O2 sensor signal.

____

9. Complete the sentence. DTC P0420 is set when the sub O2 sensor signal frequency

____

SECTION 2: Front AF Sensor(s)/Sub O2 Equipped Vehicles

Front O2/Sub O2 equipped vehicles

1. Connect Diagnostic Tester, go to DATA LIST, A/F B1S1, A/F B2S1, O2 B1S2, O2 B2S2 sensors.

2. Start the engine, and with the engine warmed up and in closed loop observe A/F B1S1, A/F B2S1, A/F B1S2 sensors

3. What is the frequency of the front A/F S1 sensor(s) compared with sub O2 S2 sensor(s).

____

4. Momentarily perform a stall test. What happened to both sensors? Is it normal?

____

5. Would the sub O2 voltage signal go high or low with a misfiring cylinder?

____

6. Disconnect an injector. Note the result of the sub O2 sensor signal.

____

7. Would the sub O2 voltage signal go high or low with a rich mixture?

____

8. Go to INJECTOR VOL ACTIVE TEST and richen the mixture. Note the result of the sub O2 sensor signal.

____

9. Complete the sentence: DTC P0420 is set when the sub O2 sensor signal

____

10. How will you know if the catalytic converter monitor passed or failed in one trip?

11. How many trips will it take for P0420 to set?

12. Will DTCs P0420 set a Freeze Frame?

Catalytic Converter Monitor

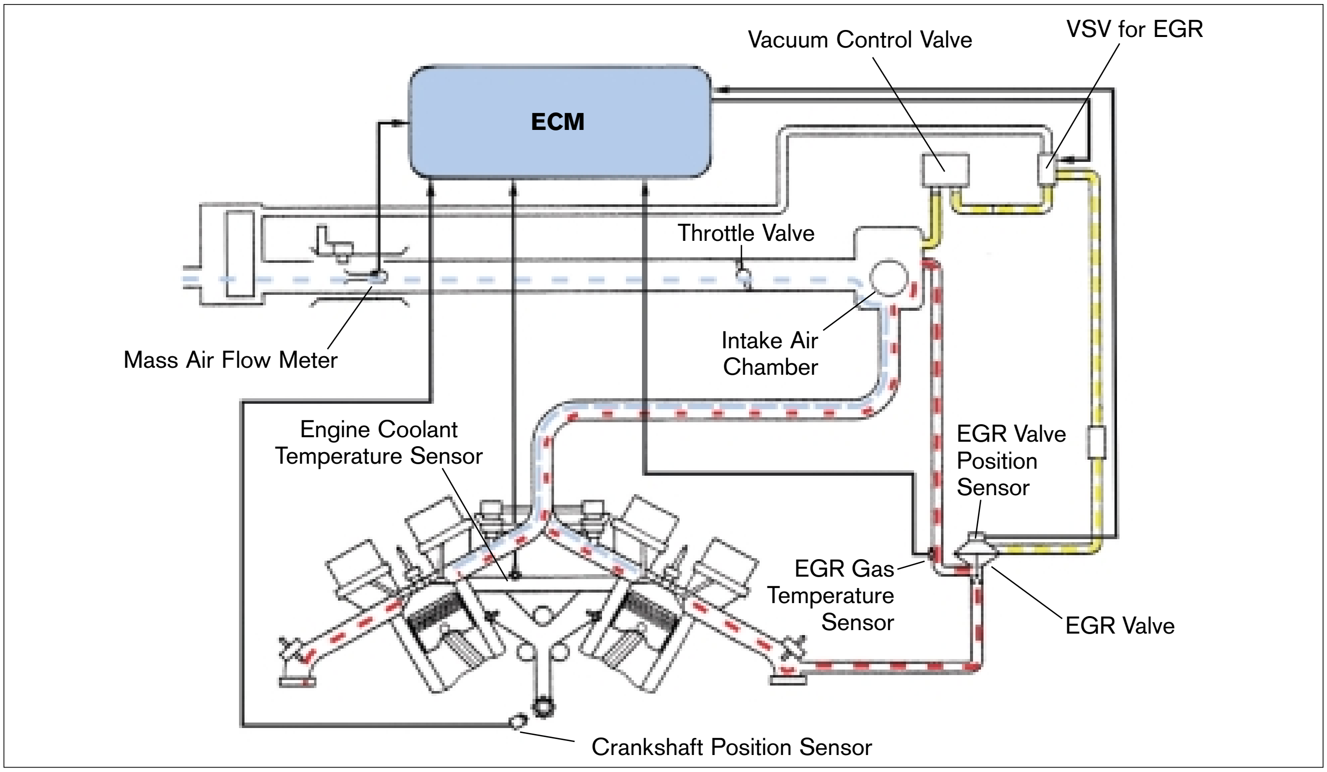
Name: ____ Date: ___________________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Determine the condition of the catalytic converter based on data and engine symptoms and determine appropriate repair			

Section 9

Exhaust Gas Recirculation (EGR) System Diagnosis



1. Determine the condition of the EGR system based on OBD II data and monitors and engine symptoms.
2. Describe the different types of EGR monitors.

Section 9
Exhaust Gas Recirculation (EGR) System Diagnosis

Basic EGR System

Exhaust gases are directed to the intake manifold to lower oxides of nitrogen emissions.

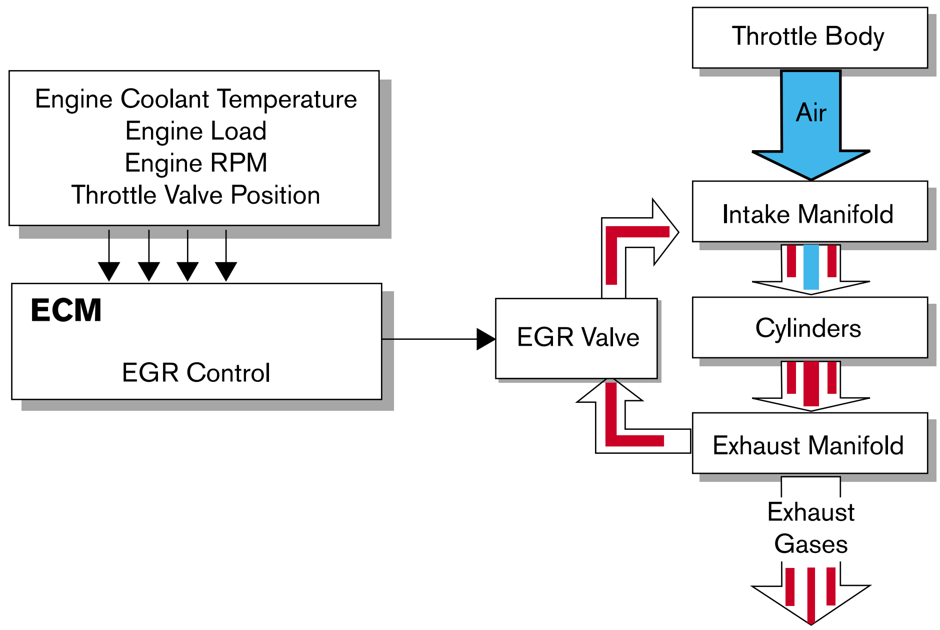


Fig. 9-1

TL874f901

Overview

Though the EGR system is used for knock control and to control oxides of nitrogen emissions, the EGR system is monitored because a failure in this system will affect hydrocarbon emissions.

Exhaust Gas Recirculation (EGR) System Monitors

The EGR monitor is designed to detect insufficient or excessive EGR flow and component performance. When the EGR valve is open, the ECM confirms that exhaust gas is flowing. When the EGR valve is shut off, the ECM confirms exhaust gas flow has stopped. The sensors are also monitored for open, shorts, and performance. There are three types of detection methods are:

- EGR temperature detection method
- EGR MAP detection method
- EGR valve position/temperature detection method

The method of detection can be determined by the type of sensors used.

EGR Monitor P0401, P0402

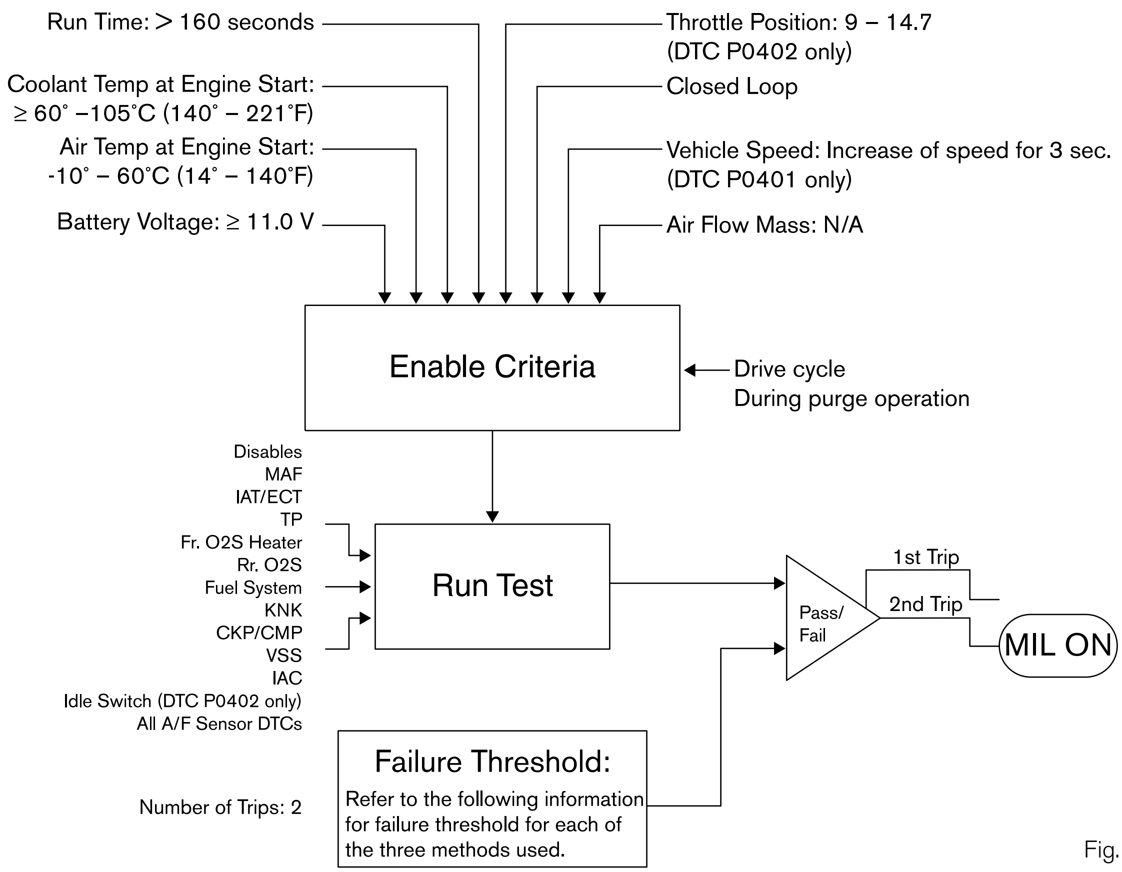


Fig. 9-2

TL874f902

Cutoff Control EGR System

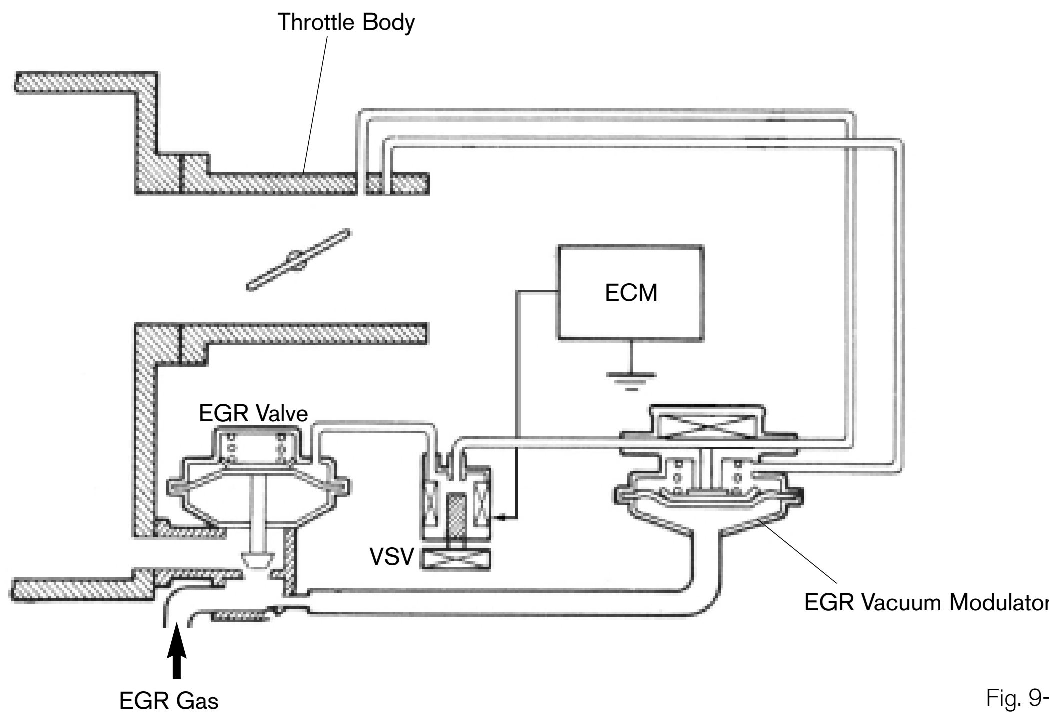


Fig. 9-3

T874f903

EGR Temperature Detection Method

This method is used on the VSV Cut-off Control EGR System. An EGR temperature sensor is installed in the EGR passageway. During normal EGR flow, the temperature of the EGR temperature sensor will rise at least 35°C (95°F) above ambient air temperature.

P0401: Insufficient Flow

When the EGR valve is open, the ECM compares EGR temperature to intake air temperature. If the temperature does not rise a specified amount over ambient temperature, the ECM assumes there is a problem in the system, and this information is stored in the ECM. If the problem occurs on the second trip, DTC P0401 will set and the MIL will turn on.

P0402: Excessive Flow

When the EGR is off, the ECM measures EGR temperature. If the EGR is open, the EGR temperature will be higher than expected. If the problem occurs on the second trip, DTC P0402 will set and the MIL will turn on.

EGR MAP Detection Method

This method is used on the VSV Cut-off Control EGR System on engines equipped with a MAP Sensor. The MAP sensor is used for EGR flow detection, therefore this system does not include an EGR temperature sensor. When the EGR valve is open intake manifold pressure rises (loss of vacuum). The MAP sensor detects this increase in manifold pressure.

P0401: Insufficient Flow

With the EGR on, if the MAP signal is not higher than the calculated value this condition would indicate a restriction in the EGR exhaust passage.

P0402: Excessive Flow

With EGR off, if the MAP signal is higher than the calculated value, this condition would indicate an open EGR valve. At idle, if MAP is higher than expected and there is a misfire, DTC P0402 will set on the second trip.

Constant Vacuum EGR

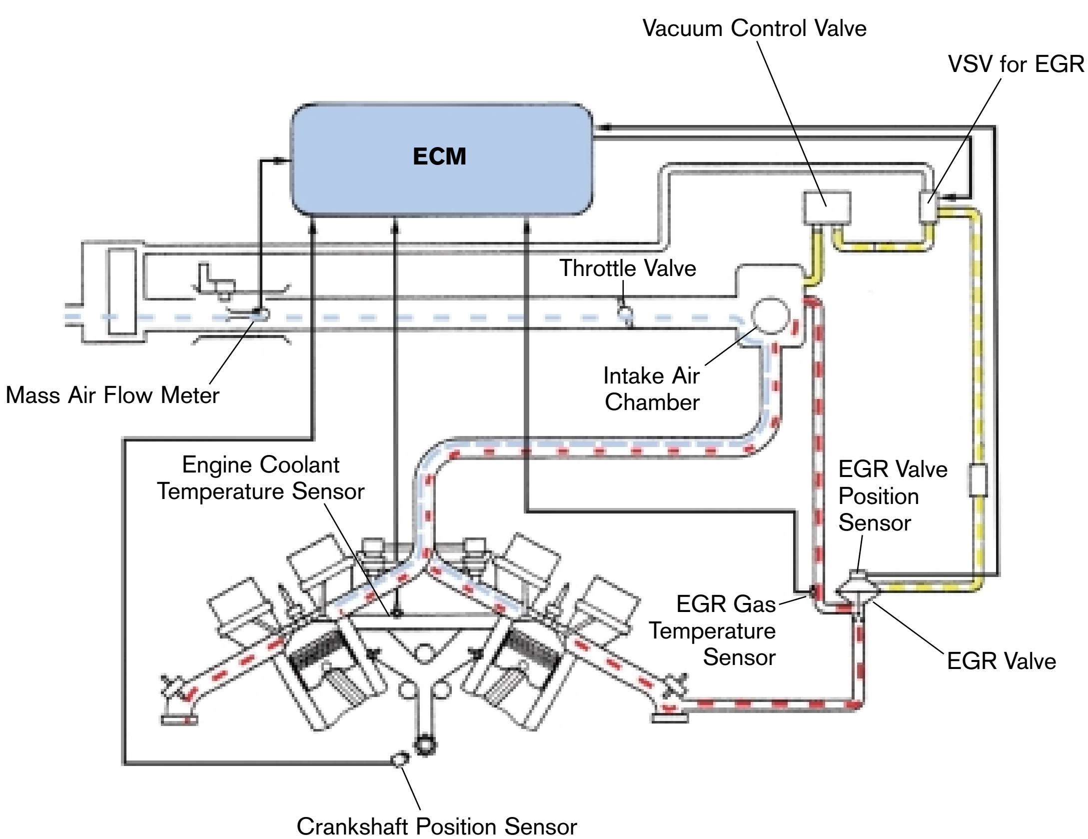


Fig. 9-4

T874f904

EGR Valve Position/ Temperature Detection Method

This method uses a temperature sensor for insufficient EGR flow and an EGR Valve Position sensor for excessive EGR flow on the Constant Vacuum EGR system.

P0401: Insufficient Flow

When the EGR valve is open, the ECM compares EGR temperature to intake air temperature. If the temperature does not rise a specified amount over ambient temperature, the ECM assumes there is a problem in the system, and this information is stored in the ECM. If the problem occurs on the second trip, DTC P0401 will set and the MIL will turn on.

P0402: Excessive Flow

The ECM uses the EGR valve height position sensor to detect excessive flow. When the EGR is off and the sensor signal is greater than the specification stored in the ECM, the ECM assumes the EGR valve did not close. If the problem occurs on the second trip, DTC P0402 will set and will turn the MIL on.

Notes

WORKSHEET 9-1
EGR Monitor

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

Investigate how the ECM monitors the EGR system based on OBD II data and monitors and engine symptoms. Determine when the EGR system is not working properly.

Tools and Equipment

- Repair Manual
- Vehicle EWD
- Diagnostic Tester
- DVOM
- Hand Tool Set with Vacuum Pump

SECTION 1 EGR Cut-off Control System/ EGR Temperature Detection System P0401/P0402

1. Disconnect EGR valve vacuum hose, and connect a handheld vacuum pump.

2. Connect Diagnostic Tester, go to the DATA LIST, EGR TEMPERATURE SENSOR.

   Record EGR Temperature signal: ______________________________

3. Start the engine, and bring the engine to operating temperature.

   Record EGR Temperature signal: ______________________________

4. Apply vacuum to the EGR valve so that the engine starts to misfire. Raise engine RPM to 1000 RPM.

   What is happening to the EGR temp?

   ____

5. After 3 minutes, disconnect vacuum pump.

   What is happening to the EGR temp?

   ____

6. How does ECM know the EGR valve failed to open?

____

7. How does ECM know the EGR valve failed to close?

____

SECTION 2 EGR Cut-off Control System/ MAP detection system P0401/P0402

1. Disconnect EGR valve vacuum hose, and connect a handheld vacuum pump.

2. Connect Diagnostic Tester, go to DATA LIST, MAP SENSOR.

   Record MAP sensor signal: ____

3. Start the engine, and bring the engine to operating temperature.

4. Apply vacuum to the EGR valve so that the engine starts to misfire.

   What happened to the MAP sensor signal?

   ____

   Did intake manifold pressure increase or decrease?

   ____

6. Remove vacuum from the EGR valve.

   What happened to the MAP sensor signal?

   ____

   Did intake manifold pressure increase or decrease?

   ____

7. How does ECM know the EGR valve failed to open?

____

8. How does ECM know the EGR valve failed to close?

____

SECTION 3: Constant Vacuum EGR Detection System P0401/P0402

1. Disconnect EGR valve vacuum hose, and connect a handheld vacuum pump.

2. Connect Diagnostic Tester, go to dATA LIST, EGR POSITION SENSOR and EGR TEMPERATURE SENSOR.

   Record EGR Position Sensor and EGR Temperature Sensor signal: ______________________________

3. Apply vacuum according to the chart below and record EGR Position Sensor at each point.

0 in. Hg	1.0 in. Hg	1.5 in. Hg	2.0 in. Hg

   What happened to the EGR Position Sensor signal?

   ____

4. Remove vacuum.

5. Start the engine and bring it to operating temperature.

   Record EGR Position Sensor signal: ______________________________

6. Apply vacuum to the EGR valve so that the engine starts to misfire.

   Record EGR Position Sensor and EGR Temperature Sensor signal: ______________________________

7. Remove vacuum from the EGR valve. Did the EGR Position Sensor return to its original position?

   ____

8. What sensor does this system use to detect if the EGR valve opened?

   ____

9. How does ECM know the EGR valve failed to open?

   ____

10. What sensor does this system use to detect if the EGR valve closed?

   ____

11. How does ECM know the EGR valve failed to close?

   ____

SECTION 4

1. List three items that could prevent the EGR flow in a Cut-Off Control System.

2. List three items that could cause excessive EGR flow in a Cut-off Control System

3. List three items that could prevent the EGR valve in a Constant Control Vacuum System from opening.

4. List three items that could prevent the EGR valve in a Constant Control Vacuum System from closing.

5. How will you know if the EGR monitor passed or failed in one trip?

6. How many trips will it take for P0401/P0402 DTCs to set?

7. Will DTCs P0401/P0402 set a Freeze Frame?

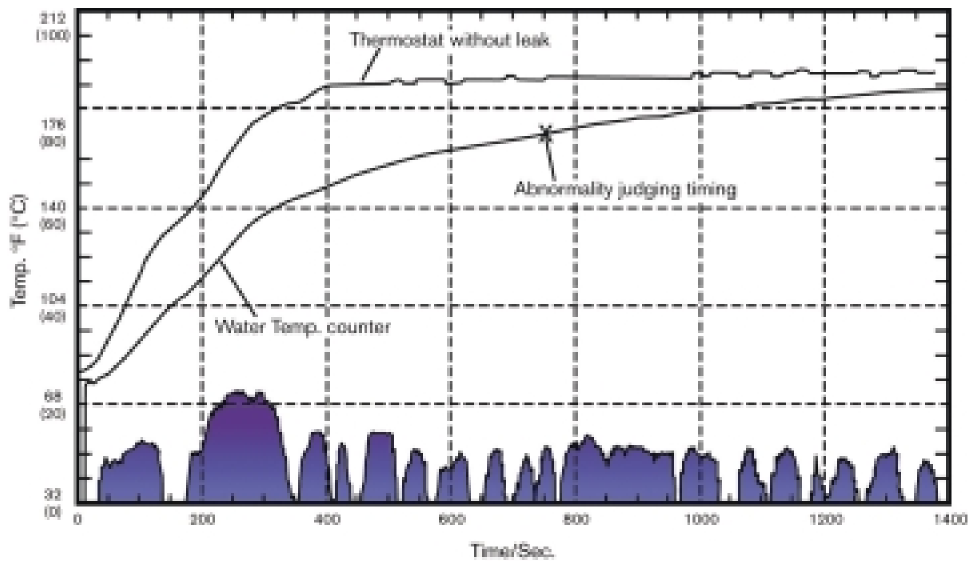
EGR Monitor

Name: ______________________________ Date: ______________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Set the conditions for the test			
Determine of the condition of the EGR system by using Readiness Tests			
Describe the different types of EGR monitors			
Test EGR Valve Position Sensor and compare to specs. to determine condition			

Additional Systems



Additional Systems

Thermostat Monitor

This monitor checks for the coolant temperature to rise to a minimum temperature of 75°C (167°F). When the coolant temperature is less than a predetermined value at engine start, the THW value is monitored during the first portion of the LA#4 driving cycle. The thermostat monitor phase began with the 2000 model year and will be complete with the 2002 model year.

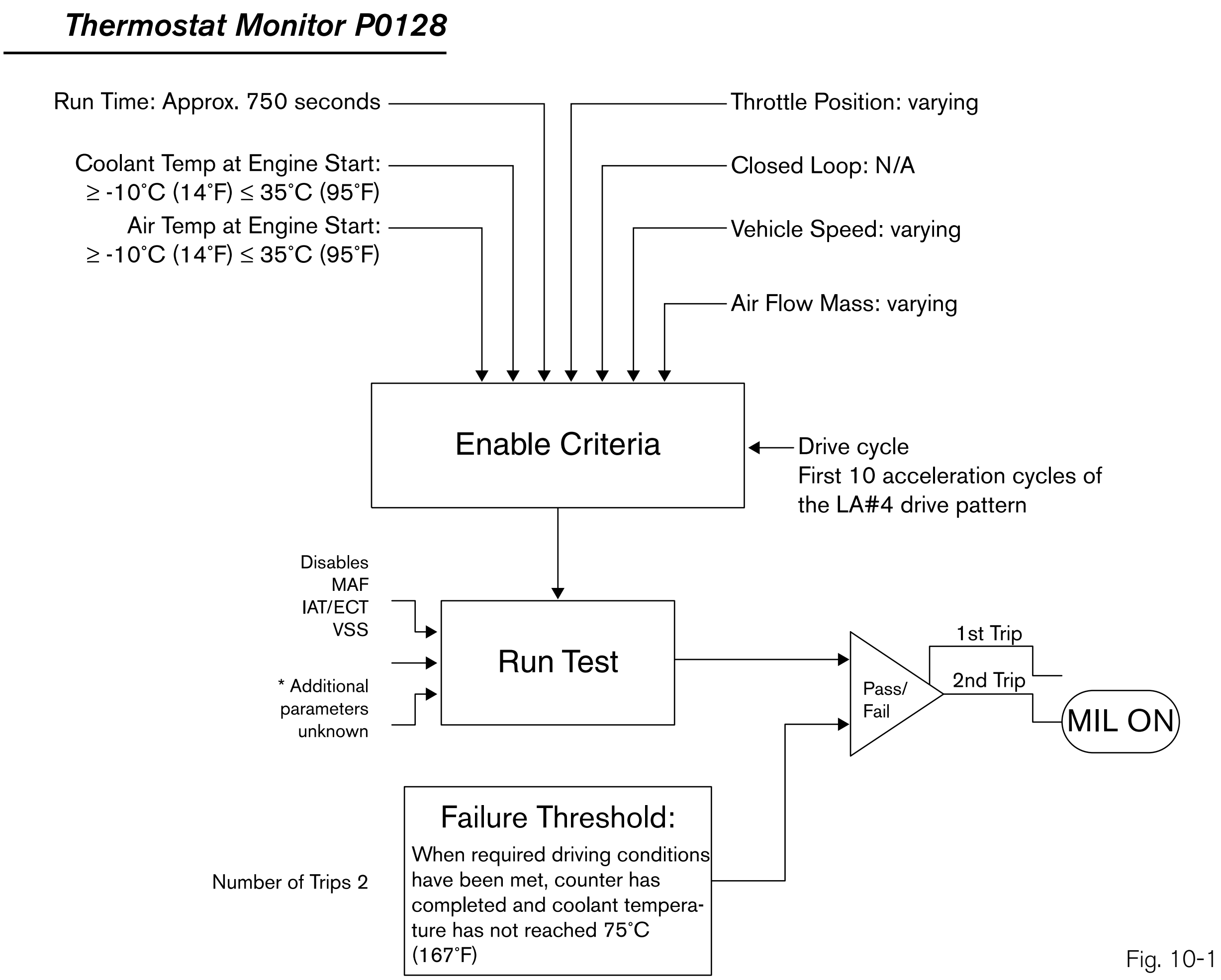


Fig. 10-1

TL874f1001

Thermostat Monitor DTC P0128

This chart shows the rise in coolant temperature during the LA#4 drive pattern. The water temperature counter is also shown. Note the point at which the ECM checks for abnormality (improper coolant temperature).

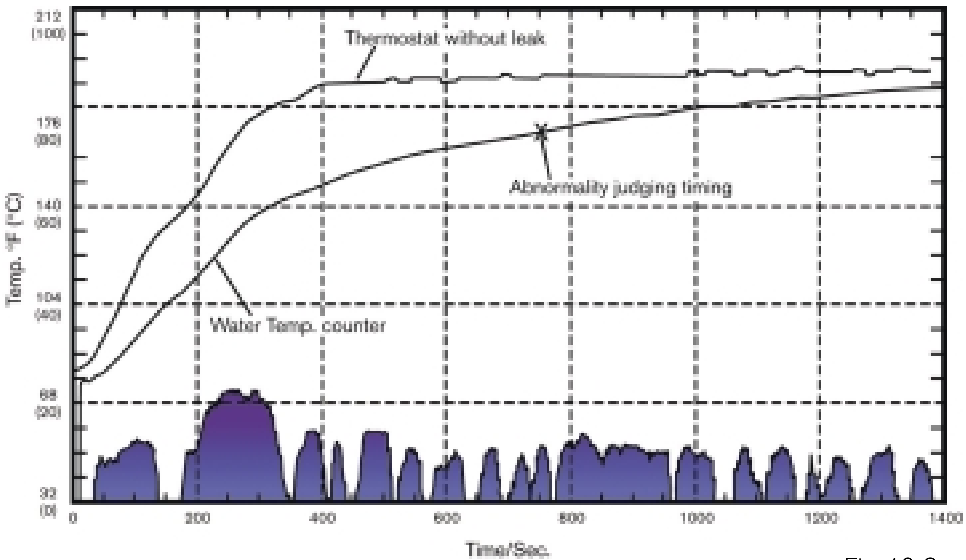


Fig. 10-2

TL874f1002

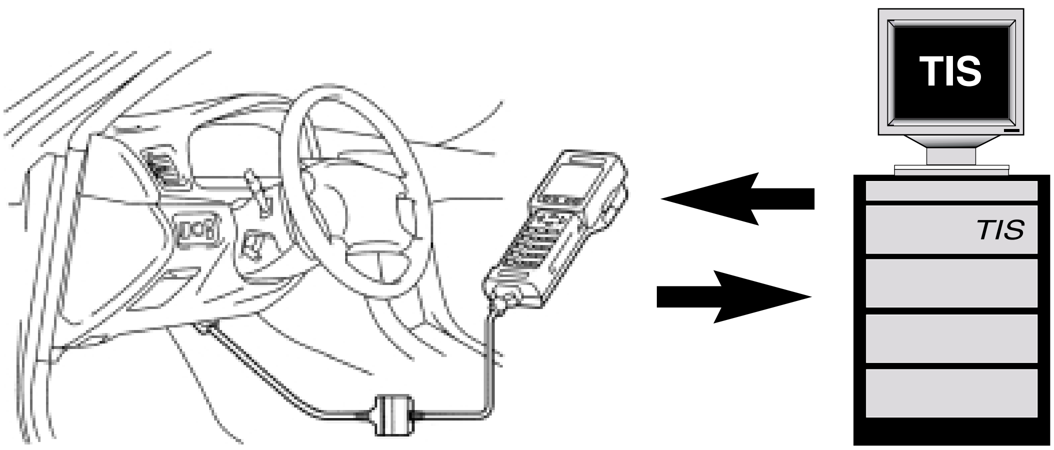
Thermostat Monitor DTC P0128 Thermostat Malfunction

When:

- coolant temperature at engine start is > -10°C (14°F) < 35°C (95°F)
- air temperature at engine start is > -10°C (14°F) < 35°C (95°F)
- during specified driving pattern and time period
- coolant temperature has not reached 75°C (167°F)

Section 11

ECM Diagnosis



Learning Objectives:

1. Diagnose ECM specific Diagnostic Trouble Codes.
2 Troubleshooting the diagnostic circuit.
3. Reprogramming the ECU.

Section 11

ECM Diagnosis

Overview

The ECM is rarely the cause of a problem. If the ECM needed to be replaced, it was often because of a change in calibration. Now, ECMs can be reprogrammed and replacement under these conditions is no longer necessary.

Still, nearly all troubleshooting procedures involve checking all systems and subsystems connected to the ECM. Additionally, with multiplexing, there are more ECUs connected to the ECM that need to be checked.

Presently, there are some DTCs that are directly associated with the ECM.

P0605: The Internal Control Module Read Only Memory Error, is displayed when the ECM has detected a problem in the read only memory area. At the time of this publication, when this DTC is displayed the ECM must be replaced.

P1600: ECM BATT malfunction is stored when there is no power to the BATT terminal of the ECM. Battery voltage is supplied to the BATT terminal even when the ignition switch is OFF. The ECM uses this power for memory and adaptive memory values such as A/F Ratio control. If DTC P1600 is displayed, the ECM does not store another DTC. The BATT circuit must be checked and confirmed normal before replacing the ECM.

P1633: ECM Malfunction (ETCS Circuit), is stored when the ECM detects an internal problem with the electronic throttle control circuit. At the time of this publication, when this DTC is displayed the ECM must be replaced.

Troubleshooting the Diagnostic Circuit

On rare occasions, you will find that the Malfunction Indicator Lamp or the Diagnostic Tester fails to operate properly. The following information is designed to help you determine a diagnostic course of action when you encounter this situation.

Malfunction Indicator Lamp Check

Before connecting your Diagnostic Tester it is important to confirm that the Malfunction Indicator Lamp (MIL) is functioning normally. A bulb check of the MIL is performed when the ignition is switched ON. If the MIL does not illuminate, it indicates that a problem exists in the MIL sub-system. This condition must be corrected before any further diagnostic work can be performed. See the diagnostic procedures for inoperative MIL in the repair manual.

Once the engine is started the MIL should turn off. If the MIL remains on after the engine is running, the diagnostic system has detected a problem in the engine control system.

Failure of Diagnostic Tester to Establish Communications with ECM

After MIL operation is confirmed, connect the Diagnostic Tester to the appropriate DLC and program for the on-board diagnostic system supported by the vehicle. Once the tester is programmed for the correct vehicle and diagnostic system, you should be able to display an ALL DATA LIST.

If any of the following messages are received you must correct this condition before proceeding with troubleshooting:

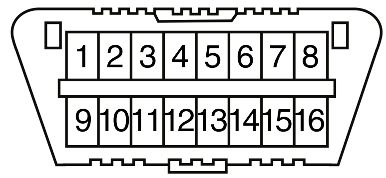
- NO COMMUNICATION WITH VEHICLE
- UNABLE TO CONNECT TO VEHICLE
- OBD II COMMUNICATIONS TIME OUT

There are several possibilities when the Diagnostic Tester fails to communicate with the vehicle. The problem could simply be the way you programmed the tester, or connecting to the wrong DLC. Once you have confirmed correct programming and proper lead connection, you will need to establish whether the problem is in the tester or the diagnostic circuit

To isolate a tester problem from a vehicle problem, simply try the tester on another vehicle. If the tester communicates normally with another vehicle, it is probably O.K. and the vehicle diagnostic system must be inspected.

DLC3 (OBD II) Connector

The vehicle's ECM uses the ISO 9141-2 communication protocol. The terminal arrangement of DLC3 complies with SAE J1962 and matches the ISO 9141-2 format.



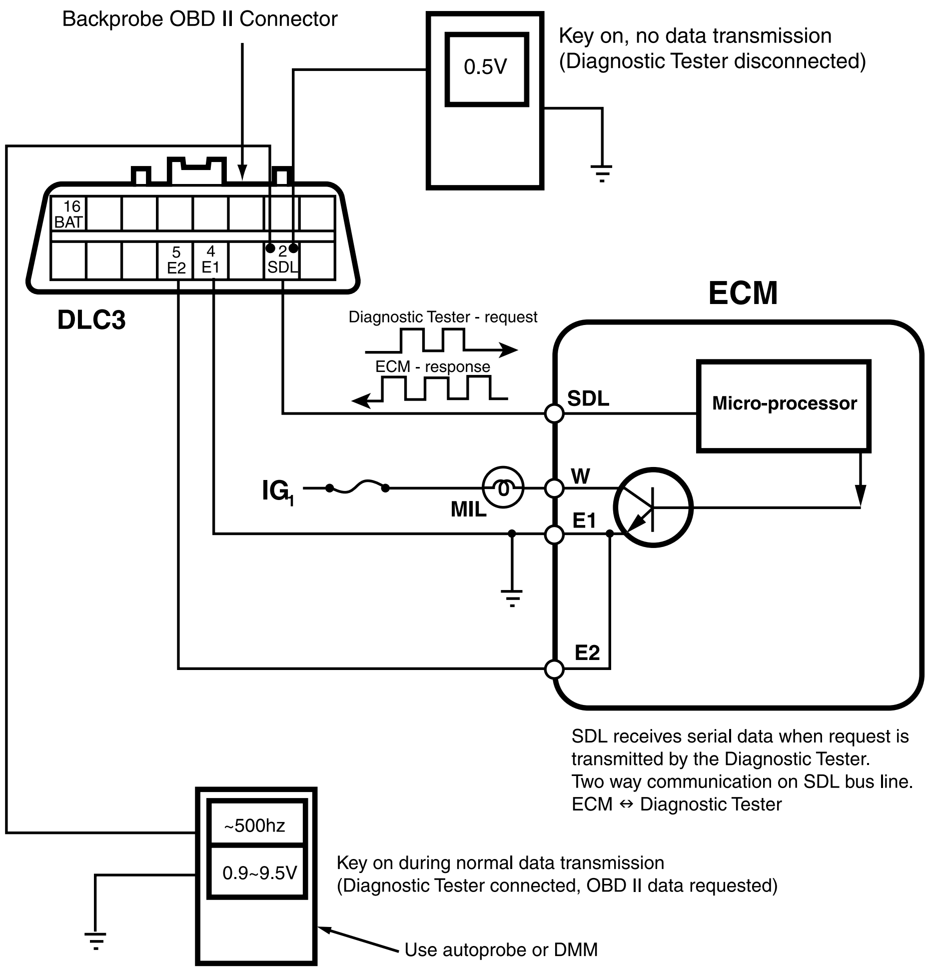
DLC3

Terminal No.	Connection/Voltage or Resistance	Condition
7	Bus ⊕ Line/Pulse generation	During Transmission
4	Chassis Ground ↔ Body Ground/1 Ω or less	Always
5	Signal Ground ↔ Body Ground/1 Ω or less	Always
16	Battery Positive ↔ Body Ground/9 – 14V	Always

Fig. 11-1

TL874f1101

DLC3 Circuit



1. CE light inoperative
- **Test W circuit**
- **Test IG1 circuit**
- **Test Vc circuit, circuit short to ground**
- **Test E1 circuit**

2. Cannot establish communication between ECM and Diagnostic Tester
- **Test Diagnostic Tester on another car**

Fig. 11-2

TL874f1102

Inspection of the OBD II Diagnostic Circuit

The OBD II diagnostic circuit is shown in the schematic. DTC functions, serial data, active test functions, and all OBD II functions are communicated across the SDL (Serial Data Link) circuit. The Diagnostic Tester initiates communication by sending a data request signal to the ECM on the SDL circuit. The ECM will respond by sending a Variable Pulse Width signal back to the tester.

DTC(s) and all data are transmitted to the Diagnostic Tester on the SDL wire in the form of serial data. The tester monitors this Variable Pulse Width signal, translates the signal, and displays the data or DTC(s). As with the OBD system, if the microprocessor develops a problem, the Diagnostic Tester will not function and the MIL will not illuminate at bulb check.

- Troubleshoot Communication Failure Between ECM and Diagnostic Tester
- Disconnect the tester and inspect the following circuits at DLC3
- Check terminal SDL (pin #2) for approximately 5 volts DC with ignition on, if not:
- Check for open or short to ground in SDL circuit
- Check for good continuity between El (pin #4) and -B at the battery (< 1Ω)
- With Diagnostic Tester connected to DLC3, CARB or ENHANCED OBD II data requested
- Backprobe SDL terminal with digital multimeter; should vary between 0.9V and 9.5V
- Backprobe SDL terminal with frequency counter; should indicate 500 hz ± 50 hz

HINT

If your display shows UNABLE TO CONNECT TO VEHICLE when you have connected the cable of the Diagnostic Tester to the DLC3, turned the ignition switch ON, and turned on the Diagnostic Tester, there is a problem on the vehicle side or tool side.

If communication is normal when the tool is connected to another vehicle, inspect the DLC3 on the original vehicle.

If communication is still not possible when the tool is connected to another vehicle, the problem is probably in the tool itself, so consult the Service Department listed in the tool's instruction manual.

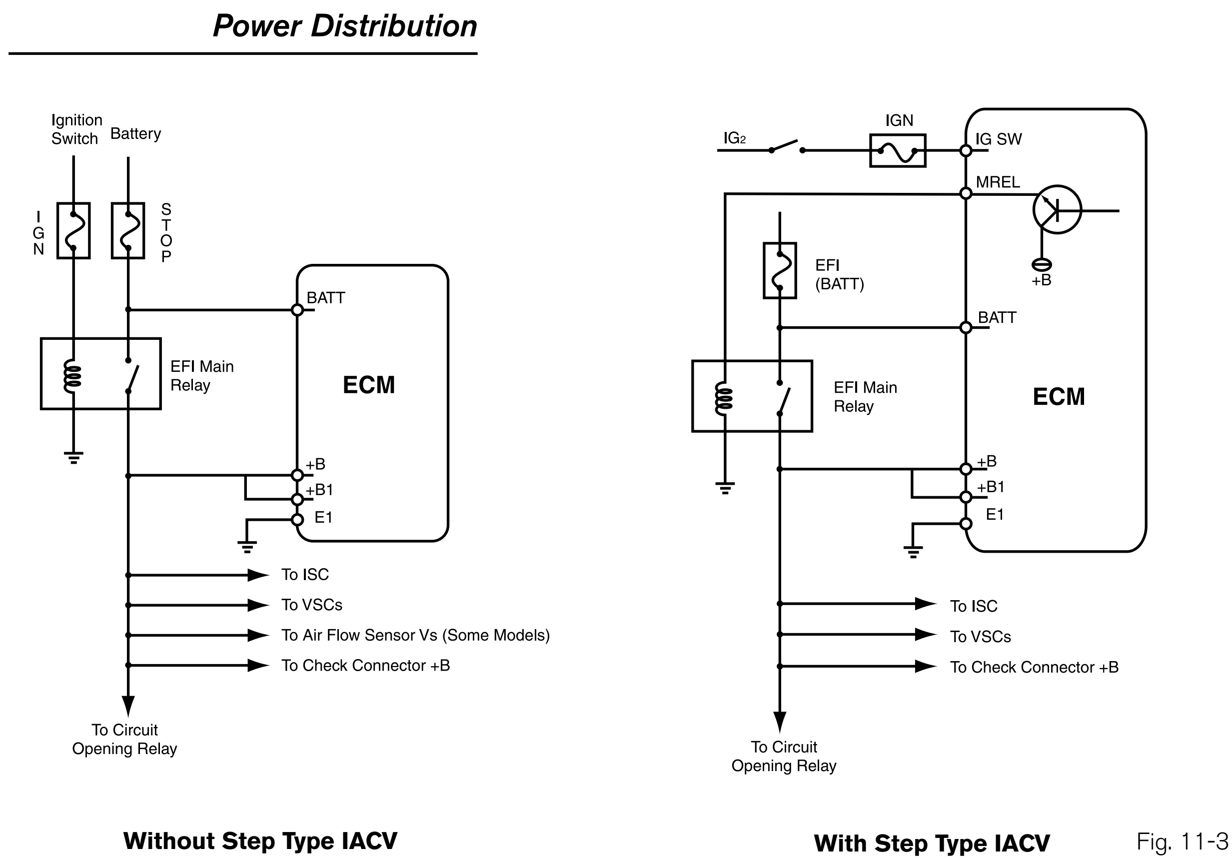


Fig. 11-3

TL874f1103

Power Distribution System

When the ignition is switched on, the engine control system is designed to power the ECM by energizing the Main Relay. The Main Relay supplies power to the ECM +B ignition feed circuits and all sub-system Vacuum Switching Valves (VSVs) and relays.

There are two basic types of Main Relay control circuits used on fuel injection engines:

- Without step type IAC: Uses a simple ignition switch controlled Main Relay. To energize the relay, current from the ignition switch flows through the Main Relay pull-in winding, to ground. This energizes the relay and powers all of the circuits mentioned above.

- With step type Idle Air Control (IAC): Uses an ECM controlled Main Relay. To energize the relay, the ECM monitors the IGSW input. When the ignition switch is turned to the ON position, current flows to the ECM through the IGSW circuit. This signals the ECM to send control current through the MREL circuit, through the Main Relay pull-in winding, to ground. This causes the relay power contacts to close, sending current to the ECM, all VSVs, and the Circuit Opening Relay.

Inspection

Circuit quick checks: If the MIL illuminates when the ignition is switched to the ON position, the Main Relay is functional and current is flowing to the ECM +B terminals. If the MIL does not illuminate, use a Voltmeter to monitor the +B terminal of DLC1.

If battery voltage is available at DLC1 +B terminal, the Main Relay is functional. Further circuit troubleshooting will be required to determine if current is flowing to the ECM consult the repair manual.

Circuit Inspection Using V-BoB: Inspect the following signals for behavior indicated above; +B, +B1, El, IGSW, MREL. Refer to the appropriate Repair Manual circuit inspection charts and to the Engine Control System schematic in the EWD for troubleshooting details.

ECU Reprogramming

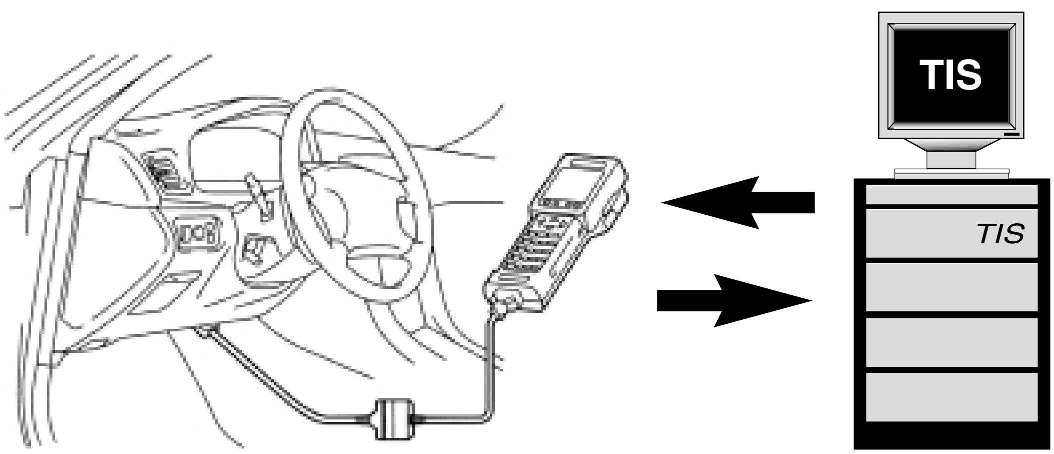


Fig. 11-4

TL874f1104

ECU Re-programming

Beginning with some 2001 model year vehicles, the ECM is capable of being reprogrammed. It is called ECU reprogramming because this procedure may be applicable for multiple processors.

This procedure allows the ECM to be updated on an as needed basis without replacement. A TSB will inform you which vehicles are to be re-programmed. TIS provides the needed re-programming information and procedure. To find the latest information, log on to TIS, go to DIAGNOSTICS, ECU FLASH REPROGRAMMING. In the ECU FLASH REPROGRAMMING section you will find the latest instructions, calibration programs, and vehicles requiring re-programming.

Here are some general guidelines:

- If a Recalibration Label is present, the vehicle has already been recalibrated and no further action is required.
- The ECU recalibration program is confirmed using the Diagnostic Tester.
- Check battery voltage. To avoid battery fluctuations while reprogramming the Engine ECU turn off all electrical accessories (i.e. radio, lights, interior fan). Confirm battery voltage is greater than 11.5V. Charge battery as necessary.

NOTE If battery voltage drops below 11.4V during ECU recalibration, damage to the Engine ECU will occur.

- Ensure that all electrical systems are turned off and doors and trunk are closed. Once the recalibration process has started, do not operate the doors or accessories.
- Recalibration can take up to 45 minutes. The length of time to reprogram will vary, depending on the type ECM and reprogram file.
- It may take up to 2 minutes for the progress bar to begin moving.

NOTE Do not move the Diagnostic Tester or cable during recalibration to prevent recalibration failures.

- Confirm that the new calibration has successfully installed.
- If applicable, attach a new calibration sticker.

WORKSHEET 11-1
ECU Reprogramming

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

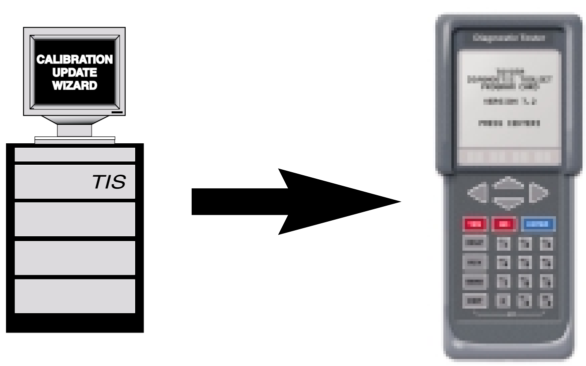
In this worksheet, you will become familiar with the procedure required to identify the vehicle calibration ID, search for updated calibrations, download calibrations from TIS, and using the Diagnostic Tester replace the vehicle ECM's calibration.

Tools and Equipment

- Vehicle
- Vehicle Repair Manual, EWD, & NCF
- Diagnostic Tester
- TIS Access
- Hand Tools, Fender Covers, Floor Mats, and Shop Towels

Step 1: Select Calibration ID from TIS

To upload the latest ECU calibration, use the Technical Information System and access the Calibration Update Wizard. Follow the instructions on the screen to down load the appropriate Calibration ID to the Diagnostic Tester.



1. What two service publications could also contain a hyperlink to access the Calibration Update Wizard?

2. When the Diagnostic Tester is turned ON and ECU RE-PROGRAMMING is selected the tester screen indicates that PC communication is "DISCONNECTED". What does "DISCONNECTED" mean?

___

3. Use the TIS to locate the new calibration for a vehicle designated by the instructor. What is the issue date?

___

4. What are the two CPU numbers and calibration IDs.

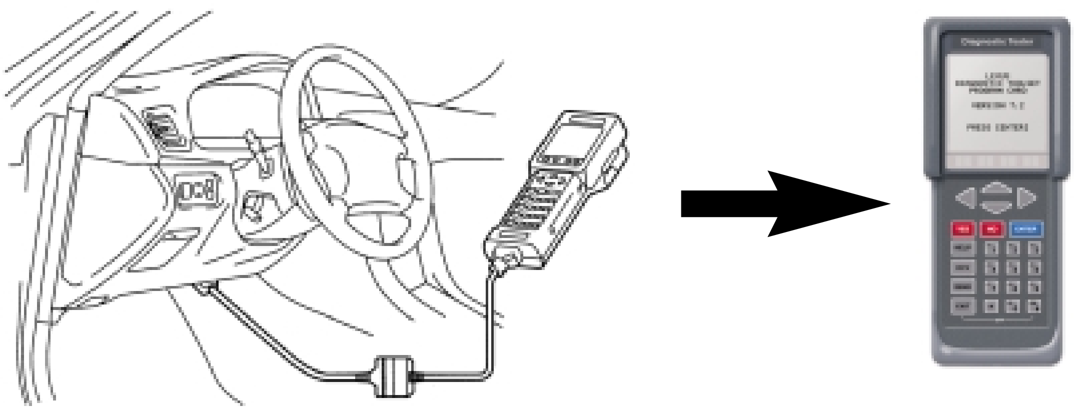
___

5. What are the new calibrations?

___

Step 2: Retrieve the Current Calibration ID from the Vehicle.

Use the Diagnostic Tester to check the current CAL ID stored in the vehicle ECM.



1. Identify the main menu selection to access the current ECU calibration

___

2. What are the current vehicle ECU calibration ID numbers?

___

Step 3: Install New Calibration ID

Use the Diagnostic Tester to update the ECU calibration.

1. What items must be confirmed prior to updating the ECU calibration?

2. Match current calibration ID number with the new ID number. What calibration ID was matched?

3. When reprogramming is interrupted, damage to the ECU is likely. If the ECU is damaged, what is the proper repair?

4. Why would the electrical load precaution be important to the reprogramming procedure?

Step 4: Installing Second New Calibration IDs

1. How is the new calibration selected for reprogramming?

Step 5: Verify New Calibration ID is Installed.

1. How can one ensure that the new calibration(s) have been installed?

Notes

ECM Reprogramming

Name: ______________________________ Date: ______________

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

Topic	I have questions	I know I can	Comment
Diagnose ECM specific diagnostic trouble codes			
Locate fuses, relays, and grounds connected to the ECM using the EWD and RM			
Trace power flow to the ECM using the EWD and RM			
Test ECM power circuits and compare to specs. to determine condition			
Test ECM ground circuits and compare to specs. to determine condition			
Test DLC 3 circuits for continuity			
Describe precautions when handling the ECM			
Reprogram the ECU			

Appendix A

Glossary

A

Actuator – A mechanism for moving or controlling something indirectly instead of by hand. See also, output actuator.

Amplitude – As it applies to the electronic control system, the amount of voltage produced in an electrical circuit.

Autoprobe – A signal measurement device that when interfaced with the Diagnostic Tester Instrumentation Port can be used for voltage, frequency, duty cycle, and pulse width measurements. When interfaced with V-Bob, the Autoprobe provides signal input for oscilloscope functions.

B

Bank – The group of cylinders which feed an O2 sensor. Bank 1 always contains cylinder #1 (the cylinder closest to the front of the engine). Under the J1979 serial data standard, O2 sensor location is identified by bank (i.e. bank 1 and bank 2) and also by sensor number (i.e. sensor 1, sensor 2) where sensor 1 is the closest to the engine. The following is an example of this type of sensor location information.

On a 1MZ-FE engine, sensor B1, S1 indicates bank 1, sensor 1. This is the main O2 sensor on the right side of the engine (facing the front of the engine). Sensor B1, S2 indicates the sub-O2 sensor located on the right side exhaust.

Base Fuel Schedule (Basic Injection Quantity) – Fuel calibration schedule programmed into the ECM when the vehicle is manufactured. The base fuel schedule is the calculated fuel delivery for a given set of input parameters prior to any trim correction being added.

Baud Rate – The speed at which data can be transmitted over a serial data link, usually measured in "bits per second" (bps).

bps – bits per second. Units used for measurement of baud rate.

C

Calculated Load Value – refers to an indication of current airflow divided by (theoretical) peak airflow, where peak airflow is corrected for altitude (when this data is available). A unitless number that provides the technician with an indication of the percentage of engine capacity that is being used.

Catalyst – A substance that can increase or decrease the rate of chemical reaction between substances without being consumed in the process.

Circuit Level Diagnosis – A diagnostic decision, which confirms that a problem exists within a particular circuit. The circuit consists of the sensor, the ECM, and all related wiring.

Closed Loop (Engine) – An operating condition or mode, which enables modification of programmed instructions, based on a feedback system.

Continuous Monitoring – Sampling at a rate no less than two samples per second.

Cursor – The highlighted text or data on the display screen. Same as marker.

D

DLC – Data Link Connector. A connector provided for access to a vehicle's on-board diagnostic data and functions.

Data List – A preprogrammed list of information being transmitted from vehicle to Diagnostic Tester. Depending on the vehicle and system being tested, the Data List could have as few as 10 parameters or as many as 80.

Data Word – One complete parameter or piece of information transmitted on a serial data line.

Default – As it relates to an engine control system, the condition that a device will return to when it is not operation or when it fails. Take a normally closed (N/C) Vacuum Switching valve for example; when this type of VSV is operated by the ECM, it will open; however, in the event that this N/C device becomes disconnected or inoperative, it will revert to the closed position.

Diagnostic Tester – A handheld tester capable of reading and displaying serial data from the vehicle Data Link Connector (DLC).

Diagnositcs – The process of identifying the cause or nature of a condition, situation or problem to determine the corrective action in repair of automotive systems.

Driving Cycle – Engine start-up, vehicle operation beyond the beginning of closed loop operation, and engine shut down.

Duty Ratio – The duty ratio is the percentage of time during one complete cycle that electrical current flows. A high duty ratio, 90% for example, means that current flow is on longer than it is off. A low duty ratio, 10% for example, means that current flow is off longer than it is on. A duty ratio of 50% would be on half of the time and off half of the time.

E

Engine Misfire – Lack of combustion in a cylinder due to the absence or inadequacy of spark, fuel metering compression, or any other cause.

F

Final Injection Quantity – The final delivery calculation after all corrections have been made for variables like temperature and battery voltage.

Frequency – Number of times every second an alternating current goes through a complete cycle. Measured in the unit Hertz (Hz).

Fuel Trim – Feedback adjustments to the base fuel schedule. Short-term fuel trim refers to dynamic or instantaneous adjustments. Long term trim refers to a more gradual adjustment to the fuel calibration schedule. Long-term trim adjustments compensate for differences between vehicles and/or changes in the vehicle, which occur over time.

Freeze Frame – A single frame of stored data, representing data parameters at the moment a fault is stored.

H

Hard Fault – A circuit fault, which is not intermittent, like a broken wire or faulty sensor.

Hz – Hertz. A unit of measurement for frequency.

I

Intermittent Fault – A circuit fault, which only happens occasionally. It sometimes can be duplicated and sometimes it cannot.

Injection Pulse Width – The amount of time the ECM switches a fuel injector to ground, allowing fuel to be delivered to the intake manifold. Pulse width is typically measured in the number of milliseconds that the fuel injector delivers fuel to the intake manifold. Also referred to as injection duration.

Injection Duration – The amount of time a fuel injector is energized or on. With a fixed fuel pressure differential across the injector, increases in injector duration to cause a proportionate amount of additional enrichment.

Instrumentation Port (I/P) – Terminal located on the bottom of the Diagnostic Tester for connection with V-Bob, Autoprobe, and NVH analyzer.

K

Keep Alive Memory – A battery powered memory location in the ECM, which allows the microprocessor to store information about the system-input failures. This information, which is stored during normal operation of the vehicle, is not erased from the ECM memory until the BATT feed to the ECM is disconnected for more than 30 seconds. Also referred to as Non-Volatile Ram (NVRAM).

L

Learned Voltage Feedback (LVF) – Fuel injection correction coefficient which tailors the standard fuel injection duration to minor differences between engines due to manufacturing tolerances, mechanical wear, and minor mixture disturbances like small vacuum leaks. This coefficient is capable of altering the calculated injection duration (before O2 sensor correction) by as much as 20% to prevent O2 sensor corrections from becoming excessive.

Look Up Table – A data table stored in a computer memory, which is used to look up information for an engine control system.

M

Malfunction – The inability of an emission related component or system to remain within design specifications. For OBD II purposes, the deterioration of a component or system to a degree that would likely cause the emissions of the vehicle to exceed 1.5 times its original design standards.

Microprocessor – A set of integrated circuits that can be programmed with stored instructions to perform given functions. Also called a microcomputer, this device consists of a central processing unit (CPU), a read only memory (ROM), and a random access memory (RAM).

O

O2S Response Rate – The delay, measured in milliseconds, between a switch of the sensor from lean to rich or vise versa, in response to a change in A/F Ratio above and below stoichiometric (14.7:1 AFR).

OBD – The first generation of on-board diagnostic capabilities for gasoline powered automobiles and light trucks mandated by the California Air Resources Board (CARB). Phased-in during the 1988 model year.

OBD II – The second generation of on-board diagnostic capabilities for gasoline powered automobiles and light trucks mandated by the California Air Resources Board (CARB). Implemented during the 1994 - 1996 model years.

Open Loop – An operating condition or mode based on programmed instructions and not modified by a feedback system.

Output Actuator – A device, which performs a mechanical action, based upon an electrical signal. See also, actuator.

P

Potentiometer – A three-wire electrical device that can vary the amount of resistance placed in an electrical circuit by sliding an electrical contact along a fixed resistor.

Pounds per Square Inch, Absolute (PSIA) – Pressure readings, which are not corrected for atmospheric pressure. At sea level, a PSIA calibrated gauge would read 14.7 pounds per square inch when sampling ambient pressure. Intake manifold pressure is typically measured on the absolute scale.

Pounds per Square Inch, Gauge (PSIG) – Pressure readings, which are corrected back to zero for atmospheric pressure. At sea level, a PSIG calibrated gauge would read zero pounds per square inch when sampling ambient pressure. Fuel pressure is typically measured on the gauge scale.

Power Transistor – The electronic switch inside an igniter assembly, which turns primary current on, and off. Designed to carry large amounts of current flow and dissipate large quantities of heat.

Programmable Read Only Memory (PROM) – Part of a microprocessor or computer in which instructions or data are semi-permanently located. PROM data can be changed (like RAM) but are not volatile memory (they do not erase when power is removed, but are permanently configured as part of the electronic circuit).

Pull-up Resistor – The first resistor (of fixed value) in a two-resistor series circuit, which creates a voltage, dividing network. As the resistance of the second resistor increases, its voltage drop also increases; therefore the voltage drop across the pull-up resistor decreases.

R

RS232/RC23C – The most standard serial communication interface used in the computer industry.

S

Secondary Air – Air induced into the exhaust system by means of a pump or aspirator valve or other means that is intended to aid in the oxidation of HC and CO contained in the exhaust stream.

Sensor – The generic name for a devise that senses either the absolute value or a change in a physical quantity such as temperature, pressure, or flow rate and converts that change into an electrical quantity signal.

Signal (Electrical/Electronic) – A fluctuating electric quantity, such as voltage or current, whose variations represent information.

Serial Data – Information about a computer system inputs, outputs, and other operating parameters which is transmitted from vehicle to Diagnostic Tester on a single wire in the Data Link Connector (DLC).

Snapshot – A mode of operation where basic diagnostic parameters are stored in the scan tool during a road test and can be examined, printed, or transferred to a computer at the end of the test.

Standard Voltage Values – Normal voltage and resistance values which are established for a given sensor, actuator, or circuit. These standard values can be found in the repair manual.

Stoichiometry – The theoretically ideal air/fuel mixture for combustion in which all oxygen and all fuel will be completely burned.

Square Wave – A digital, electronic signal which is either on or off. There is virtually no time between the on and off states.

T

Trip Cycle – Vehicle operation (following an engine off period) of duration and driving modes, such that all components and systems are monitored at least once by the diagnostic system (except those systems which are steady state monitored).

Two Trip Detection Logic – ECM diagnosis strategy which prevents a diagnostic code or the check engine light from coming on until the problem has duplicated itself twice, with a key off cycle in between.

V

V-BoB – Vehicle Break-out Box.

VIN – Vehicle identification number.

W

Warm-up Cycle – Sufficient vehicle operation such that the coolant temperature has risen at least 40°F from engine starting and/or reaches a minimum temperature of 160°F.

Appendix B

Data Parameters

Current and Past TMC Engines Covered in this Section

Fig. B-1

TL874fB01

OBD Data Parameters

Signal Category	Display Item	Parameter Description	Units of Measurement	Normal Condition (warm idle, accessories off)
Oxygen Feedback	Target A/F (L & R)	Long term fuel trim (learned value) for left ad right cylinder banks	0V to 5V	2.50V ± 1.25V (except 2JZ-GE = 2.50V ± 1.85V)
	A/F FB (L & R)	Loop status for left and right cylinder banks	ON or OFF	ON
	Ox Signal (L & R)	Main O2 sensor signal	Rich or Lean	Switching between rich and lean, no minimum switching frequency
Major Inputs	Engine Coolant Temperature (ECT)	Temperature of engine coolant	Degrees fahrenheit or celsius	80°C to 95°C (176°F to 203°F)
	Engine Speed	Engine rpm	Crankshaft revolutions per minute	Normal warm curb idle as specified in Repair Manual
	Air Flow Meter (VS)	Volume of air entering the engine	Volts	2.50V ± 0.5V (Except following engines: 22R-E = 6 ± 1m3/hr 3VZ-E = 2.8V ± 0.6V) 1FZ-FE = 1.8V ± 0.6V
	Air Flow Meter (KS)	Volume of air entering the engine	milliseconds	35 ± 5ms (except `94 LS 400 = 40 ± 5ms)
	Mass Air Flow Meter	Mass of air entering engine	grams per second	3.8 ± 1.2 gm/sec
	Intake Manifold Pressure (Intake Man.)	Absolute pressure in intake manifold	inches of mercury (in. HG), millimeters of Mercury (mmHG), Kilopascals (Kpa)	4A & 7A-FE = 9.8 ± 1.2 in. HG (250 ± 30 mmHG)) 5S-FE = 9 ± 2 in. HG (230 ± 50 mmHG)
	Throttle	Throttle opening angle in degrees, 90° theoretical maximum	angle in degrees	0° (< 5° KOEO)
	IDL Signal	Throttle closed signal (closed IDL contact)	ON or OFF	ON
	STA Signal	Engine cranking signal	ON or OFF	OFF (except when ignition is switched to start position)

Normal Condition (warm, 2500 rpm, no load)	Cranking Values	Addition Information
2.50V ± 1.25V	N/A	AFR feedback correction value, displayed as correction factor, 2.50V = no correction. 2.50V = lean correction for rich condition. > 2.50V = rich correction for lean condition. Part of basic injection calculation.
ON	N/A	AFR feedback loop status. Open indicates that ECM ignores feedback from the exhaust O2 sensor. Open loop is forced during accel, decel, and cold engine operation. Closed indicates final injection duration is corrected for O2 sensor feedback.
Switching between rich and lean, minimum 8 switches in ten seconds (use O2S/RPM test)	N/A	Signal voltage for main O2 sensor. High concentration of exhaust oxygen (lean condition) = LEAN (< 400 my 02S voltage). Low concentration of exhaust oxygen (rich condition) = RICH (> 600mv 02S voltage)
80°C to 95°C (176°F to 203°F)	Actual temperature	Displayed value determined by comparing THW analog voltage signal to look-up table stored in Read Only Memory. 'Default =176°F if circuit open or shorted
Should agree with tachometer	> 100 rpm	Engine revolutions calculated by comparing Ne signal with microprocessor clock pulses.
N/A	N/A	Displayed value is same as analog voltage signal at VS terminal of ECM.
N/A	N/A	Displayed value represents time that Ks signal is low. As signal frequency increases, time decreases. (time displayed is reciprocal of signal frequency)
N/A	N/A	Displayed value calculated by comparing VG analog voltage signal to a look-up table stored in Read Only Memory.
N/A	N/A	Determined by comparing analog signal voltage at PIM terminal of ECM to look-up table stored in Read Only Memory.
N/A	N/A	Displayed value determined by comparing VTA analog signal voltage to look-up table stored in Read Only Memory. Note: some applications display this value in steps, skipping approximately 8' per step. Value should indicate >70°at WOT.
OFF	N/A	Display determined by status of voltage at IDL terminal of ECM. Low voltage will cause display to read ON, high voltage will read OFF.
OFF	ON	Display determined by status of voltage signal at STA terminal of ECM. High voltage will cause display to read ON. May not indicate ON unless engine is cranked >2 seconds.

OBD Data Parameters (continued)

Signal Category	Display Item	Parameter Description	Units of Measurement	Normal Condition (warm idle, accessories off)
Other Inputs	Vehicle Speed	Road speed of vehicle	miles or kilometers per hour	0 mph/kph vehicle stopped
	A/C Signal	Air conditioning switch status	ON or OFF	On when A/C compressor is running
	PNP Signal	Park/Neutral safety switch status	N-P or Gear	N-P when in neutral or park, GEAR when in any forward or reverse gear
	Knock Retard	Status of ignition spark knock retard	ON or OFF	OFF
Outputs	Injector	Injection duration of #10 injector or injection group	Milliseconds injection time	1.8 o 50ms (see parameter definition)
	Ignition	Timing advance of cylinder #1	Degrees before top dead center crankshaft angle (CA)	5° to 20°
	IAC Step #	Commanded position of step type idle speed control valve	Steps	35 ± 15 steps (see additional information)
	ISC Duty	Commanded duty ratio to Rotary Solenoid Idle Air Control Valve	Percentage of time that voltage is high on RSO (open) coil	5% to 60% (see parameter definitions)

Normal Condition (warm, 2500 rpm, no load)	Cranking Values	Addition Information
0 mph/kph vehicle stopped	N/A	Displayed value calculated by comparing the pulsed vehicle speed sensor signal to the ECM internal clock pulse.
Cycles ON/OFF with A/C compressor (with A/C on)	N/A	Display determined by status of voltage at A/C terminal of the ECM.
N-P when in neutral or park, GEAR when in any forward or reverse gear	N/A	
OFF	N/A	May indicate ON during stall test or rapid acceleration.
Refer to engine control specifications in appendix	N/A	Normal values will vary with engine model, refer to engine control specifications in appendix. Duration decreases cold to warm and increases with load.
N/A	N/A	Computed timing advance (in addition to initial timing set with distributor), timing of IGT signal with respect to NE and G signals.
N/A	N/A	Commanded, not actual position. 125 steps = fully open (maximum by-pass air). 0 steps = fully closed (valve seated position). If valve is mechanically stuck, commanded position will continue to change until 0 or 125 steps are achieved. 2JZ-GE = 20 -25 steps, 1UZ-FE = 30 - 40 steps, 1FZ-FE = 30 - 50 steps
N/A	N/A	Duty ratio increases when A/C is ON or A/T is in GEAR.

OBD II Data Parameters

Signal Category	Display Item	Parameter Description	Units of Measurement/ Range	Normal Condition (warm idle, accessories off)
Oxygen Feedback	Fuel Sys (#1 & #2)	Loop status, cylinder bank 1 & 2	CLOSED or OPEN	CLOSED
	Short FT (#1 & #2)	Short term fuel trim, cylinder bank 1 & 2	% correction to injection duration. Range 0% ± 35%	0% ± 35%
	Long FT (#1 & #2)	Long term fuel trim, cylinder bank 1 & 2	% correction to basic injection duration. Range 0% ± 35%	0% ± 35%
	O2S (B1, S1 & B2, S1)	Main O2 sensor signal voltage, cylinder bank 1 & 2	0 to 1000 millivolts	Varying between 0 to 1000 millivolts, no minimum switching frequency
	O2S (B1, B2)	Sub-O2 sensor signal voltage, cylinder bank 1	0 to 1000 millivolts	Typically fixed voltage (does not vary significantly)
	O2 FT (B1, S1 & B2, S1)	Main O2 sensor fuel trim, cylinder bank 1 & 2 (same as Short FT)	% correction to basic injection duration	0% ± 35%
	Total FT (B1 & B2)	Average total fuel trim, cylinder bank 1 & 2	Decimal value with normal range of 0.8 to 1.2. Normal value is 1.0	0.8 to 1.2 (80% to 120%)
	O2 LR (B1, S1 & B2, S1)	Main O2 sensor lean to rich switch time, cylinder bank 1 & 2	Time in milliseconds	0 to 1000 millivolts
	O2 RL (B1, S1 & B2, S1)	Main O2 sensor rich to lean switch time, cylinder bank 1 & 2	Time in milliseconds	0 to 1000 millivolts
	AFS (B1, S1 & B2, S1)	Voltage output of A/F sensor, cylinder bank 1 & 2	volts	Idling 2.8V - 3.8V
Major Inputs	Coolant Temperature (ECT)	Temperature of engine coolant	Degrees fahrenheit or celsius	80°C to 95°C (176°F to 203°F)
	Engine Speed (rpm)	Engine rpm	Crankshaft revolutions per minute	700 rpm ± 50 rpm
	Mass Air Flow (MAF)	Mass of air entering the engine	grams per second	2.4 to 4.8 gm/sec

Normal Condition (warm, 2500 rpm, no load)	Ignition Switch On, Engine Not Running	Engine Cranking	Addition Information
CLOSED during cruise condition	N/A	N/A	AFR feedback loop status. Open indicates that ECM ignores feedback from the exhaust oxygen and AF sensor. Open loop is forced during accel, decel, and cold engine operation. Closed indicates final injection duration is corrected for O2 sensor feedback.
0% ± 35%	N/A	N/A	AFR feedback correction value, applied to injection duration (after basic injection calculation). Positive value = rich correction for lean condition. Negative value = lean correction for rich condition. Value should be varying during closed loop.
0% ± 35%	N/A	N/A	AFR feedback correction value, part of basic injection calculation. Positive value = rich correction for lean condition. Negative value = lean correction for rich condition. Value should remain stable during closed loop.
Varying between 0 to 1000 millivolts, minimum 8 switches in ten seconds	N/A	N/A	Signal voltage (in millivolts) for main O2 sensor. High concentration of exhaust oxygen (lean condition) = low signal voltage (< 400 mv). Low concentration of exhaust oxygen (rich condition) = high signal voltage (> 600mv)
Typically fixed low voltage (except when driving under normal road load)	N/A	N/A	Signal voltage (in millivolts) for sub O2 sensor. High concentration of post catalyst oxygen = low signal voltage (< 400 mv). Low concentration of post catalyst oxygen = high signal voltage (> 600mv)
0% ± 35%	N/A	N/A	AFR feedback correction value (same as Short, FT), displayed as the percentage of rich or lean correction applied to injection duration. Positive value = rich correction. Negative value = lean correction. Should closely follow Short FT. Percentage will vary with different engines.
0.8 to 1.2 (80% to 120%)	N/A	N/A	Total correction including basic and correct injection duration values. Normal value is 1.00. < 1.00 = reduced duration (lean correction for rich condition). > 1.00 = increased duration (rich correction for lean condition).
N/A	N/A	N/A	Time in milliseconds for signal voltage to go from > 600 mv to < 400 mv. Switching time is effected by the age and condition of the O2 sensor. Faster switching times are desirable.
N/A	N/A	N/A	Time in milliseconds for signal voltage to go from < 400 mv to > 600 mv. Switching time is effected by the age and condition of the O2 sensor. Faster switching times are desirable.
3.3V (Range 2.8V - 3.8V)	N/A	N/A	Signal voltage for A/F sensor. A rich condition is below 3.3V, a lean condition above 3.3V. In closed lope, the ECM maintains a 3.3V output signal.
80°C to 95°C (176°F to 203°F)	Actual temperature	Actual temperature	Displayed value determined by comparing THW analog voltage signal to look-up table stored in Read Only Memory.
Should agree with tachometer	N/A	> 100	Engine revolutions calculated by comparing Ne signal with microporcessor clock pulses.
7.9 to 16.2 gm/sec	ON	N/A	Displayed value calculated by comparing VG analog voltage signal to a look-up table stored in Read Only Memory.

OBD II Data Parameters (continued)

Signal Category	Display Item	Parameter Description	Units of Measurement/ Range	Normal Condition (warm idle, accessories off)
Major Inputs (cont.)	Throttle Pos (TP)	% of theoretical maximum throttle opening	Percentage	7% to 11% (Higher KOEO)
	CTP SW	Closed throttle position signal (closed IDL contact)	ON or OFF	ON
	Starter Sig	Engine cranking signal	ON or OFF	Off (except when ignition is switched to start position)
	Calc Load	Percent of maximum possible enigne load	Percentage	12.9% to 25.2%
Other Inputs	EGRT Gas	Temperature of exhaust gas recirculation intake port	Degrees fahrenheit or celsius	> Intake air temperature, < Engine Coolant temperature
	Vehicle Spd (VSS)	Road speed of vehicle	Miles or kilometers per hour	0 mph/kph vehicle stopped
	Intake Air	Temperature of air entering the intake manifold	Degrees fahrenheit or celsius	Approximately same as understood ambient air temperature
	A/C Sig	Air conditioning switch status	ON or OFF	On when compressor is on
	PNP SW	Park/Neutral switch signal status	ON or OFF	On with transmission inP or N, otherwise Off
	Electrical Load Sig	Status of electrical load from rear window defogger and/or taillight circuit	ON or OFF	On when taillight and/or rear window defogger relay is on
	Stop Light SW	Status of stop lamps	ON or OFF	On when brake pedal is depressed (stop light switch contacts closed)

Normal Condition (warm, 2500 rpm, no load)	Ignition Switch On, Engine Not Running	Engine Cranking	Addition Information
N/A	throttle opner > idle value	7% to 11%	Displayed valve determined by comparing VTA analog Signal voltage to look-up table stored in Read Only Memory. Each 5V signal amplitude equals 10% throttle opening (65% to 75% wide open throttle)
OFF	On (unless throttle opener holds throttle valve open)	On (unless throttle opener holds throttle valve open)	Displayed value determined by monitoring signal voltage at IDL terminal of ECM. With CTP (IDL) switch contact closed, voltage is low, ON will be displayed on data stream.
OFF	OFF	ON	Displayed value determined by monitoring signal voltage at STA terminal opf ECM. When ignition is switched to START position, voltage goes high, ON will be displayed on data stream.
11.7% to 23.9%	N/A	N/A	Displayed value is calculated mathematically using the formula: actual air volume ÷ maximum possible air volume x 100%.
Increase in temperature EGR valve opens	N/A	N/A	Value is determined by comparing THG analog voltage signal to look-up table in Read Only Memory. Use active test to confirm operation.
0 mph/kph vehicle stopped	N/A	0 mph	Displayed value calculated by comparing the pulsed vehicle speed sensor signal to the ECM internal clock pulse.
Approximately same as underhood air temperature	Same as ambient air temperature, with cold engine	Same as ambient air temperature, with cold engine	Value is determined by comparing THA analog voltage signal to look-up table in Read Only Memory. Same as ambient and coolant temperature after 8 hour cold soak.
On when compressor is on	N/A	N/A	ON when compressor clutch is energized (voltage low at ECM). OFF when compressor cycles off due to low evaporator temperature.
ON with transmission in P or N, otherwise OFF	ON with transmission in P or N, otherwise OFF	N/A	ON when PNP switch is closed, voltage low at NSW terminal of ECM.
ON when taillight and/or rear window defogger relay is on	N/A	N/A	ON whenever taillight or rear window defogger relay(s) are energized, voltage high at ECM.
ON when brake pedal is depressed (stop light switch contacts closed)	N/A	N/A	ON when stop light switch closed, voltage high at STP terminal of ECM.

OBD II Data Parameters (continued)

Signal Category	Display Item	Parameter Description	Units of Measurement	Normal Condition (warm idle, accessories off)
Major Outputs	Ign Advance	Timing advance of cylinder #1	Degrees before top dead center	12° ± 5° BTDC
	Injector	Injection duration of cylinder #1	Milliseconds injection on time	2.2 to 5.7ms
	IAC Duty Ratio	Rotary solenoid intake air control valve duty ratio	% of time that voltage is high on the RSO (open) coil.	30% to 38%
Misfire Data	Misfire RPM	Engine Rpm when misfire code sets	Crankshaft revolutions per minute	With 0 misfires detected: 0 rpm
	Misfire Load	Engine load when misfire code sets	grams per engine revolution	With 0 misfires detected: 0 g/r
	Misfire Cyl #1 - 8	Misfire rate detected in each individual cylinder	Percentage per 1000 crankshaft revolutions	No misfires detected = 0%
	Ignition	Ignition events expected every 1000 crankshaft revolutions	Ignition events (6 cly = 0 to 3000, 4 cyl = 0 to 2000, 8 cyl = 0 to 4000)	0 to 3000 (6 cyl)
Other Outputs	FC IDL	Fuel cut with CTP (IDL) switch contacts closed, engine rpm above specified threshold	ON or OFF	OFF
	FC TAU	Fuel cut which takes place as result of light load deceleration (CTP switch contact open)	ON or OFF	OFF
	Intake Ctrl VSV	Status of ACIS VSV	ON or OFF	OFF
	EGR System	Status of EGR system	ON or OFF	OFF
	Fuel Pres Up VSV	Status of FPU VSV	ON or OFF	OFF (will be ON during and for short time after high temperature restart)
	A/C Idle Up VSV	Status of A/C Idle Up VSV	ON or OFF	OFF with A/C off, ON if A/C is on with compressor running
	A/C Cut Sig	Status of A/C cut signal from ECM to A/C control assembly	ON or OFF	ON with A/C switch off, OFF with A/C switched on

Normal Condition (warm, 2500 rpm, no load)	Ignition Switch On, Engine Not Running	Engine Cranking	Additional Information
N/A	N/A	N/A	Calculated by comparing relationship between crankshaft position sensor (Ne) and camshaft position sensor (G) signals. Gap on Ne timing rotor (36-2 tooth configuration) identifies #1 cylinder TDC. G signal identifies 90° BTDC, #1 cylinder compression.
N/A	N/A	Milliseconds injection on time	Determined by monitoring and displaying commanded injector driver duration for #1 cylinder. NOTE: injector may read normal pulse during failsafe fuel cut.
N/A	N/A	N/A	Duty ratio applied to RSO coil of Rotary Solenoid Idle Air Control Valve. Longer duty ratio (higher percent open time) = greater idle air by-pass volume = higher idle speed.
With 0 misfires detected: o mph	N/A	N/A	Freeze frame data stored when misfire is detected by OBD II software. This parameter represents engine rpm at the moment misfire code was set.
With 0 misfires detected: 0 g/r	N/A	N/A	Freeze frame data stored when misfire is detected by OBD II software. This parameter represents engine load at the moment misfire code was set.
No misfires detected = 0%	N/A	N/A	Percentage of misfire for each individual cylinder. Formula: Cylinder misfires + total ignition events per 1000 crankshaft revolution cycle (i.e 6 cyl engine experiences 300 misfires during 1000 crank revolutions, 300 + 3000 = 10% misfire rate).
0 to 3000 (6 cyl)	N/A	N/A	Ignition event counter used to determine the percentage of ignition misfire occurring. Counter resets every 1000 crankshaft revolutions. Vehicle must be in closed loop and a time requirement satisfied before counting begins.
OFF (will go ON with closed throttle above threshold rpm)	N/A	N/A	Signal will be ON when closed throttle deceleration is detected above specified rpm threshold.
OFF (will go ON during rapid deceleration with CTP [IDL] switch contacts open)	N/A	N/A	Signal will be ON when decel fuel cut is commanded by ECM with CTP switch open.
OFF (ON above specified throttle % and below specified rpm)	N/A	N/A	Display will indicate ON when ECM energizes VSV (Voltage low at ACIS terminal of ECM, ACIS air valve closes, high speed torque mode).
ON (within specified throttle, rpm and load range)	OFF	OFF	Display will indicate ON when ECM de-energizes VSV (voltage high at EGR terminal of ECM, vacuum allowed to pass to the modulator/EGR valve). When VSV is on, EGR system is off. NOTE: some systems may use reverse EGR VSV logic, consult repair manual.
OFF (will be ON during and for short time after high temperature restart)	N/A	ON (during high engine temp. cranking)	Display will indicate ON when ECM energizes VSV (voltage low at FPU terminal of ECM, vacuum bleed to fuel pressure regulator open to atmosphere, hot restart mode)
OFF with A/C off, ON if A/C is on with compressor running	N/A	N/A	Display will indicate ON when ECM energizes VSV (voltage low at ACV terminal of ECM, compressor clutch energized)
ON with A/C switch off, OFF with A/C switched on	N/A	N/A	With A/C switch on, display will indicate On when ECM pulls ACT terminal low (requests A/C compressor cut due to heavy load operation).

Appendix C

Data Definitions

Serial Data Interpretation

OBD II Data Stream (CARB) Parameter Definitions

FUEL SYS (#1 AND #2)

Air/fuel ratio feedback loop status displayed as either open or closed loop. Open indicates that ECM ignores feedback from the exhaust O2 sensor. Closed indicates final injection duration is corrected for O2 sensor feedback.

CALC LOAD

Engine load displayed as a percentage of maximum possible load. Value is calculated mathematically using the formula: actual air volume = maximum possible air volume x 100%.

COOLANT TEMP

Temperature of the engine coolant displayed in degrees Fahrenheit or Celsius. Value determined by comparing the THW voltage signal to corresponding temperatures in a look-up table.

SHORT FT (#1 and #2)

A/F Ratio feedback correction value (for cylinder banks #1 and #2 respectively.) Displayed as the percentage of rich or lean correction being applied to corrected injection duration. Short fuel trim is based on rapidly switching exhaust O2 sensor values.

A positive value indicates fuel delivery is being increased to correct for a lean A/F Ratio. A negative value indicates fuel delivery is being decreased to correct for a rich A/F Ratio. Maximum possible short correction is ± 20% of basic injection duration.

LONG FT (#1 AND #2)

Learned value (adaptive memory) correction to A/F Ratio feedback control system. Displayed as a percentage of rich or lean correction applied to basic injection duration calculation. For example:

Case #1 LONG FT = 0%

MAF = 5.0 grams/sec

ENGINE SPD = 1500 rpm

INJECTOR = 4.0 ms

Case #2 LONG FT = 10%

MAF = 5.0 grams/sec

ENGINE SPD = 1500 rpm

INJECTOR = 4.4 ms

A positive value indicates a rich correction due to an extended period of lean exhaust indication. A negative value indicates a lean correction due to an extended period of rich exhaust indication.

Long fuel trim compensates for changes in engine operating conditions like fuel pressure, air leaks, injection spray pattern, changes in fuel properties, and etc. Maximum long fuel correction is 20% to 30% plus or minus basic injection duration. Changes in long fuel trim occur very slowly only after short fuel trim corrections fail to bring air/fuel ratio back to neutral value.

ENGINE SPD

Engine revolutions per minute calculated by comparing the NE signal with the ECM internal clock.

VEHICLE SPD

Vehicle road speed displayed in miles or kilometers per hour. Calculated by comparing the pulsed vehicle speed sensor signal with the ECM internal clock.

IGN ADVANCE

Ignition spark advance angle referenced to #1 cylinder Top Dead Center. Calculated by comparing the relationship between the crankshaft position sensor (NE) and camshaft position sensor (G) signals. The two missing teeth on the (NE) timing rotor (36 minus 2 tooth configuration) identify #1 cylinder TDC. The (G) signal identifies the approach of #1 cylinder compression stroke, occurring at 90° BTDC.

INTAKE AIR

Temperature of air entering the intake manifold, displayed in degrees Fahrenheit or Celsius. Value determined by comparing the THA voltage signal to corresponding temperatures in a look-up table.

MAF

Total mass of air entering the intake manifold, represented in grams per second. This signal is determined by comparing the analog voltage signal from the VG terminal of the MAF sensor to a corresponding value in a lookup table.

THROTTLE POS

Position of the throttle valve displayed as a percentage of fully open. Value is determined by comparing VTA voltage to corresponding value in a look-up table. Normal throttle opening ranges from about 8% at normal curb idle to 80% at wide open throttle. Each .5V = 10% throttle opening.

02S (B1, S1 and B1, S2)

Signal voltage (in millivolts) for the main and sub O2 sensors respectively, located in Bank 1. High concentration of oxygen in exhaust (lean condition) causes signal voltage to go low (less than 400 mv), low concentration of oxygen in exhaust causes signal voltage to go high (greater than 600 mv).

02FT (B1, S1 and B2, Sl)

The short term fuel trim correction taking place based upon the value of the main O2 sensor located in cylinder banks 1 and 2 respectively. This value is expressed as the percentage of correction to basic injection duration. It should closely follow SHORT FT.

Positive percentage means injection is increased to correct for a lean A/F Ratio. Negative percentage indicates injection is decreased to correct for a rich A/F Ratio.

MISFIRE RPM

Freeze frame data stored when misfire is detected by OBD II software. This parameter represents the engine rpm at the moment that misfire code was set.

OBD II Data Stream (Enhanced) Paramater Definitions

MISFIRE LOAD

Load at which misfire code was set, measured in grams per revolution.

INJECTOR

Calculated time in milliseconds that fuel injector is open, delivering fuel.

IAC DUTY RATIO

Duty ratio signal applied to the Rotary Solenoid Idle Air Control Valve displayed as the percentage of time that voltage is high on the RSO (open) coil. The longer the duty ratio (higher percent open time), the greater the air by-pass volume, the higher the idle speed.

STARTER SIG

ON/OFF status of the STA signal at the ECM. Signal will be ON whenever the ignition switch is in the START position (voltage high at ECM).

CTP SW

ON/OFF status of IDL contact. Signal will be ON whenever the throttle is fully closed and the IDL switch contact is closed (voltage low at ECM).

A/C SIG

ON/OFF status of the A/C magnetic clutch input to the ECM. Signal will be ON anytime the air conditioning compressor clutch is energized (voltage low at ECM). Signal will cycle OFF whenever compressor cycles off due to low evaporator temperature.

PNP SW

(A/T only) ON/OFF status of the neutral safety switch input to the ECM. Signal will be ON whenever the automatic transmission is in the neutral or park gear positions (voltage low at ECM).

ELECTRICAL LOAD SIG

ON/OFF status of the ELS input signal to the ECM. Signal will be ON whenever the tail light or rear window defogger relays are energized (voltage high at ECM).

STOP LIGHT SW

ON/OFF status of the STP signal input to the ECM. Signal will be ON whenever the brake pedal is depressed (stop light switch closed, high voltage at ECM).

FC IDL

ON/OFF status of the IDL fuel cut program in the ECM. Signal will be ON whenever deceleration fuel cut is commanded as a result of closed IDL contact with engine rpm above fuel cut speed.

FC TAU

ON/OFF status of the deceleration enleanment program in the ECM. Signal will be ON whenever deceleration enleanment is commanded as a result of rapid deceleration taking place with the IDL switch contact open.

(MISFIRE) CYL #1 - 8

Percentage of time each individual cylinder is detected misfiring during a specified ignition event detection cycle (see IGNITION). For example, cylinder #2 is detected misfiring 1500 times during a 3000 event detection cycle. MISFIRE CYL#2 will read 50%.

Maximum possible misfire per cylinder is 100%.

IGNITION

Ignition event counter, which is used to determine the percentage of ignition, misfire occurring. This counter resets every 3000 ignition cycles on a 6 cylinder engine, every 2000 ignition cycles on a 4 cylinder engine, and every 4000 ignition cycles on an 8 cylinder engine.

EGRT GAS

Temperature of exhaust gas (in degrees Fahrenheit or Celsius) passing into the intake manifold through the EGR valve (measured on the intake side of the valve.) Value is determined by comparing the THG voltage signal to corresponding temperatures in a look-up table.

INTAKE CTRL VSV

ON/OFF status of the ACIS VSV, which controls the vacuum supply to the ACIS, vacuum actuator. Signal will be ON whenever the VSV is energized (voltage low at ECM) and vacuum is being passed to the ACIS actuator.

EGR SYSTEM

ON/OFF status of the EGR system. Signal will indicate ON whenever EGR system is operating and will indicate OFF whenever VSV is energized preventing/bleeding vacuum flow to EGR valve and modulator. When VSV is energized, EGR system is off' and when VSV is de-energized, EGR system is on.

FUEL PRES UP VSV

ON/OFF status of the FPU VSV which controls the vacuum bleed in the manifold vacuum line to the fuel pressure regulator. Signal will be ON whenever the VSV is energized, bleeding atmosphere into the fuel pressure regulator vacuum chamber.

A/C CUT SIG

ON/OFF status of A/C cutoff (ACT) signal from ECM to A/C amplifier. Signal is ON (low voltage at ECM) whenever A/C compressor cut is requested as a result of wide open throttle operation.

A/C IDLE UP VSV

ON/OFF status of A/C idle up VSV which controls the A/C idle up air by-pass. Signal is ON whenever (low voltage at ECM) whenever the A/C magnetic clutch is energized.

TOTAL FT (B1 and B2)

Total fuel trim correction to injectors feeding cylinder banks 1 and 2 respectively. Nominal value is 1.00. Values less than 1.00 indicate reduction in fuel injection duration to correct for overall rich condition. Values greater than 1.00 indicate increase in fuel injection duration to correct for overall lean condition. This number remains fairly stable.

02 L→R (B1, S1 and B2, S1)

O2 sensor switch time from lean to rich, displayed in milliseconds. Affected by the age and condition of the O2 sensor.

02 R→L (B1, S1 and B2, S1)

O2 sensor switch time from rich to lean, displayed in milliseconds. Affected by the age and condition of the O2 sensor.

Certain types of 02S contamination or degradation effect the switching time more significantly from rich to lean (or vise versa).

OBD Data Stream Parameter Definitions

INJECTOR

Calculated injection time in milliseconds. Time that fuel injector is open, delivering fuel.

IGNITION

Ignition spark advance angle in addition to base timing (determined by distributor position) referenced to #1 cylinder Top Dead Center. Calculated by comparing the relationship between the NE and G signals.

ISC STEP #

Commanded position of the idle air control pintle valve. Value represents valve position relative to the fully closed position. 125 steps indicate valve is fully retracted (maximum by-pass air). Zero steps indicate fully closed or seated valve position.

ECM will command step position changes until actual engine speed is within 50 rpm of target idle speed. Therefore, if the valve is mechanically incapable of moving, commanded valve position will continue to change until zero or 125 steps is reached.

ENGINE SPD

Engine revolutions per minute calculated by comparing the NE signal with the ECM internal clock.

AIRFLOW (Karman)

Volume of air entering the intake manifold (measured with the Karman vortex air flow meter). The Karman sensor generates a variable frequency signal, which increases as intake air volume increases. Signal value is expressed in milliseconds; the time between these frequency pulses. As signal frequency increases, the time between signals decreases. Signal time is calculated by comparing the pulse train generated by the sensor to the clock in the ECM.

AIRFLOW (VAF[VS])

Volume of air entering the intake manifold (measured with the Volume Air Flow meter). Airflow meter voltage signal is converted from analog to digital for use by the ECM then changed back to an analog voltage for display on the serial data stream. On OBD equipped vehicles, signal voltage decreases as intake air volume increases.

INTAKE MAN

Manifold Absolute Pressure, displayed as pressure in mmHg (millimeters of mercury), in. Hg, or Kilopascals. Signal value is determined by comparing the PIM voltage signal to corresponding pressures in a look-up table. As load is applied to the engine, manifold pressure increases (approaching atmospheric pressure.)

COOLANT

Temperature of the engine coolant displayed in degrees Fahrenheit or Celsius. Value determined by comparing the THW voltage signal to corresponding temperatures in a look-up table.

THROTTLE

Position of the throttle valve displayed in degrees of throttle angle opening. Some OBD applications display this value in steps, skipping several degrees between each position update. Value is determined by comparing VTA voltage to corresponding value in a look-up table. Typical signal range is between 0° at closed throttle, 70° to 80° at wide open throttle.

VEHICLE SPD

Vehicle road speed displayed in miles or kilometers per hour. Calculated by comparing the pulsed vehicle speed sensor signal with the ECM internal clock.

TARGET A/F (L AND R)

Learned value (adaptive memory) correction to A/F Ratio feedback control system (based on left and right main O2 sensors respectively). Displayed as a zero to five volt signal, which changes in 1.25 volt steps. Neutral value (no feedback correction) is displayed as 2.50V. Voltage lower than neutral indicates fuel delivery is being decreased to correct for a rich A/F Ratio. Voltage higher than neutral indicates fuel delivery is being increased to correct for a lean A/F Ratio.

Learned value correction is similar to OBD II LONG FT, maximum possible correction is ± 20% of basic injection duration. For example:

Case #1 TARGET A/F = 2.50V

VAF = 2.7V

ENGINE SPD = 800 rpm

INJECTOR = 4.0 ms

Case #2 TARGET A/F = 5.0V

VAF = 2.7V

ENGINE SPD = 800 rpm

INJECTOR = 4.8 ms

A/F FB (L ,AND R)

The same as OBD II FUEL SYS. A/F Ratio feedback loop status (for left and right cylinder banks respectively), displayed as either OFF (open loop) or ON (closed loop.) Open loop indicates that the ECM ignores feedback from the exhaust O2 sensor and relies on other major sensors to determine final injection pulse width (i.e. intake air volume or mass, engine rpm, and coolant temperature.) When in closed loop, Ox SIGNAL values should be constantly variable.

KNOCK RETARD

ON/OFF status of knock retard system operation. Indicates ON whenever detonation is sensed and knock retard is being commanded.

Ks

Volume of air entering the intake manifold (measured with the Karman vortex air flow meter). The Karman sensor generates a variable frequency signal which increases as intake air volume increases. Signal value is expressed in milliseconds; the time between these frequency pulses. As signal frequency increases, the time between signals decreases. Signal time is calculated by comparing the pulse train generated by the sensor to the clock in the ECM.

#10

Calculated injection time in milliseconds. Time that fuel injector is open, delivering fuel.

Vs

Volume of air entering the intake manifold (measured with the Volume Air Flow meter). Air flow meter analog voltage signal is tapped directly from the Vs signal wire at the ECM.

OX(L/R)

Main exhaust O2 sensor signal, displayed as either RICH or LEAN. High concentration of oxygen in exhaust (lean condition) causes signal display to go LEAN (less than 400 mv sensor signal voltage). Low concentration of oxygen in exhaust causes signal to go RICH (greater than 600 mv sensor voltage).

OXS

Sub-O2 sensor signal, displayed as either RICH or LEAN. High concentration of oxygen in exhaust (lean condition) causes signal display to go LEAN (less than 400 mv sensor signal voltage). Low concentration of oxygen in exhaust causes signal to go RICH (greater than 600 mv sensor voltage).

THW

Temperature of the engine coolant displayed in degrees fahrenheit or celsius. Value determined by comparing the THW voltage signal to corresponding temperatures in a **look-up table**.

THA

Temperature of the intake air displayed in degrees fahrenheit or celsius. Value determined by comparing the THA voltage signal to corresponding temperatures in a **look-up table.**

VTA

Position of the throttle valve displayed in degrees of throttle angle opening. Value is determined by comparing VTA voltage to corresponding value in a look-up table. Typical signal range is between 0° at closed throttle, 70° to 80° at wide-open throttle.

IDL

ON/OFF status of IDL contact. Signal will be ON whenever the throttle is fully closed and the IDL switch contact is closed (voltage low at ECM).

IGF

Ignition fail signal displayed in revolutions per minute. Calculated by comparing IGF voltage pulses to fixed clock pulse.

SPl

Vehicle road speed displayed in miles or kilometers per hour. Calculated by comparing the pulsed vehicle speed sensor signal a fixed clock pulse.

NSW

(A/T only) ON/OFF status of the neutral safety switch input to the ECM. Signal will be ON whenever the automatic transmission is in the neutral or park gear positions (voltage low at ECM).

A/C

On applications with ACMG, this is the request signal from the A/C control assembly, which informs the ECM that magnetic clutch, should be energized.

On applications where A/C magnetic clutch is controlled by the A/C amplifier, this signal informs the ECM that the magnetic clutch is energized.

STA SIGNAL

Same as OBD II STARTER SIG. ON/OFF status of the STA signal at the ECM. Signal will be ON whenever the ignition switch is in the START position (voltage high at ECM).

IDL SIGNAL

Same as OBD II CTP SW. ON/OFF status of IDL contact. Signal will be ON whenever the throttle is fully closed and the IDL switch contact is closed (voltage low at ECM).

A/C SIGNAL

Same as OBD II A/C SIG. ON/OFF status of the A/C magnetic clutch input to the ECM. Signal will be ON anytime the air conditioning compressor clutch is energized (voltage low at ECM). Signal will cycle OFF whenever compressor cycles off due to low evaporator temperature.

NSW SIGNAL

Same as OBD II NEUTRAL SAFETY (PNP) SW. (A/T only) ON/OFF status of the neutral safety switch input to the ECM. Signal will be ON whenever the automatic transmission is in the neutral or park gear positions (voltage low at ECM).

Ox (L AND R) SIGNAL

Similar to OBD II 02S Exhaust O2 sensor signal displayed as either RICH or LEAN. High concentration of oxygen in exhaust (lean condition) causes signal display to go LEAN (less than 400 my sensor signal voltage). Low concentration of oxygen in exhaust causes signal to go RICH (greater than 600 my sensor voltage).

V-BoB Data Stream Preselected Parameter Definitions

NE

Engine revolutions per minute calculated by comparing the NE signal with a fixed clock pulse.

ACMG

ON/OFF status of the A/C magnetic clutch control by the ECM. Signal will be ON anytime the air conditioning compressor clutch is energized (voltage low at ECM). Signal will cycle OFF whenever the ECM cycles the compressor off.

FPU

ON/OFF status of the Fuel Pressure Up VSV. Signal is on when the VSV is energized (voltage low at ECM). When energized the FPU VSV bleeds atmosphere into the fuel pressure regulator vacuum chamber for hot engine restarts.

STA

ON/OFF status of the STA signal at the ECM. Signal will be ON whenever the ignition switch is in the START position (voltage high at ECM).

STJ

ON/OFF status of the STJ cold start injector driver circuit in the ECM. Signal will be ON during cranking whenever engine coolant temperature is below a specified threshold.

B

Battery voltage sensed at +B and +B1 terminals of the ECM. Battery voltage will be present anytime the EFl main relay power contacts are closed (when ignition switch is on).

VC

Voltage constant 5V sensor circuit reference voltage. Will be approximately 5V whenever the ignition is on.

E01

Ground circuit for fuel injectors. Should be less than 100 millivolts with the engine running.

E2

Ground circuit for ECS system sensors. Should be less than 100 millivolts with the engine running.

Technical Reference & Specifications

Diagnostic Tester

Fig. D-1

TL874fD01

DIAGNOSTIC REFERENCE INFORMATION

Vane Air Flow Meter (Vs)

Circuit Description

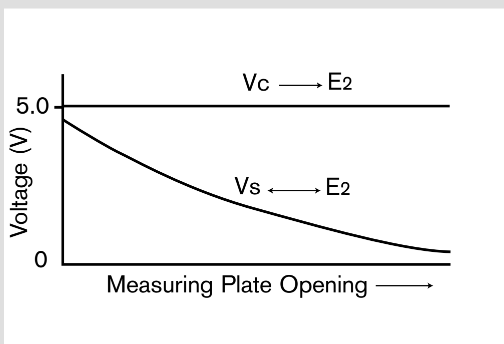
The vane air flow meter is located in the intake air duct between the air cleaner housing and the engine throttle body. It provides the ECM information on the amount of load placed on the engine by directly measuring intake air volume.

During engine operation, intake air flow reacts against the meter's measuring plate, which causes it to deflect in proportion to the volume of air flow. This movement is transferred through a shaft to a movable arm on the meter's potentiometer (variable resistor). The Vs signal to ECM varies according to the potentiometer's position.

The vane air flow meter also houses the intake air temperature sensor and a fuel pump switch. The fuel pump switch is used to maintain fuel pump operation after start-up (when sufficient air flow exists to open the measuring plate).

Vane Air Flow Meter

The Vs signal represents the amount of load placed on the engine. The potentiometer provides a variable voltage signal back to the Vs terminal of the ECM.



As shown in the graph, Vs signal voltage decreases with higher air flow (larger measuring plate opening). The Vc - E2 line represents the 5V reference source.

NOTE: The 22R-E and 4A-GE engines use an air flow meter with opposite voltage logic.

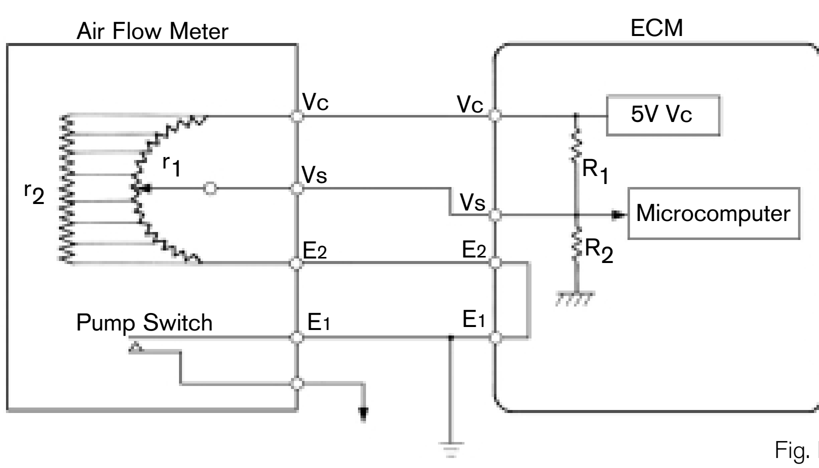


Fig. D-2

TL874fD02

Troubleshooting Hints

- The air flow meter is provided a regulated 5V reference at Vc terminal.
- As indicated in the graph, the voltage reading at Vs terminal with Ignition ON, Engine OFF should be between 3.7V - 4.3V.
- Once the engine is started, Vs signal voltage should decrease to indicate initial measuring plate opening.
- The r_2 resistor (which is connected in parallel to the r_1) allows the meter to continue to provide a Vs signal in the event an open occurs in the main potentiometer (r_1).
- The R_1 and R_2 resistors provide the ECM with self-diagnostic capabilities and also provides a fail-safe voltage in the event of an open circuit.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	Vs Circuit	Open or Short (Vc) in Air Flow Meter Circuit for Specified Time
32	Vs Circuit	Open or Short (Vc – Vs) in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	Vs	volts	2.5V ± 0.5V[1]
OBD II	————	————	————
V-BoB	Vs	volts	2.5V ± 0.5V[1]

1. 3VZ-FE = 2.8V ± 0.6V

DIAGNOSTIC REFERENCE INFORMATION

Karman Vortex Air Flow Meter (Ks)

Circuit Description

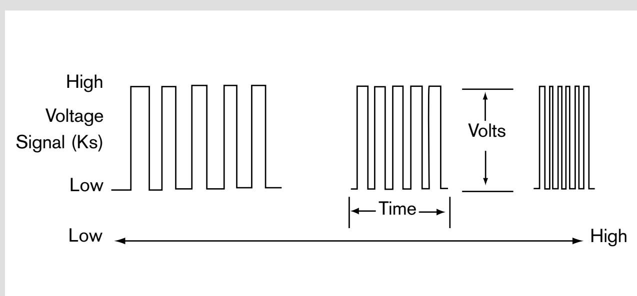
Like the vane air flow meter, the Karman Vortex Air Flow Meter is located between the air cleaner housing and the engine's throttle body. It also provides the ECM with the same type of information; an intake air volume signal that is used to determine the amount of load placed on the engine.

The operation of the Karman Vortex Air Flow Meter differs from that of the vane type. During engine operation, a swirling effect is created in the intake air stream when it reacts against the meter's vortex generator. A sample of this pulsating air is then applied to a movable metal foil mirror, which causes it to flutter. The oscillating mirror causes light from the photo coupler's LED to be alternately applied and diverted from a phototransistor.

As a result, the phototransistor rapidly switches the 5V Ks signal to the ECM. As shown in the diagram, the frequency of the Ks signal increases proportionally with intake air flow.

Karman Vortex Air Flow Meter

Inside the Karman Vortex air flow meter, intake airflow oscillates a movable mirror which turns a light sensitive photo transistor on and off.



As shown in the diagram, the Ks diagram, the Ks 5V square wave signal increases in frequency with higher intake air volume.

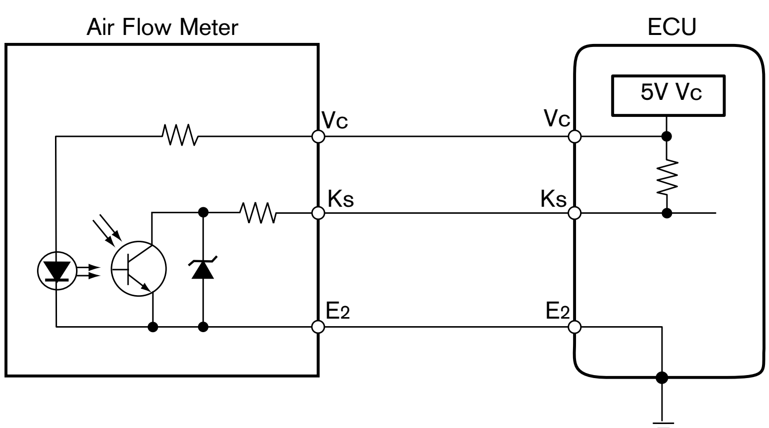


Fig. D-3

TL874fD03

Troubleshooting Hints

- Remember a 5V signal operating at a 50% duty cycle will read approximately 2.5V. Since Ks operates at approximately 50% duty cycle during engine operation, Ks signal voltage will provide little useful information during diagnosis.

- Ks signal frequency changes dramatically with engine load changes. For this reason, observing Ks frequency changes would provide the most useful diagnostic information. Accurate Ks signal inspection requires using an oscilloscope or high quality digital multimeter with frequency capabilities (non-OBD vehicles).

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	Ks Circuit	Open or Short in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	Ks	ms	40ms ± 15ms
OBD II	————	————	————
V-BoB	Ks	ms	40ms ± 15ms

DIAGNOSTIC REFERENCE INFORMATION

Mass (Hot-Wire) Air Flow Meter (VG)

Circuit Description

The Mass Air Flow Meter provides some distinct advantages over the "volume" type air flow meters. Since this type of air flow meter directly measures air mass (and not just volume), any factor affecting the density of the intake air will influence the output signal. These factors include air temperature, humidity and altitude.

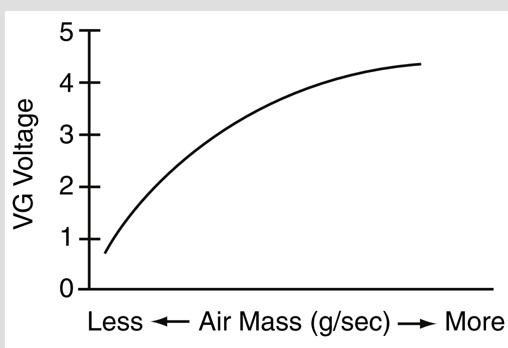
This type of Mass Air Flow Meter uses a "hot wire" and thermistor placed in a path of sample intake air flow. It operates on the theory that the hot wire is cooled by incoming air mass, in proportion to air flow. The circuit is the hot wire and incoming air flow by regulating bot wire current flow with the power transistor.

The circuit operates as a "feedback" system to equalize the electrical potential between points A and B. If a difference exists, the operational amplifier varies the output of the power transistor to rebalance the circuit. In this way, a variable DC voltage signal is output to the VG terminal of the ECM.

Mass Air Flow Meter

The Mass Air Flow Meter signal takes into account any factor affecting air mass or density, such as: air temperature, humidity and altitude.

Incoming air cools the "hot wire," lowering its resistance value and increasing output voltage at point B (VG signal).



As shown in the graph, VG signal voltage increases with higher intake air mass. The ECM interprets higher VG voltage as increased load placed on the engine, increasing injection quality and retarding spark.

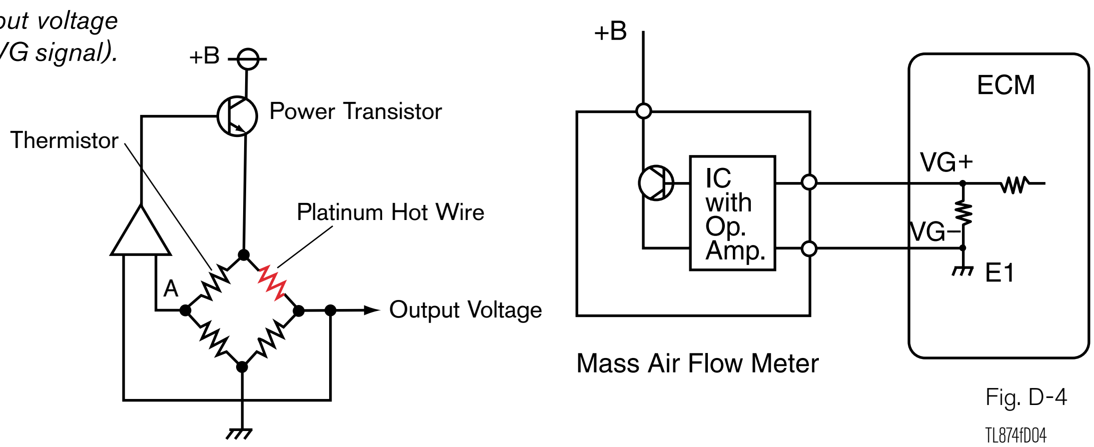


Fig. D-4

TL874fD04

Troubleshooting Hints

- Unlike volume airflow meters, this hot-wire mass air flow meter uses battery voltage (+B) rather than the 5V-reference voltage source VC.

- A VG signal check may be performed with Ignition ON, Engine OFF: While blowing towards the hot wire, observe the VG signal changes.

- **On OBD II vehicles** the following diagnostic rule applies:

  - a MAF reading of **0 gm/sec** would indicate an open in +B circuit or open or short in VG circuit.

  - a MAF reading of **271 gm/sec or more** would indicate an open in VG- (ground) circuit.

OBD Diagnostic Trouble Codes

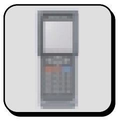
DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
31	VG Circuit	Open or Short in Air Flow Meter Circuit for Specified Time

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Air Flow Meter Circuit	Air Flow Meter Circuit Malfunction
P0101	Air Flow Meter Circuit	Air Flow Meter Circuit Range/Performance Problem

Typical Serial Data

Data Source	Name	Units	Warm Idle
OBD	VG	gm/sec	3.8 ± 1.2 gm/sec
OBD II	VG	gm/sec	3.8 ± 1.2 gm/sec
V-BoB	VG	volts	0.7V to 1.7V



DIAGNOSTIC REFERENCE INFORMATION

Engine Coolant Temperature Sensor Circuit (ECT)

Circuit Description

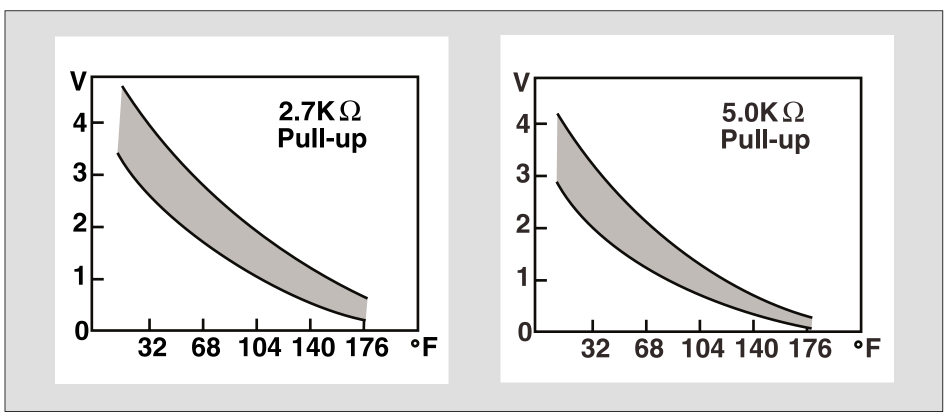
The Engine Coolant Temperature sensor circuit is used to monitor engine temperature, supplying the ECM with important information to determine fuel enrichment, spark angle, idle speed control, and emissions control system status.

The sensor, which is typically located near the thermostat housing, is a negative temperature coefficient (NTC) thermistor. Sensor resistance falls as the temperature rises. The sensor is connected in series with a pull-up resistor in the ECM, which acts as a voltage divider. As resistance of the sensor falls with increasing coolant temperatures, the voltage drop across the sensor also falls. The sensor circuit, therefore, generates an analog voltage signal, which varies inversely with the temperature of the engine coolant.

Pull-up resistor R_1 can have a resistance value of either 2.7KΩ or 5KΩ depending on engine application The chart below shows the normal signal voltage characteristics for both resistance values.

Engine Coolant Temperature Sensor Circuit

The Engine Coolant Temperature sensor monitors engine temperature by use of a voltage divider circuit. The pull-up resistor in the ECM is fixed value while the resistance of the sensor thermistor varies inversely with coolant temperature.



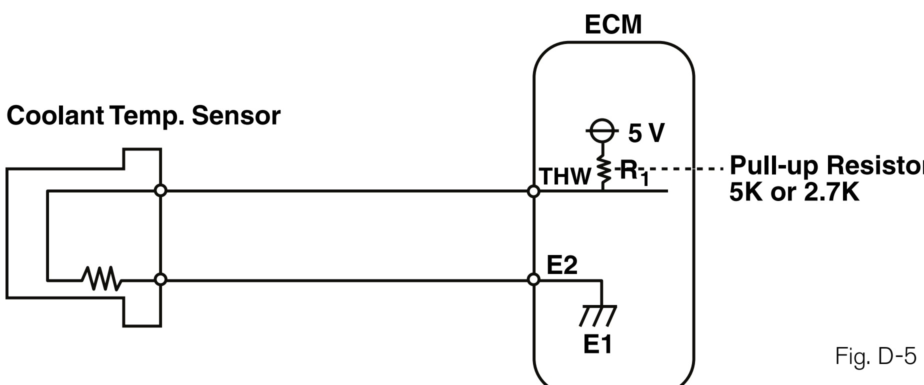


Fig. D-5

TL874fD05

Troubleshooting Hints

- The Engine Coolant Temperature sensor signal is represented on a Diagnostic Tester in °F or °C temperature units. When using the Vehicle Break-out Box (V-BoB), coolant temperature can be displayed either in temperature units or as a voltage (by toggling the F7 key.)

- Engine Coolant Temperature sensor information is replaced by a failsafe value whenever the ECM detects a fault in the circuit. When troubleshooting with a Diagnostic Tester, using the OBD data stream, failsafe value is displayed rather than actual value.

- To quick check circuit integrity using the OBD data stream, install a 1.2KW resistor across the ECT sensor harness terminals. If temperature displayed on Diagnostic Tester reads between approximately 35°C (95°F) to 43°C (110°F), the electrical circuit is good.

- To quick check circuit integrity using OBD II or V-BoB data stream:

  - Disconnect sensor harness: displayed temperature should go to approximately -40°C (-40°F) (5V)

  - Short sensor harness THW to E2: displayed temperature should go to approximately 120°C (248°F) (0V)

OBD Diagnostic Trouble Codes

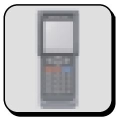
DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
22	Engine Coolant Temperature Sensor Circuit	Detects an open or short circuit in the Engine Coolant Temperature circuit for more than a specified amount of time.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0115	Engine Coolant Temp. Circuit Malfuntion	Detects an open or short circuit in the Engine Coolant Temperature circuit for more than a specified amount of time.
P0116	Engine Coolant Temp. Circuit Range Problem	Detects sensor range or performance problem by monitoring the time it takes for sensor signal to reach and exceed a specified minimum temperature.

Typical Serial Data

Data Source	Name	Units	Warm Idle	THW shorted to E2	Circuit Open
OBD	ECT	°F or °C	85°C to 104°C (185°F) to (220°F)	80°C (176°F)	80°C (176°F)
OBD II	COOLANT TEMP.	°F or °C	85°C to 104°C (185°F) to (220°F)	120°C (248°F)	-40°C (-40°F)
V-BoB	THW	°F or °C or volts	85°C to 104°C (185°F) to (220°F) 0.1V to 0.5V	120°C (248°F) or 0V	-40°C (-40°F) or 5V



DIAGNOSTIC REFERENCE INFORMATION

Throttle Position (TP) and Closed Throttle Position (CTP) Sensor Circuit

Circuit Description

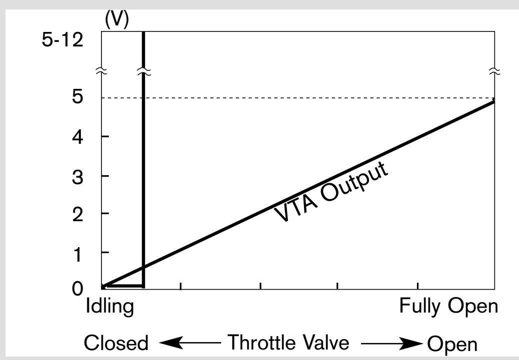
The Throttle Position sensor is attached to the throttle body. It monitors throttle valve opening angle and closed throttle status.

The sensor generates an analog voltage signal, which varies in proportion to throttle opening, from low to high as the throttle is opened. The TP sensor also includes a digital idle contact switch, which is closed at idle and opens as the throttle is tipped open. Signal characteristics are represented by the graph shown below.

Information from the this sensor is used by the ECM to make judgments about power enrichment, deceleration fuel cut, idle air control, spark advance angle corrections, and the status of emissions control sub-systems.

Throttle and Closed Throttle Position Sensor Circuit

Throttle position sensor uses a potentiometer and simple switch contact to monitor throttle angle and closed throttle status.



TP signal can be easily measured with a voltmeter or a scan tool. The voltage signal moves from low to high as the throttle opens. The CTP signal is low at idle and goes high when the throttle is opened.

Scan data is displayed in degrees throttle valve angle or in percentage of opening.

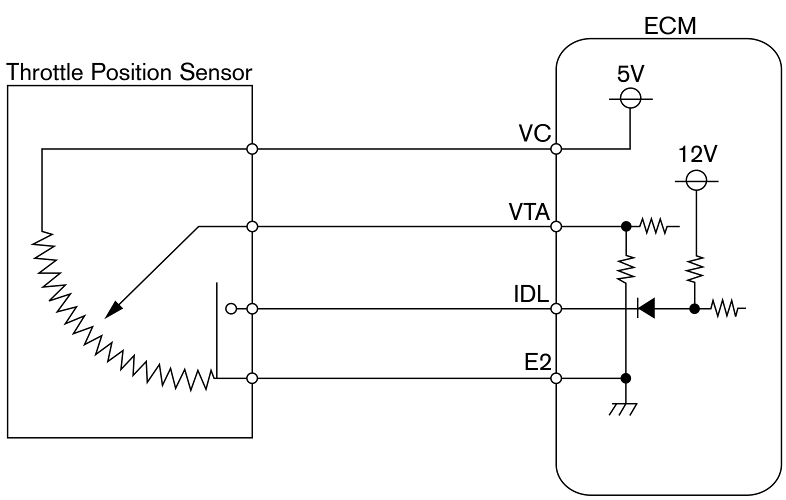


Fig. D-6

TL874fD06

Troubleshooting Hints

- Throttle Position sensor signal is represented differently on OBD and OBD II data streams. OBD displays opening angle in degrees ranging from 0° to 75°. OBD II displays throttle opening as a percentage of wide-open throttle, ranging from about 5% to 80%.

- On V-BoB, TP sensor signal is represented in degrees opening angle or as an analog voltage (by toggling the F7 key).

- Throttle angle scan data defaults to a failsafe value when a fault is detected in the TP sensor circuit. Depending on application, throttle angle will go to either 30° or 0° when a fault is detected, as long as the CTP switch remains open. When the CTP switch closes, the signal defaults to 0° and remains there. If the fault is intermittent, the TP signal will return to normal only after the vehicle speed sensor indicates 0 mph.

- To quick check the circuit using a Diagnostic Tester, observe serial data while depressing the accelerator pedal to wide open. Signal should increase to near maximum. For intermittent problems, use V-BoB data or oscilloscope.

- Code 51 for CTP switch contact will only set when an open circuit fault is detected. Shorted CTP will cause fuel cut to occur above fuel cut rpm threshold.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
41	Throttle Position Sensor Circuit	Open or short detected in the VTA line to ECM for more than a specified amount of time. (NOTE: disconnected sensor will not set code 41)
51	Switch Condition Signal	Open detected in Closed Throttle Position switch circuit (NOTE: Only displays when TE1 is grounded [code display mode]. Will also display if PNP signal indicates trans in gear or if A/C input is ON. Code does not store in memory.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0100	Throttle Position Sensor Circuit	Open detected in circuit (VTA lower than specified with CTP switch open) Short detected in circuit (VTA higher than specified voltage)
P0121	Throttle Position Sensor Signal Range Problem	With CTP switch closed, VTA is greater than specified voltage

Typical Serial Data

Data Source	Name	Units	Key ON/Wide Open Throttle	Warm Idle
OBD	Throttle	° Open	> 70°	0°
OBD II	Throttle POS	% Open	≈65% to 75%	7% to 11%
V-BoB	VTA	° Open or volts	>70° or 3.5V to 4.8V	0° or 0.2V to 0.8V

DIAGNOSTIC REFERENCE INFORMATION

Power Distribution Circuit

Circuit Description

The power distribution circuit consists of a Main Relay, the ignition switch, the ECM, and related wiring. There are basically two different types of power distribution circuits, ECM controlled and ignition switch controlled.

ECM controlled power distribution is used on applications with a Step Motor IAC system. All other applications use the ignition switch controlled system. In both cases, the power distribution electrical wiring carries electrical current from the battery, through the Main Relay, through the ECM, and back to the battery through the E1 ground.

Power Distribution Circuit

With Step Motor IACV
When the ignition switch is in the Start or Run position, current flows to the ECM IGSW terminal, signaling the ECM to turn on the MREL circuit. The ECM sends current through the MREL circuit and Main Relay pull-in winding, to ground. This closes the power contact, causing current to flow to the ECM +B terminals.

Without Step Motor IACV
When the Ignition switch is in the Start or Run position, current flows through the main relay pull-in winding, to ground, causing the power contact to close. This causes current to flow through the power contact to the ECM +B terminals.

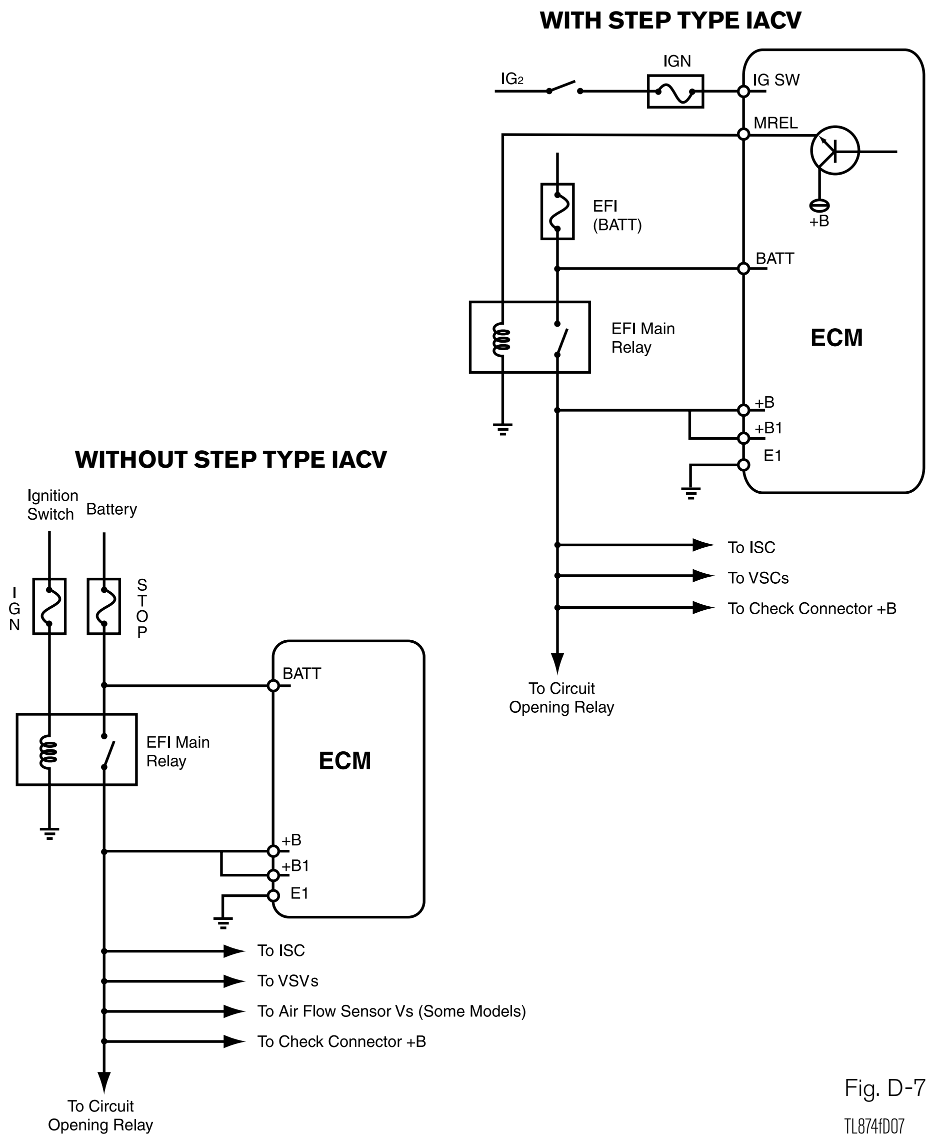


Fig. D-7

TL874fD07

DIAGNOSTIC REFERENCE INFORMATION
Fuel Pump Control Circuit

Circuit Description

Fuel pump control methods differ between models that use a vane air flow meter and those that do not. On models using a vane air flow meter, a fuel pump switch located inside the meter is used to maintain fuel pump operation once the engine has started. During cranking, the STA signal commands the circuit opening relay to provide power to the fuel pump. After start-up, intake air flow opens the air flow meter's measuring plate closing the fuel pump switch. As a result, the circuit opening relay will maintain fuel pump operation after the engine has started.

On other systems, the circuit opening relay still operates the fuel pump from the STA command during cranking; however after the engine has started, the ECM must switch on the Fc circuit to continue pump operation. On this type of system, the ECM must continue to see an engine speed signal (NE) in order to continue operating the fuel pump after the engine has started.

Fuel Pump Control Circuit

During cranking, the circuit opening relay powers the fuel pump based on the STA signal command.

After start-up fuel control differs in that systems using a vane air flow meter use a fuel pump switch to maintain pump operation. All others use ECM control of the Fc signal to maintain fuel pump operation.

Terminal / Condition	+B	Fc	Fp
Cranking	12V	–	12V
Engine Running	12V	< 1V	12V

As shown in the chart, Fc control voltage is pulled low (grounded) by either the fuel pump switch (when intake air flow is sufficient) or the ECM (when Ne signal is above a specified rpm) to keep the fuel pump operating after start-up.

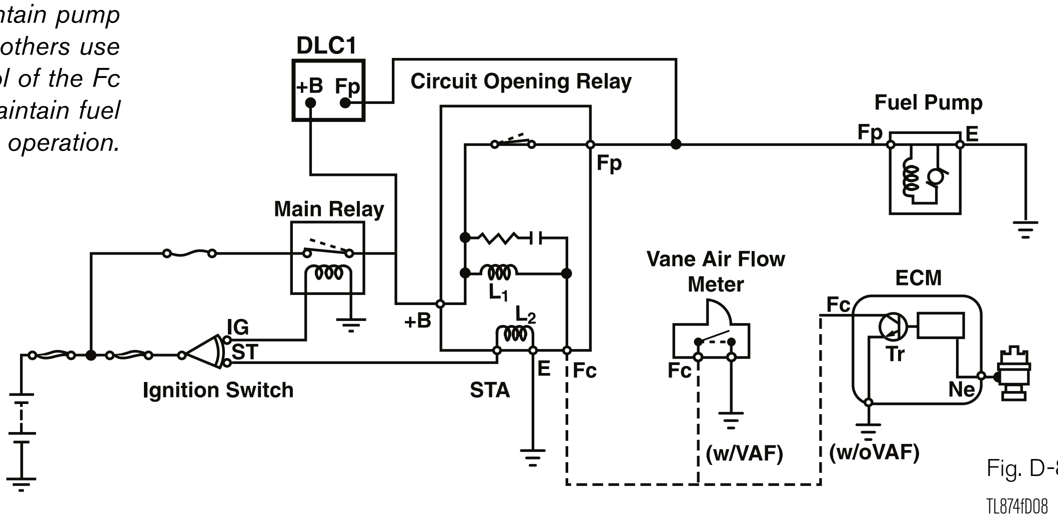


Fig. D-8

TL874fD08

DIAGNOSTIC REFERENCE INFORMATION
Injector Drive Circuit

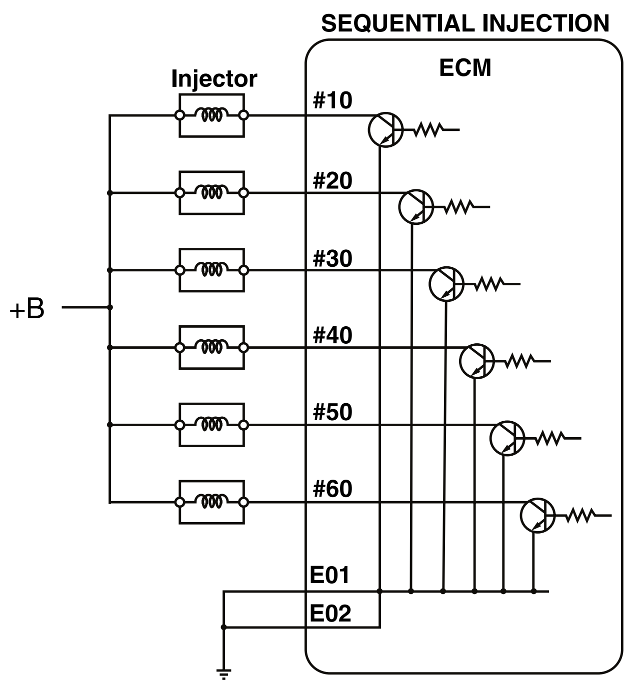
Circuit Description

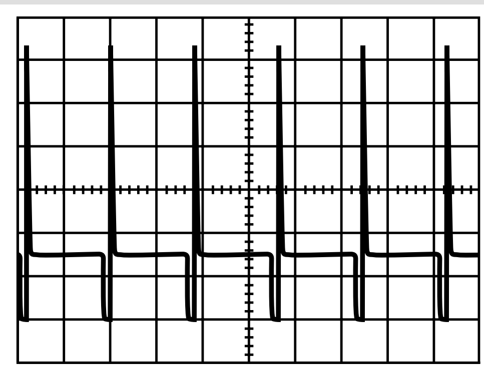
The design of the injector drive circuit determines when each injector delivers fuel in relation to the operating cycle of the engine. Depending on the engine application, the drive circuit design may be either a Simultaneous, Grouped, or Sequential type. In all designs, voltage is supplied to the injectors from the ignition switch or EFI main relay and the ECM controls injector operation by turning on the driver transistor grounding the injector circuit.

On Simultaneous type drive circuits, all injectors are pulsed at the same time by a common driver circuit. Injection occurs once per engine revolution, just prior to TDC No. 1 cylinder. Twice per engine cycle, one-half of the calculated fuel is delivered by the injectors. With Grouped drive circuits, injectors are grouped in pairs and a separate driver controls each group of injectors. Injection is timed to pulse just prior to TDC for the leading cylinder in the pair. On Sequential drive circuits, each injector is controlled separately and is timed to pulse just prior to each intake valve opening.

Injector Drive Signal

Depending on engine application, the injector drive circuit may be either a Simultaneous, Grouped or Sequential type.





100ms/Division (Idling)

The horizontal line in the scope pattern above represents battery voltage applied to the injector circuit. As the injector driver turns on (to open the injector) the signal drops to near 0V. Once the driver opens (to close the injector) a voltage spike occurs as a result of the collapsing magnetic field.

Fig. D-9

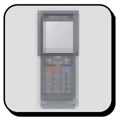
TL874fD09

Troubleshooting Hints

- Diagnostic Trouble Code for injector circuit can set for any misfire, regardless of cause.
- No Diagnostic Trouble Codes for injector circuit on OBD equipped engines.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P0201	Injector Circuit #1	Specified cylinder misfire continuously (two trip detection logic)
P0202	Injector Circuit #2	
P0203	Injector Circuit #3	
P0204	Injector Circuit #4	
P0205	Injector Circuit #5	
P0206	Injector Circuit #6	



DIAGNOSTIC REFERENCE INFORMATION

Ignition Circuit (IGT & IGF Signals)

Circuit Description

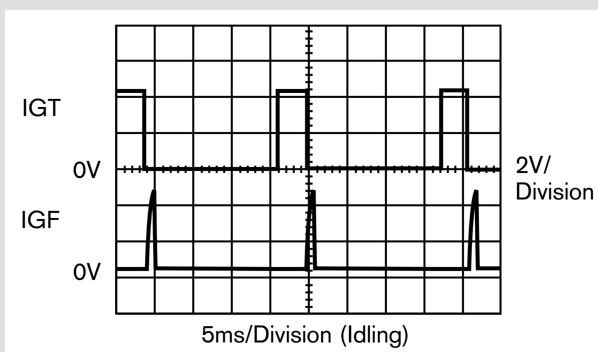
The ignition timing (IGT) and ignition fail (IGF) signals provide crucial information in the control of ignition system timing, injection timing, and Fail-Safe activation. Based on an initial timing angle calculated from the NE and G signals, the ECM outputs an IGT signal to the igniter as a reference point from which it determines ignition dwell period. A special circuit inside the igniter controls the ignition dwell period by controlling when the power transistor is switched on. When the ECM determines the proper time to provide spark, it turns the IGT signal off, which turns the igniter power transistor off, producing a spark.

The IGF signal is used by the ECM to determine if the ignition system is working and to protect the catalytic converter. When the ECM does not detect the IGF signal, the ECM goes into fail-safe mode. With no IGF signal, the ECM will store a DTC(s), depending on model year and number of cylinders affected. There are different fail-safe modes depending on the ignition system, cylinder displacement and model year. The following is general summary.

IGT & IGF Signal Relationship

The IGT signal triggers the igniter power transistor. Without IGT, spark will not occur.

The IGF signal confirms that an ignition event has occurred. Without IGF, the ECM shuts down injection pules.



The IGT signal trailing edge indicates the point where the power transistor is turned off, firing the coil.

The IGF signal is generated by the igniter each time spark occurs.

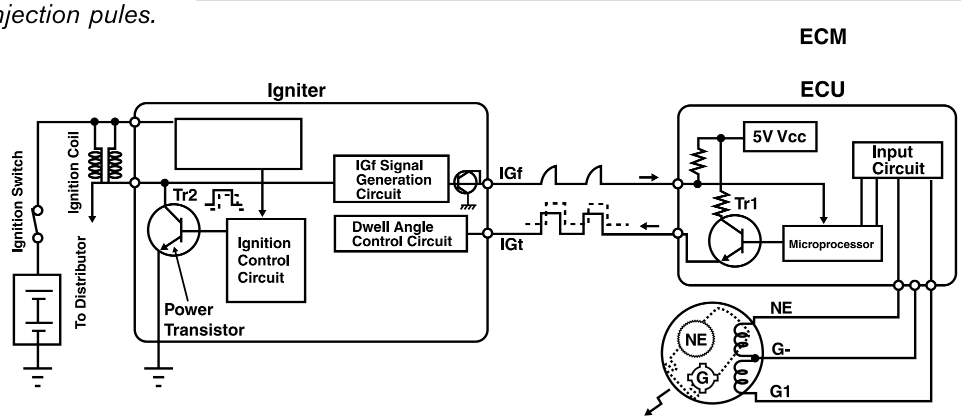


Fig. D-10

TL874fD10

If there is no IGF signal on engines before 1998 model year, the ECM will enter fail-safe and turn off all the fuel injectors.

Beginning with the 1998 model year, V-6 and V-8 engines equipped with direct ignition system with integrated ignition coil/igniter (1 ignition coil/lighter per cylinder), the engine will still run without the IGF signal, but the MIL will be on.

Beginning with the 2001 model year on 1 ignition coil/igniter per cylinder engines, the ECM fail-safe will turn off the fuel injector if there is no IGF signal for that cylinder and if engine conditions (such as load and temperature) are sufficient to damage the catalytic converter. If the IGF signal returns to normal while the engine is running, the injector may remain off until the next engine start.

Due to the rapid, high frequency nature of these signals, inspection should be performed using an oscilloscope or high quality digital multimeter with frequency capabilities.

Troubleshooting Hints

- On older systems, if engine will not start due to missing IGF, injectors will pulse once or twice during cranking. Use injector test light to confirm this condition.
- Scan data indicates an injection duration even when injectors are disabled due to IGF fuel cut fail-safe.
- Regardless of the type of IGF fail-safe mode, the IGF DTCs must be diagnosed **before** attempting to diagnose a fuel system/injection problem. The IGF DTCs are one trip DTCs.
- Use oscilloscope to diagnose IGT and IGF circuits.

OBD Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
14	IGF Circuit	ECM does not detect IGF signal for 6 consecutive IGT signals.

OBD II Diagnostic Trouble Codes

DTC #	Effected Circuit	Diagnostic Trouble Code Detection Condition
P1300 Series	IGF/Igniter Circuit Malfunction	ECM does not detect IGF signal for 6 or 8 consecutive IGT signals with engine running.

Fail-Safe Conditions

Fail-Safe Conditions, OBD

DTC	Circuit Effected	Fail-Safe Trigger	Fail-Safe Operation
12	Cranshaft Position	ECU does not receive either G1 or G2 signal	ECU defaults to remaining sensor; if both sensors lost, engine will not restart
14	Igniter IGF	ECU fails to receive IGF singal more than 4-6 weeks in a row	Fuel injection stopped to protect catalyst
22	Engine Coolant Temperature	ECT > 138°C (280°F) or < -50°C (-58°F)	Standard value substituted for ECT signal, typically 80°C (176°F)
24	Intake Air Temperature	THA > 138°C (280°F) or < -50°C (-58°F)	Standard value substituted for THA signal, typically 20°C (68°F)
31/32	Air Flow Meter	Open or short detected signal circuit	Standard value substituted based on STA and ID singals
35	High Altitude Compensation	Open or short detected in HAC signal circuit	Standard value substituted for HAC; value equals 29.92 in. Hg
41	Throttle Position	Open or short detected in TPS signal	Standard value substituted for VTA; typically 0° or 30° based on IDL
52/53	Knock Sensor	Open or short detected in knock signal circuit or ECU detects internal fault	Maximum corrective retard applies to ESA

Fail-Safe Conditions, OBD II

DTC	Circuit Effected	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0100	Mass Air Flow	Ignition timing fixed at 5° Injection timing fixed •STA ON = 11.0 ms •IDL ON = 3.5 ms •IDL OFF = 6.3 ms	When fault is no longer detected
P0100	Intake Air Temperature	IAT fixed at 20°C (68°F)	When fault is no longer detected
P0115	Engine Coolant Temperature	ECT fixed at 80°C (176°F)	When fault is no longer detected
P0120	Throttle Position	TP fixed at 0%	CTP switch is ON with VTA between 0.1 to 0.95 volts
P0135 P0141 P0155	Oxygen Sensor Heater	Heater circuit effected is turned off	After ignition is switched off
P0325 P0330	Knock Sensor	Maximum knock retard	After ignition is switched off
P0720	A/T Speed Sensor	Gear shift program based on rpm and TP	When fault is no longer detected
P0753	Shift Solenoid A	Power to solenoid valve and lock-up solenoid valve is cut	When fault is no longer detected
P0758	Shift Solenoid B	Power to solenoid valve and lock-up solenoid valve is cut	When fault is no longer detected
P0773	Shift Solenoid E	Power to solenoid valve is cut	When fault is no longer detected
P1300	Igniter IGF	Fuel cut	After IGF is not detected for 2≈6 consecutive IGT signals (See Section 4, Primary Circuit SA)
P1605	Knock Control CPU	Maximum knock retard	When fault is no longer detected
P1765	Accumulator Pressure Linear Solenoid	Power to solenoid valve is cut	When fault is no longer detected

Appendix F

TechView Guide

Guide Contents:

TechView has been designed to assist technicians in quickly diagnosing vehicles by graphing Real-Time Data, Snapshot Data, DTC Information, OBD System Monitor, and Freeze Frame Data. The following guide will navigate you through the extensive features it has to offer.

Tools and Equipment

- Diagnostic Tester
- Computer with TechView
- Vehicle

Section 1: Getting Started

1. Connect Diagnostic Tester
2. Create New User
3. Enter File Information
4. View Real-Time Data
5. View Specific Data List
6. Change Parameters
7. Remove and Add Parameters

Section 2: Graph Data

8. Graph Data

Section 3: Record and Retrieve Real-Time Data

9. Record and Retrieve Real-Time Data
10. Add a Record

Section 4: Take Snapshot Data

11. Take Snapshot Data

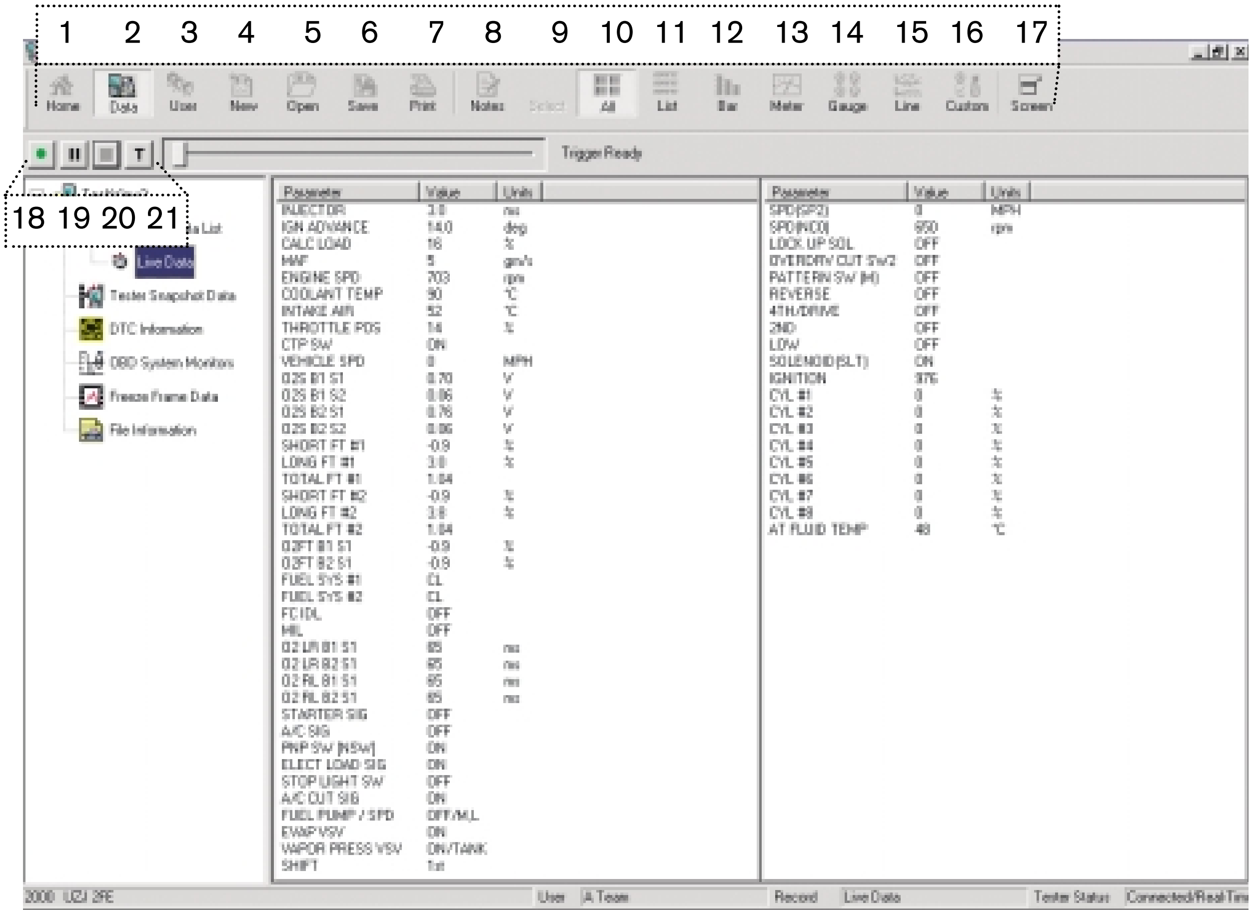
Section 5: DTC Information

12. View DTC Information

Section 6: Save File

13. Save File
14. Print File

Screen Commands Overview



1. Home Page
2. Select Data
3. Select User
4. Open New File
5. Open Existing File
6. Save File
7. Print File
8. Record Notes
9. Select Parameters
10. Select All Data
11. List Specific Data
12. Bar Graph
13. Meter Graph
14. Gauge Graph
15. Line Graph
16. Custom Graph
17. Full Screen
18. Trigger
19. Pause
20. Stop
21. Trigger Setup

NOTE: A Help button is also located at the top of the screen to aid in any questions.

Fig. F-1

TL874fF01

SECTION 1: Getting Started

1. Connect the Diagnostic Tester to DCL 3 in the vehicle. Place the Diagnostic Tester next to the TIS machine and plug the RS232 line into the tester. Turn the Diagnostic Tester ON and go into the Enhanced OBD II mode.

   Note: TechView supports serial and V-BoB data, but does not support NVH or oscilloscope data.

2. Create a new **User**. Follow the diagram below and enter your name. Having your own user name will keep your files separate from other technicians.

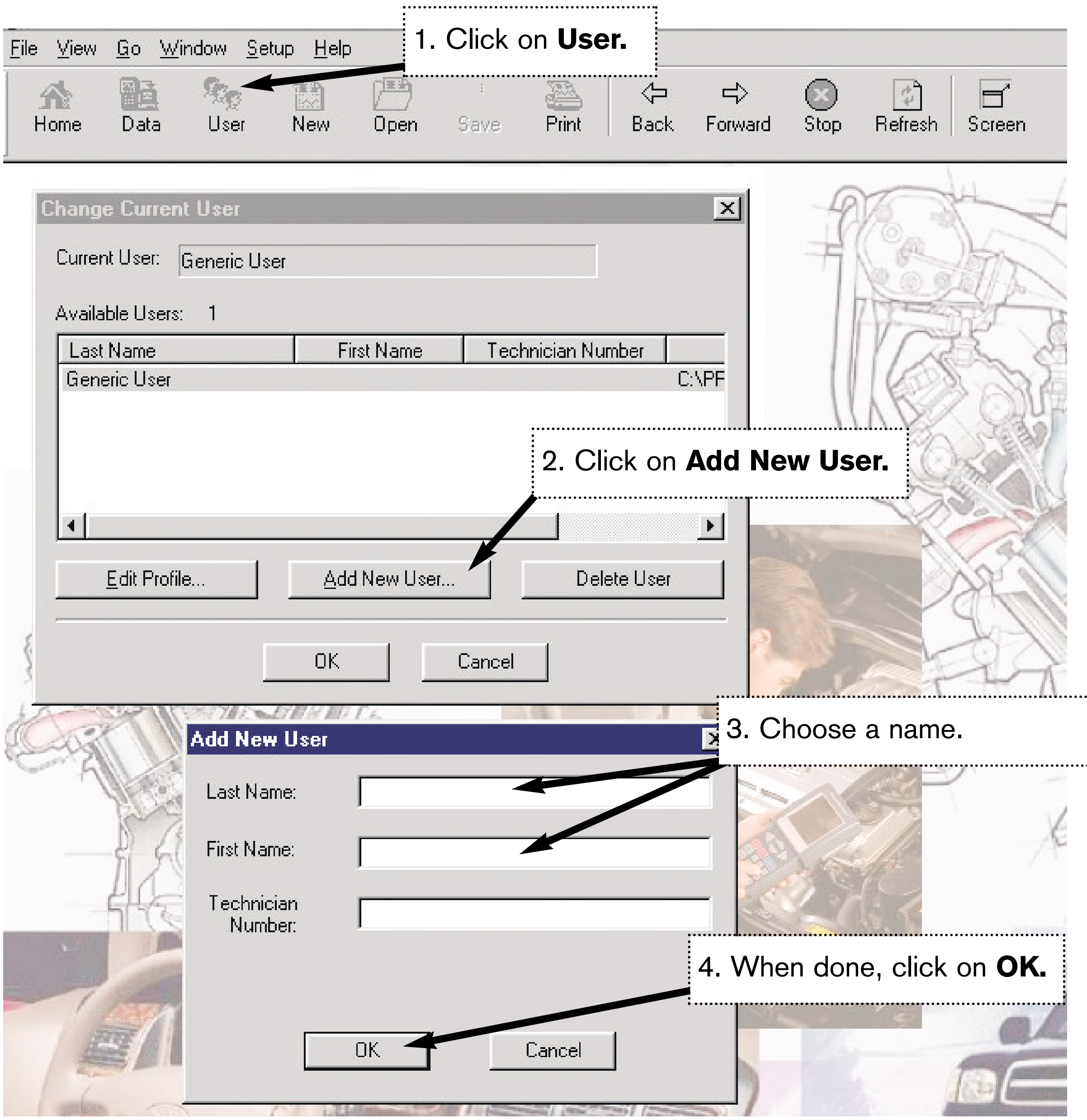


Fig. F-2

TL874fF02

2a. After creating a new User, open a New document.

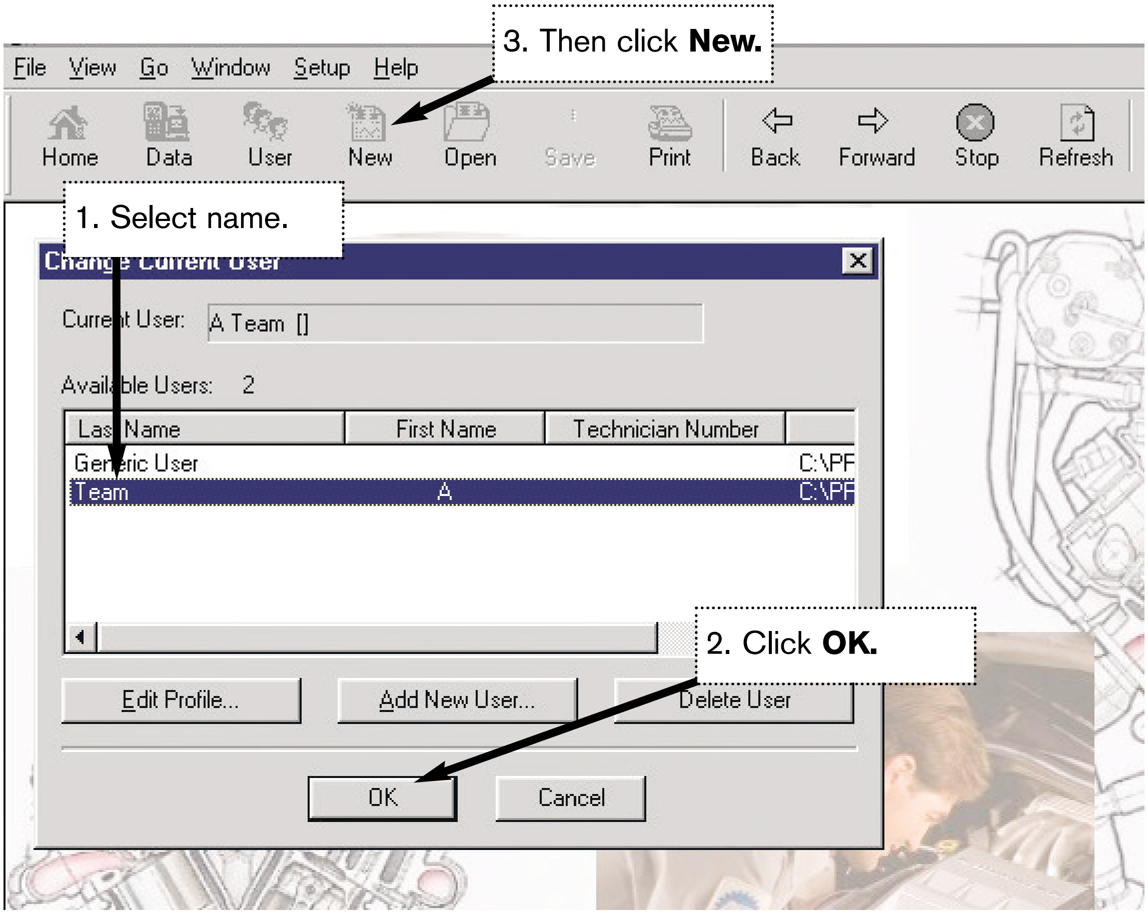


Fig. F-3
TL874fF03

3. Enter File Information. This screen allows you to store vehicle diagnostic information as well as shop information.

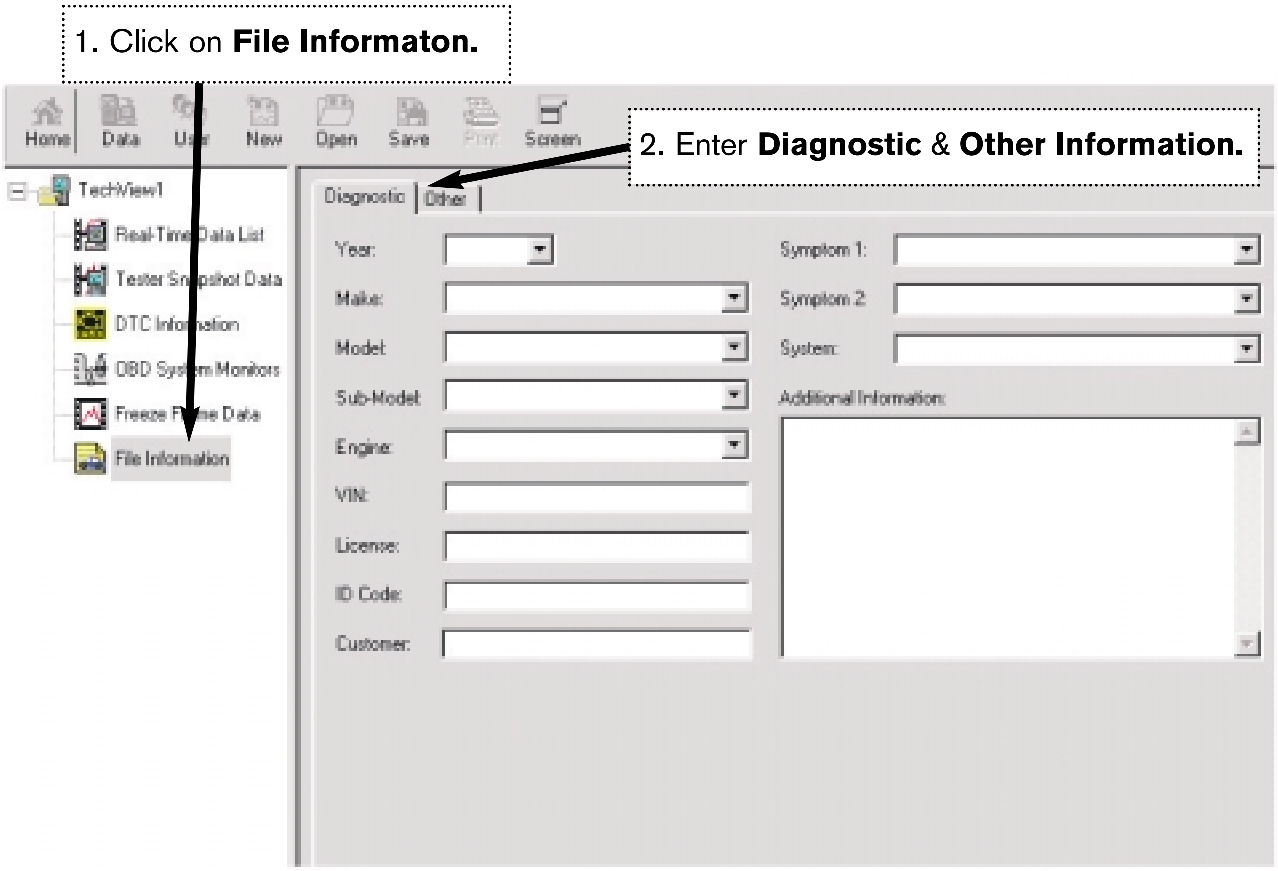


Fig. F-4

TL874fF04

4. View the Real-Time Data List. To view live tester data, follow the steps below to get into the correct mode.

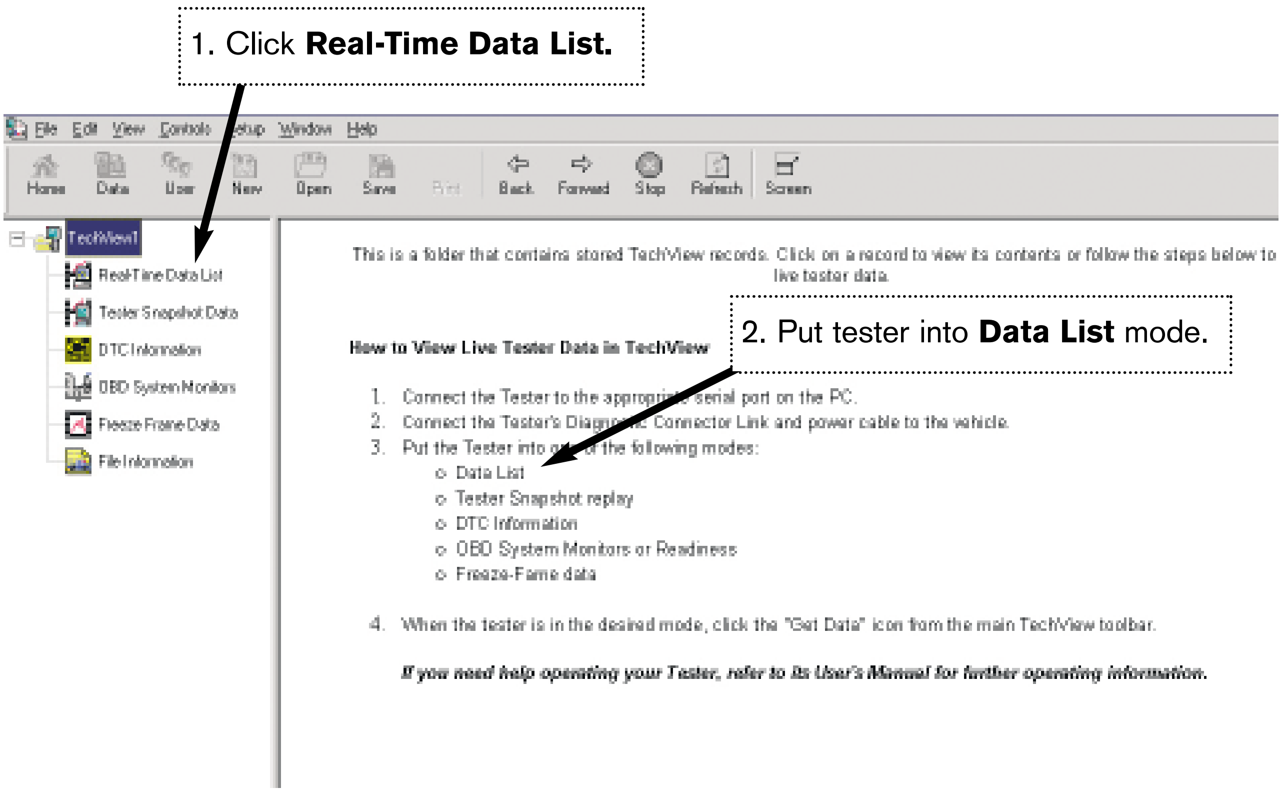


Fig. F-5

TL874fF05

Note: If you receive the error message listed below after clicking the Data button, check the RS232 line (the cable from the computer to the tester) and then the DLC 3 cable (from the tester to the vehicle) are in place. If you are still receiving an error message, reboot the computer.

Error - No response from the Diagnostic Tester. Ensure the Diagnostic Tester is properly connected. (Code: 325)

If the error message still occurs, refer to TSB SS0004-00 for Diagnostic Tester warranty repair.

4a. View Live Data.

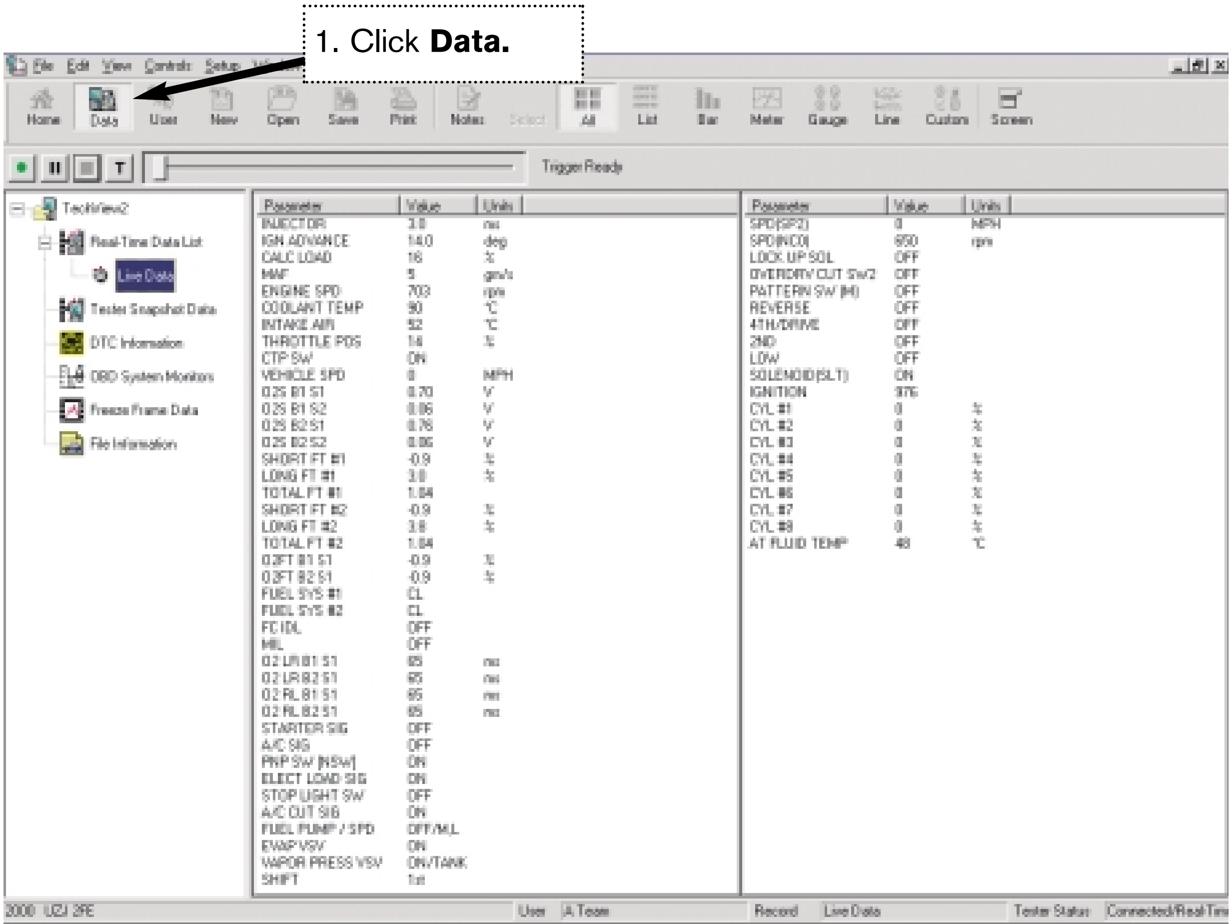


Fig. F-6

TL874fF06

5. View a specific data list.

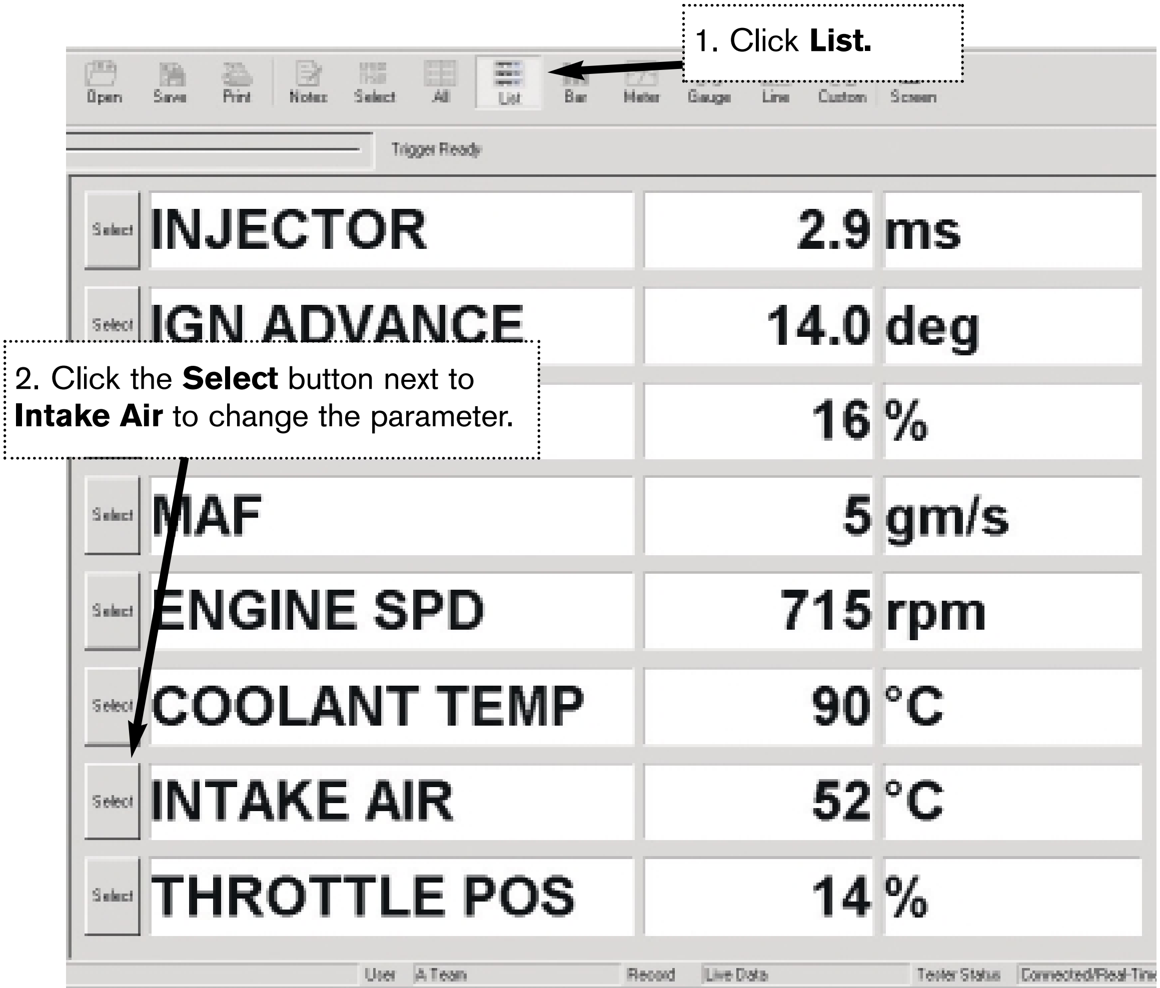


Fig. F-7

TL874fF07

6. Change the parameters. This function allows you to view and compare specific data.

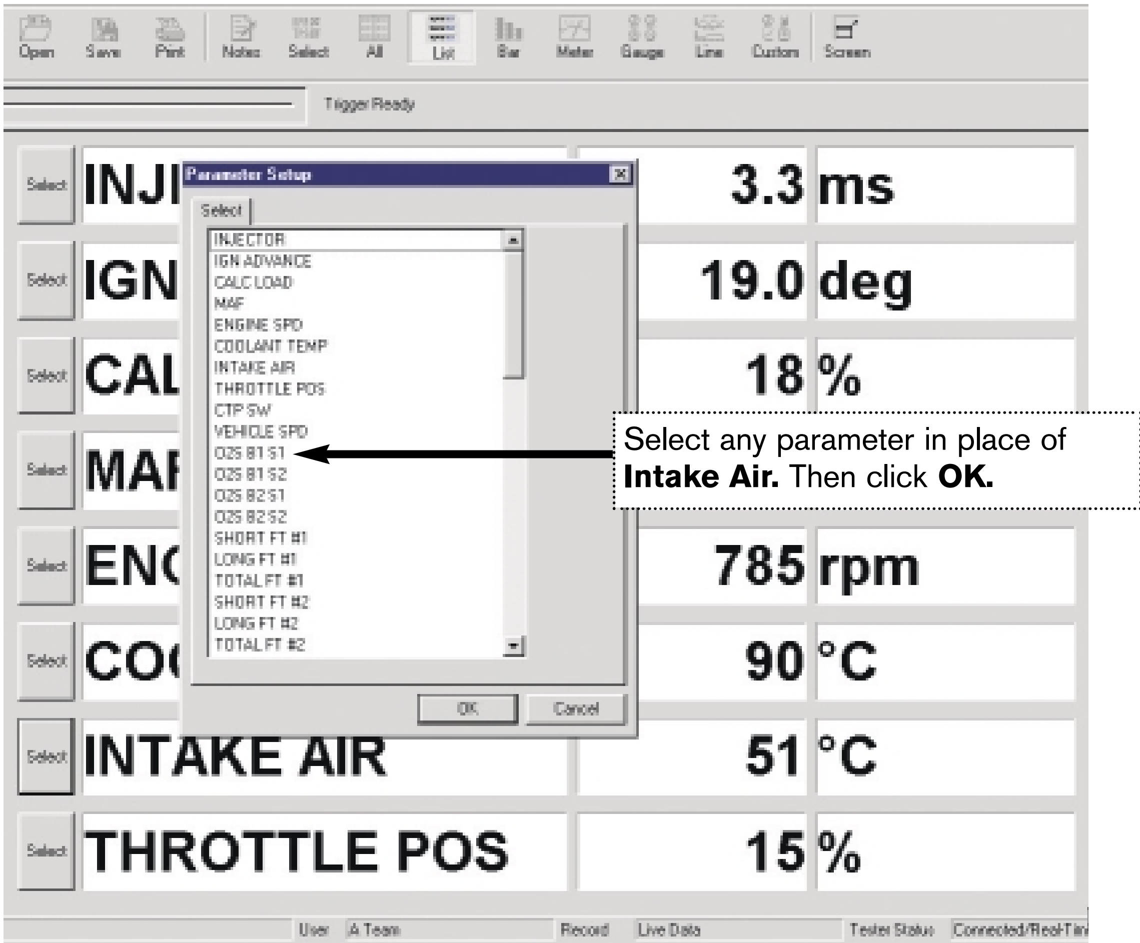


Fig. F-8

TL874fF08

7. Remove and add parameters. In this screen, up to eight parameters can be selected at one time.

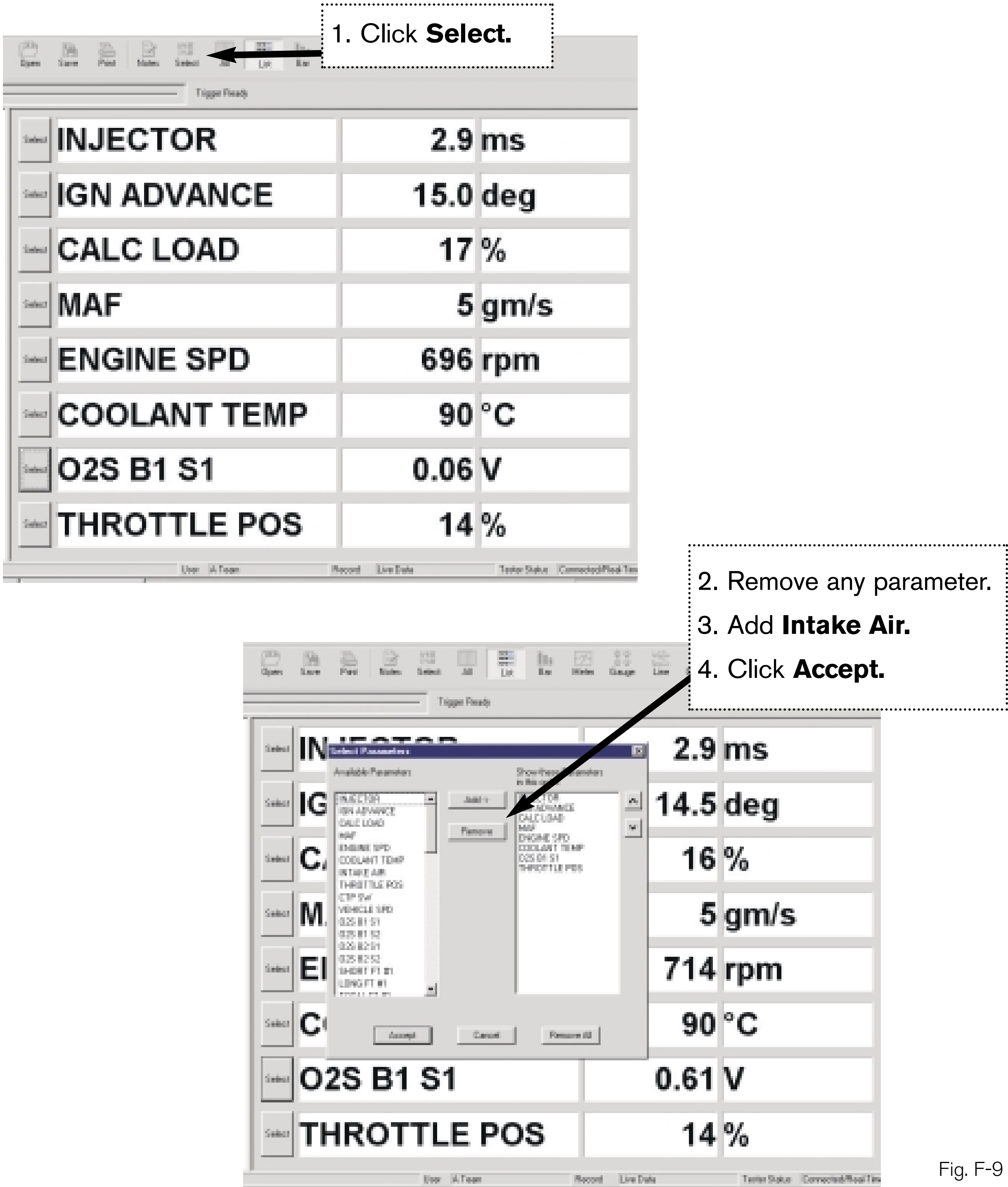


Fig. F-9

TL874fF09

Note: Selecting fewer parameters with the Diagnostic Tester will NOT allow the program to run faster. The refresh rate is only as fast as the ECM.

SECTION 2: Graph Data

8. Graph Data. The next few screens will show you several ways to graph vehicle data.

Note: Notice that the red represents the maximum and the green represents the minimum in all graphs.

Fig. F-10

TL874fF10

8a. View the Meter and Gauge graphing options.

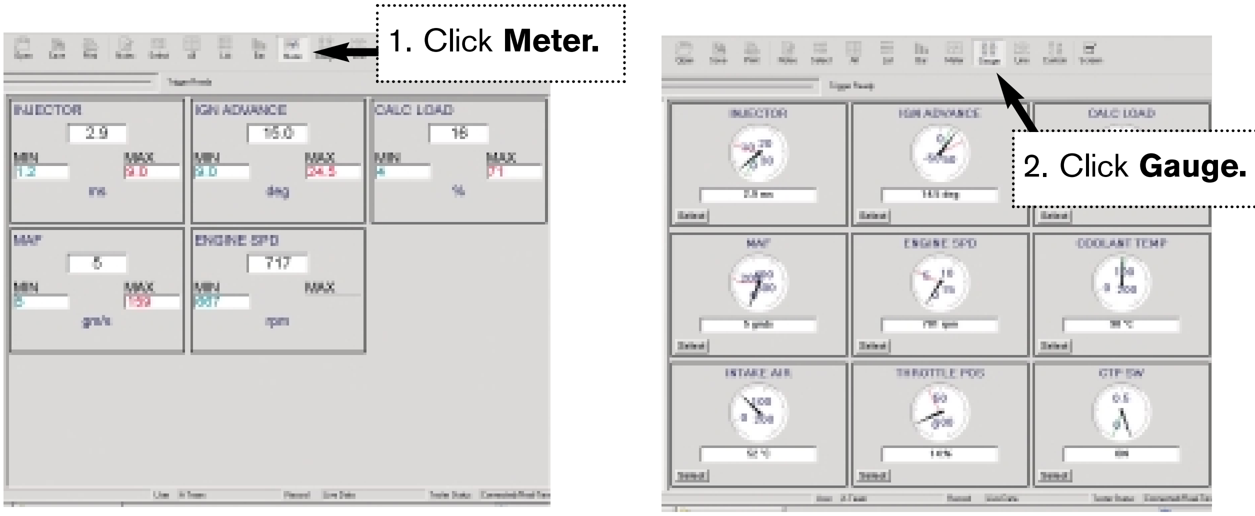


Fig. F-11

TL874fF11

8b. You can view several line graphs at one time. By clicking on the graph button you can view the graphs one at a time.

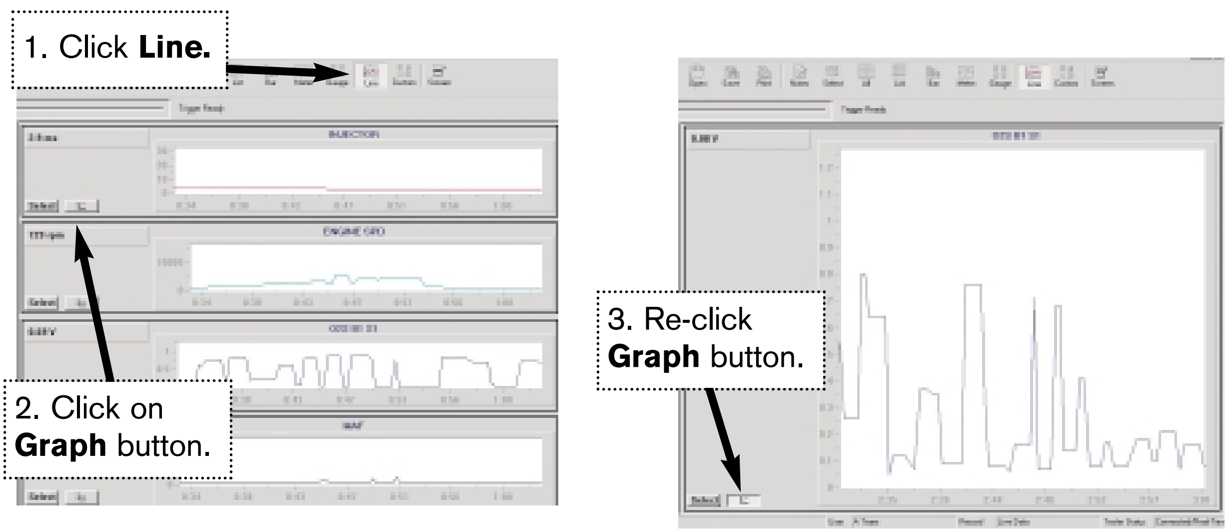


Fig. F-12

TL874fF12

8c. Another option is to watch several line graphs at one time in two different views.

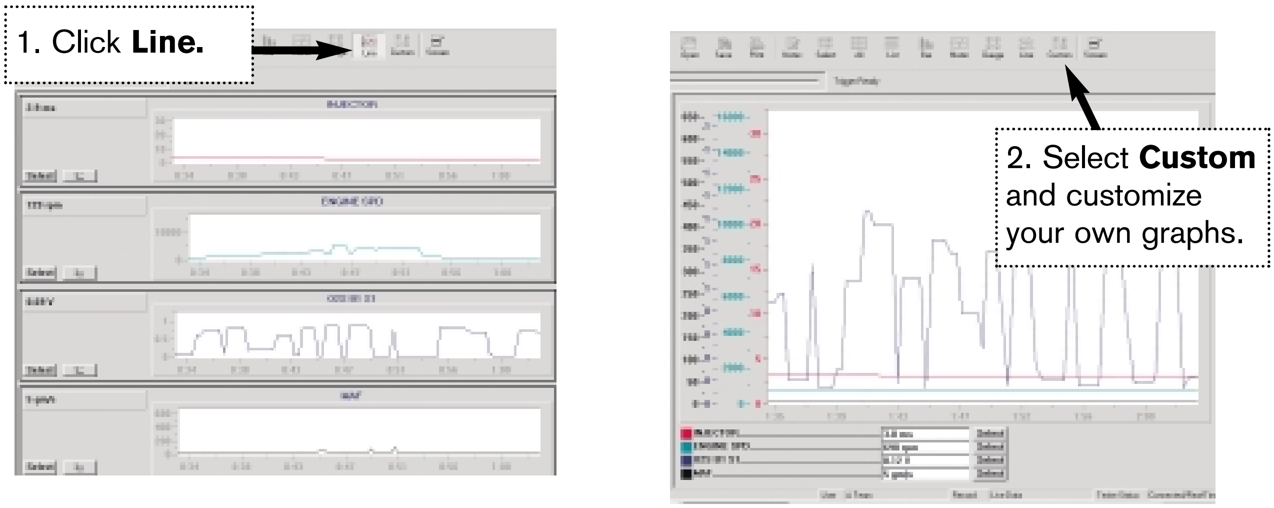


Fig. F-13
TL874fF13

8d. Customize Graph. This option will allow you to graph the data using any or all types of graphs.

Fig. F-14
TL874fF14

SECTION 3: Record and Retrieve Real-Time Data

9. Record and Retrieve Real-Time Data. Notice the four buttons on the left side of the screen, starting with the green button. This is the Play button, followed by the Pause, the Stop, and then the Trigger button.

Practice Exercise

After clicking on ALL in step 1, set the recording time for 15 seconds. Follow the diagrams below to use the Trigger button to record the data. Increase the rpms to 3000, 3 times in order to see the data change. Recording time can be set up to 10 minutes.

Note: A TechView Record can contain multiple Live Data Lists, Snapshot Data, DTC Information, OBD System Monitors, and Freeze Frame Data.

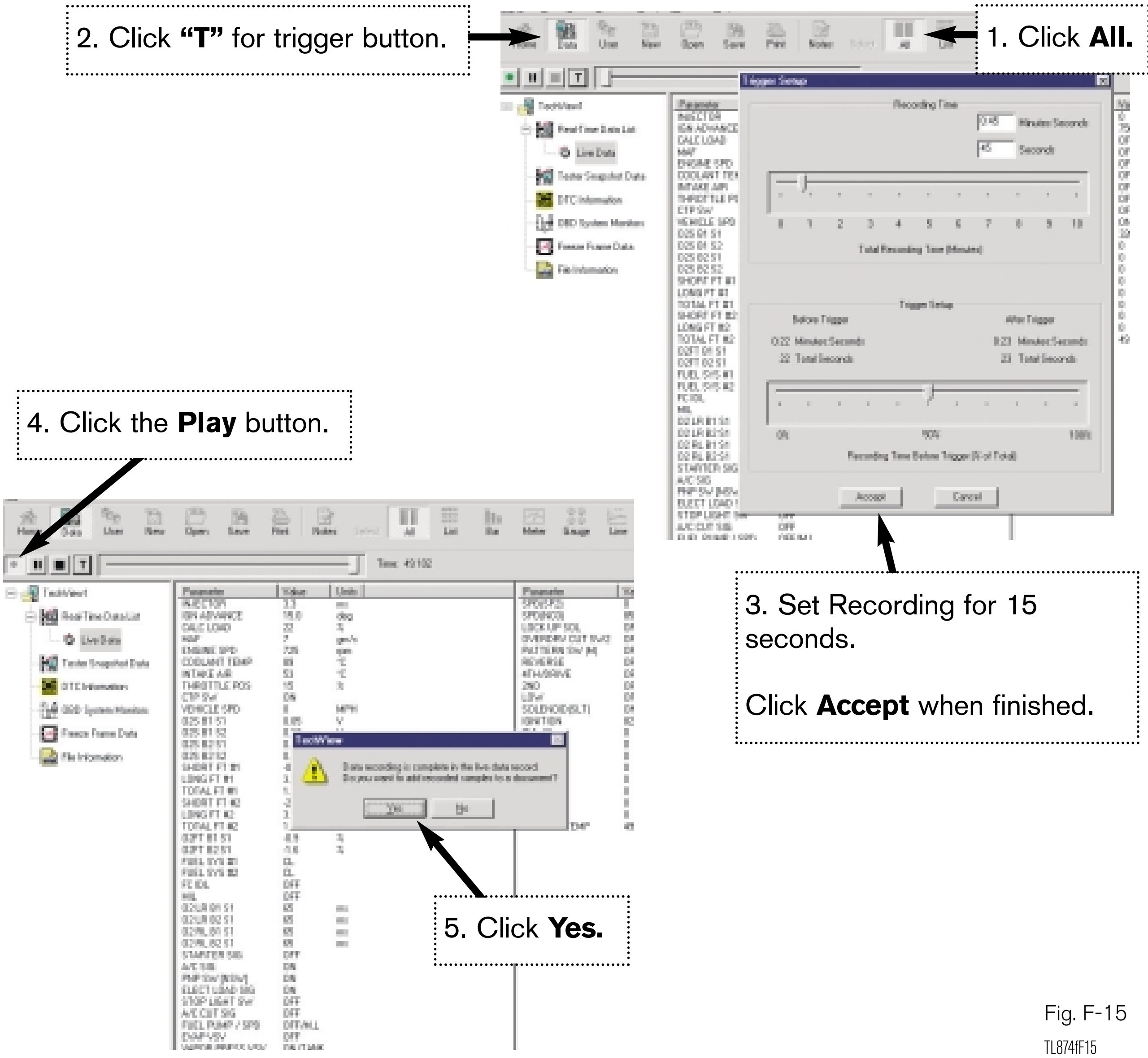


Fig. F-15

TL874fF15

10. Add Real-Time Data Record. The "Add Record" box will appear whenever you want to view data in TechView. Save the Record and name it according to the vehicle and the condition. This naming process is going to be left to your own discretion. Relate the Record name to the purpose of the created data.

Example: Misfire Data

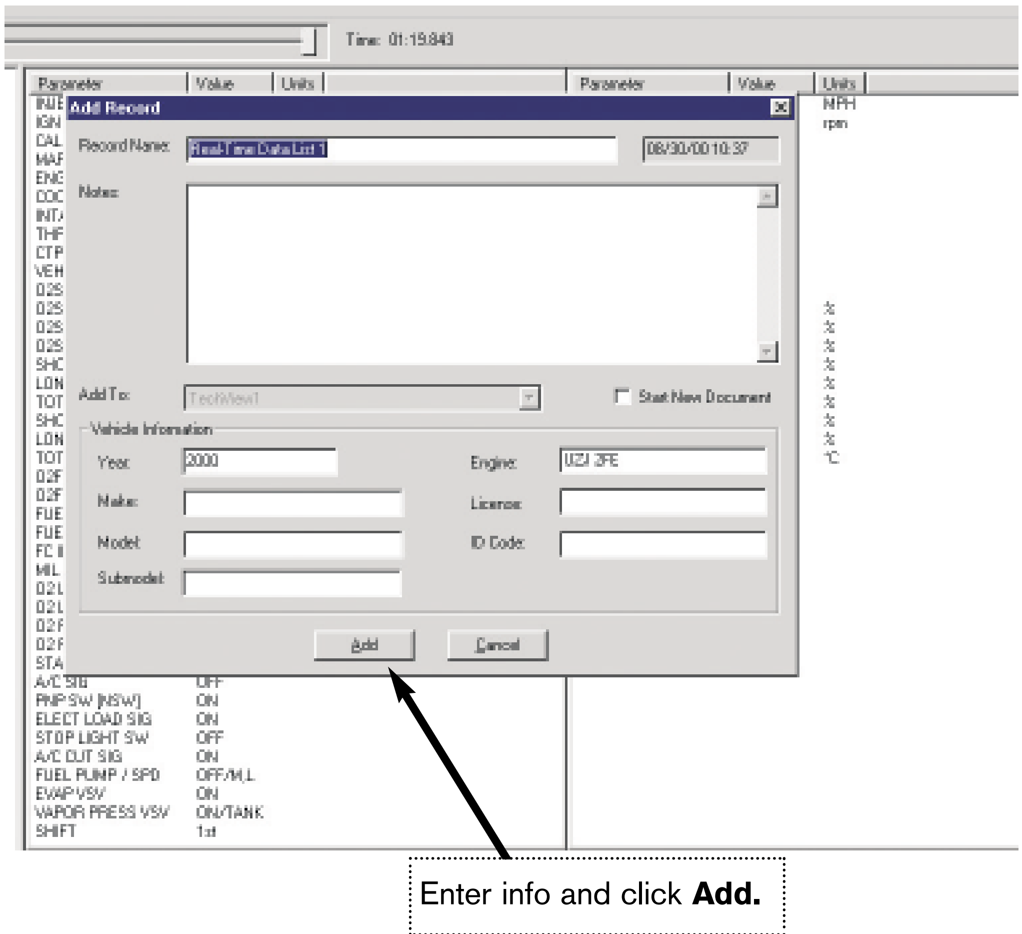


Fig. F-16

TL874fF16

SECTION 4: Take Snapshot Data

11. TechView allows you to take Snapshot Data with the Diagnostic Tool and retrieve it in TechView. There will be times when you will want to record and retrieve a data stream. The following exercise will help you understand this process.

Practice Exercise

With the vehicle running, take Snapshot Data of the Throttle Position, O2 sensor, Engine Speed, and MAF using the Diagnostic Tester. Then view the snapshots using TechView by following the diagram below.

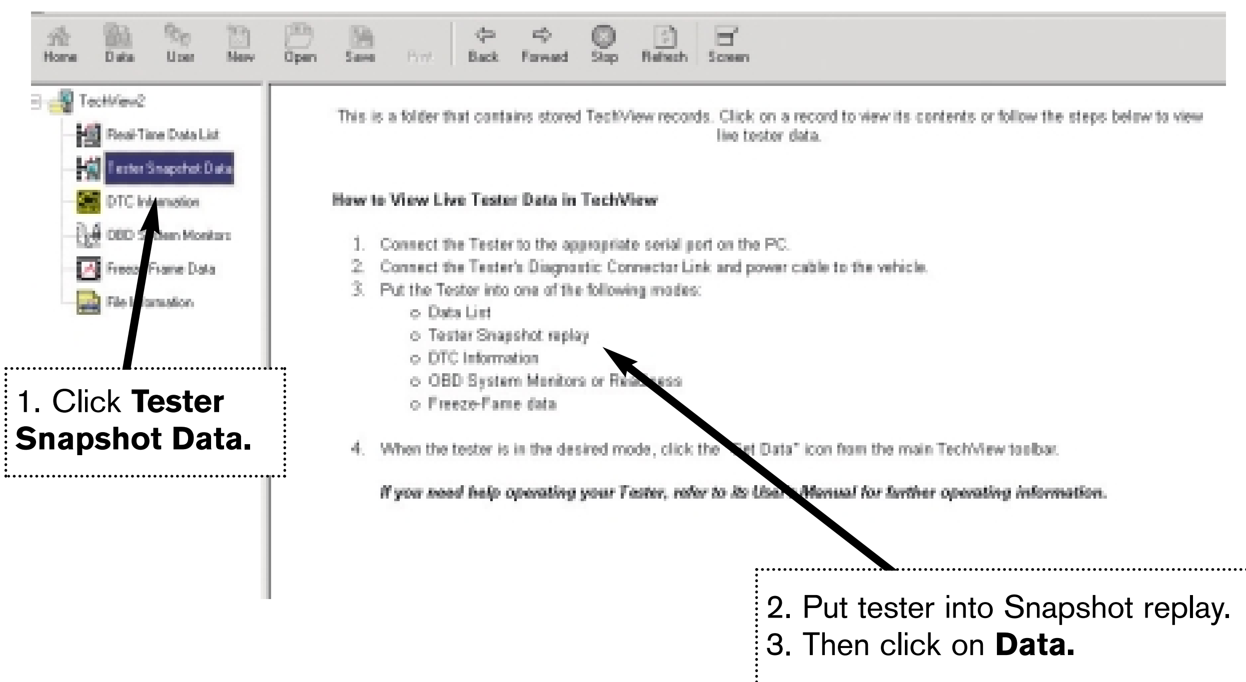


Fig. F-17

TL874fF17

11a. Add Snapshot Record Notes and Vehicle Information.

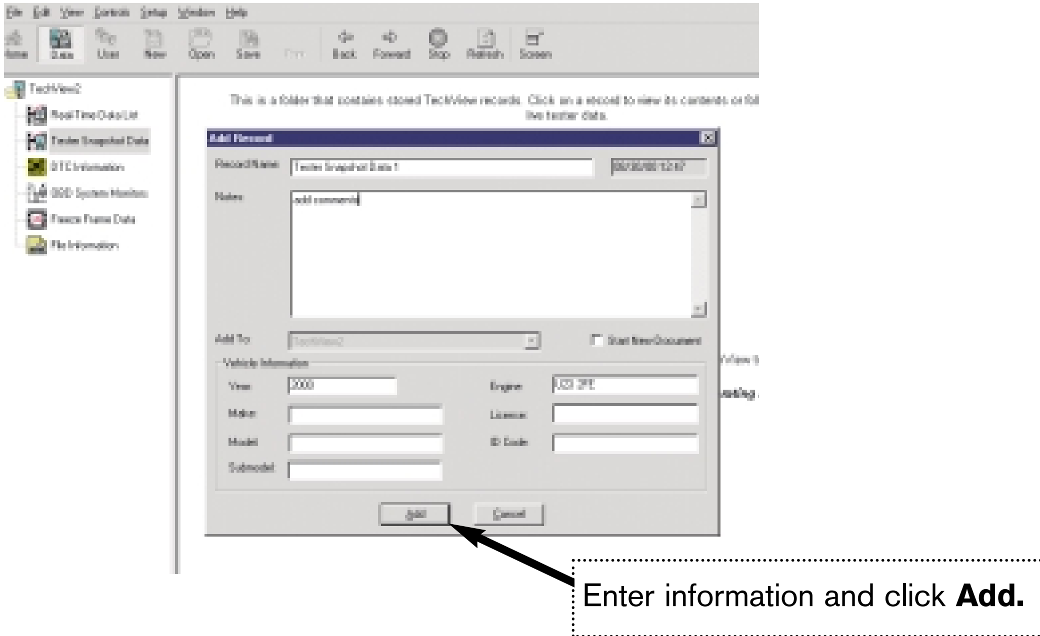


Fig. F-18

TL874fF18

11b. Now you are able to graph and play the snapshot data from the Diagnostic Tester. Simply click on any of the graph features.

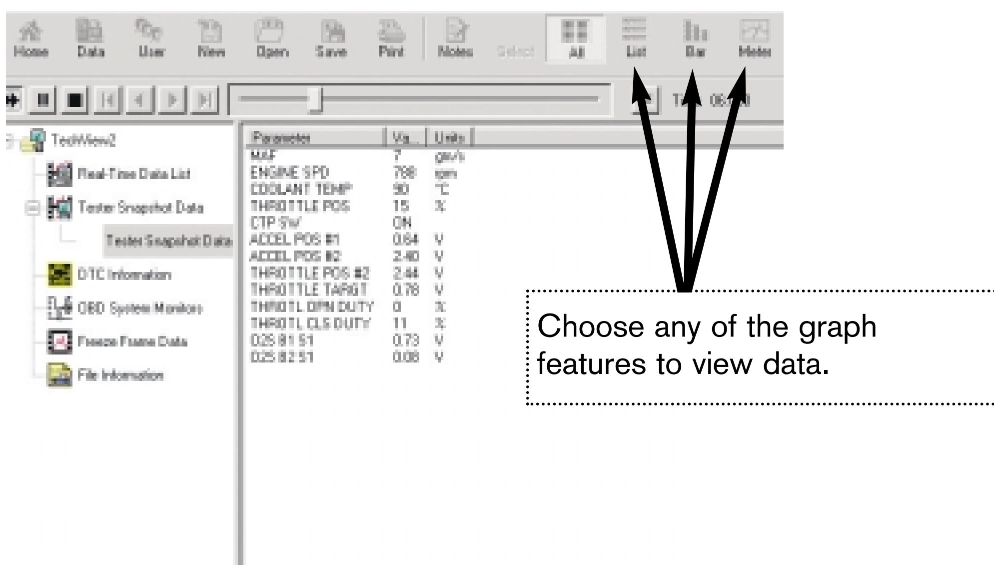


Fig. F-19

TL874fF19

SECTION 5: DTC Information

12. View DTC Information. After storing the vehicle's DTCs on the tester, follow the diagram below.

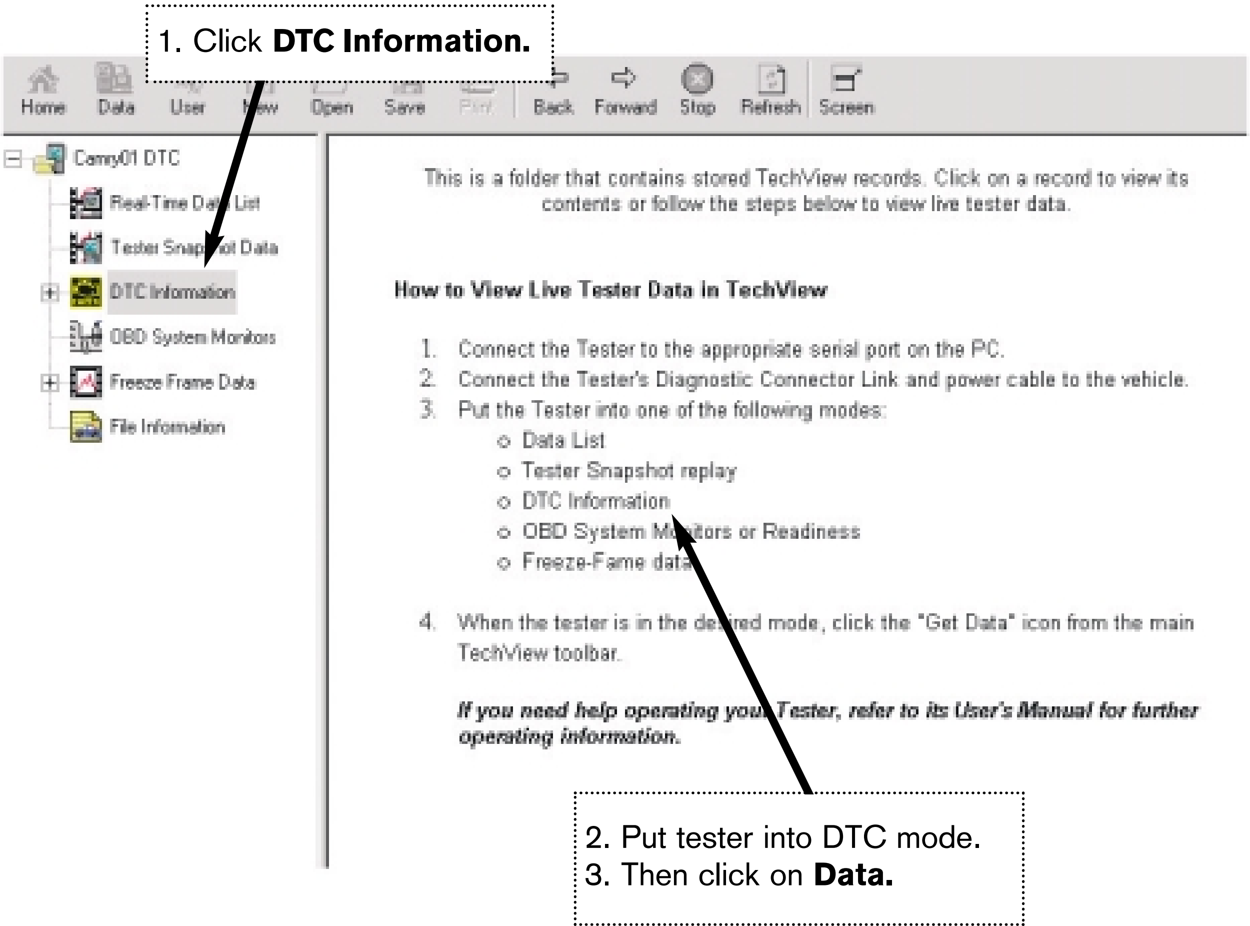


Fig. F-20

T874fF20

12a. Add DTCs to file. Click on the Add button at the top of the screen to save a DTC Record to your file.

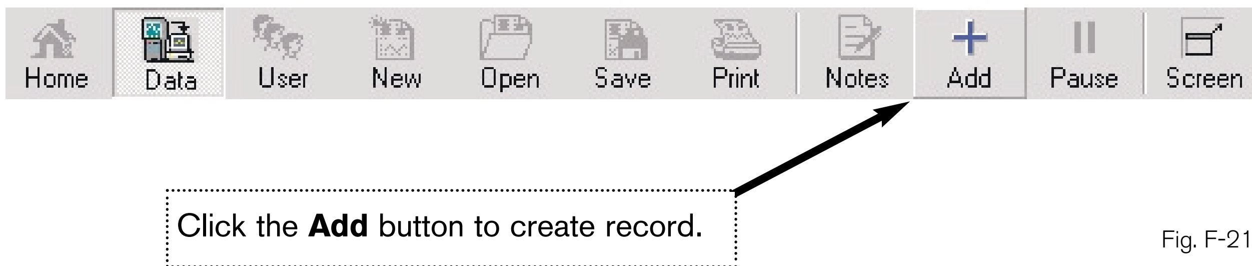


Fig. F-21

TL874fF21

12b. Add DTC Record

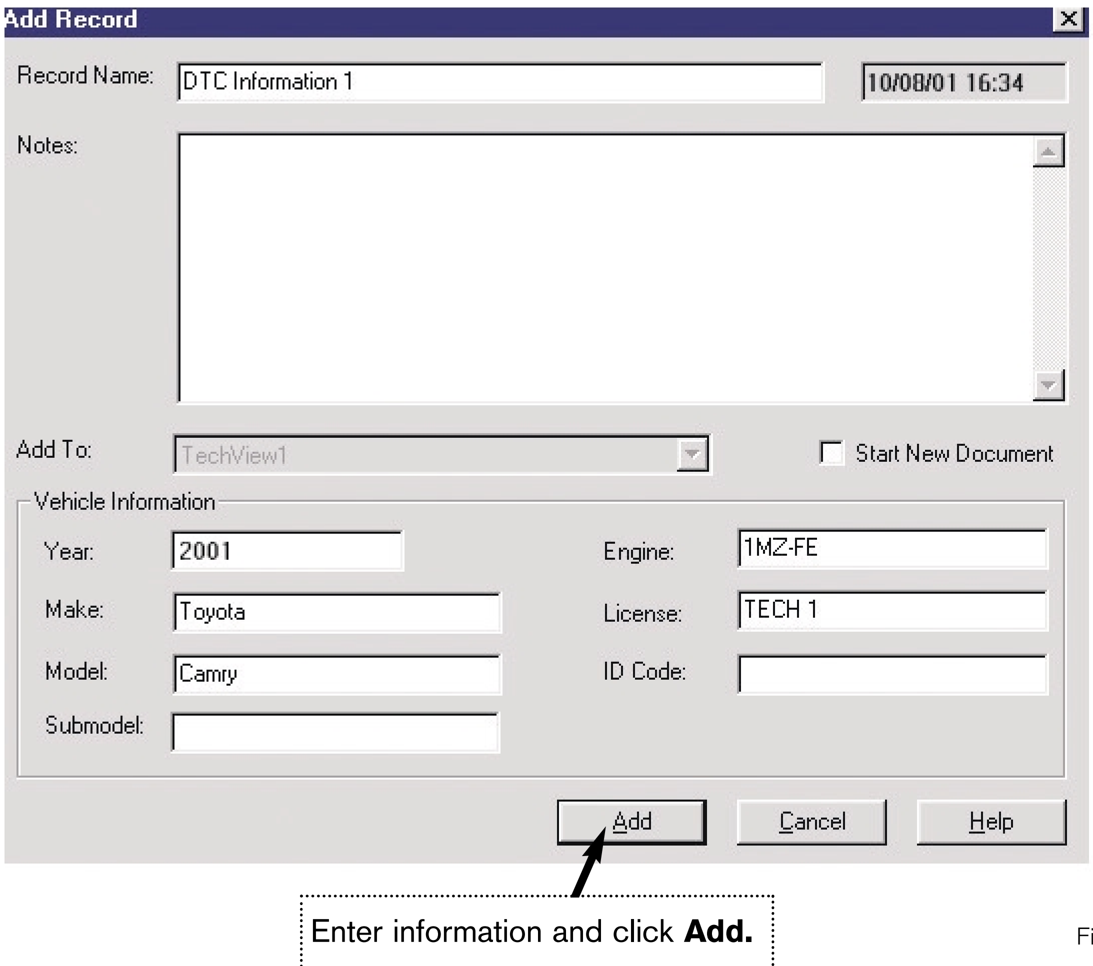


Fig. F-22

T874fF22

Note: To retrieve OBD System Monitors and Freeze Frame Data, follow the same procedure as above. Always put the Diagnostic Tester into the desired mode, then put TechView in that same mode to retrieve data.

12c. DTCs are stored.

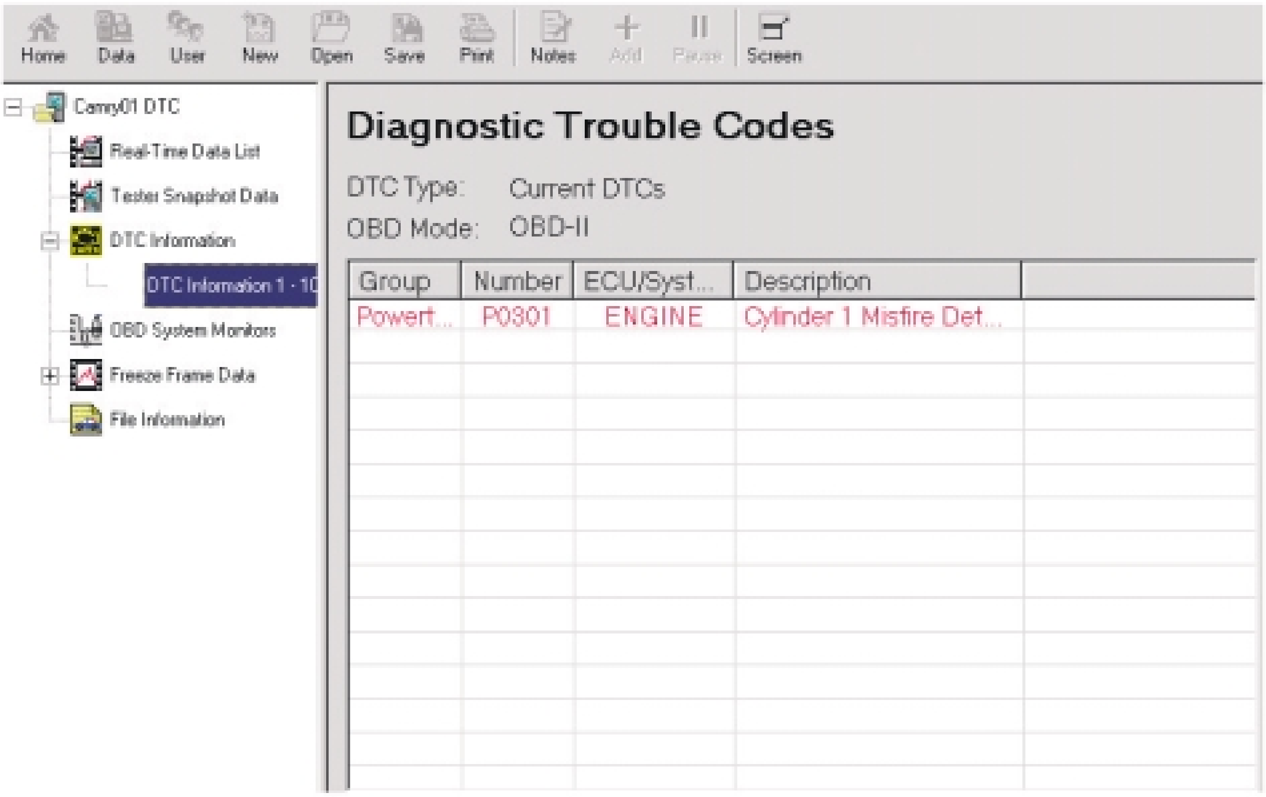


Fig. F-23

T874fF23

SECTION 6: Save File

13. Save information. Save all the information have gathered by clicking the Save button at the top of the screen. Name the file by following the example below:

Example: Camry 01

Always start with the vehicle name (Camry), then the year (01). It is extremely important to always follow this naming system. It will make it much easier to find and sort files in the future because they will automatically be sorted into alphabetical order.

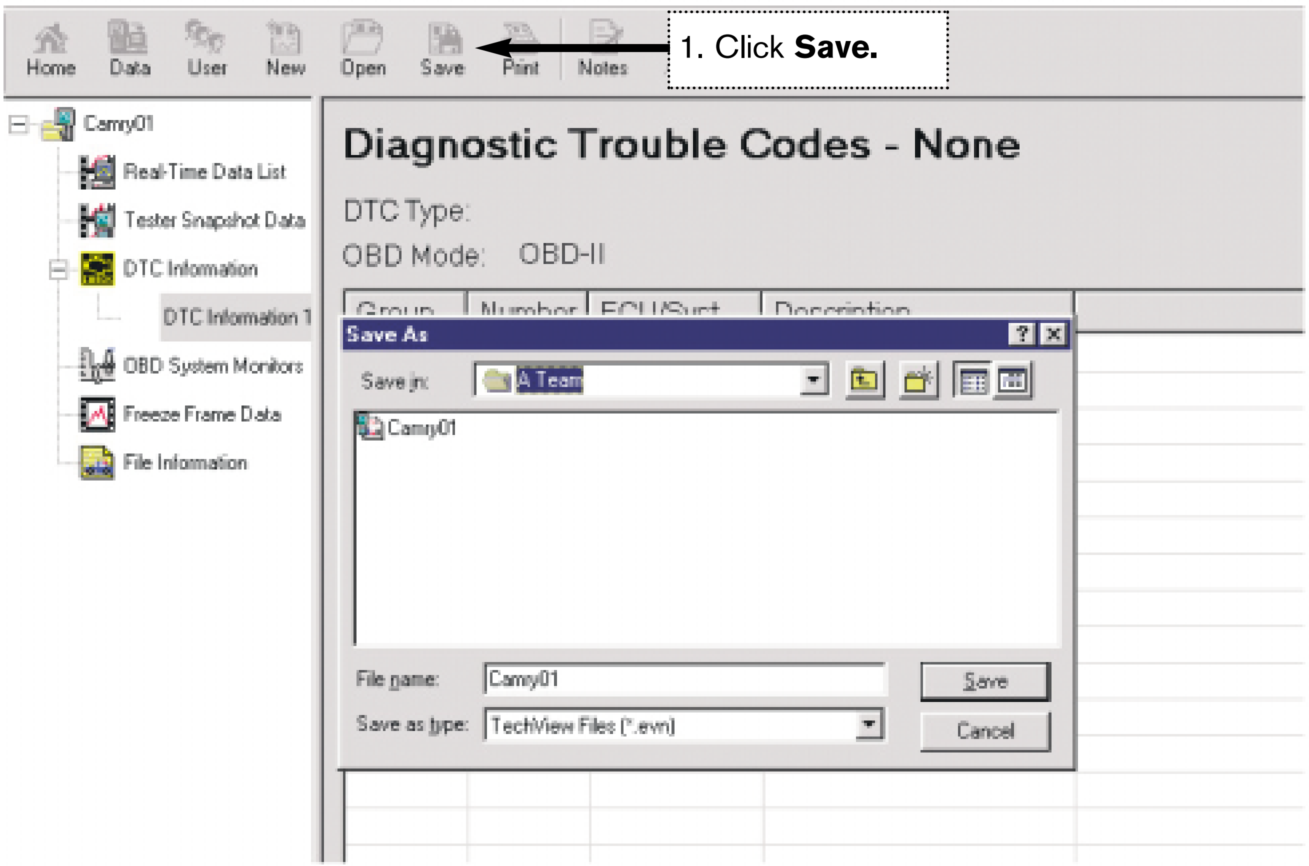


Fig. F-24
T874fF24

13a. Close the window and re-open the file to see that you have saved it.

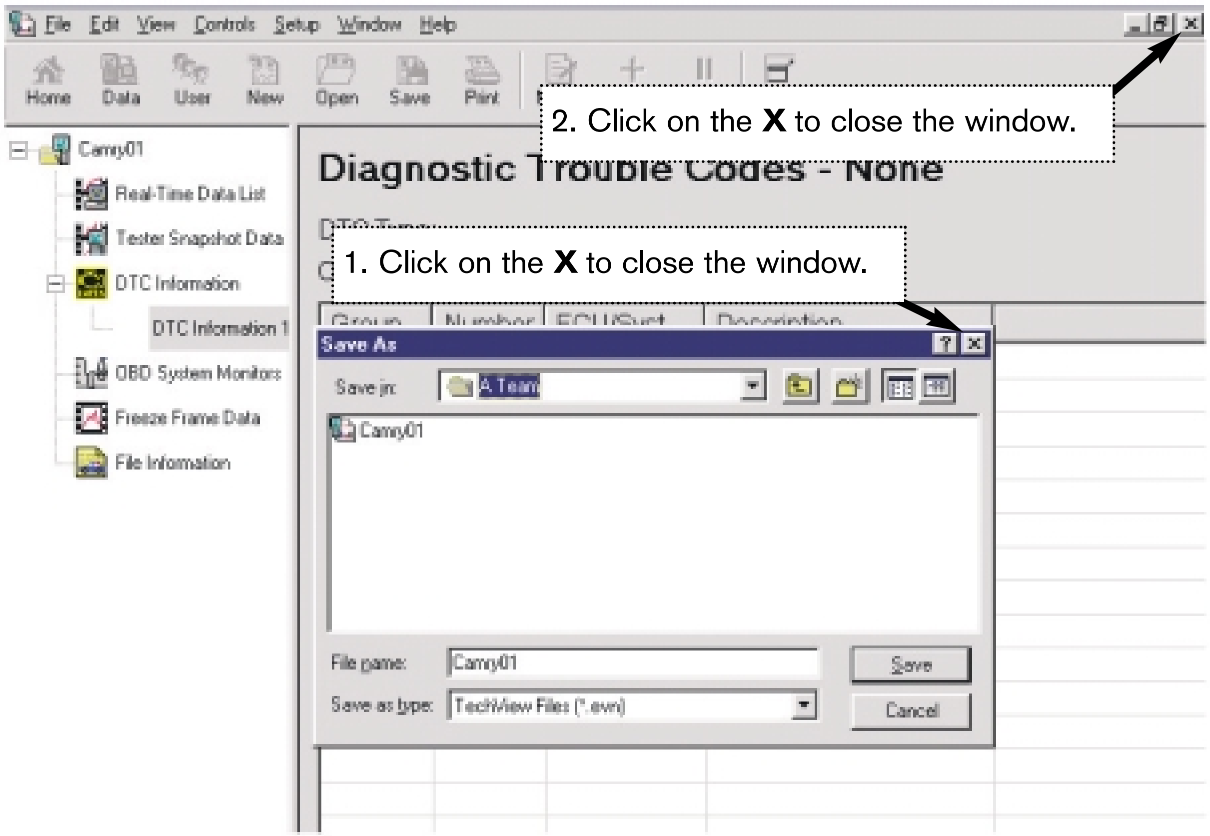


Fig. F-25

T874fF25

13b. Re-open the file by clicking Open and then double clicking on the file name.

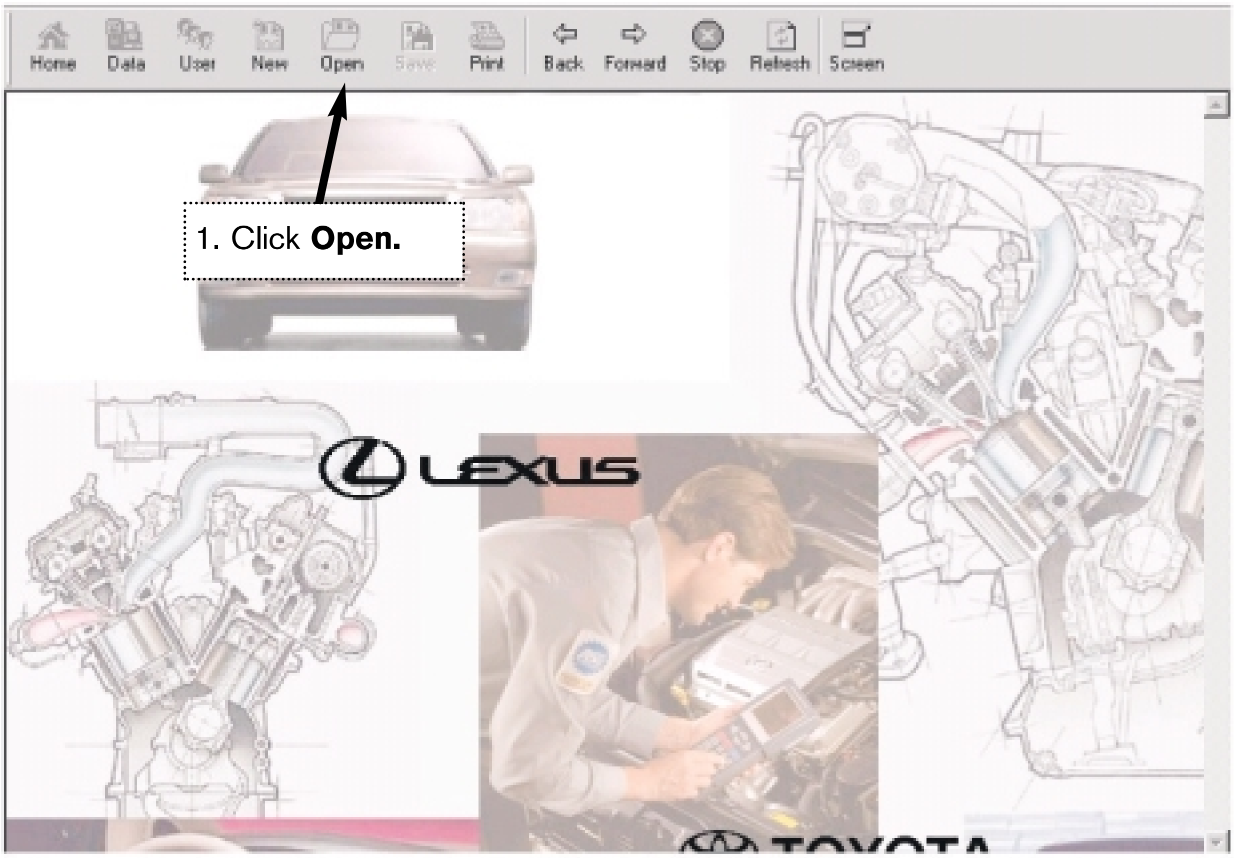


Fig. F-26

TL874fF26

14. Print File. After opening your file, simply click on the Print button to print the file.

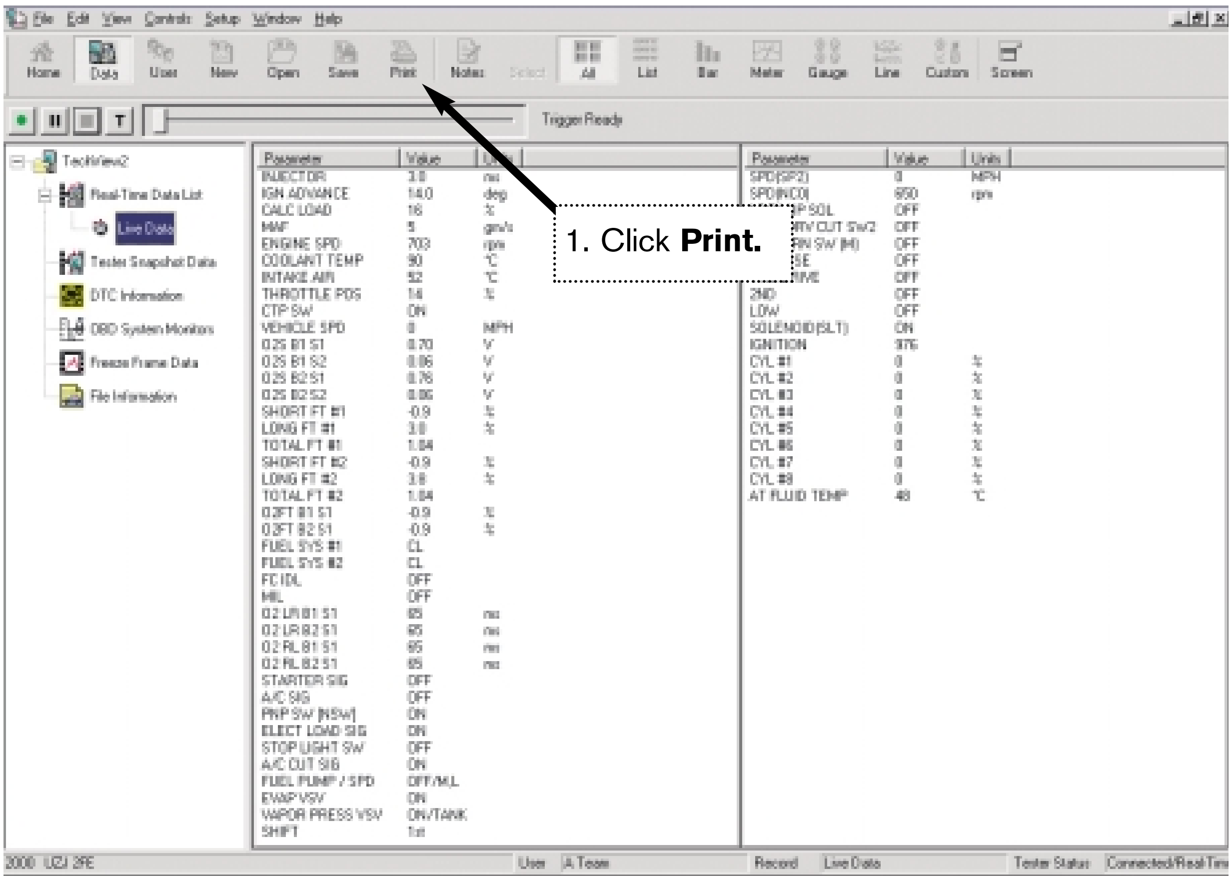


Fig. F-27

TL874fF27

EVAP Canister Component Locations

Late Type EVAP Components

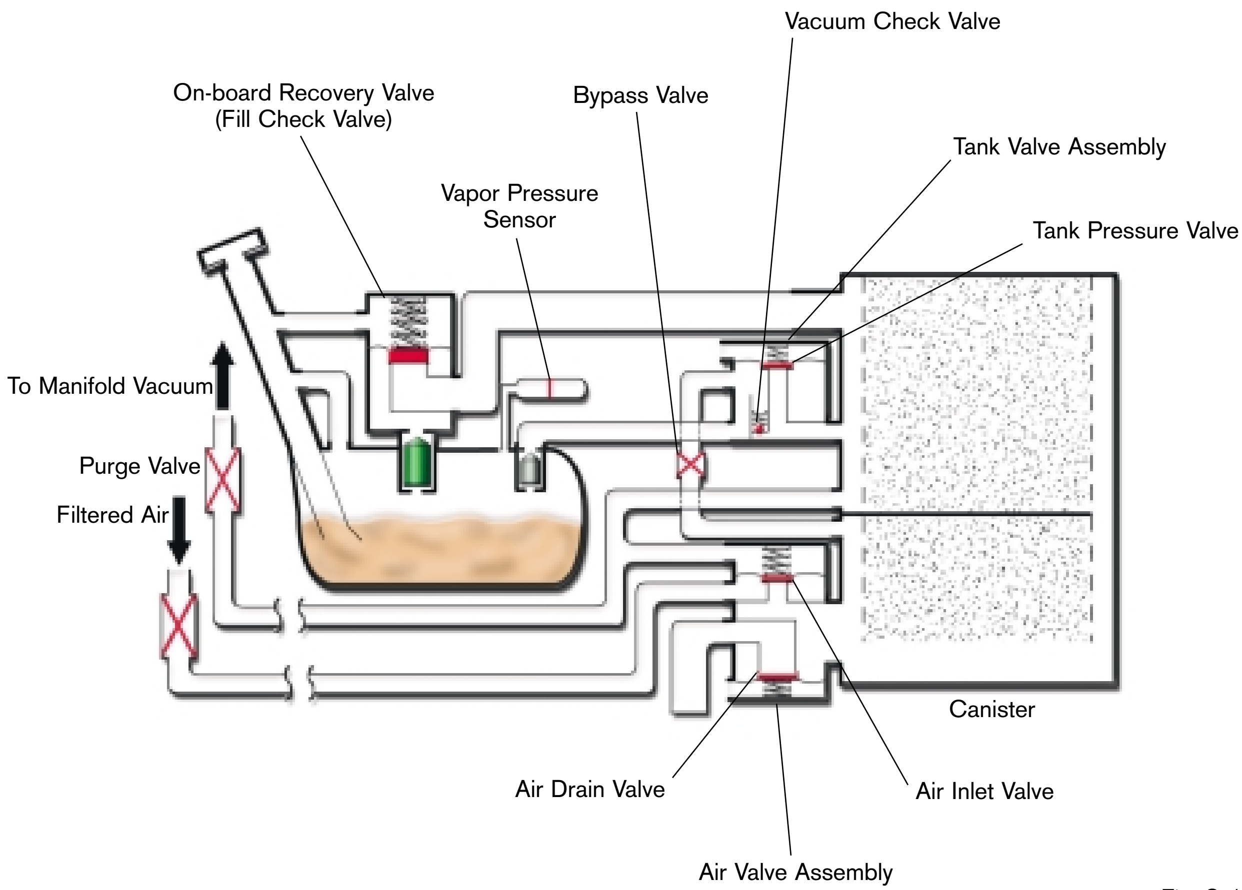


Fig. G-1

TL874fG01

Air Drain Port

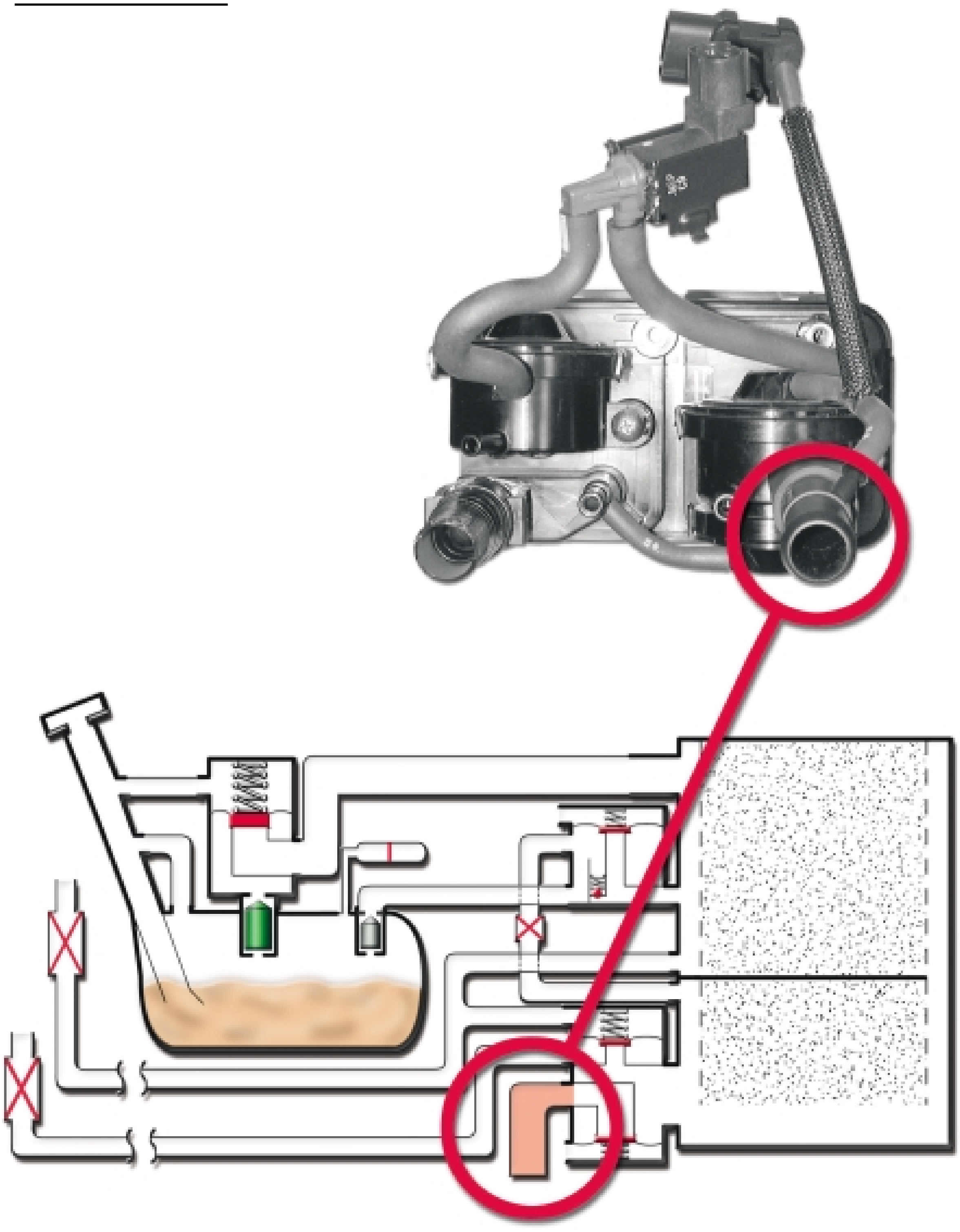


Fig. G-2

TL874fG02

Air Inlet Port

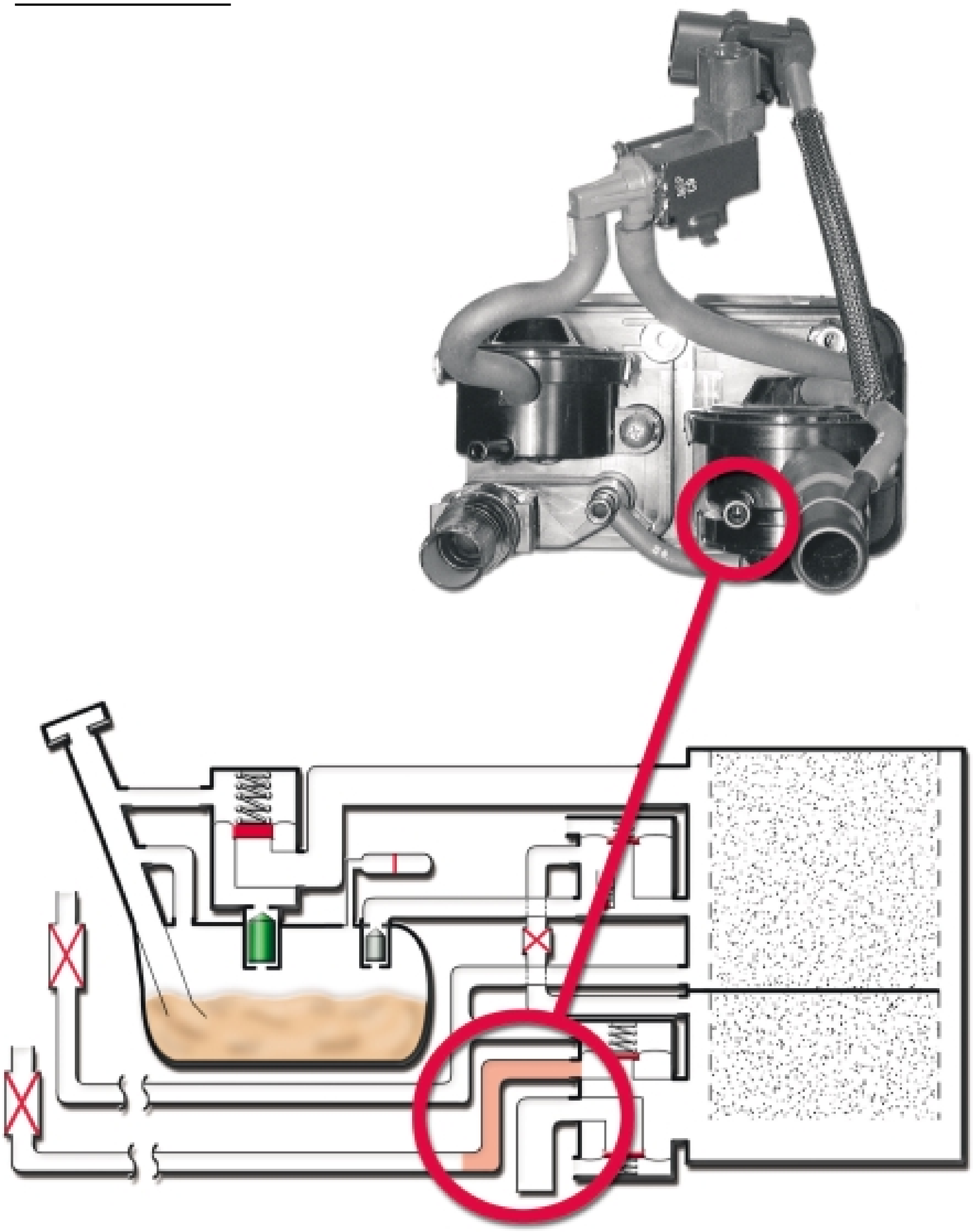


Fig. G-3

TL874fG03

Purge Port

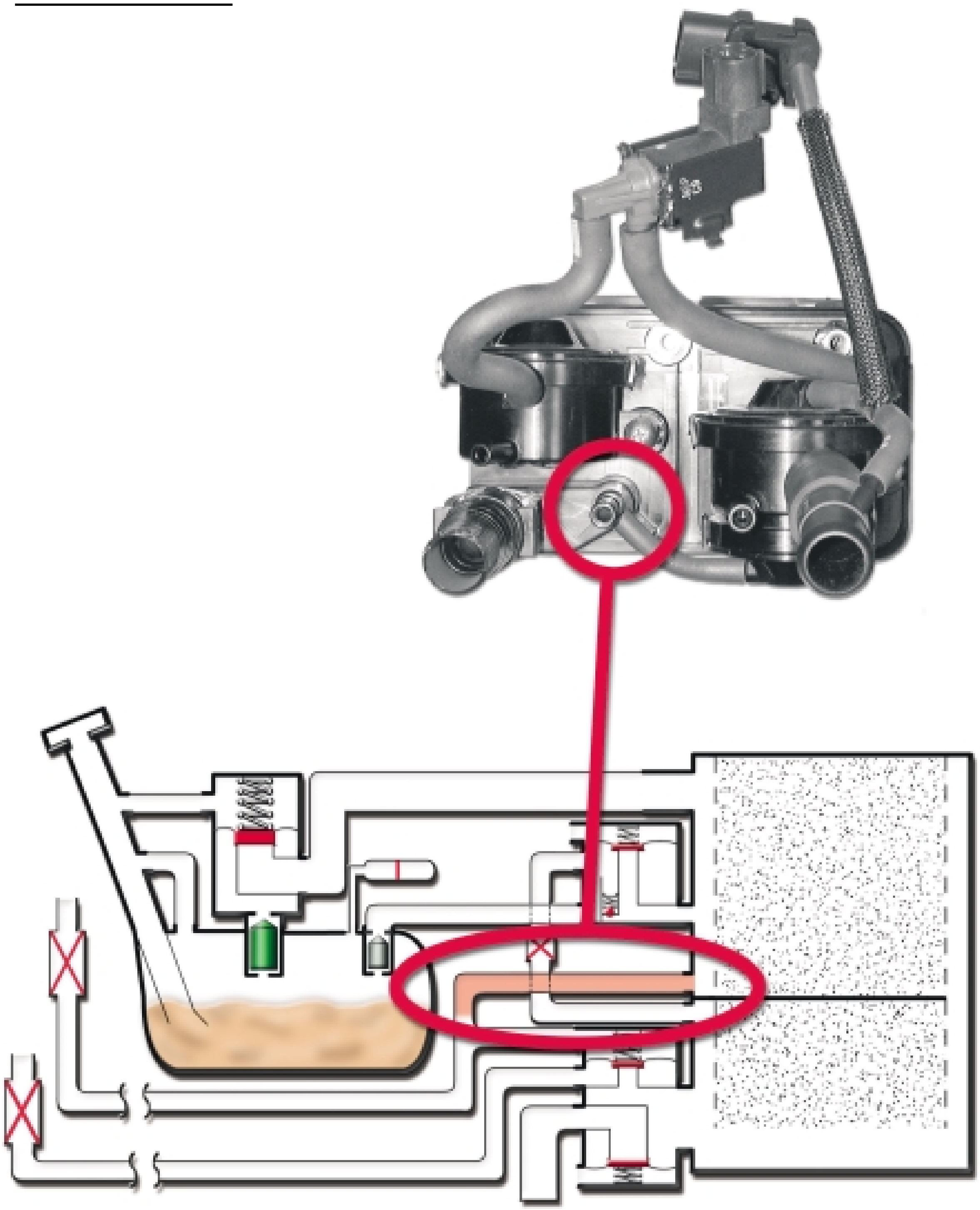


Fig. G-4

TL874fG04

Air Inlet Control Valve Port

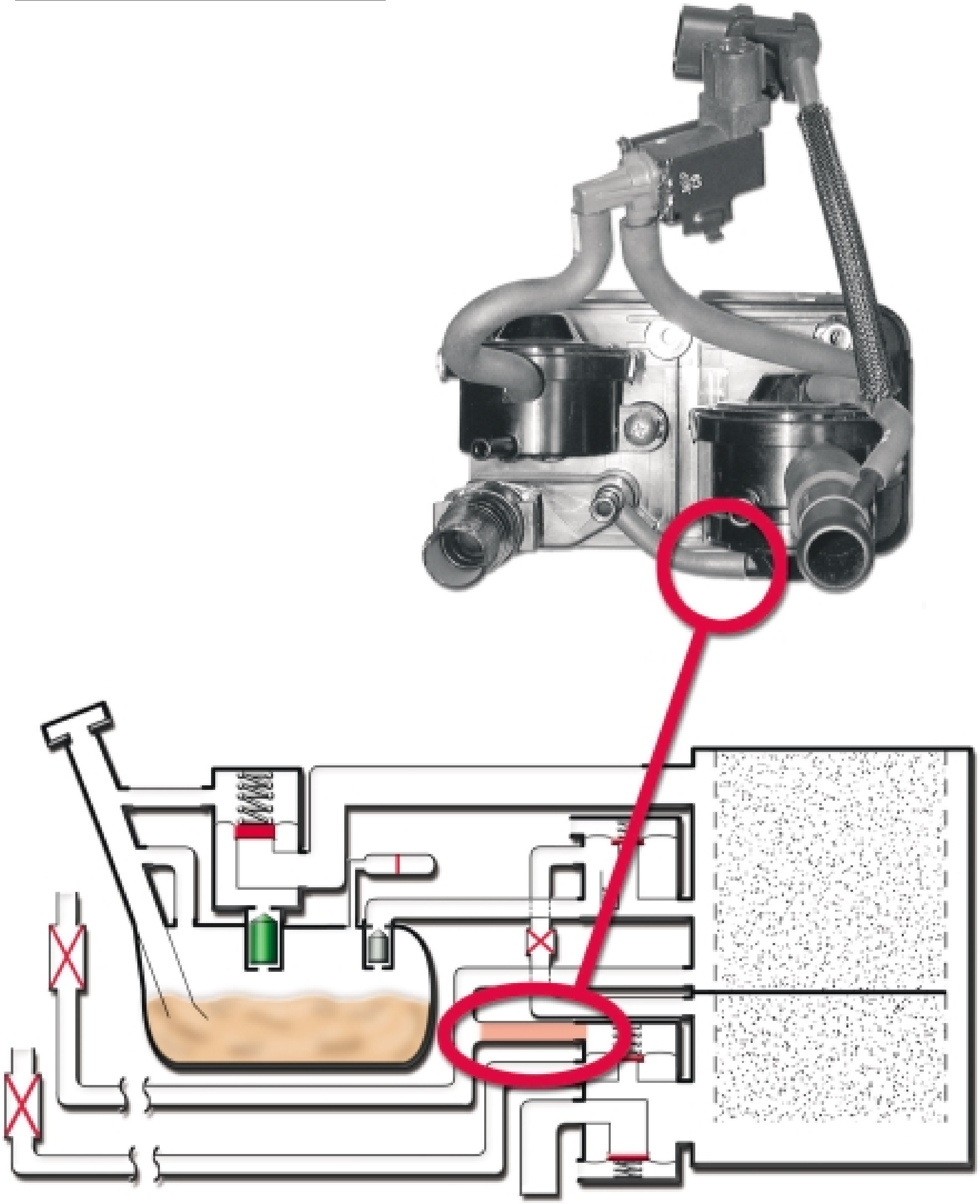


Fig. G-5

TL874fG05

Bypass Valve

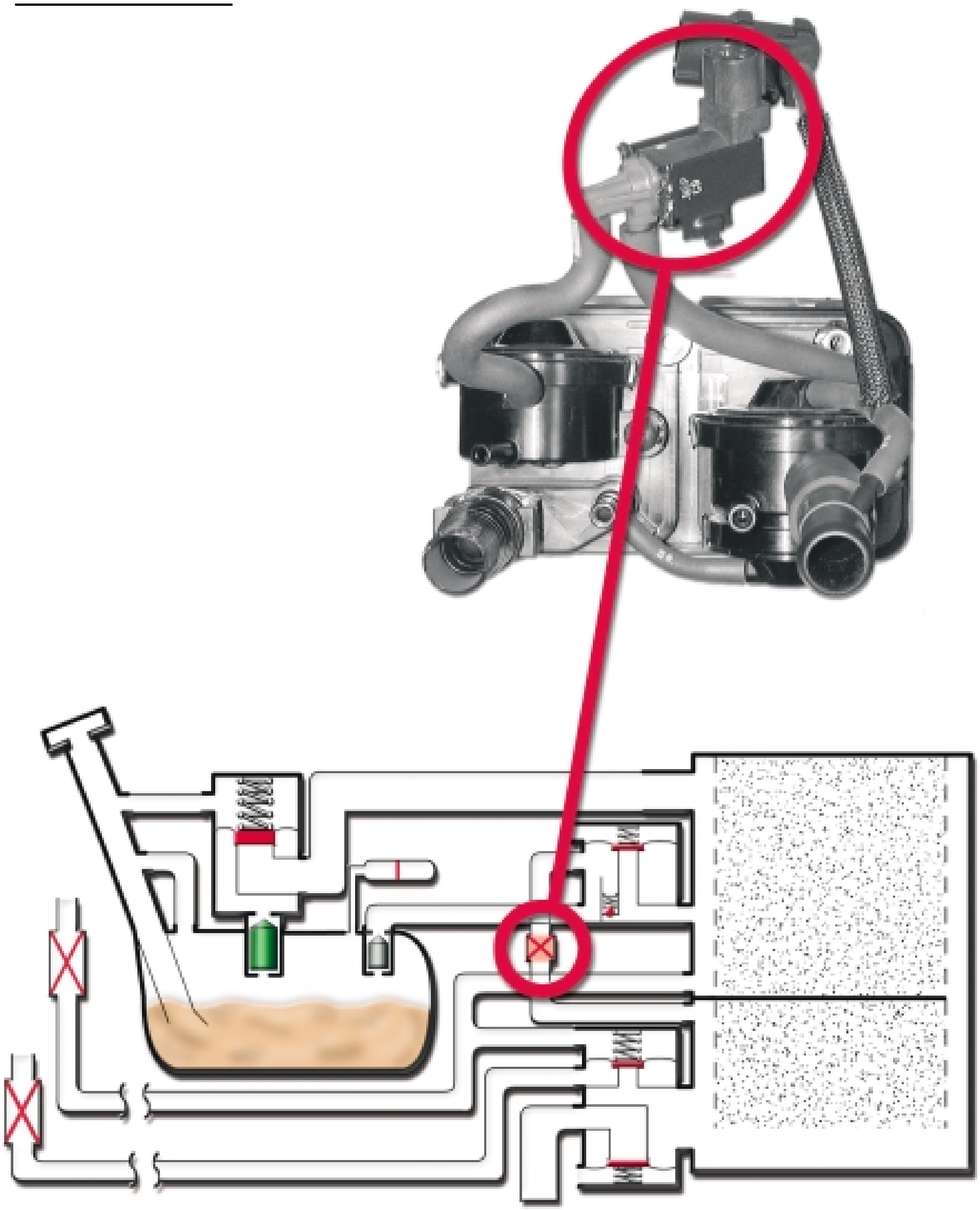


Fig. G-6

TL874fG06

Bypass Valve Ports

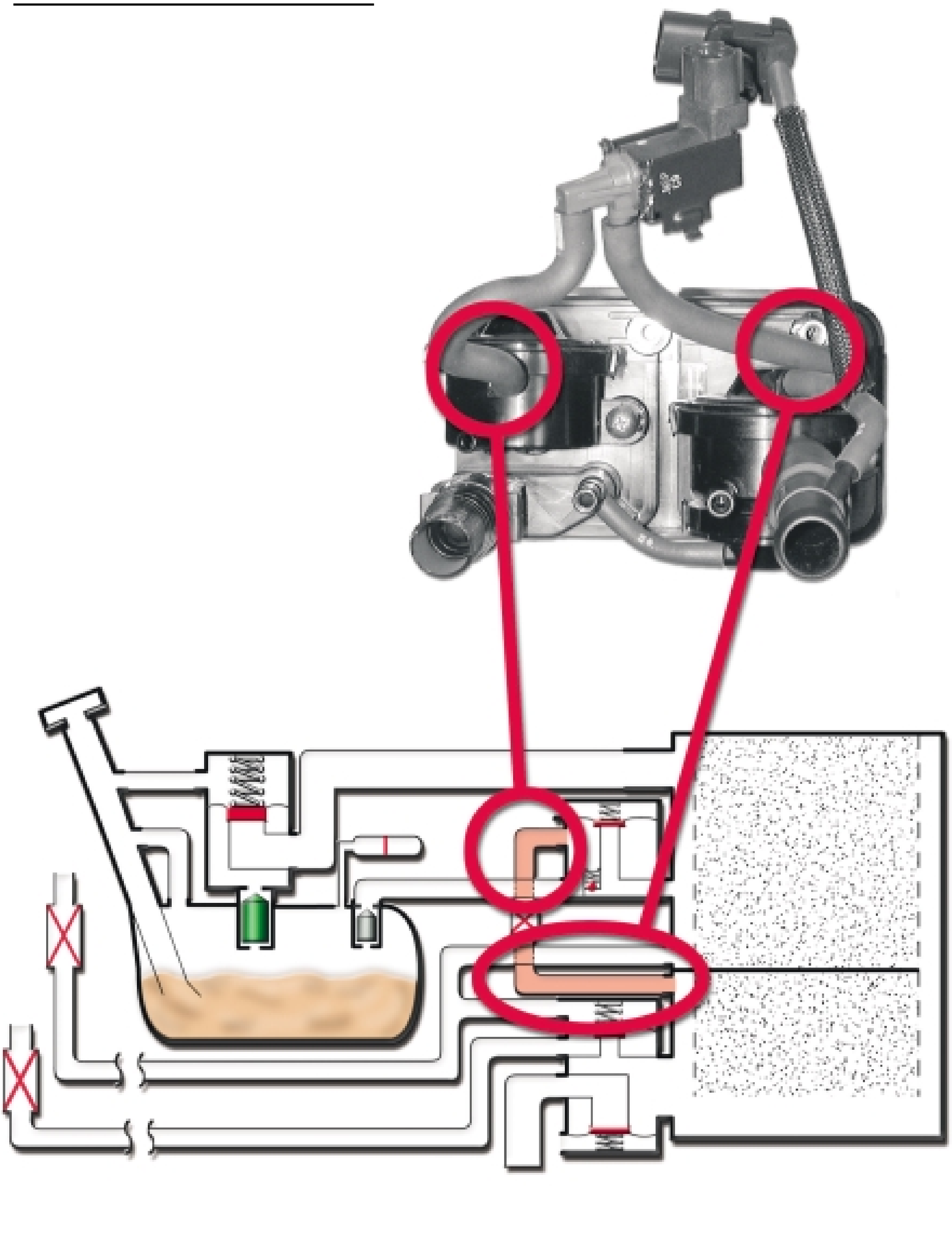


Fig. G-7

TL874fG07

EVAP Port

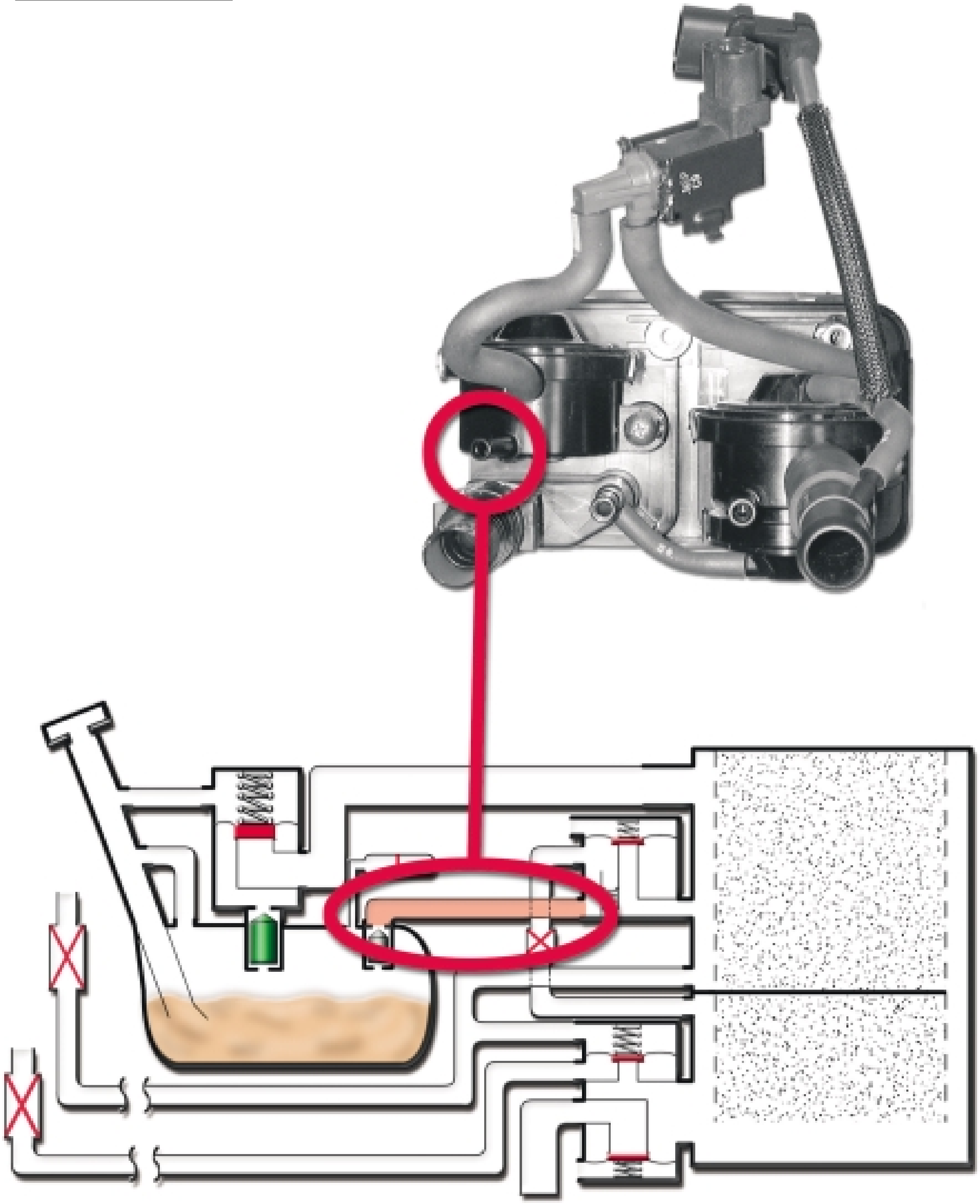


Fig. G-8

TL874fG08

Vent (Fill Check Line) Port

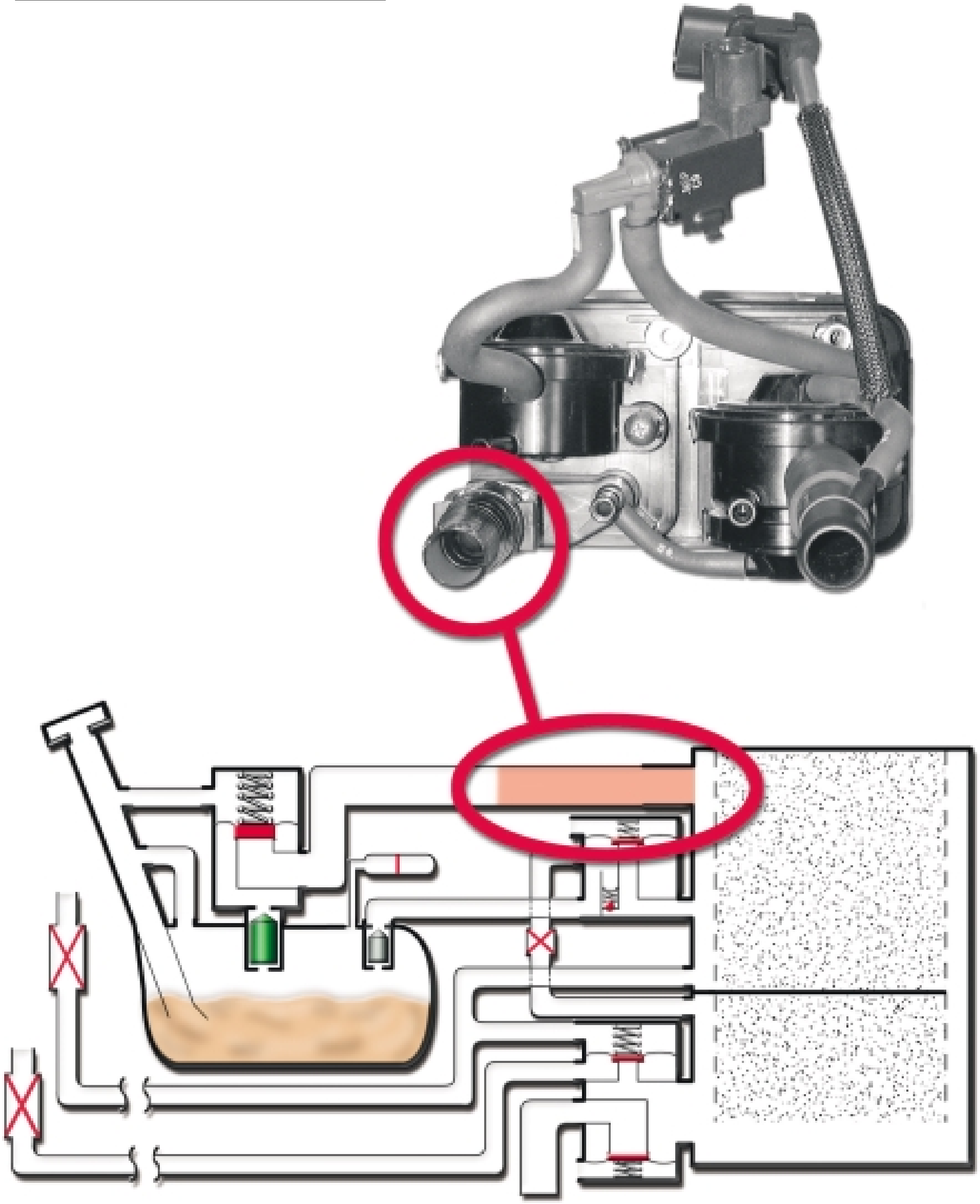


Fig. G-9

TL874fG09

Vapor Pressure Sensor

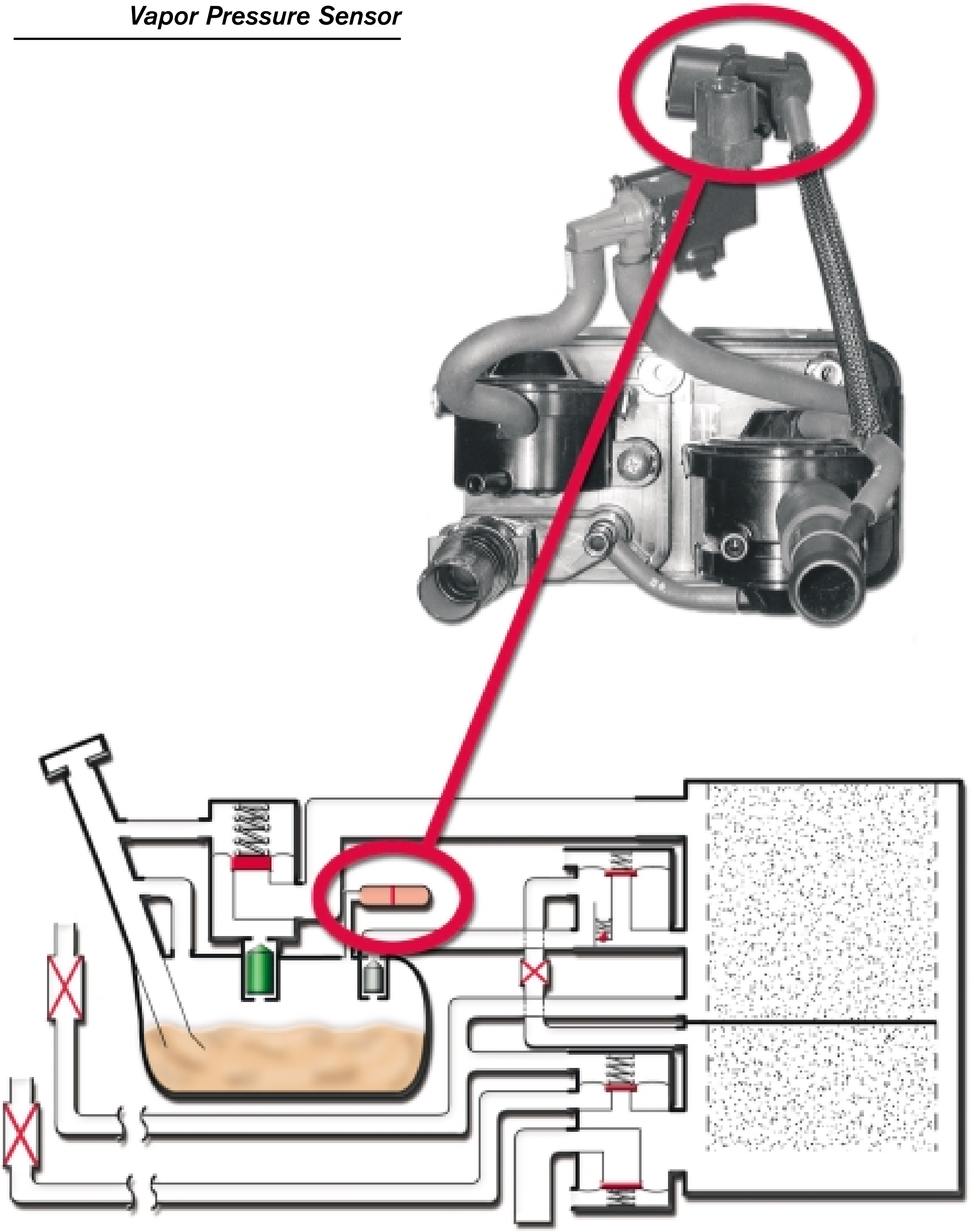


Fig. G-10

TL874fG10

Readiness Tests Drive Patterns Examples

The following Readiness Tests drive patterns examples are a guide to the preconditions and drive patterns needed to operate the Non-Continuous monitors. Please consult the latest service information before performing the drive patterns.

EGR Monitor (All Except 1FZ-FE)

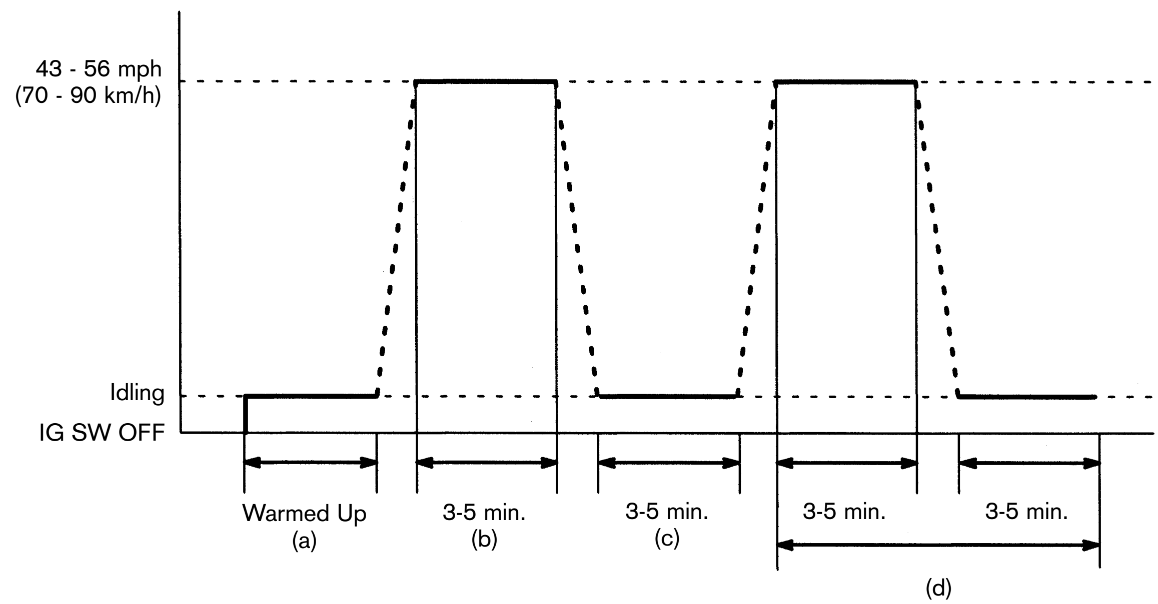


Fig.. H-1

TL874fH01

EGR Monitor (All Except 1FZ-FE)

Preconditions

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less
- IAT (Intake Air) is -10°C (14°F) or greater

Drive Pattern

Connect the Diagnostic Tester to the DLC3 connector to check monitor status preconditions.

a) If IAT (Intake Air) is less than 10°C (50°F) when starting the engine, idle the engine for approximately 10 minutes.

b) Drive vehicle at 43 – 56 mph (70 – 90 km/h) for a period of 3 – 5 minutes.

NOTE

- **Do not allow the Throttle Position (TP) to exceed 30%.**
- **Drive with smooth throttle operation and avoid sudden acceleration.**

c) Stop vehicle and let engine idle for 3 – 5 minutes

d) Repeat steps "b" and "c" once

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "b" through "d".

EGR Monitor (For 1FZ-FE Engine)

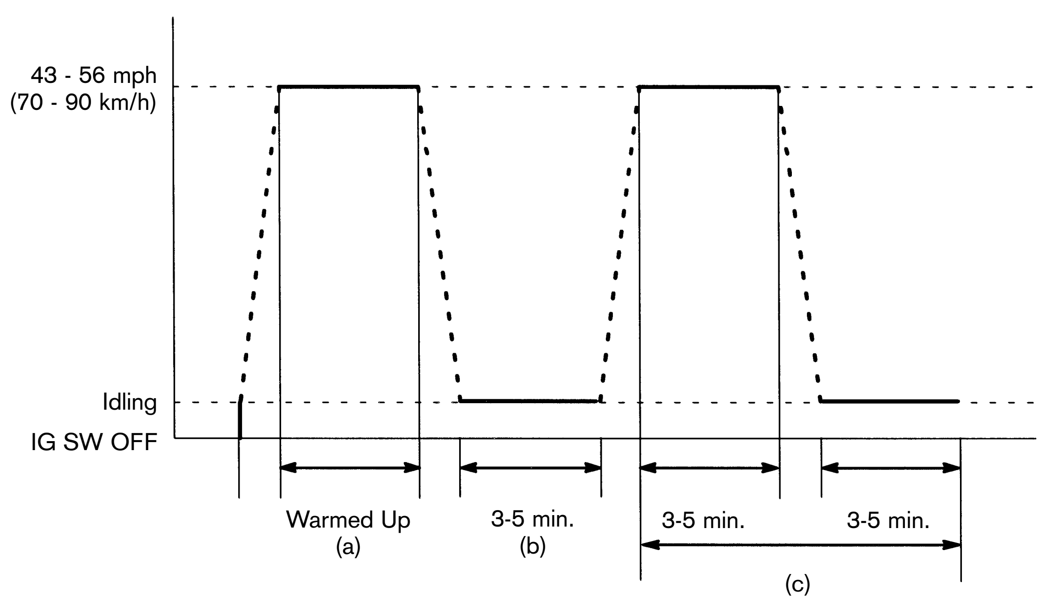


Fig.. H-2

TL874fH02

EGR Monitor (For 1FZ-FE Engine)

Preconditions

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less
- IAT (Intake Air) is -10°C (14°F) or greater
- ECT (Coolant Temperature) is less than 40°C (104°F)

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions.

a) Start the engine and immediately begin driving vehicle at 43 - 56 mph (70 - 90 km/h) for a period of 3 - 5 minutes.

NOTE

- **Do not allow the Throttle Position (TP) to exceed 30 %.**
- **Drive with smooth throttle operation and avoid sudden acceleration.**

b) Stop vehicle and let engine idle for 3 - 5 minutes.

c) Repeat steps "a" and "b" once.

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "a" through "c".

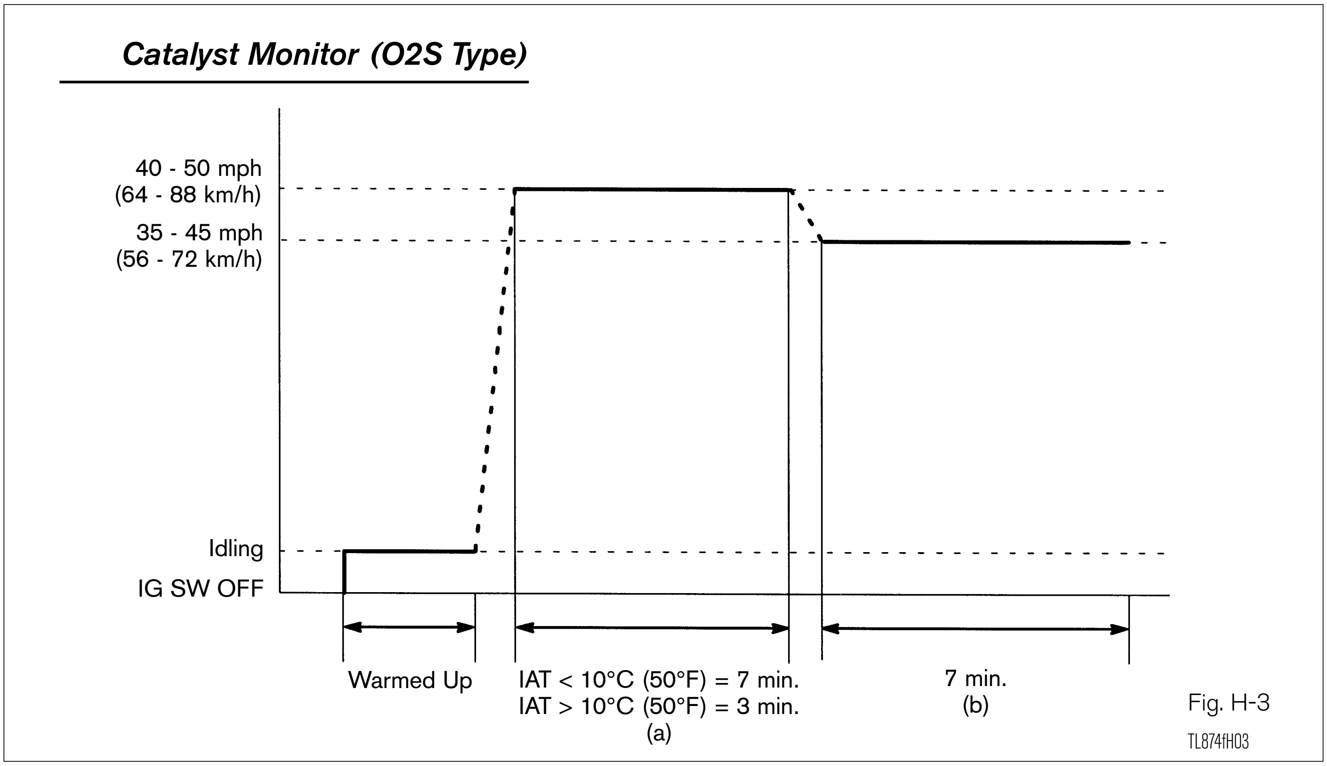


Fig. H-3

Catalyst Monitor (O2S Type)

Preconditions

The monitor will not run unless:

- MIL is OFF
- IAT (Intake Air) is 14°F (-10°C) or greater
- ECT (Coolant Temperature) is 176°F (80°C) or greater

NOTE

For 2002 and later MY vehicles:

- **The readiness test can be completed in cold ambient conditions (less than -10°C (14°F)), if the drive pattern is repeated a second time after cycling the ignition off.**

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions. Note the IAT (Intake Air) value during engine startup. The driving time must be adjusted during step (a) based upon IAT (Intake Air) value at startup.

a) Drive vehicle at 40 - 55 mph (64 - 88 km/h) for the time described below:

- If IAT (Intake Air) was less than 10°C (50°F) when engine started. then drive for 7 minutes.
- If IAT (Intake Air) was greater than 10°C (50°F) when engine started. then drive for 3 minutes.

b) Drive vehicle at 35 - 45 mph (56 - 72 km/h) for approximately 7 minutes.

NOTE

- **Drive with smooth throttle operation and avoid sudden acceleration.**
- **Drive with smooth throttle operation and avoid sudden deceleration as much as possible with the throttle fully closed.**

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "a" through "b".

Catalyst Monitor (A/F Sensor Type)

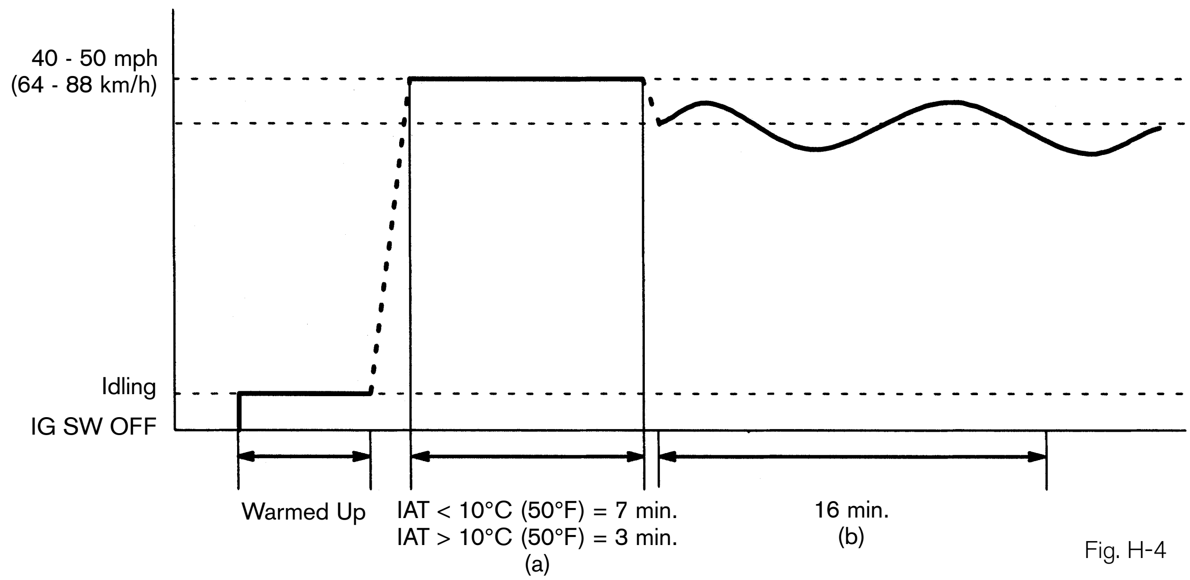


Fig. H-4

Catalyst Monitor (A/F Sensor Type)

Preconditions

The monitor will not run unless:

- MIL is OFF
- IAT (Intake Air) is -10° C (14 °F) or greater
- ECT (Coolant Temperature) is 80° C (176 °F) or greater

NOTE

For 2002 and later MY vehicles:

- **The readiness test can be completed in cold ambient conditions (less than -10°C (14°F)), if the drive pattern is repeated a second time after cycling the ignition off.**

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions. Note the IAT value (Intake Air) during engine startup. The driving time must be adjusted during step (a) based upon IAT value (Intake Air) at startup.

a) Drive vehicle at 40 - 55 mph (64 - 88 km/h) for the time described below:

- If IAT (Intake Air) was less than 10°C (50°F) when engine started then drive for 7 minutes

- If IAT (Intake Air) was greater than 10°C (50°F) when engine started then drive for 3 minutes.

b) Drive vehicle allowing speed to fluctuate between 35 - 45 mph (56 - 72 km/h) for about 16 minutes.

NOTE

- **Drive with smooth throttle operation and avoid sudden acceleration.**

- **Drive with smooth throttle operation and avoid sudden deceleration as much as possible with the throttle fully closed.**

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "a" and "b".

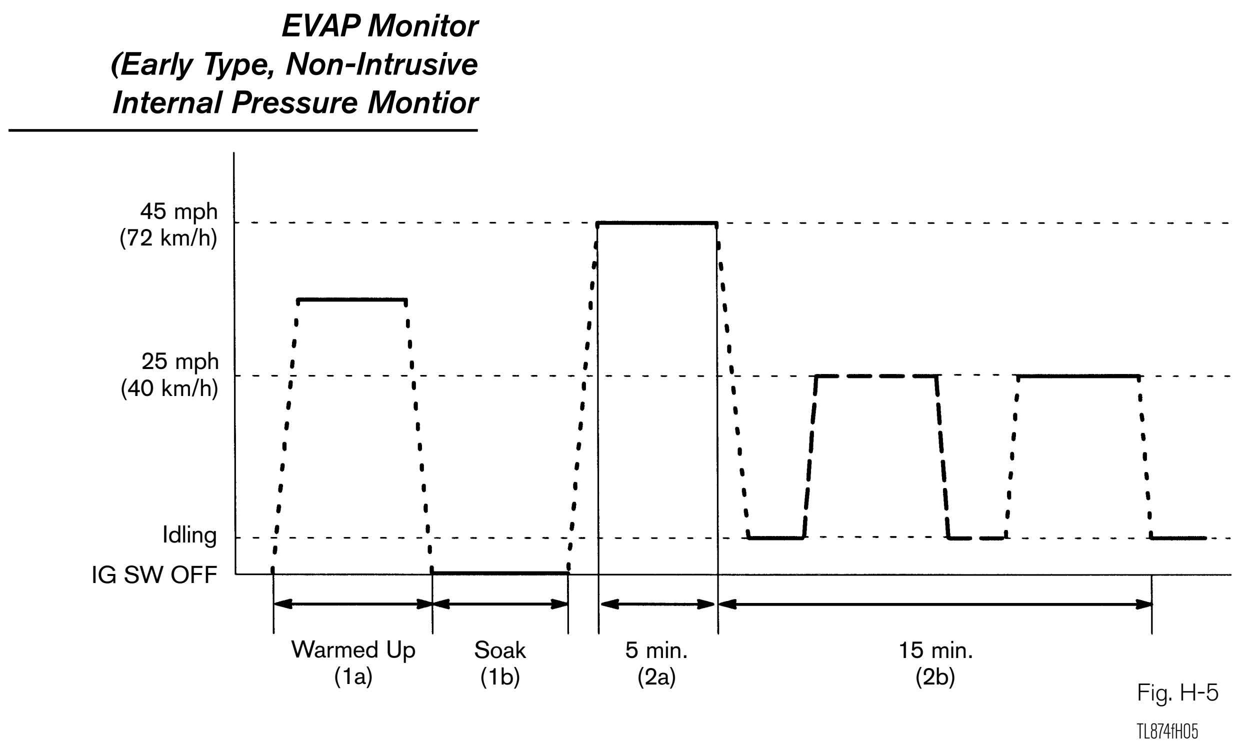


Fig. H-5

EVAP Monitor (Early Type, Non-Intrusive Internal Pressure Monitor)

Cold Soak Preconditions

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less

NOTE **For faster operation, the fuel level should be approximately 1/2 to 3/4 full.**

IMPORTANT **A cold soak must be performed prior to conducting the drive pattern to complete the Internal Pressure Readiness Monitor.**

Cold Soak Procedure

1a) Start the engine and allow ECT (Coolant Temperature) to reach 80°C (176°F) or greater

1b) Let vehicle cold soak for 8 hours or until the difference between IAT (Intake Air) and ECT (Coolant Temperature) is less than 7°C (13°F)

Drive Pattern Preconditions

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less
- ECT (Coolant Temperature) is between 4.4°C - 35°C (40°F and 95°F)
- IAT (Intake Air) is between 4.4°C - 35°C (40°F and 95°F)
- Cold Soak Procedure has been completed

NOTE

- **Before starting the engine, the difference between ECT (Coolant Temperature) and IAT (Intake Air) must be less than 7°C (13°F)**

Drive Pattern Procedure

- Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions.
- Release pressure in fuel tank by removing and then reinstalling the fuel tank cap.
- Start the engine and begin driving as directed.

NOTE

- **Do not turn the ignition off until drive pattern is complete.**
- **Drive on smooth roads to reduce excessive fuel sloshing.**

2a) Start the engine and immediately begin driving at approximately 45 mph (72km/h) for approximately 5 minutes.

2b) Drive vehicle at approximately 25 mph (40 km/h) for about 15 minutes and include a minimum of two stops for approximately 30 seconds.

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, repeat step"2b".

Cold Soak Preconditions

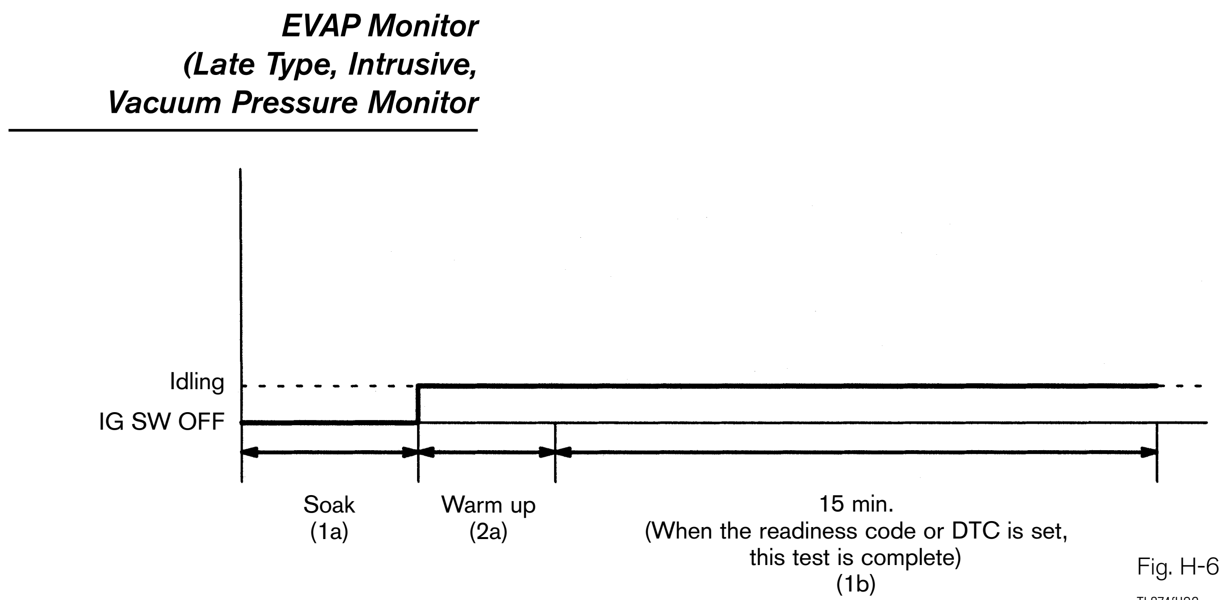


Fig. H-6

TL874fH06

EVAP Monitor (Late Type, Intrusive Vacuum Pressure Monitor)

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less

NOTE

For faster operation, the fuel level should be approximately 1/2 to 3/4 full.

Cold Soak Procedure

1a) Let the vehicle cold soak for 8 hours or until the difference between IAT (Intake Air) and ECT (Coolant Temperature) is less than 7°C (13°F).

Drive Pattern Preconditions

The monitor will not run unless:

- MIL is OFF
- Altitude is 7800 feet (2400m) or less
- ECT (Coolant Temperature) is between 4.4°C - 35°C (40°F and 95°F)
- IAT (Intake Air) is between 4.4°C - 35°C (40°F and 95°F)

- Cold Soak Procedure has been completed

- Before starting the engine, the difference between ECT (Coolant Temperature) and IAT (Intake Air) must be less than 7°C (13°F)

NOTE

- **2002 and later MY vehicles the readiness test can be completed in cold ambient conditions (less than 4.4°C (40°F) and/or high altitudes (more than 7800 feet (2400m)) if the drive pattern is repeated a second time after cycling the ignition OFF.**

Drive Pattern Procedure

- Connect the Diagnostic Tester to the DLC3 to check monitor status and preconditions.

- Release pressure in the fuel tank by removing and then reinstalling the fuel tank cap.

2a) Start the engine and allow it to idle until ECT (Coolant Temperature) is 75°C (167°F) or greater.

1b) Allow the engine to idle with the A/C ON (to create a slight load) for 15 minutes.

NOTE

- **If vehicle is not equipped with A/C put a slight load on the engine by:**

  1) Securely set the parking brake.

  2) Block the drive wheels with wheel chocks.

  3) Allow vehicle to idle in drive for 15 minutes.

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met by turning the ignition OFF; then, allow vehicle to idle as directed in step 1b for an additional 35 minutes.

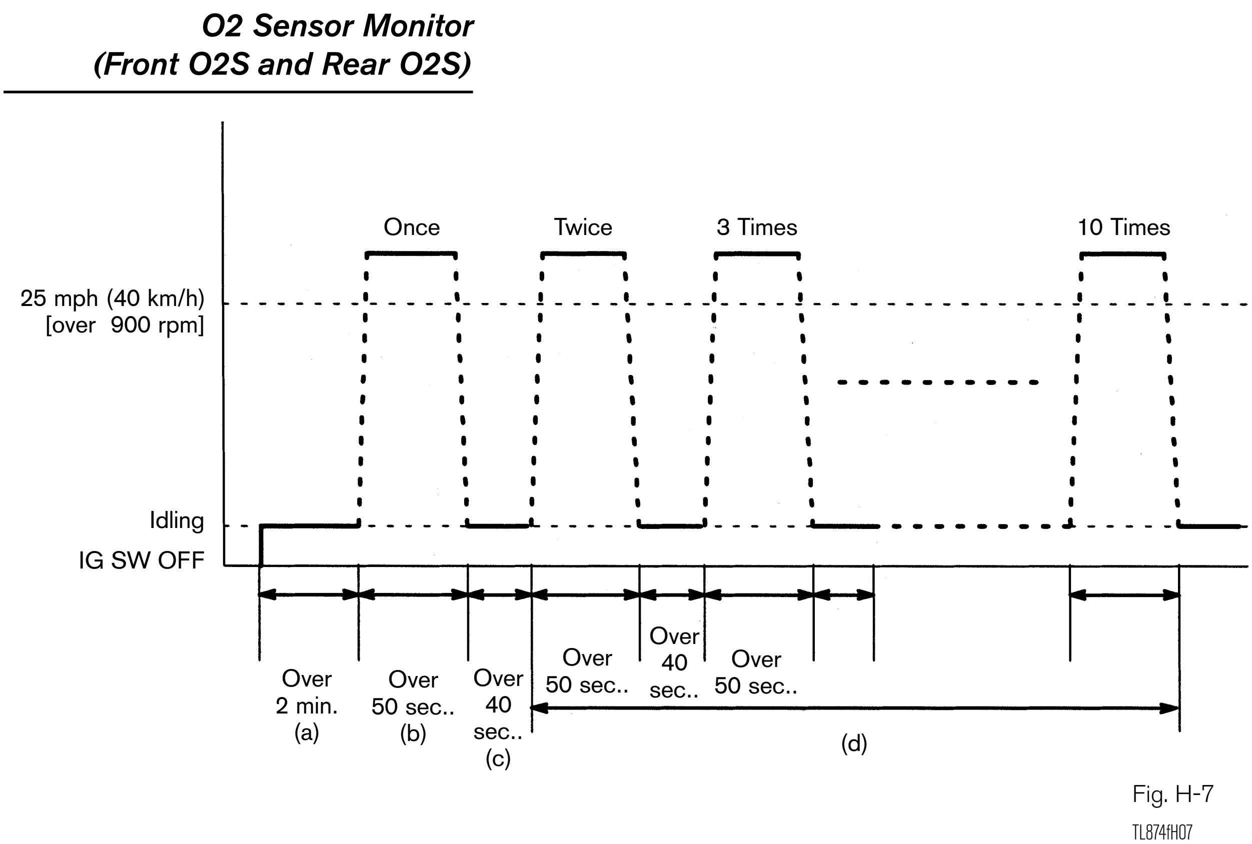


Fig. H-7

O2 Sensor Monitor (Front O2S & Rear O2S)

Preconditions

The monitor will not run unless:

- MIL is OFF

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions.

a) Start the engine and allow to idle for 2 minutes or more.

b) Drive vehicle at 25 mph (40 km/h) or more for at least 50 seconds.

c) Stop vehicle and allow engine to idle for 40 seconds or more.

d) Perform steps "b" and "c" ten times.

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "a" through "d".

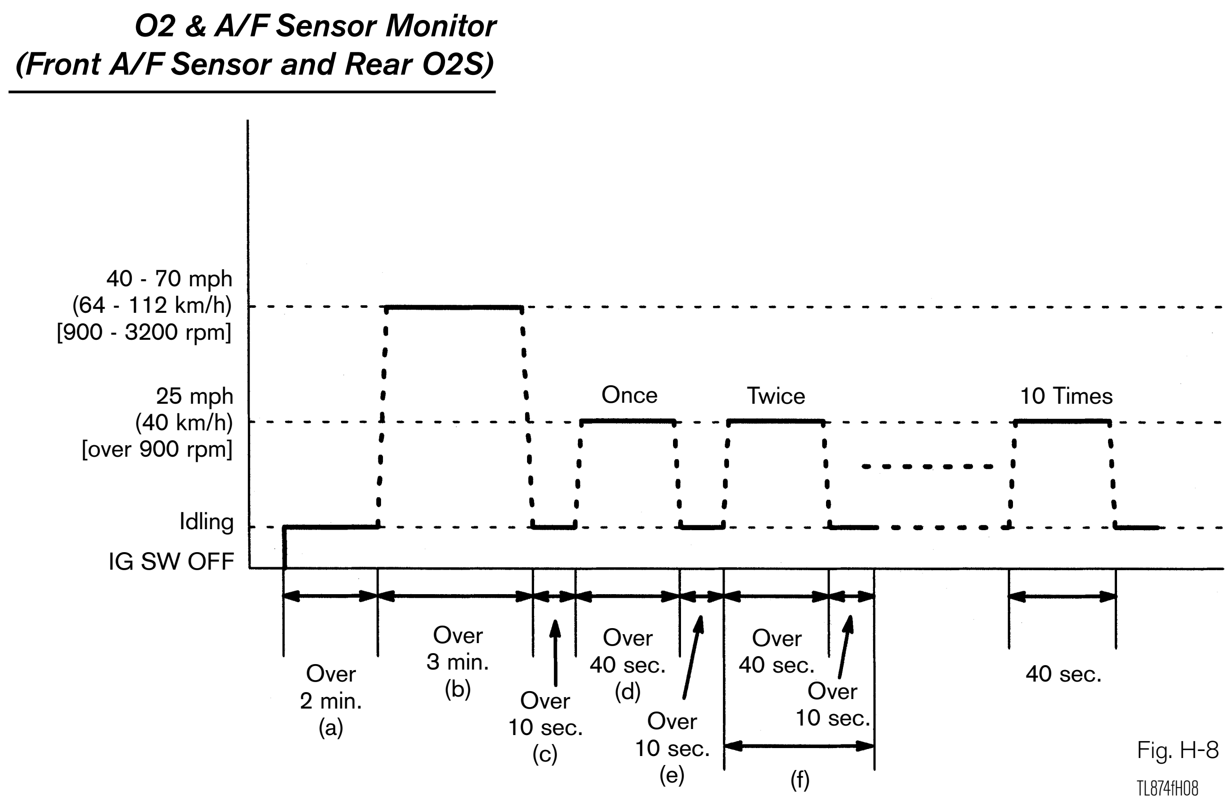


Fig. H-8

O2 & A/F Sensor Monitor (Front A/F Sensor & Rear O2S)

Preconditions

The monitor will not run unless:

- MIL is OFF

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions.

a) Start the engine and allow to idle for 2 minutes or more.

b) Drive vehicle at 40 - 70 mph (64 - 112 km/h) or more for at least 3 seconds.

c) Stop vehicle and allow engine to idle for 10 seconds or more.

d) Drive vehicle at 25 mph (40 km/h) for at least 40 seconds or more.

e) Stop vehicle and allow engine to idle for 10 seconds or more.

f) Perform steps "d" and "e" ten times.

Observe status of Readiness Tests monitors. If readiness status does not switch to complete, go to the Non-Continuous Tests screen to see monitor status. If Non-Continuous Tests screen still shows Pass, ensure preconditions are met, turn ignition OFF, and then repeat steps "a" through "f".

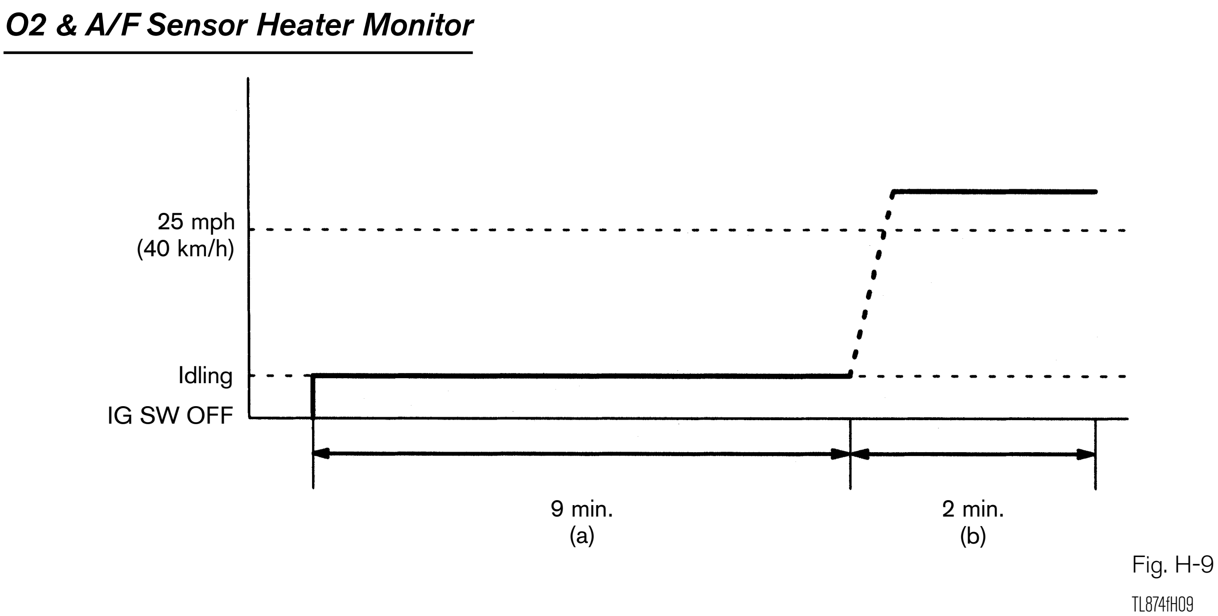


Fig. H-9

O2 & A/F Sensor Heater Monitor

Preconditions

The monitor will not run unless:

- MIL is OFF

Drive Pattern

Connect the Diagnostic Tester to DLC3 to check monitor status and preconditions.

a) Start the engine and allow to idle for 9 minutes.

b) Drive vehicle at 25 mph (40 km/h) or more for at least 2 minutes.

If readiness status does not switch to complete, ensure preconditions are met, turn ignition off and then repeat steps "a" and "b".