## Chapter 10

# Diagnosis and Troubleshooting

## Contents

## 1. INTRODUCTION

In this chapter you'll see the diagnostic and troubleshooting procedures that apply to fuel-injection and engine-control systems in Ford cars and trucks, both EEC and MECS. Troubleshooting and diagnosis is the most important part of service today. In the early days of fuel injection, a mechanic (and I use the word "mechanic" instead of "technician" advisedly) would wet his finger and prescribe, "You need a new control module." That didn't cut it then, and it won't cut it now.

This chapter will guide you to the source of problems. Section **2. Diagnosis and Troubleshooting Basics**, gives you some troubleshooting tips and general information you should know before beginning. Section **3. Diagnostic Routines**, gives you the specific troubleshooting steps. Later sections expand on the basic procedures. In all cases, the results of your troubleshooting will indicate specific components that need further testing or replacement. Look for this information in Chapter 11.

If you're an owner, troubleshooting your own car, you'll need to recognize there's a limit to how far you can "wade into this pool." But you'll be way ahead of those who have said to me, "When I raise the hood on these fuel-injected cars, I'm afraid to touch anything."

If you're servicing professionally, you have more tools and you can "wade in farther." I think you'll be pleasantly surprised how much you can find out, using this book.

By this point in this book, you should know:

- Fundamentals—what the system is supposed to do
- Operation of the sensors, the control module, the actuators and systems
- Strategies and how the control system deals with various operating conditions
- The differences between Ford EEC systems and Ford MEC systems:

| Ford Electronic Engine Control | Mazda Engine Control System |
|---|---|
| EEC (say "eek") | MECS (say "mex") |
| NAAO—North American Auto Operations | Non-NAAO—Non-North American Auto Operations |

If you've turned to this chapter without going through the previous chapters, you're going to be troubleshooting by the numbers with little understanding of what you are doing. For example, do you know what the BOO switch is? (If you don't, look it up, using the Index.) You will use the BOO switch in troubleshooting. Today's engine controls are too complicated and too interrelated to service by the numbers. Believe me, you can't afford the time or the dollars to try the old routine of "substitute a known good part." When you try that, you're flying blind.

When you finish these chapters, you'll know how to deal with diagnostics and troubleshooting and with the real problems. You'll know how to:

- Perform specific diagnostic checks to narrow the list of tests you will make for specific complaints
- Run a series of general tests that use the control module to lead you to specific service procedures

**Fig. 1-1.** Engine compartments are laid out with a great deal of logic to help you troubleshoot and repair fuel-injection/engine-control problems.

### 1.1 Terminology

Beginning in 1993, some of the names of the engine-control components were changed to comply with the SAE standardization J1930, in order to provide common terms for the same general part throughout the automotive industry. For more information on terminology changes, see Chapter 1. This chapter uses the terminology applicable for the years 1988–1992. For reference, **Table a** lists those terms and their equivalents that changed in 1993.

**Table a. 1993 and Later J1930 Terms**

| 1988–1992 Term | 1993 Equivalent |
|---|---|
| Air Charge Temperature (ACT) | Intake Air Temperature (IAT) |
| Barometric Pressure (BP) | BARO |
| Check Engine Light (CEL) | Malfunction Indicator Light (MIL) |
| Control Module/Electronic Control Assembly (ECA) | Powertrain Control Module (PCM) |

continued on next page

**Table a. 1993 and Later J1930 Terms (cont'd)**

| 1988–1992 Term | 1993 Equivalent |
|---|---|
| Distributorless Ignition System (DIS) | Electronic Ignition (EI)—Low *Data Rate* |
| DIS / EDIS / TFI Module | Ignition Control Module (ICM) |
| Electronic Distributorless Ignition (EDIS) | Electronic Ignition (EI)—High Data Rate |
| Heated Exhaust Gas Oxygen (HEGO) | Heated Oxygen Sensor (HO2S) |
| Idle Speed Control (ISC) | Idle Air Control (IAC) |
| Inertia Switch (IS) | Inertia Fuel Shut-off Switch (IFS) |
| Intake Air Control (IAC) | Intake Manifold Runner Control (IMRC) |
| Integrated Relay Control Module (IRCM) | Constant Control Relay Module (CCRM) |
| Profile Ignition Pickup (PIP) | Crankshaft Position (CKP) |
| Self-Test Connector (STC) | Data Output Line (DOL) |
| Self-Test Output (STO) | Data Link Connector (DLC) |
| Spark Angle Word (SAW) | Spark Output (SPOUT) |
| Thermactor Air–Bypass (TAB) | Air Injection Reaction Bypass (AIRB) |
| Thermactor Air–Diverter (TAD) | Air Injection Reaction Diverter (AIRD) |
| Thick Film Integrated-IV (TFI-IV) Ignition | Distributor Ignition (DI) |
| Vane Air Temperature (VAT) | Intake Air Temperature (IAT) |
| Variable Reluctance (VRS) | Crankshaft Position (CKP) |

## 2. Diagnosis and Troubleshooting Basics

### 2.1 Tips

Don't expect all the details for all cars to be in the book you're reading now. Ford Customer Service Division needs several thousand pages to cover all Ford fuel-injection and engine-control systems. But to help you with basic troubleshooting information and test values, you'll find a comprehensive set of wiring diagrams and specifications in Chapter 12.

#### What Parts Cause Trouble

I will tell you some of the more likely causes of problems, and some of the things often blamed but seldom guilty. If you know from experience what's most likely to go wrong, then it makes sense to start your troubleshooting there before going to the diagnostic routines.

- Ignition modules have given Ford more than its share of problems, particularly in the earlier TFI-IV systems
- Early model Throttle Position (TP) sensors can develop "glitch areas". The wiper track develops drop-outs, particularly where the TP sits for cruise control
- The inertia switch, a feature of Ford EEC and some MEC systems not generally found in other cars, can cause a No-Start, and I'll tell you why
- *Carbon build-up on the EGR valve seat on on the* pintle can cause the valve to remain open, setting a fault code
- The port injectors on early models can foul, and the intake passages can collect deposits
- Cracked or loose fan blades can cause a rough idle, easily blamed on the engine-control system
- Connectors have been a problem, particularly before it was realized how even small amounts of corrosion can interfere with the milliamps of current in the signal circuits. Ford devotes considerable attention to reliable links between sensors, actuators and control module. So should you in your troubleshooting
- Non-resistor spark plugs can introduce stray electrical noise in the sensor circuits—known as "spark echo." The low-amperage engine-control current flows can be skewed by spark echo, resulting in incorrect air-fuel ratios, spark timing, and even idle air
- Quick-check for No-start on MAP sensor equipped vehicles: Disconnect the MAP sensor and crank the engine. The Failure Mode Effects Management will substitute a fixed value. If the engine starts, then you know you probably have a MAP sensor problem. Don't forget to clear the trouble code when finished

**Fig. 2-1.** Connectors, harnesses and grounds are common trouble spots in electronic engine-control systems. Make sure connections are clean and tight. In earlier systems, cleaning corrosion from connectors will often fix problems without replacing components.

## Corrosion in Wiring

Corrosion in wiring harnesses can change the resistances and induce current leakage, affecting the signals from sensors. Once upon a time, we wrapped a splice to insure no contact with another lead or with ground. Now it's important to prevent moisture from entering connectors and conduits.

If water and salts enter, they can move along the harness, propelled by temperature changes, vibration, and wicking. Protect every point of entry into the harness from intrusion of moisture and dirt. If you find crystalline residues, white and blue green in color, clean off the corrosion damage and look for the points where moisture could enter. An old-fashioned tape splice may hide the source of your problem. Puncturing insulation to DVOM-measure a circuit may save the time and cost of a breakout box; but that pin-prick opening may haunt you in time ahead. If you find any pinholes in wiring, always seal them with a dab of silicone sealant.

## Road Testing

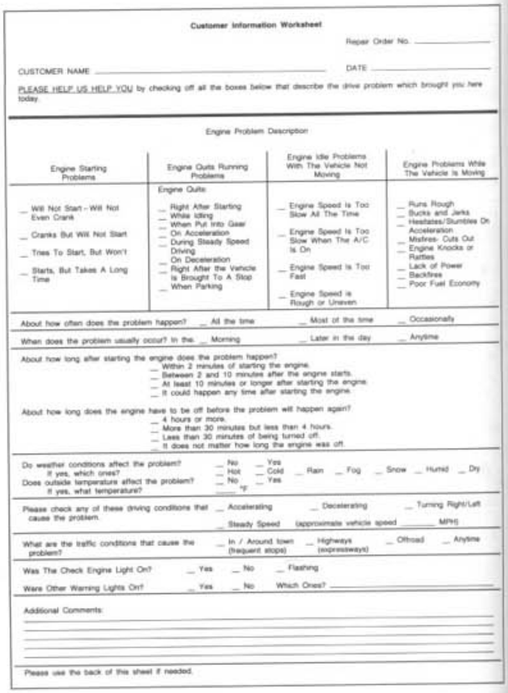
Whether you are servicing your own car or someone else's, begin by road testing, observing with your best analytical eyes and ears. As you drive the vehicle, listen and feel for the specific signs that verify the complaint and lead you to focus your troubleshooting.

In my experience, one of the toughest diagnostics, short of sudden failure, is analyzing your own car. Driving it day-to-day, you may fail to recognize changes that have occurred gradually. Day 365 doesn't seem much different from day 360, but it really is different from day 1.

Two suggestions that I've found valuable:

1. Ride as a passenger. With someone else driving and telling you what they are doing with the accelerator, you can better concentrate on the engine response to changing conditions.
2. Follow the car under test. Again, you need to know what the other driver is doing, but consider this, for example: If he suddenly closes the accelerator and you see a brief puff of blue smoke, you'll probably find worn valve guides. It's not likely the driver of the test car would see the blue smoke puff so he might blame the high HC emissions on the engine-control system.

Another helpful tip is something Ford service people use when they write up a repair: a customer information sheet. See Fig. 2-2. When you fill it out yourself, you may define the problem.



**Customer Information Worksheet**

Repair Order No. ______

CUSTOMER NAME ______ DATE ______

PLEASE HELP US HELP YOU by checking off all the boxes below that describe the drive problem which brought you here today.

Engine Problem Description

| Engine Starting Problems | Engine Quits Running Problems | Engine Idle Problems With The Vehicle Not Moving | Engine Problems While The Vehicle Is Moving |
|---|---|---|---|
| _ Will Not Start - Will Not Even Crank<br>_ Cranks But Will Not Start<br>_ Tries To Start, But Won't<br>_ Starts, But Takes A Long Time | Engine Quits:<br>_ Right After Starting<br>_ While Idling<br>_ When Put Into Gear<br>_ On Acceleration<br>_ During Steady Speed Driving<br>_ On Deceleration<br>_ Right After the Vehicle is Brought To A Stop<br>_ When Parking | _ Engine Speed Is Too Slow All The Time<br>_ Engine Speed Is Too Slow When The A/C Is On<br>_ Engine Speed Is Too Fast<br>_ Engine Speed is Rough or Uneven | _ Runs Rough<br>_ Bucks and Jerks<br>_ Hesitates/Stumbles On Acceleration<br>_ Misfires- Cuts Out<br>_ Engine Knocks or Rattles<br>_ Lack of Power<br>_ Backfires<br>_ Poor Fuel Economy |

About how often does the problem happen? _ All the time _ Most of the time _ Occasionally

When does the problem usually occur? In the: _ Morning _ Later in the day _ Anytime

About how long after starting the engine does the problem happen?
_ Within 2 minutes of starting the engine.
_ Between 2 and 10 minutes after the engine starts.
_ At least 10 minutes or longer after starting the engine.
_ It could happen any time after starting the engine.

About how long does the engine have to be off before the problem will happen again?
_ 4 hours or more.
_ More than 30 minutes but less than 4 hours.
_ Less than 30 minutes of being turned off.
_ It does not matter how long the engine was off.

Do weather conditions affect the problem? _ No _ Yes
If yes, which ones? _ Hot _ Cold _ Rain _ Fog _ Snow _ Humid _ Dry
Does outside temperature affect the problem? _ No _ Yes
If yes, what temperature? ____ °F

Please check any of these driving conditions that cause the problem. _ Accelerating _ Decelerating _ Turning Right/Left _ Steady Speed (approximate vehicle speed ______ MPH)

What are the traffic conditions that cause the problem? _ In / Around town (frequent stops) _ Highways (expressways) _ Offroad _ Anytime

Was The Check Engine Light On? _ Yes _ No _ Flashing

Were Other Warning Lights On? _ Yes _ No Which Ones? ______

Additional Comments:

Please use the back of this sheet if needed.

**Fig. 2-2.** Sample customer information worksheet.

## Engine Condition

It's easy to jump from a complaint to "a quick answer" for the problem. To some who are familiar with carburetors or points and condensers, electronic engine-control systems are still a new technology. So, often they blame the fuel injection or the control module first.

It's better to follow a definite troubleshooting procedure without skipping around. We used to teach the necessity of checking basic engine condition first. We said, when the vehicle is older or has higher mileage, be sure your troubleshooting is not fooled by poor compression, leaking valves, and deposits on the injectors or in the intake passages. That's still true of some driveability complaints. But, as it turns out, with the longevity built into today's engines, you are more likely to cure the bad emitter of pollution by first checking the engine-control system.

One of my favorite troubleshooting stories, from Gus's Garage in Popular Science, long ago:

LOL (Little Old Lady): "Gus, sometimes my car does not start."

GUS: "What do you mean, 'Sometimes?'"

LOL: "Well, when I drive to the ice-cream store and buy vanilla ice cream, it starts OK, but when I buy peppermint-stick candy ice cream, it won't start."

GUS: "Well, let's drive your car down to the ice-cream store and buy some ice cream." (You can tell this is a troubleshooting story from way back when garage owners had time to do this kind of thing. Either that, or this customer drives a Rolls-Royce).

Gus and LOL drive to the store, enter. Gus orders a pint of vanilla and a pint of peppermint-stick candy. Without delay, the clerk reaches into the freezer and hands Gus a pre-packed pint of vanilla. He then goes in the back room and returns in about 10 minutes with a custom-packed pint of peppermint-stick candy ice cream. Gus immediately troubleshoots the problem. What do you think?

LOL's car has a hard hot-start problem. During the ten minutes it takes to pack the peppermint-stick candy ice cream, the fuel is boiling in the lines. The engine has a vapor lock and so, a hard hot start. When she buys vanilla, she restarts the engine soon, before the fuel has time to boil. Imagine a shop troubleshooting a Repair Order: "Customer complains car will not start after she purchases peppermint-stick candy ice cream"!

Discussing diagnostics, I told this story to some engineers from Germany. One turned to the other and said triumphantly, "You see, I told you we could not program the diagnostic computer for all troubleshooting."

No, it takes knowing how the engine and its control system operate.

In a 1992 SAE paper, EPA reported testing some 245 four-cylinder cars, averaging about 50,000 miles on the odometer. All had failed an Inspection & Maintenance (I&M) test. EPA and vehicle manufacturers found that HC and CO emissions could be reduced by repair to the system, regardless of whether the vehicle had low or high cylinder compression. Of course, NOx formation is reduced with lower compression. Conclusion: "Reasonable emission levels can be achieved with proper repairs to the emission control system even on vehicles with internal engine problems."

On the other hand, don't overlook the basics. For example, you'd be barking up the wrong tree if you replace an Engine Coolant Temperature Sensor based solely on a scan-tool readout. The problem may really be caused by low coolant level that doesn't reach the sensor.

Two engine problems seem to crop up regularly on high mileage cars:

1. EGR valve clogged with carbon buildup. This can make the valve stick open or cut off EGR flow completely.
2. Buildup of fuel gum and crankcase blowby sludge in the throttle housing and around the throttle plate. This will affect air flow at all engine speeds, but especially idle.

Ford Service Engineering learns from these lessons: Most late-model engines are designed to meet emission limits without an EGR system. And most late-model throttle bodies (91+) are coated to resist sludge and gum.

Finally, let me suggest a few other basics often overlooked:

- Fuel—enough in the tank, and good quality
- Ignition—general condition of wires, moisture contamination, cracks in the distributor cap, damage
- Battery and starter—circuits, system grounds
- Vacuum hoses—cracked or disconnected (Fortunately, you have fewer vacuum hoses with EEC and MECS)

### Use the Control Module

Ford engine control systems test themselves to give you a lot of help troubleshooting. These Self-Tests are designed into the system to:

1. Test major subsystem elements.
2. Display test results with minimum test equipment.
3. Reduce time required for diagnostics.
   - Keep-Alive Memory (KAM) stores diagnostic routines and fault memories in the control module
   - KAM stores adaptive corrections
   - Failure Mode Effects Management (FMEM) improves the ability of the engine to run even with the failure of some component, while retaining information about the failure in the memory

In the Diagnostic Routines section of this chapter I'll show you how to use the control module to guide you to the problem. You'll find three kinds of Self-Test:

1. Continuous: tests during normal operation, all the time you're driving.
2. Key On, Engine Off: tests static sensor readings.
3. Engine Running: tests outputs by forcing various conditions and looking for responses.

See Fig. 2-3. These are also called Quick Tests, or On-Demand Tests. You demand the tests through the Self-Test Input (STI), and see the results through the Self-Test Output (STO). See **3. Diagnostic Routines**.

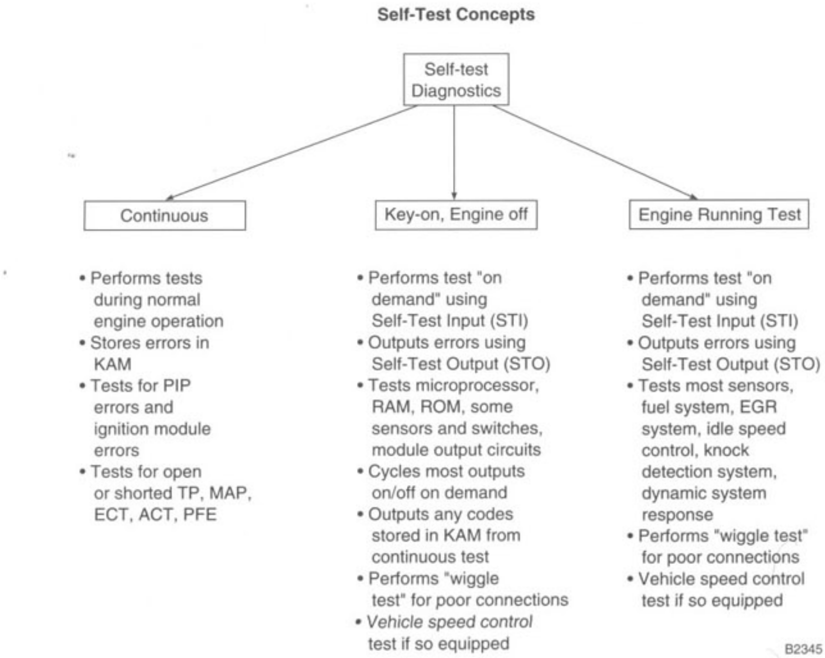



**Fig. 2-3.** Flow chart showing different types of Self-Tests made by control module.

## 2.2 Tools

Let's start with your need for a basic selection of good quality tools: wrenches, sockets, screwdrivers, pliers, and a timing light. You will also need a few specialized tools and some others will be helpful, even if not required.

You'll need a shop tachometer to read engine rpm. Don't depend on the dash instrument, particularly for reading small rpm changes.

A vacuum pump was more necessary when many systems operated by vacuum signals or vacuum power. You may need one for certain engine controls, particularly older MY systems or larger displacement engines. You might need a vacuum gauge with a range of 0-30 in-Hg. (0-100 kPa). You can also use the gauge on the vacuum pump.

You'll need a fuel pressure gauge, such as the one shown in Fig. 2-4, for fuel pressure tests. Most Ford systems operate at high pressure so be sure your gauge has the proper scale.

For ignition testing, you'll need a timing light to observe timing marks, and a Spark Tester to check ignition quality. A tester is available as special tool. See Fig. 2-5.

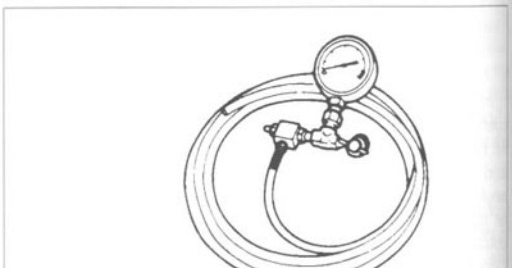



**Fig. 2-4.** Fuel pressure gauge.

### Volt-Ohmmeter

Many of the electrical tests in this book call for the measurement of resistance (ohms) or voltage signal of sensitive electronic components. A DVOM (Digital Volt-Ohm Meter) with high-input impedance registers millivolts and milliamps, and does not overload electronic components.

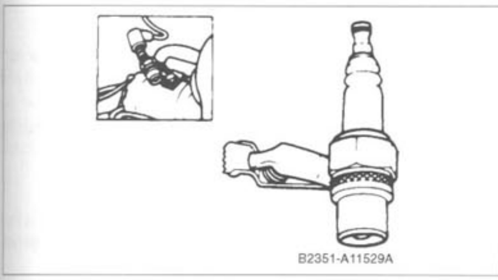



**Fig. 2-5.** Spark tester.

**NOTE —**
When making AC voltage readings, use a "standard" VOM. Do not use a "true" RMS-type meter because the readings will be incorrect.

You can use an analog voltmeter to read trouble codes, but it takes longer than a scan tool and needs more interpretation on your part.

## Scan Tools

Any extended troubleshooting requires a scan tool to plug into the Self-Test Connector. The Ford tools are known as:

- STAR (Self-Test Automatic Readout)
- Super STAR II
- NGS (New Generation Star)

NGS reads serial data—that is, actual values to and from the sensors and actuators. This serial data is available when you are driving, so it really can help you troubleshoot problems that occur only on the road.

Generic scan tools help troubleshoot Ford vehicles as well as other makes. Some offer additional capabilities. The Fluke Scope meter combines a multimeter with a small scope display. The Snap-On Scanner combines a four-line LCD readout with replaceable cartridges to update vehicle-specific data.

> If you drive with a scan tool on the road, take a helper. I've driven with a diagnostic tester while I designed and produced a video training program on a scan tool. The data stream can be so fascinating as to be dangerously diverting. Reminds me of the description of a tachometer in the first how-to-drive book I read when I was 12. It was a British book, written before the days of synchromesh transmissions. "TACHOMETER—OBSERVE THE INSTRUMENT CAREFULLY AND YOU WILL BE ABLE TO ENGAGE GEARS WITHOUT A SOUND EXCEPT FOR THE CRASH OF THAT LARGE PLATE GLASS WINDOW YOU DRIVE THROUGH." Ah, British humor. You watch the scan tool while your helper drives.

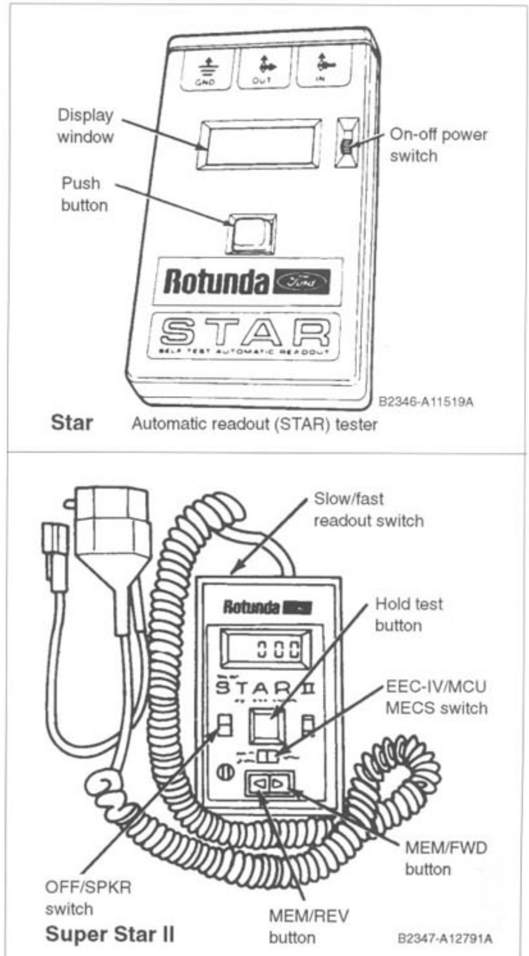



**Fig. 2-6.** MEC systems do not display in STAR; use Super STAR II.

If you don't use a scan tool, you'll need a test light to indicate current flow. For component protection it should not have an incandescent bulb, but should be of the high-input-impedance type, such as an LED (Light Emitting Diode) test light.

## BreakOut Box

For more advanced troubleshooting, some shops use a BreakOut Box, commonly known as BOB. See Fig. 2-8. This fits between the connector and the control module, providing access for measuring signals in individual circuits during operation.

Some techs say they don't need a breakout box. They insert a fine probe into a connector from the back to read circuit volt-

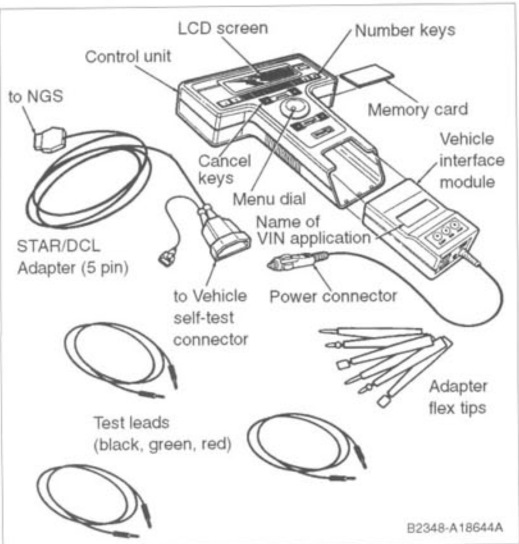



**Fig. 2-7.** New Generation STAR (NGS) adapts to different model years with a replaceable memory card. It reads data from Self-Test Connector and displays on LCD screen.

**Fig. 2-8.** BreakOut Box (BOB) installs between control unit connector and control unit to provide testing of signals as engine operates.

ages/resistances. This is sometimes called "backprobing". But be very careful. Do not insert probes from the front of the connector. This can cause pin damage and later lead to problems.

### EEC-IV Monitor

The Rotunda (Ford trade name) EEC-IV Monitor is also used by shops servicing Ford vehicles. It's self contained and actually easier to use than a BOB. In the service bay or on the road, it measures the sensors and actuators and translates their operation into understandable terms. Aftermarket monitors are available.

The Monitor saves time when you're chasing problems that are intermittent, that don't generate service codes, or generate too many codes.

The Monitor helps you locate non-electronic failures because it shows you the same information seen by the control unit as the vehicle operates, and how the processor reacts to this information.

### Engine Analyzer

Finally, if you're doing lots of troubleshooting, you'll need access to an engine analyzer to supplement your scan tool; they make a good troubleshooting team.

- When the scan tool points to the problem, the analyzer scope patterns help you to concentrate your troubleshooting on specific sensor/actuator signals
- Your problem may show up in the scope patterns on the analyzer even if the scan tool shows no problem

A modern engine analyzer will show much more than the traditional ignition patterns. You can see clues that lead you to the troubleshooting answers:

- Whether the problem is in one or two cylinders, or in all cylinders
- The effects of different air-fuel mixtures in one or more cylinders
- Injector patterns, and even patterns from some sensors

## 2.3 Precautions

Before performing any work, read the general Warnings and Cautions at the beginning of this book, and follow basic safety rules, as well as those specific to fuel injection and ignition systems.

***WARNING —***
*• Gasoline fuel is one of the most concentrated sources of energy around. Keep any spilled fuel away from hot engine parts. Do not smoke or create sparks when fuel is present, and always have a fire extinguisher handy. Work in a well-ventilated area.*

*• Fuel injection systems operate under pressures much higher than other fuel systems. See Fig. 2-9.Confine the fuel spray during any injector testing or opening of fuel lines to minimize the chance of a fire.*

***WARNING —***

*• Remove jewelry, metal watches, and watchbands. If one of those shorts a circuit, you may wear the scar the rest of your life.*

*• An engine has the power to crush you. If you run the engine of a car with an automatic transmission while testing, do not trust your life to the PARK position of the lever. Set the parking brake and chock the drive wheels. Avoid working in front of the bumper whenever possible.*

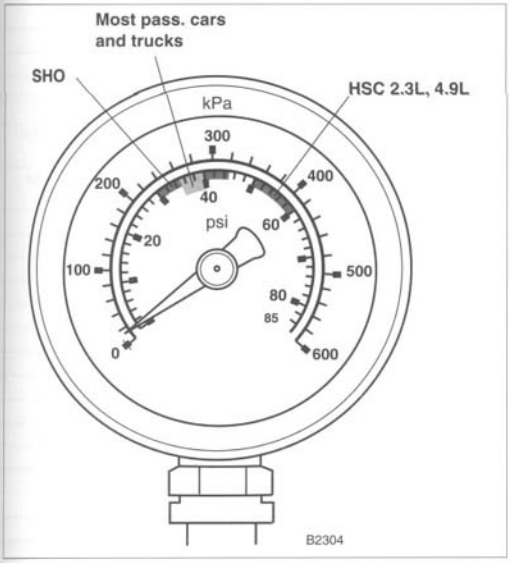



**Fig. 2-9.** Most Ford fuel injection systems operate at high pressures. Key On Engine Off values shown.

***CAUTION —***

*• For many tests, such as compression checks or cylinder balance checks, either disable the fuel injection system or keep the duration of the test short. Cranking a fuel-injected engine without starting it can deliver raw fuel into the cylinders, and from there into the exhaust system. This may cause the catalytic converter to overheat and melt down when the engine is restarted.*

*• Avoid the use of high-voltage battery boosters or chargers. Anything greater than 16 volts is potentially harmful. Be aware that some service stations use 24-volt boosters to turn over engines in sub-zero weather.*

*• Turn off the key and isolate both ends of a circuit when checking for shorts or continuity.*

***CAUTION —***

*• Disconnect solenoids and switches from the harness before measuring for continuity, resistance, or before energizing.*

*• Any time you disconnect a connector, inspect for damaged or pushed out pins, loose wires, corrosion. Take care not to damage terminals when testing. When assembling the connector, make sure the connection is tight.*

*• Do not disconnect or reconnect the wiring harness connector to the control unit with ignition ON. This can send a damaging voltage spike through the control unit.*

*• Dirt is the first enemy of fuel injection systems. Even minute particles can clog the small orifices of the components. Before you open a fuel fitting, wipe it clean with a solvent.*

*• If the system is open, avoid using compressed air, and don't move the car unless necessary. If you leave the job unfinished, cover removed parts and system openings with plastic, not cloth. When installing new parts, unwrap them just before installation.*

Only perform electrical tests(what Ford calls "Pinpoint Tests") when directed by the Quick Test procedures. Otherwise, the incorrect results may lead you to replace good components.

Avoid excess voltage or voltage spikes to the control unit. Ford fuel-injection/engine-control systems are protected from surge and overvoltage, but watch for the following conditions which may damage any system:

- Check for disconnected or loose battery connections. Alternator output goes up as the voltage regulator senses low battery voltage. An open battery circuit will cause the alternator to deliver excess voltage that could damage the control unit as well as the wiring harnesses.
- Before you disconnect a booster or charger with the engine running make sure you have an electrical load. You want to avoid a voltage spike. I'm suggesting you add load just for the moment it takes to disconnect the cables. Turn on the lights and blower or rear window heater. As soon as the booster cables are disconnected, you can turn everything off again.

## 2.4 Vehicle Identification

Before you begin any work or troubleshooting you need to know just what engine and engine-control systems are installed on the vehicle.

## Engine and Model Year (MY)

First, determine the engine and its EEC or MECS system. Start with the Vehicle Emission Control Information (VECI) decal under the hood. See Fig. 2-10. You'll see the engine-control system and what's adjustable, and what's not. You may need to verify whether this is a 49-state car, a California car, or a 50-state car. Those differences can be important. You'll see the Model Year (MY), which can be trickier than you think. Some 1991 MY cars were introduced as early as March 1990.

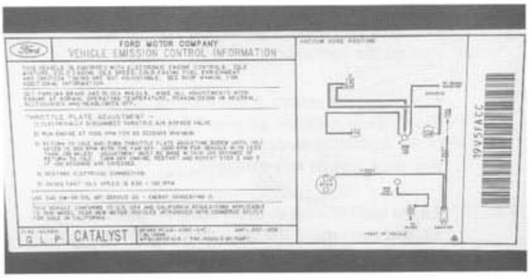



**Fig. 2-10.** VECI decal for 1991 1.8L Escort.

## Vehicle Identification Number

Learn to read the VIN and what it can tell you about the Engine Code and MY. Look for it inside the lower windshield frame ahead of the driver. Look for it also on the plate inside the door frame showing the VIN and the build-date. See Fig. 2-11. You'll need to know the VIN to use the STAR or other scan tools, to choose the wiring diagrams, and to apply service bulletin information. What looks like the same engine may have a different Engine Code, even if it is the same capacity, and it may differ according to the MY. Do not guess.

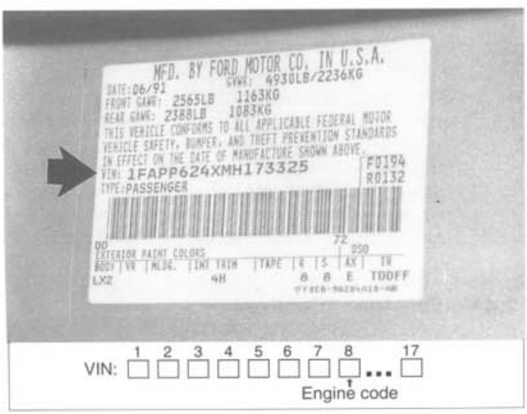



**Fig. 2-11.** Vehicle Identification Number (VIN) on door jamb. Look at eighth digit to determine engine code.

| Engine | VIN Code | Transmission |
|---|---|---|
| **EEC-IV Passenger Cars** | | |
| 5.0L MAF-SFI (1988–93) | E | |
| 5.0L MAP-SFI (1988–92) | E | |
| 4.6L 4V MAF-SFI (1993) | V | AODE |
| 4.6L MAF-SFI (1991–93) | W | AOD (AODE '93) |
| 3.8L MAF-SFI SC (1989–93) | R (C early) | |
| 3.8L MAF-SFI (1988–93) | 4 | AXODE some |
| 3.2L MAF-SFI (1993) | P | AXODE |
| 3.0L FF (Flexible Fuel Vehicle) | 1 | AXODE |
| 3.0L MAF-SFI (1988–93 SHO) | Y | |
| 3.0L MAF-SFI (1988–93) | U | AXODE |
| 3.0L MAP (1988–92) | U | |
| 2.3L MAF-SFI (1988–92) HSC | A | |
| 2.3L MAP (1988–91) HSC | A | |
| 2.3L MAF-SFI (1988–93) OHC | S | |
| 2.3L MAP (1988–90) OHC | S | |
| 2.0L MAF-SFI (1993 Probe) | A | (See MECS for '93 4EAT) |
| 1.9L MAF-SFI (1990–93) | J | See MECS for 1.8L Escort |
| 1.9L VAF (1988–89) | X | |
| **Nissan Engine Control** | | |
| 3.0L MAF-SFI (Villager) | W | 4F20E |
| **EEC-IV Light Trucks** | | |
| 5.8L MAP (1988–93) | H | |
| 5.0L MAF-SFI (1993) | N | AODE |
| 5.0L MAP (1988–93) | N | |
| 4.9L MAP (1988–93) | Y | |
| 4.0L MAF-SFI (1993 CA) | X | |
| 4.0L MAF-SFI (1990–93) | X | |
| 4.0L MAF (1990–93) | X | |
| 3.0L MAF-SFI (1992–93) | U | |
| 3.0L MAF (1991) | U | |
| 3.0L MAP (1988–91) | U | |
| 2.9L (1992) | T | |
| 2.9L MAP/MAF (1988–91) | T | |
| 2.3L OHC MAF (1988–93) | A | |
| **Mazda Engine Control Systems (MECS)** | | |
| 2.5L V-6 MC-VAF-SFI | B | |
| 2.2L Turbo | L | |
| 2.2L Non-Turbo | C | |
| 2.0L (automatic only) | A | 4EAT (See EEC for MTX) |
| 1.8L | 8 | |
| 1.6L Turbo | 6 | |
| 1.6L Non-Turbo | Z | |
| 1.3L | H | |

**Fig. 2-12.** Engine VIN identification codes for vehicles covered by this book. Firing Order & Cylinder #1

The VECI decal usually supersedes what you might read in a shop manual. Some VECI decals may be pasted over the original for an engine-control system modified for a recall. Also, be on the lookout for such oddities as non-stock engine-control modifications made for performance. If the car is not yours, or if you bought it used, try to find out as much about the car's history as possible. Beginning in 1991, VECI decals use the new terminology recommended in SAE J1930. See Chapter 1 for more information.

### Firing Order and Cylinder #1

Here's a special tip for checking Ford engines: *learn to identify the cylinder numbers and the firing orders.* I know that sounds weird, but we've got three problems:

1. What is the firing order? Although they look alike outside, most Ford 5.0L engines fire 1-5-4-2-6-3-7-8, while the 5.0L HO fires 1-3-7-2-6-5-4-8. See Fig. 2-13.
2. Where is cylinder #1? Most diagrams show cylinder #1 next to the fan. But with transverse engines (across the engine bay) the electric fan is next to the radiator and useless as a clue. On Ford engines, cylinder #1 is farthest from the flywheel or the transaxle. On V-type engines, it's on the cylinder bank to your right when facing the engine. On transverse V-type engines, it's on the cylinder bank closest to the firewall.

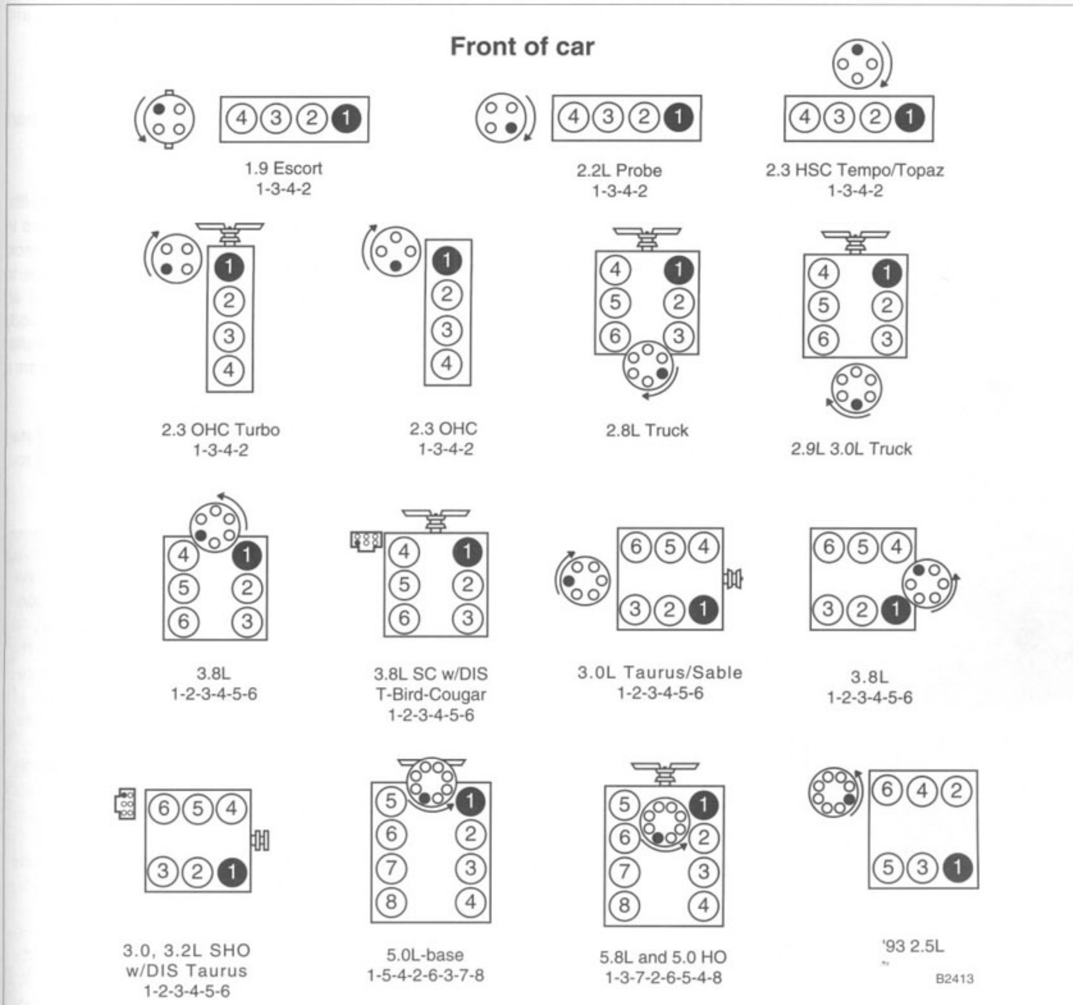



**Fig. 2-13.** Ford numbers cylinders differently from most other makers. Ford firing orders differ even on engines seemingly the same. Most Ford 5.0L engines fire 1-5-4-2-6-3-7-8, while the 5.0L H.O. fires 1-3-7-2-6-5-4-8. Notice how '93 Probe 2.5L numbering differs from Ford V-type engines.

3. Where is cylinder #2 in a V-type engine, next to #1 or across in the other bank? Ford has its own way of numbering cylinders that can fool you on a V-type, particularly transverse as in Taurus/Sable and recent Continentals. For U.S. transverse V-type engines, the right bank is the rear bank. Ford engines number consecutively along each bank. Begin 1-2-3 along the right bank, looking from the driver side, then 4-5-6 on the left bank. That's different from the 1993 Probe 2.5L V-6: #1 in right bank (closest to bulkhead, and alternating across, 1R, 2L, 3R, 4L, 5R, 6L. Most other V-type engines also alternate, beginning the other way: usually 1L, 2R, 3L, 4R, 5L, 6R.


**Fig. 2-14.** Ford identifies cylinder numbers differently from other manufacturers. It pays to check the diagrams or the cylinder number identifiers on the plug wires of late-model engines.

## 3. Diagnostic Routines

For any complaint, the possible causes are many. If you just troubleshoot randomly you could be at it for hours before you find the source of the problem. I've already given you some basic tips about how to begin your troubleshooting, now let's take it one step further.

To make troubleshooting easier and faster, Ford has developed Diagnostic Routines. These charts list the best order to check systems and components for specific problems. The routines are based on years of technician experience, and have been developed considering three factors:

1. Probability—how likely is this to be the cause?
2. Ease of accomplishment—how easy is it to check this?
3. Accessibility—how easy is it to get at the part?

For example, if the engine is fitted with long-life, platinum-tipped spark plugs, and some of them are hard to reach, those are likely to be lower on the list of things to check. On Ford vehicles, intake air leaks are less common due to component mounting locations. So checking for intake air leaks or bad gaskets at the intake manifold or throttle body mounting is also lower on the list. If you're one who is familiar with many Bosch systems, you know that intake air leaks are a common problem due to long ducting.

The moral of this is that if you want to save time, don't start hooking up your testers until you follow the diagnostic routines.

Control modules are often blamed unfairly. It is true that many early troubleshooting charts ended at the control module, saying something like, "Check every sensor, connector, cable, and actuator. We don't know how to tell you to check the control module so if everything else is OK, replace the control module." I've heard that Ford had a warehouse full of modules returned under warranty, most of which tested OK. Bosch told me of similar experiences. These days, that's less true for at least three reasons:

1. Shops are finding that modules are more reliable than expected. Control modules are complex but have nothing mechanical to wear out. They're checked out on the assembly line and they don't leave the factory if they're not good. One general electronics rule of thumb: if it's going to fail, it will be within the first hours or days of operation.
2. In the control module, improved On-Board Diagnostics (OBD) increase your chances to find the real problem instead of blaming the module by default.
3. Troubleshooting charts no longer end with "Replace the control module".

In other words, control modules have gotten smarter and so have we.

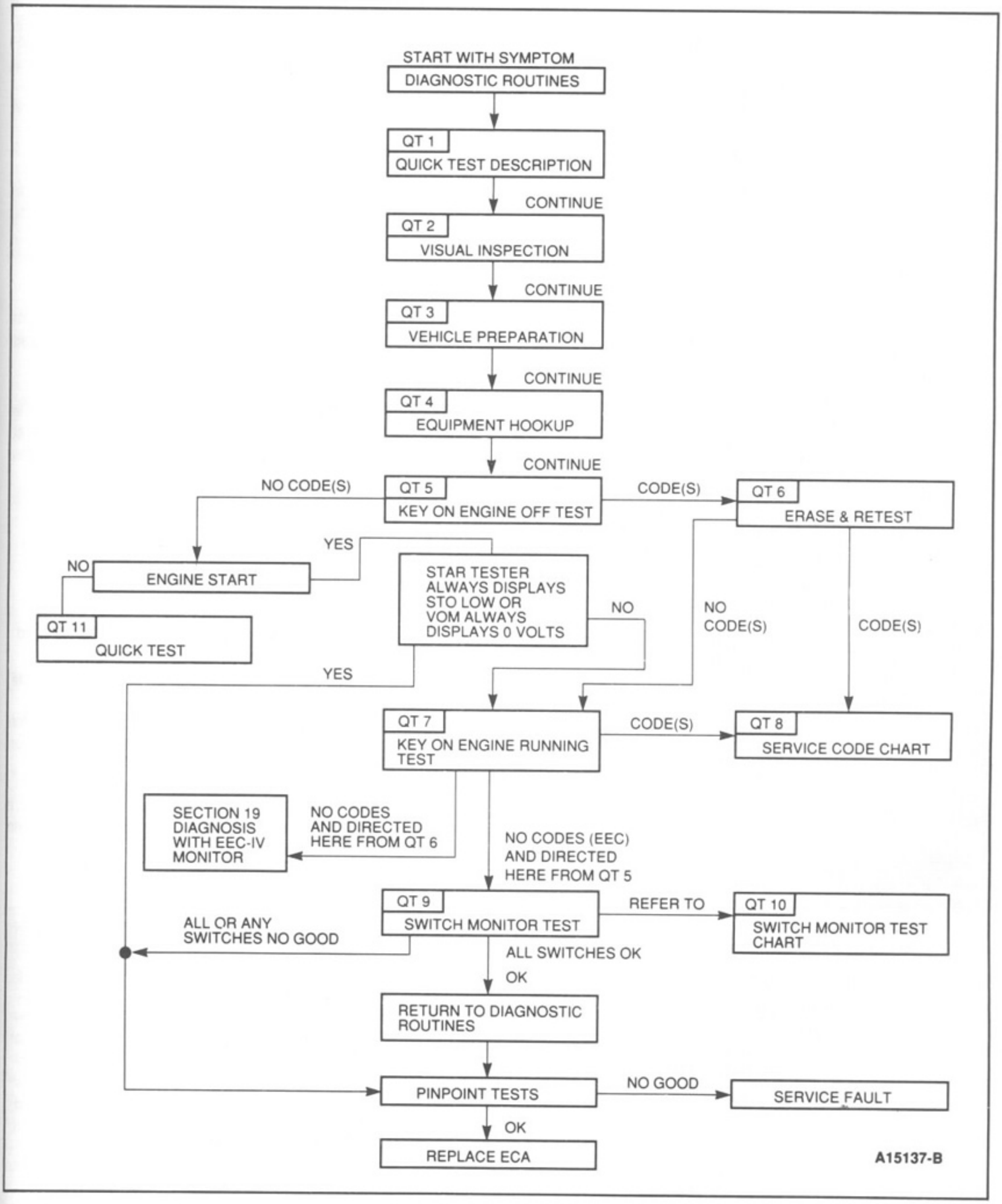



**Fig. 3-1.** Example of Diagnostic Routines Flow Chart for *Mazda Engine Control System (MECS)* equipped vehicles.

10

### No-Crank

Before we go to the routine charts, let's talk about a No-Crank condition. You've checked the battery, the starter relay, the Neutral Drive/Clutch switch, the starter and the key switch. But turning the key to START produces nothing, not even a groan. What does the control system have to do with cranking? Let me suggest two possibilities:

1. The inertia switch cuts off power to the Fuel Pump Relay. If it opens, you have a No-Start. That open circuit can happen with a vigorous slam of the trunk lid or hatch. Beginning in some 1991 vehicles, a dash warning lamp signals "FUEL CUTOUT" if the inertia switch opens the fuel pump circuit.
2. There's one strange item that's not on Ford's list for a No-Crank condition: Check for an Anti-Theft device. Be especially wary of an aftermarket anti-theft with an ignition and/or starter cut-off. If triggered, it cuts off the ignition and the starter.

> No-Start was a condition that gave our younger son problems when he bought a used 1980 Fiat Spyder (with Fiat's first use of Bosch L-Jetronic fuel injection). He would phone from across the country, "The mechanic says I need a new air box. What do you think?" I'd say, "Did he say why? Find another mechanic," Another mechanic said it would need a new control module. Son found a diagnostic technician who reported the correct fix: Previous owner had installed an aftermarket anti-theft system that cut off power to the fuel pump. Any jostle of the car was causing the anti-theft to open the fuel pump circuit. When he reset the anti-theft switch, son cured his No-Start condition, without a new airbox, or a new control module.

### Emission Tests

Studies by EPA and manufacturers have shown the parts most likely required to repair cars that failed emission tests. According to recent studies reported to the SAE, for example, these parts are more likely to need replacement to pass the idle-emission test for hydrocarbons (HC):

- Oxygen sensor: 50 to 70% of the cars
- Catalytic converter: 20%
- Computer: 5 to 8%

To pass the Carbon Monoxide (CO) test:

- Oxygen sensor: 80 to 95%

**NOTE —**
While it is important for the engine to be at normal operating temperature before idle testing emissions, extended idling causes EEC-IV to change timing and increase rpm. If your engine idles extensively before testing, you may have to shut the engine off and restart to reset normal idle before testing.

The diagnostic routines give possible causes for test failure, but let's consider the problem first. With proper conditioning, any Ford vehicle with fuel injection in good condition is designed to pass these idle tests with room to spare. Just remember a couple of things before you let them test your vehicle.

**NOTE —**
The following applies to no-load emission tests for HC and CO, both at idle and 2500 rpm. In the coming years though, you'll see more emission tests required under loaded conditions on a dynamometer, testing NOx as well as HC and CO. Engines operating under no-load conditions produce little or no NOx, so that emission gas is not tested under current Inspection & Maintenance (I&M) tests.

- The engine temperature must be warm and stabilized before the test
- The vehicle must not be tested immediately after idling too long in the line awaiting the test. If the test is preceded by a long period of idling, run the engine at about 2500–3500 rpm for 15 to 30 seconds before the test

Make sure the test operator checks the following:

- Verifies normal operating temperature
- Verifies all accessories OFF
- Reads idle emissions
- Revs engine to about 2500 rpm (2200 to 2800) and reads 2500 rpm emissions within 30 seconds
- Again reads idle emissions within 30 seconds of idle

If the operator of the Emission Idle Test facility does not follow these steps, the test may not reflect the emission condition of the vehicle.

Knowing what you know about KAM (Keep Alive Memory), if you replace any emission components, be sure to clear the KAM before re-running any emission tests.

> A word of warning for the chip changers: I hear talk that future Emission Testing may learn from your own engine control module if you have removed your performance chip module just to pass the Smog Test. A recent report by CARB (California Air Resources Board) estimates installation of at least 100,000 performance chips in California alone. Performance chips modules may (or may not) improve your performance, but they are such a threat to air quality that Ford now solders the chip. When I asked CARB engineers about this, they smiled and said, "Not yet, but we're working on it." That probably applies to 1993 and later cars and trucks with new diagnostics, but be aware of so-called "street-legal" chips. (See Chapter 9)

## 3.1 Diagnostic Routines

The following tables list the diagnostic routines for EEC-IV and MECS cars. When you see a reference in the routines to a specific component, that means go to that component and check it. Ford calls these Pinpoint Tests. There are also references in the routines to Quick Test, checking fuel supply, and the ignition system. Full diagnostic procedures for the fuel supply system, ignition system, and other Pinpoint Tests are described in detail in Chapter 11 and in Chapter 12. Quick Test, which uses the control module to help you diagnose problems, is described in the next section. Tempting as it may be to start with Quick Test, be guided by the diagnostic routine charts.

The charts are arranged in order of what component/system to check first. The numbers in the first two columns indicate where to start, depending on the engine control system. For example, for a Hard Start on EEC-IV systems, you'd look at the ignition system first. On Mazda Engine Control Systems (MECS) cars you'd start at the air intake system, since vacuum leaks are more likely to cause problems on these cars.

**Table 1. Hard Start/Long Crank**

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 3 | Ignition | Scope engine for:<br>Spark Plugs<br>Coil<br>Secondary Ignition Wires<br>Spark Plugs Fouled<br>TFI IV:<br>Distributor Cap, Adapter and Rotor<br>DIS/EDIS:<br>Single or Dual Hall Crankshaft Sensors<br>Hall Camshaft Sensor<br>DIS/EDIS Ignition Module<br>Coil Pack(s) |
| 2 | 2 | Engine Control | Quick Test |
| 3 | 4, 5 | Fuel/<br>Throttle Body | Filter<br>Pump<br>Pump Switch (in VAF meter)<br>Water/Dirt/Rust Contamination in Fuel<br>Fuel Lines<br>Fuel Pressure Regulator<br>Sender Filter<br>Injectors<br>Improper Fuel<br>Idle Air flow (ISC-BPA) |
| 4 | 10 | Exhaust | Component (restricted) |
| 5 | 1, 7 | Air Intake and Vacuum Distribution | Vacuum Leaks<br>Air Cleaner Element Restricted<br>VAF meter binding |
| 6 | 8 | Cooling | Electric Fan (Hot Start Only) |
| 7 | 6 | EGR | Valve |
| 8 | — | PCV | Valve |
| 9 | — | EVAP | Components |
| — | 9 | Basic engine | Compression, camshaft and valve train |

**Table 2. No Crank**

| System | Component |
|---|---|
| Starting | Battery<br>Starter Relay<br>Starter<br>Neutral Drive Switch/Clutch Switch<br>Brake Interlock Switch<br>Ignition Switch<br>Transmission<br>Linkage Adjustment |
| Control System | Neutral Drive Switch /Clutch Switch |
| Base Engine | Flywheel<br>Engine Seized |
| Fuel/Throttle Body | Injectors (hydro-lock) |
| Ignition | Harness (START wire short to GND) |

**Table 3. No Start/Normal Crank**

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 3 | Engine Control | Quick Test |
| 2 | 2 | Ignition | Electrical Connections<br>Secondary Ignition Wires<br>Spark Plugs Fouled<br>Ignition Switch<br>TFI IV:<br>Ignition Coil<br>Ignition Module<br>Rotor Alignment<br>Distributor Cap, Adapter, Rotor and Stator<br>DIS/EDIS:<br>Single and Dual Hall Crankshaft Sensors<br>Hall Camshaft Sensor<br>DIS/EDIS Ignition Module<br>Coil Pack(s) |
| 3 | 8 | Fuel/<br>Throttle Body | Fuel Filter<br>Fuel Pump<br>Pump Switch (in VAF meter)<br>Water/Dirt/Rust Contamination in Fuel<br>Fuel Lines<br>Tank (Fuel Supply)<br>Fuel Sender Filter<br>Fuel Pressure Regulator<br>Injectors<br>Inertia Switch |
| 4 | 4 | Base Engine | Compression, Camshaft Timing |
| 5 | 6 | EGR | Valve |
| 6 | 7 | Exhaust (Turbocharger, where app.) | Component (Restricted) |
| 7 | 5 | Air Intake | Air Tube, VAF meter binding |
| — | 1 | Engine Electrical | Fuses, Power Relays |

### Table 4. Stalls After Start, Stalls or Quits at Idle

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 2 | Engine Control | Quick Test |
| 2 | 3, 4 | Fuel/<br>Throttle Body | Idle Air flow (ISC-BPA)<br>Electrical and Vacuum Connections<br>Fuel Filter<br>Fuel Pump<br>Pump Switch (in VAF meter)<br>Water/Dirt/Rust Contamination in Fuel<br>Fuel Lines<br>Tank (Fuel Supply)<br>Sender Filter<br>Fuel Pressure Regulator<br>Injectors<br>Improper Fuel |
| 3 | 1 | Vacuum Distribution | Vacuum Leaks |
| 4 | 11 | Ignition | Electrical Connections<br>Secondary Ignition Wires<br>Ignition Switch<br>TFI IV:<br>Ignition Coil<br>Ignition Module<br>Rotor Alignment<br>Distributor Cap, Adapter, Rotor and Stator<br>Ballast Resistor<br>DIS (Thunderbird SC only):<br>Hall Camshaft Sensor (CID) |
| 5 | 7 | Exhaust (Turbo charger, where app.) | Component (restricted) |
| 6 | 5 | EGR | Valve |
| 7 | 6 | Air Intake System | Air Tube<br>Intercooler Tube (Thunderbird SC)<br>VAF meter binding |
| 8 | 9, 10 | Base Engine | Camshaft and Valve Train |
| — | 8 | PCV | Valve |

### Table 5. Fast Idle, Diesels

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 3 | Fuel/<br>Throttle Body | Idle Air flow (ISC-BPA)<br>Throttle Plate and Linkage<br>Speed Control Chain |
| 2 | 1 | Vacuum Distribution | Vacuum Leaks |
| 3 | 6 | Engine Control | Quick Test |
| 4 | 2 | Air Intake System | Air Tube<br>Intake Manifold Gasket<br>VAF meter binding |
| 5 | 4 | Cooling | Overheating |
| 6 | — | Air Conditioning | A/C Clutch<br>A/C Demand<br>A/C Cyclic Pressure Switch<br>A/C Refrigerant Charge |
| — | 5 | Ignition | Base timing plus advance and retard |
| — | 7 | EVAP | Components |

### Table 6. Rolling Idle, Rough Idle

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 3 | Ignition | Scope Engine For: Spark Plug, Coil, Secondary Ignition Wires, Distributor Cap, Adapter and Rotor, Ignition Timing |
| 2 | 5 | Engine Control | Quick Test |
| 3 | 2,4 | Fuel/Throttle Body | Idle Air flow (ISC-BPA)<br>Electrical and Vacuum Connections<br>Fuel Pressure Regulator<br>Injectors<br>Fuel Rail<br>Fuel Lines |
| 4 | 1 | Vacuum Distribution | Vacuum Leaks |
| 5 | — | Cooling | Thermostat Fan (loose or cracked) |
| 6 | 6 | EGR | Valve |
| 7 | 10 | Base Engine | Compression<br>Valve Train<br>Camshaft<br>Intake Manifold Gaskets |
| 8 | 8 | PCV | Valve |
| 9 | — | EVAP | Components |
| 10 | 7 | Air Intake System | Air Tube<br>Intercooler Tube (Thunderbird SC)<br>VAF meter |
| 11 | — | Charging System | Components |
| 12 | 9 | Exhaust (Turbo charger, where app.) | Components |
| 13 | — | Thermactor | Thermactor System Components |

### Table 7. Low Idle Stalls or Quits on Deceleration

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 1, 2 | Fuel/<br>Throttle Body | Idle Air flow (ISC-BPA)<br>Electrical and Vacuum Connections |
| 2 | 4 | Engine Control | Quick Test |
| 3 | — | EGR | Valve |
| 4 | — | Base Transmission (A/T with overdrive) | Transmission Oil Level<br>Converter Clutch Control Solenoid<br>Modulated Converter Clutch Control Solenoid |
| — | 3 | Fuel Delivery | Pump Switch in VAF Meter |

### Table 8. Stalls/Quits on Acceleration or Cruise, Bucks/Jerks, Hesitates/Stumbles, Surges

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 2 | Engine Control | Quick Test |
| 2 | 3 | Ignition | Scope engine for: Spark Plug, Coil, Secondary Wires, Distributor Cap and Rotor, Crossed Wires<br>Ignition Timing |
| 3 | 4 | Fuel/Throttle Body | Idle Air flow (ISC-BPA)<br>Fuel Filter<br>Fuel Pump<br>Water/Dirt/Rust Contamination in Fuel<br>Fuel Lines<br>Fuel Pressure Regulator<br>Sender Filter<br>Injectors |
| 4 | — | Vacuum Distribution | Vacuum Leaks |
| 5 | 5 | Air Intake Systems | Air Cleaner, Air Duct<br>Intercooler Tube (Thunderbird SC) |
| 6 | 6 | EGR | Valve |
| 7 | — | PCV | Valve |
| 8 | 9 | Exhaust | Restriction (with Backpressure EGR system (PFE)) |
| 9 | 7 | Base Transmission (A/T with Overdrive) | Converter Clutch Control Solenoid<br>Converter Clutch Override<br>Converter Clutch<br>Modulated Converter Clutch Control Solenoid |
| 10 | 8 | Base Engine | Components |
| — | 1 | Bypass air control | ISC-BPA |

### Table 9. Runs Rough on Acceleration or Cruise, Misses

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 1 | Ignition | Scope engine for: Spark Plug, Coil, Secondary Wires, Distributor Cap, Adapter and Rotor<br>Ignition Timing |
| 2 | 2 | Engine Control | Quick Test |
| 3 | 3 | Fuel/Throttle Body | Fuel Filter<br>Fuel Pump<br>Fuel Lines<br>Fuel Pressure Regulator<br>Sender Filter<br>Injectors |
| 4 | 5 | EGR | Valve |
| 5 | — | Vacuum Distribution | Vacuum Leaks |
| 6 | — | Base Engine | Components |
| — | 4 | Bypass air control | ISC-BPA |

### Table 10. Surges on Cruise

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 5 | Engine Control | Quick Test |
| 2 | 4 | Fuel/Throttle Body | Filter<br>Pump<br>Lines<br>Fuel Pressure Regulator<br>Sender Filter<br>Octane<br>Idle Air flow |
| 3 | 2 | Ignition | Scope engine for: Spark Plugs, Wires, Coil, Secondary Ignition Wires<br>Timing |
| 4 | 1 | Vacuum Distribution | Vacuum Leaks |
| 5 | 6 | EGR | Valve |
| 6 | 7 | Air Intake System | Air Intake Components |
| 7 | 8 | EVAP | Components |
| 8 | — | Base Engine | Valve Train and Camshaft<br>Intake Manifold and Gaskets |
| 9 | — | Thermactor | Thermactor System Components |
| 10 | — | Supercharger | Assembly |
| 11 | — | Base Transmission (A/T with Overdrive) | Converter Clutch Control Components |
| — | 3 | Bypass Air Control | ISC-BPA |
| — | 9 | Turbocharger | Components |

### Table 11. Backfires

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 2 | Ignition | Scope engine for: Spark Plugs, Wires,<br>Coil,<br>Crossed Wires, Ignition Timing |
| 2 | 1 | Vacuum Distribution | Vacuum Hoses, Connections |
| 3 | 4 | Engine Control | Quick Test |
| 4 | — | Thermactor | Thermactor System Components |
| 5 | 3 | Base Engine | Intake Manifold Gaskets<br>Compression Checks<br>Camshaft<br>Valves |
| 6 | 5 | Exhaust | Components (restricted) |
| 7 | 6 | Fuel/Throttle Body | Filter<br>Pump<br>Water/Dirt/Rust/ Contamination in Fuel Lines<br>Fuel Pressure Regulator<br>Injectors<br>Sender Filter<br>Octane |

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### Table 12. Lack/Loss of Power

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 2 | Ignition | Scope engine for: Spark Plugs, Wires, Coil, Timing |
| 2 | 6 | Engine Control | Quick Test |
| 3 | 3 | Fuel/Throttle Body | Filter<br>Pump<br>Lines<br>Fuel Pressure Regulator<br>Fuel Sender Filter<br>Injectors<br>Idle Air flow |
| 4 | 7 | Exhaust | Component (restricted) |
| 5 | — | Cooling | Thermostat |
| 6 | — | Vacuum Distribution | Vacuum Leaks |
| 7 | 1 | Air Intake Systems | Air Cleaner Duct and Element<br>Throttle plates and linkage<br>Electrical and Vacuum connections<br>VAF Meter |
| 8 | 4 | EGR | Valve |
| 9 | 5 | Base Engine | Compression Check<br>Camshaft<br>Valves |
| 10 | 9 | Drivetrain | Clutch, Automatic Transmission, Brakes |
| 11 | — | Supercharger | Assembly |
| — | 8 | Turbocharger | Components |

### Table 13. Spark Knock

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 1 | Ignition | Timing |
| 2 | 4 | Engine Control | Quick Test |
| 3 | 5 | Cooling | Overheating |
| 4 | — | Base Engine | Oil Level<br>Compression Check<br>Intake Manifold Gasket |
| 5 | — | Fuel/Throttle Body | Filter<br>Pump<br>Lines<br>Fuel Pressure Regulator<br>Sender Filter<br>Injectors |
| 6 | — | PCV | Valve |
| 7 | 3 | EGR | Verify Correct Application, then Diagnose |
| 8 | — | Air Intake System | Air Cleaner Duct and Element |
| 9 | — | Thermactor | Thermactor System Components |
| 10 | — | Base Transmission (E4OD, AODE, AXOD-E) | Transmission Controls |
| — | 2 | Vacuum distribution | Vacuum leaks, Delay Valve, Vacuum Reservoir |
| — | 6 | Turbocharger | Components |

### Table 14. Poor Fuel Economy

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 4 | Fuel/Throttle Body | Fuel Pressure Regulator<br>Fuel Return Line Blocked |
| 2 | 3 | Air Intake System | Air Cleaner Duct and Element, VAF Meter |
| 3 | 2 | Ignition | Scope engine for: Spark Plugs, Wires, Coil, Secondary Wires, Distributor Cap, Timing |
| 4 | 5 | Engine Control | Quick Test |
| 5 | 7 | Cooling | Thermostat |
| 6 | 8 | Factors External to the Engine | Tire Pressure<br>Clutch Operation<br>Converter Clutch Override<br>Automatic Transmission Shift Pattern, Fluid Level<br>Brake Drag<br>Exhaust System<br>Speedometer/Odometer<br>Gear Ratio<br>Axle Ratio<br>Vehicle Load<br>Road and Weather Conditions<br>Aftermarket Add Ons |
| 7 | — | Base Transmission (A/T with Overdrive) | Converter Clutch Control Components<br>Modulated Converter Clutch Control Solenoid |
| 8 | 6 | EGR | Valve Operation |
| — | 1 | Vacuum distribution | Vacuum leaks |
| — | 9 | Base Engine | Compression, Camshaft, Intake Manifold Gasket |

**Table 15. Emissions Compliance, Idle Test**

| EEC-IV | MECS | System | Component |
|---|---|---|---|
| 1 | 2 | Engine Control | Quick Test |
| 2 | 4 | Ignition | Scope engine for: Spark Plugs, Wires, Coil, Timing |
| 3 | 6 | Vacuum Distribution | Vacuum Leaks/Blockage |
| 4 | 3 | Fuel/Throttle Body | Idle Air flow<br>Injectors<br>Fuel Rail<br>Fuel Pressure |
| 5 | 1 | EGR | Valve<br>Vacuum Regulator |
| 6 | 8 | PCV | Valve |
| 7 | 7 | EVAP | Valve |
| 8 | — | Thermactor | Thermactor System Components |
| 9 | 9 | Exhaust | Pipes, Muffler, Catalysts, Resonator, etc. |
| 10 | 10 | Cooling | Unstabilized Engine Temperature |
| 11 | 12 | Base Engine | Scheduled Maintenance<br>Compression<br>Valve Train<br>Camshaft<br>Intake Manifold Leaks |
| — | 5 | Inlet air control | Throttle plates of linkage, Air Cleaner and Duct |
| — | 11 | Turbocharger | Components |

## 4. QUICK TEST

This section explains the part of the diagnostic routines known as Quick Test. You can perform Quick Test on any EEC-IV (or MECS) vehicle. Although it is quicker to use special equipment, you can perform a full Quick Test with just an analog VOM. Generally, you'll perform Quick Test for two reasons:

1. When directed to by the diagnostic routines.
2. If the dash warning light is on. This is known as the Malfunction Indicator Light (MIL). Depending on the vehicle, it can read CHECK ENGINE, or SERVICE ENGINE SOON.

Quick Test results depend on proper operation of the engine itself. While engines have grown increasingly sturdy and reliable, all the things that went wrong with engines before electronic controls can still go wrong to cause driveability problems. Just because you know all about electronic control systems after reading this book, don't automatically assume that all problems start with the electronics. You'll save time if you perform the prescribed diagnostic routines in order.

### What Is Quick Test?

Quick Test means using the built-in diagnostic capabilities of the engine control module to find faults in the fuel-injection and engine-control systems.

If you've done troubleshooting in the traditional way, isolating each circuit or sensor, and measuring resistance, you know it can take hours. When you perform Quick Test, you'll appreciate how much diagnostic capability you have in the control module to help you find a problem—and why it's called Quick Test. Running Quick Test helps you to do three things:

1. Look inside the control module memory for stored information about specific system faults.
2. Use the control module to qualify sensors and actuators—to see if they are working within operating ranges.
3. Direct you to specific diagnostics of certain sensors, actuators and circuits (Pinpoint Tests).

A SERVICE ENGINE SOON message is often considered less threatening than CHECK ENGINE. Some owners, seeing the red CHECK ENGINE light immediately stop the car and have it towed. But that's not necessarily so. The message of either light is just to take the car in for service as soon as possible.

### Trouble Codes

When the control module tests the system and finds faults, it makes a record of the fault in the form of a trouble code. Trouble codes are a series of digital pulses that represent numbers. See Fig. 4-1. During Quick Test, the control module will read out one or more codes. You then compare the trouble code numbers to a chart to lead you to specific tests to identify the fault. You'll find trouble code charts in Chapter 12.

## 4.1 Quick Test and Trouble Codes

You will perform Quick Test Key ON Engine OFF (KOEO) and Engine Running (ER). You may also see reference to KOER (Key On, Engine Running), but I prefer the simpler ER—it's easier to keep it separate from KOEO, and you don't need KOER because the key must be ON if the engine is running. In both those steps you read a number of different codes.

Codes for KOEO:

1. **Self-Test codes**. These are the results of the system testing itself during Quick Test and detecting faults. Self-Test verifies control module memory integrity and processing capability. It also verifies that sensors and actuators are connected and operating properly. These codes are known as HARD faults. They are also sometimes called On-Demand codes.
2. **Separator Pulse codes**. These are issued 6 to 9 seconds after the last Self-Test code. This separates Self-Test codes from Continuous Memory codes.
3. **Continuous Memory codes**. The Continuous Self-Test program in the control module creates these codes. It continually checks the system as you drive and stores fault codes in KAM. These codes can indicate chronic and intermittent problems. They include SOFT codes, intermittent faults that happened in the past but are not now present. KAM does not store these soft codes indefinitely. If the engine warms up 80 times (40 times on a few engines) without the fault re-occurring, the module assumes that the fault was a fluke, and "forgets" it—erases the soft fault code.
4. **Fast codes**. They contain the same information as the regular codes but are transmitted 100 times faster. The manufacturer uses special instruments to read these during the building of the car. You can read these by Super STAR II. Three-digit trouble codes show only in fast codes, so you can't use a START tool.

Codes for ER:

1. **I.D. Pulse codes**. They identify the type of engine in the vehicle. They also verify that the proper control module is installed and that Self-Test has been entered.
2. **Dynamic Response code**. This may appear to signal additional checks of wide open throttle during the ER portion of Quick Test. It is not on all vehicles.
3. **Self-Test codes**. The same type of codes as during KOEO.

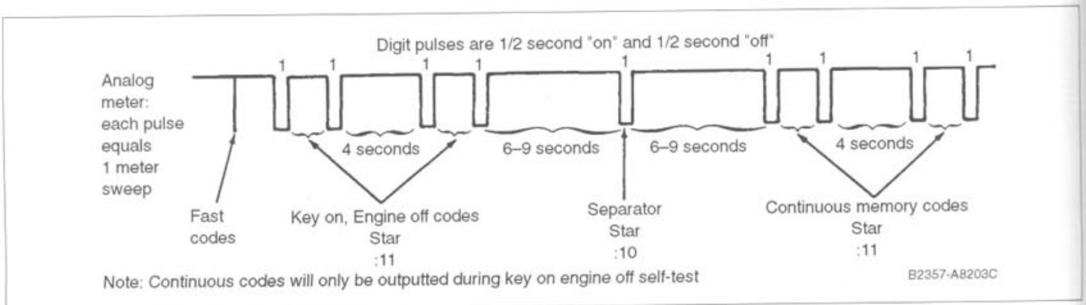



**Fig. 4-1.** EEC-IV trouble code output format. Digital pulses indicate numbers. 2-digit codes shown. MECS codes are similar.

## 4.2 Code Generation

**Continuous Memory** codes: As you drive, the control module continuously checks sensors and even its own Central Processing Unit (CPU) to determine the signals being sent. For example, in Fig. 4-2, the Continuous Test samples the Engine Coolant Temperature (ECT) signal. ECT signal should range between 91% of VREF (Reference Voltage = 5v.) and 4% VREF. If ECT rises above 91% VREF (4.55v) for between 50 and 300 milliseconds (ms), the Keep Alive Memory (KAM) starts counting. If the error repeats several times, KAM stores Service Code 51. If ECT falls below 4% of VREF (0.20v) several times, KAM stores Service Code 61. Follow those examples through on the above chart and you'll understand Continuous Memory Codes for ACT, TPS, MAP or MAF or VAF, EGR sensor, EGO (Exhaust Gas Oxygen), and each other input tested.

**OBD SYSTEM DESCRIPTION**

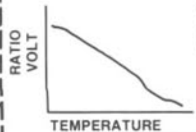
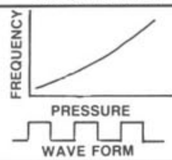
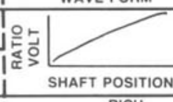
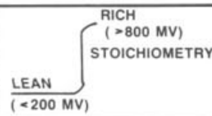
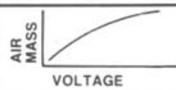
| SENSED PARAMETERS | SERVICE CODES | MINIMUM TIME | SIGNAL RANGE | SIGNAL DESCRIPTION |
|---|---|---|---|---|
| (ACT)/(VAT) AIR CHARGE TEMPERATURE | 54 | 50-300 MSEC | >91% VREF |   NON-PULSATING THERMISTOR RESISTANCE THAT VARIES NON-LINEARLY AND INVERSELY WITH RESPECT TO TEMPERATURE |
| | 64 | " | <4% VREF | |
| (ECT) ENGINE COOLANT TEMPERATURE | 51 | " | >91% VREF | |
| | 61 | " | <4% VREF | |
| (TPS) THROTTLE POSITION | 53 | " | >97% VREF |   NON-PULSATING POTENTIOMETER RESISTIVE ELEMENT THAT VARIES LINEARLY AND IS DIRECTLY PROPORTIONAL TO THROTTLE PLATE MOVEMENT |
| | 63 | " | <4% VREF | |
| (MAP) MANIFOLD PRESSURE | 22 | 150-300 MSEC | <8 Hz |   PULSATING RECTANGULAR FREQUENCY SIGNAL THAT IS PROPORTIONAL TO PRESSURE |
| (BP) BAROMETER PRESSURE | 22 | 150-300 MSEC | <16 in. H.g. | |
| EGR SENSOR | 31 | 50-300 MSEC | <4% VREF |   NON-PULSATING POTENTIOMETER RESISTIVE ELEMENT THAT VARIES LINEARLY WITH SHAFT DISPLACEMENT |
| | 35 | " | >96% VREF | |
| EGO | 41 | MUST REGISTER EIGHT EGO SWITCHES WITHIN FOUR MINUTES OF REACHING NORMAL OPERATING TEMPERATURE | |   SWITCHING, SELF-GENERATING VOLTAGE SIGNAL THAT INDICATES WHETHER THE A/F RATIO IS LEAN OR RICH COMPARED TO STOICHIOMETERY |
| STEREO EGO | 91 | | | |
| (VAF)/(MAF) AIR FLOW SENSOR | 56 | 50-300 MSEC | >98% VREF |   NON-PULSATING POTENTIOMETER WHICH THE ANALOG VOLTAGE OUTPUT HAS A LOGARITHMIC RELATIONSHIP TO VOLUMETRIC AIR FLOW |
| | 66 | " | <3% VREF | |
| CPU OK | 11 | 11-17 MSEC | TIME SINCE LAST CPU-OK PULSE >14 ± 3 MSEC. SIGNAL IS INTERNAL TO THE PROCESSOR. | |
| D.C. MOTOR | 13 | 50-300 MSEC | RATIONALITY CHECK-USES TPS FEEDBACK | OUTPUT |
| (ITS) IDLE TRACKING SWITCH | 71 | MONITORED AT KEY-OFF AND DISPLAYED DURING ENGINE RUNNING | | LEVEL (ON/OFF) INPUT |

**Fig. 4-2.** Example Self-Test mode diagnostic procedures in the control module.

QUICK TEST

10

Continuous Memory codes are stored for each sensor that falls out of range as indicated. But if the engine starts and warms up 80 (40 on some vehicles) times without that fault repeating, KAM erases it. Otherwise, the Service Code waits in the KAM for you to read it in the Self-Test.

**KOEO (Key ON Engine Off)** codes: To see what happens when you activate KOEO Self-Test, follow the flow chart in Fig. 4-3. From Self-Test Output (STO) OFF, the sequence begins with Microprocessor instruction-execution test.

- If that fails, it turns STO on continuously and exits test
- If that passes, it proceeds to RAM/KAM test
- Test ROM, setting memory code if that fails
- Test Analog to Digital (A/D) inputs for proper range, and switch for proper state - open or closed, setting memory codes for those that fail

The chart shows how the control module tests system circuits KOEO, from the top A to the bottom A, setting memory codes for those that fail.

Now the control module sends the stored memory codes, as described below. First the codes for the KOEO test, faults in the system at this time. Then the Continuous codes, faults that may have existed in the past, but are not present now (intermittent faults).

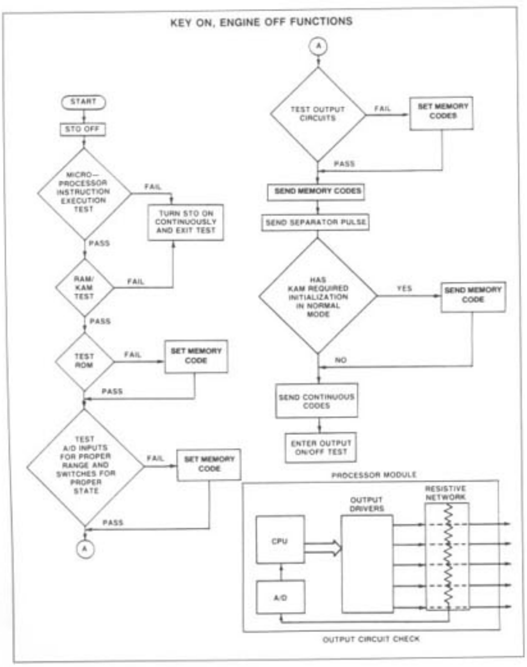



**Fig. 4-3.** Key On Engine Off (KOEO) Self-Test.

**ER (Engine Running)**: To see what happens when you start the engine in Self-Test, follow the flow chart Fig. 4-4. With the engine running, the control module tests sensors for proper range, tests switches for proper state. Those that fail set memory codes.

- The control module ramps the fuel lean—that is, it cuts back on fuel-injection pulse times until the mixture is too lean, looks at the oxygen sensor to see if it reports a lean mixture. If EGO does not, KAM sets an error code
- The module ramps the fuel rich, increasing pulse times to see if the oxygen sensor reports rich mixture

Follow A to A on the next line. The control module checks that the EGR is in proper range, then signals to increase the EGR, looking to see if the rpm drops when EGR increases.

The control module checks that the Idle Speed Control rpm is in the proper range.

Then it stores several idle values for comparison, and sets the spark for the "goose" test. When it signals for dynamic response, you briefly press Wide Open Throttle (WOT). The control module looks for a knock (if Knock Sensor fitted), then looks to see if the signals changed as they should ("Delta" means difference). It sends any stored codes. And finally, fixes the spark for two minutes so you can perform a timing check. Whew!

As you read this, it may sound complicated. But follow it through, and try it with a scan tool. You'll be surprised how

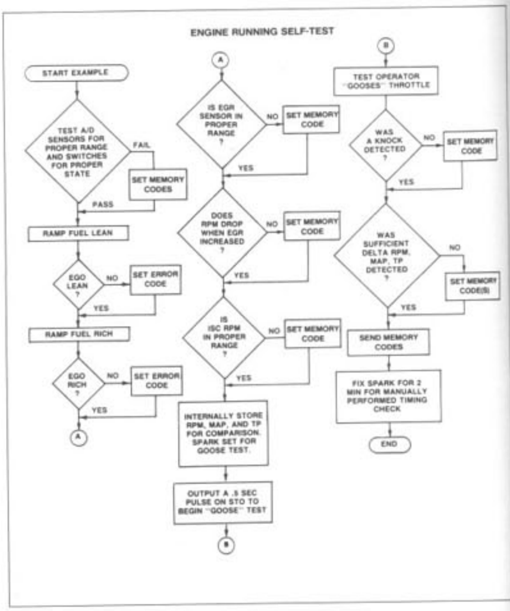



**Fig. 4-4.** Engine Running (ER) Self-Test.

*QUICK TEST*

much time this saves, and how much work it would be to do all this manually, one sensor and actuator at a time.

### Reading Trouble Codes

The control module sends the trouble code pulse signal to two places, the Self-Test Output (STO) wiring connector and the Malfunction Indicator Light (MIL). When you ground the Self-Test Input (STI), the control module starts sending codes.

Look for STO under the hood, usually near the cowl. The MIL is in the instrument cluster. The STI is the single-wire connector next to the STO connector.

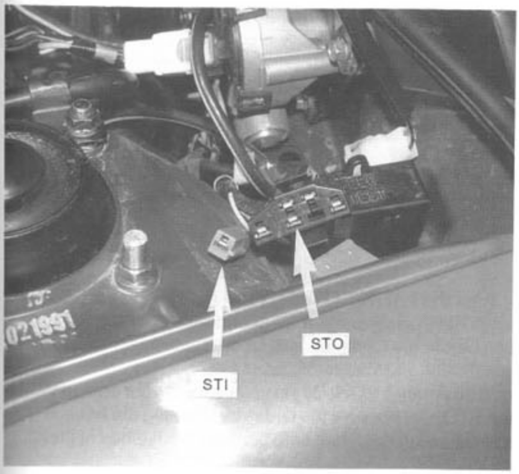



**Fig. 4-5.** Look for Self-Test Output (STO) and Self-Test Input (STI) connectors under hood, near cowl.

You can read the codes in several different ways, depending on your equipment. From the simplest to the most expensive these include: MIL, analog voltmeter, STAR (EEC system, but not MECS-I), scan tool, Super STAR II or New Generation STAR (NGS).

> ***WARNING —***
> *Do not use a device that draws more than 0.5 amps to read trouble codes. Hooking a high current draw device to the STO may damage the control module.*

With the MIL or voltmeter, you see and count the pulses. A scan tool such as STAR translates those pulses into specific numbers. Some scan tools even display the English language interpretation of those numbers so you don't have to refer to the tables. In Fig. 4-6, the two "pulse, pulse" signals are read by the STAR as 11-11, the code for SYSTEM PASS. The separator pulse is read as 10. The Continuous Memory Codes are read as 11 (SYSTEM PASS). That does not mean you're done. It does not tell you, for example, if the intake passage deposits are causing a problem. It means the engine-control system passes and the problem is somewhere outside the fuel-injection/engine-control system.

In the Engine Running part of Quick Test, the I.D. pulse code identifies the number of cylinders that fire on one turn of the crankshaft. 2, read by STAR as 20, means 4-cylinder engine. 3 means 6-cylinder. 4 means 8-cylinder. I'll discuss the other ER codes during the test procedure, below.

**With MIL**: With the MIL, you read codes by counting light flashes. It may seem difficult, but once you've tried it, it's not so hard. See Fig. 4-7.

Each code is usually two digits, sometimes three. Look for a 2-second pause between digits.

- To display the number or digit 2, the MIL flashes, waits 2 seconds, then flashes again. Flash, flash.
- To display 23, the MIL goes flash, flash, waits 2 seconds, then flash, flash, flash.

When the control module memory has more than one code, the display pauses 4 seconds between codes.

Suppose you had a 23 and a 53, you'd see:

- flash, flash PAUSE flash, flash, flash (23)
- 4 second pause
- flash, flash, flash, flash, flash PAUSE flash, flash, flash (53)

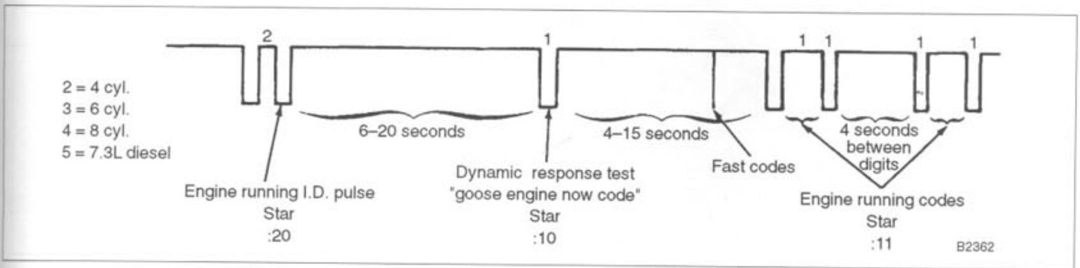



**Fig. 4-6.** Engine Running (ER) Self-Test code format.

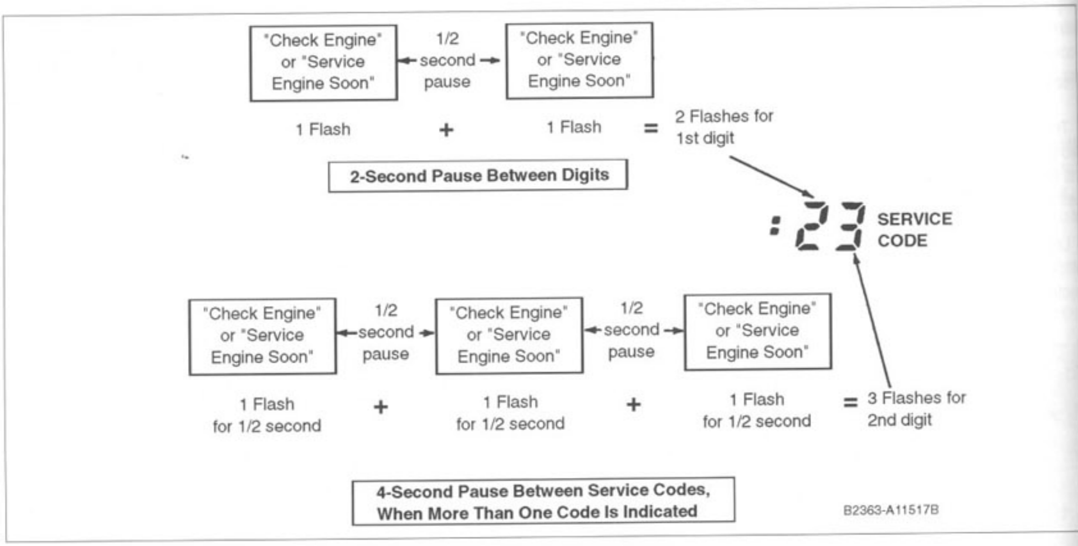



**Fig. 4-7.** MIL trouble code output format.

Questions you might ask about the MIL:

1. If the MIL is ON because there's a problem, how can it flash to tell me the code? Simple. When you activate Quick Test, the MIL changes to code mode.
2. How do I know the MIL is working at all? Also simple. The MIL should light each time you turn the key to START. If it's FLASHING during driving, that's a sign of an intermittent problem.

After the last KOEO code, you'll notice a 6-second delay, a single flash, and another 6-second delay. This is the separation before the Continuous Memory Codes.

**With Analog VOM**: When you connect your analog VOM to the STO, you observe the codes by counting the sweeps of the needle, using the same time basis as the flashes of the MIL.

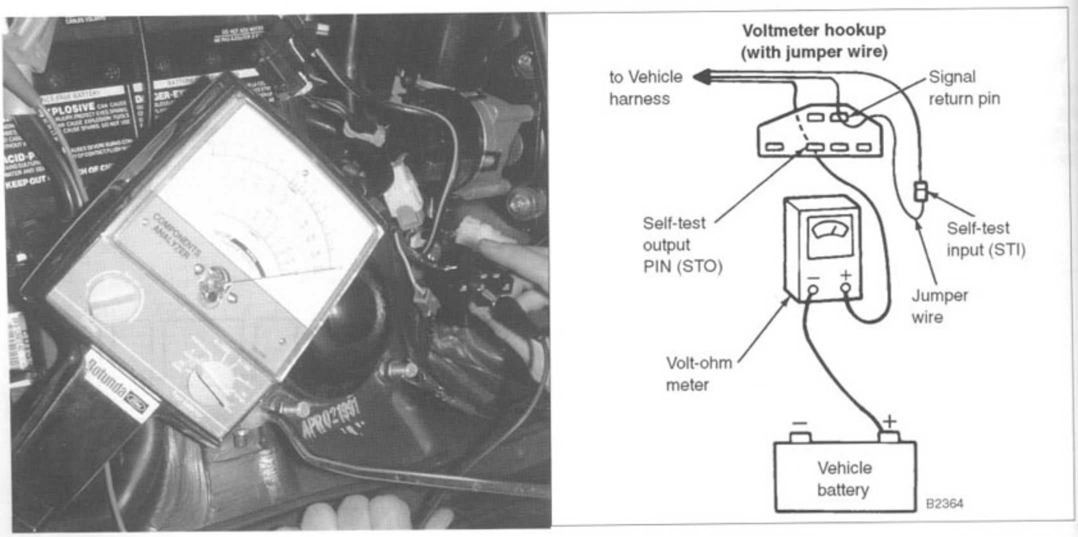



**Fig. 4-8.** Volt-Ohmmeter (VOM) connection for reading trouble codes.

23: sweep, sweep PAUSE sweep, sweep, sweep. See Fig. 4-9.

**With STAR Tester**: The STAR tester reads 88 during its display check, and 00 when it's ready to start the Self-Test. During the tests, codes will display directly as numbers, rather than as flashes. See Fig. 4-10 and Fig. 4-11.

**With Super STAR II**: Super STAR II reads fast codes and slow codes. You must set to it to fast-code mode to read out three-digit codes used in some later model cars. It reads the STI circuit used to initiate the test, as well as the STO.

Super STAR II first displays 888, lights all the prompts on the left side, and beeps the speaker. When the tester is ready, you'll see STI-LO and STO-LO, but the readout will be blank until you turn the key ON

For most MECS, slide the adapter switch to MEC, but for 1.8L and 2.0L MTX engines, slide the adapter switch to EEC. See Fig. 4-12.

**Fig. 4-10.** STAR tester hookup to read trouble codes.

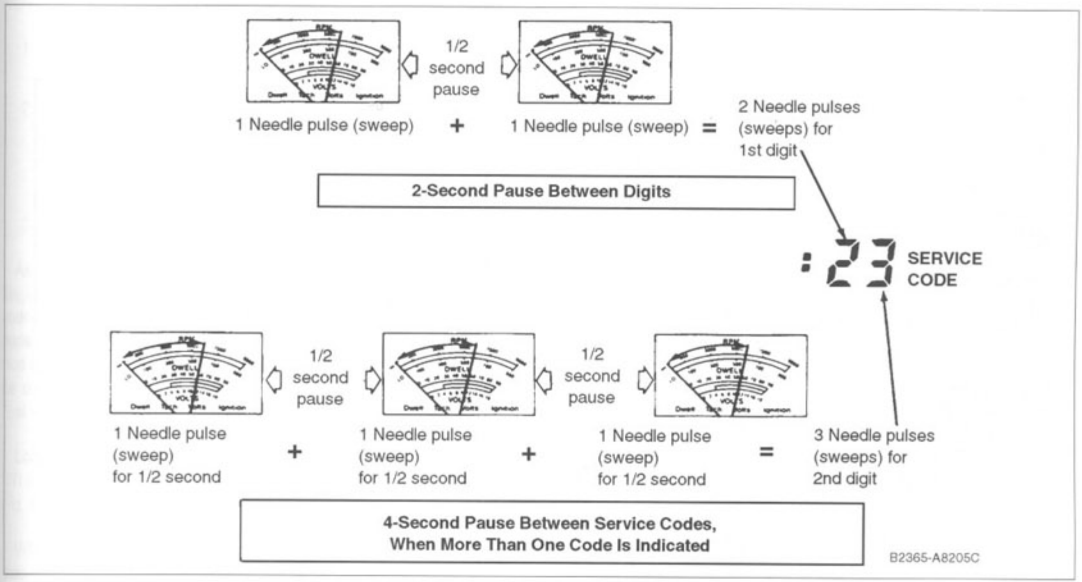



**Fig. 4-9.** VOM trouble code output format.

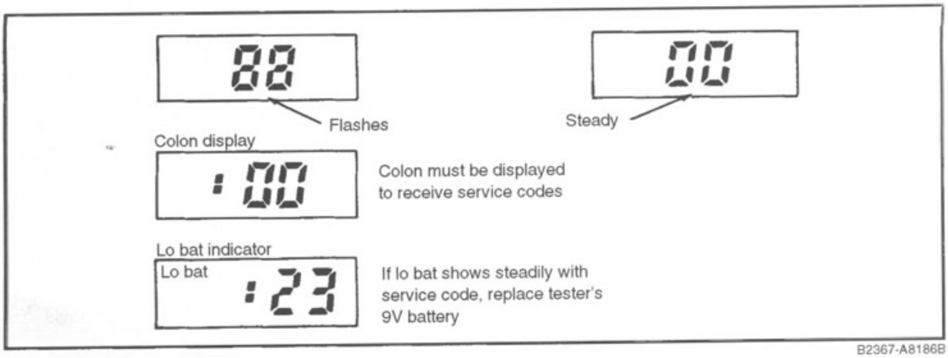



**Fig. 4-11.** STAR tester trouble code output.

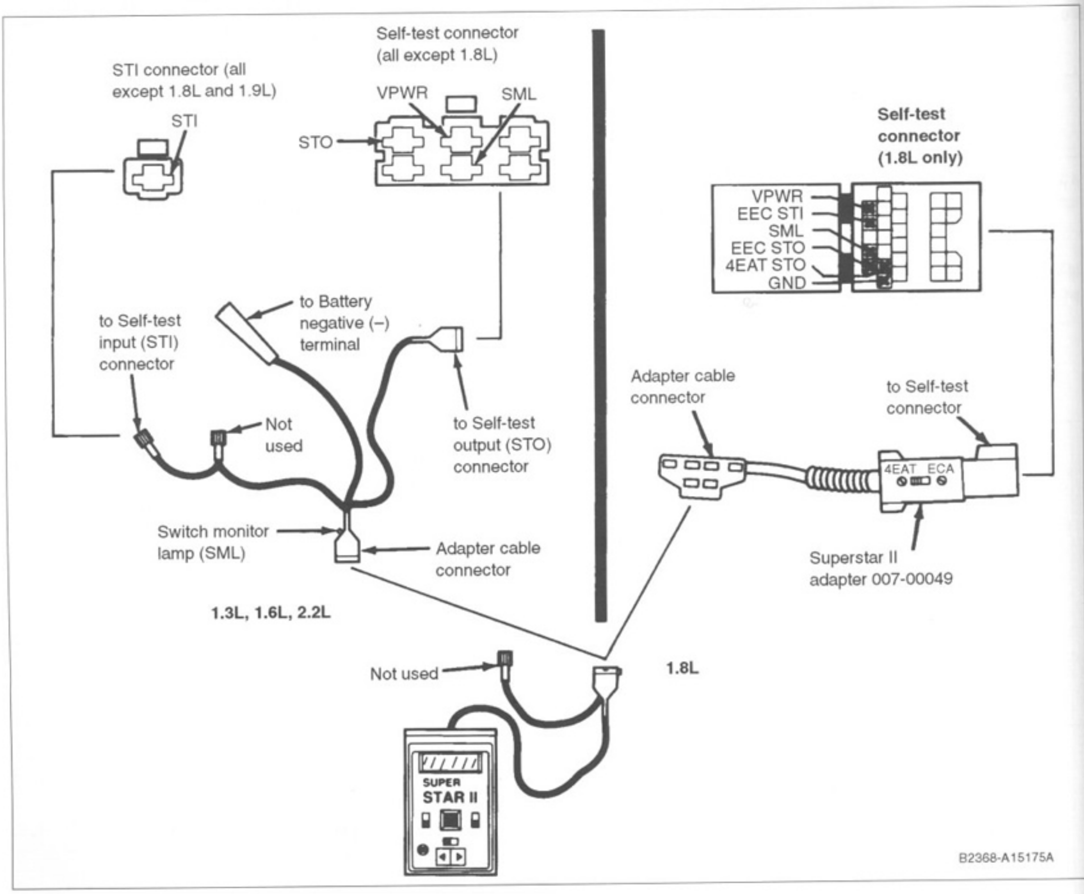



**Fig. 4-12.** Super STAR II hookup for reading trouble codes on MECS-equipped vehicles.

If you're checking a late model Continental, you'll find codes displayed in the Message Center.

1. Jumper STI to SIG RTN at the Self-Test connectors, or connect the STAR tester and latch center button in the down position. (TIP from the field: Listen for the sound of solenoids clicking when you ground STI, or latch the STAR button.)
2. While pressing all three buttons, Select, Reset, System Check, turn the key ON. Release buttons. 4255 indicates Self-Test has been entered successfully. Observe and record codes. Service code output will be the right three digits. 4011 means PASS.
3. While pressing all three buttons, start engine. Release buttons. 4030 indicates engine ID code (3 for 6 cylinders), and that Self-Test has been entered successfully. Observe and record codes.
4. Ignition OFF, and remove jumper, or unlatch STAR tester.

## 4.3 Running Quick Test

This section gives the steps for running Quick Test. In summary:

1. Hook up your VOM or scan tool to the control module Self-Test Output (STO) terminal.
2. Signal the control module to begin Quick Test.
   - With MIL or VOM, you send the signal by grounding another wire, the Self-Test Input (STI)
   - With a STAR tester, you latch the center button down
3. Record any trouble codes.

As I said before, there are two parts to Quick Test, Key On Engine Off (KOEO), and Engine Running (ER) to read all codes. If you read more than one code, start servicing the first code received. Proceed to the electrical tests indicated to service each succeeding code. After completing electrical tests, be sure all components are reconnected. Then rerun Quick Test or verify that the complaint is fixed.

Look for the STO in the 6-pin self-test connector; look for the STI in the small connector next to the larger connector. See Fig. 4-13.

When you see the instruction "activate Self-Test", that means either ground the STI terminal or latch the tester button. Deactivate means remove the ground/unlatch the button. Look for Trouble code tables and typical Self-Test values in Chapter 12. Before beginning Quick Test check the vacuum hoses, the wiring harness and all connectors for faults or looseness.

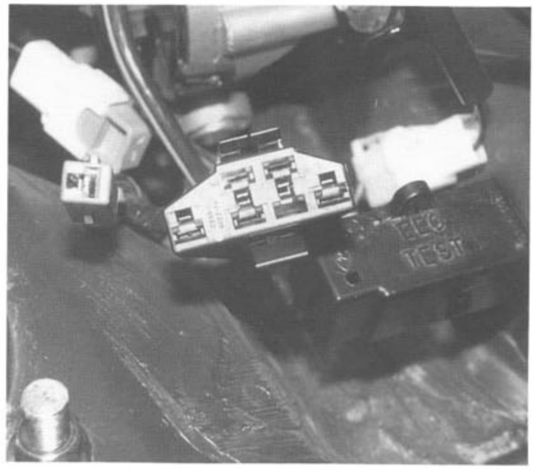



**Fig. 4-13.** Self-Test Input terminal is located in small connector next to 6-pin self-test connector. Ground terminal by inserting a grounded lead into STI.

**To Quick Test (EEC-IV, all except Super STAR II):**

1. Parking brake ON, Shift lever in PARK (Neutral in M/T vehicles). Block drive wheels and turn off all electrical loads. Warm engine to normal operating temperature.
2. Perform KOEO to read codes:
   - turn key OFF for 10 seconds
   - activate Self-Test (ground STI/latch button)
   - key ON, do not start engine
   - record all Self-Test and Continuous Memory codes

   **NOTE —**
   If no codes are displayed, skip Step 3 (below) and go to Step 4. If PASS (11) is displayed, but MIL is ON, check Continuous Memory code charts. If PASS is displayed on an MPI or SFI engine that runs or idles rough, check Throttle Air Bypass ISC. Disconnect it and check to be sure it operates properly for idle rpm drop or stall. If PASS is displayed on a DIS or EDIS engine that runs or idles rough, check for Continuous Memory codes # 45, 46, 48.

3. Check computed timing:
   - key OFF, wait 10 seconds
   - activate Engine Running Self-Test (ground STI/latch button)
   - start engine
   - with timing light, check computed timing to be base timing, plus about 20 (17 to 23) degrees

**NOTE —**
Timing will vary until the last ER code, then will remain fixed for 2 minutes unless you disconnect STI ground. Base timing is usually 10 degrees BTDC. Check VECI decal for correct base timing. Adjust if necessary, following procedures on VECI.

4. Perform ER (Engine Running) test:
   - deactivate Self-Test
   - be sure engine is at operating temperature
   - run engine at 2500 rpm. With the unheated oxygen sensor, run for at least 2 minutes
   - engine OFF for 10 seconds
   - activate Self-Test (ground STI/latch button)
   - start engine

After the I.D. code:
- within 1-2 seconds, turn power-steering wheel at least one-half turn and release
- if equipped with BOO, depress brake pedal and release
- if equipped with manual transmission, depress clutch pedal
- if equipped with E4OD, cycle OCS (Overdrive Cancel Switch)
- record all Self-Test codes
- if a Dynamic Response code shows, briefly press Wide Open Throttle

**NOTE —**
If PASS (code 11) is displayed, and you received pass codes in KOEO, you've completed diagnostic testing of EEC-IV. If you've still got a problem, it's elsewhere in the powertrain. If codes are displayed, perform electrical tests. If no codes are displayed, either PASS or otherwise, you may have a problem with the Self-Test circuits. See **4.8 No Codes Displayed**.

### To Quick Test (EEC-IV, with Super STAR II):

1. Parking brake ON, Shift lever in PARK (Neutral in M/T vehicles). Block drive wheels and turn off all electrical loads. Warm engine to normal operating temperature.
2. Plug in both connectors of the tester. Set switch to EEC-IV. Select FAST CODE or SLOW CODE. Turn tester power ON.
3. Perform KOEO (Key ON, Engine OFF) to read codes:
   - press test button to activate Self-Test
   - turn ignition ON
   - record Self-Test and Continuous Memory codes
4. Perform ER (Engine Running) test:
   - engine at normal operating temperature
   - turn engine OFF
   - press test button to activate Self-Test
   - restart the engine

For vehicles with 2-digit service codes, look for:
- engine I.D. code
- Dynamic Response code (some vehicles)
- Self-Test codes

For vehicles with 3-digit service codes, look for:
- Dynamic Response Indicator, but no D.R. code
- Self-Test codes

**NOTE —**
If PASS (code 11 or 111) is displayed, and you received pass codes in KOEO, you've completed diagnostic testing of EEC-IV. If you've still got a problem, it's elsewhere in the powertrain. If codes are displayed, perform pinpoint tests in the trouble code charts. If no codes are displayed, either PASS or otherwise, you may have a problem with the Self-Test circuits. See **4.8 No Codes Displayed**.

### To Quick Test (MECS):

**NOTE —**
On MEC systems, use MIL, VOM, Super STAR II, or NGS for Quick Test.

1. Parking brake ON, Shift lever in PARK (Neutral in M/T vehicles). Block drive wheels and turn off all electrical loads. Warm engine to normal operating temperature.
2. Plug in both connectors of the tester. Set switch to MECS. Select SLOW CODE. Turn tester power ON.
3. Perform KOEO to read codes:
   - turn key OFF for 10 seconds
   - activate Self-Test (ground STI/latch button, turn on Super Star II)
   - key ON, do not start engine
   - on Super Star II only, unlatch then latch button
   - record all codes

   **NOTE —**
   If codes are displayed, do not go to electrical tests. Go to step 3. If no codes are displayed, go to the ER test below.

4. Erase codes and retest KOEO:
   - deactivate Self-Test (remove STI ground/unlatch button and turn off Super Star II)
   - disconnect negative battery cable
   - depress brake pedal for 5 to 10 seconds
   - reconnect battery cable and rerun KOEO test
   - record all codes

**NOTE —**
If codes recorded the first time do not reappear, tap sensors and components, wiggle harnesses, or drive the car to induce a fault.

5. Perform ER (Engine Running) test:
   - deactivate Self-Test
   - be sure engine is at operating temperature
   - run engine at 2000 rpm for at least 3 minutes
   - activate Self-Test (ground STI/latch button)
   - engine OFF
   - start engine and run at idle
   - on Super Star II only, unlatch then latch button
   - record all codes

**NOTE —**
If PASS (code 11) is displayed, and you received pass codes in KOEO, you've completed diagnostic testing. If you've still got a problem, it's elsewhere in the powertrain. If codes are displayed, perform electrical tests in the trouble code charts. If no codes are displayed, either PASS or otherwise, you may have a problem with the Self-Test circuits. See **4.4 No Codes Displayed**.

## 4.4 Continuous Monitor Test (Wiggle Test) (EEC-IV only)

The Continuous Monitor Test can help you to find the cause of an intermittent fault. The test is sometimes called the "wiggle test" because you attempt to recreate the fault by wiggling wiring and connectors under Self-Test conditions. Use the Wiggle Test only if a Quick Test indicates that a such a pinpoint test is necessary for an intermittent fault.

**To wiggle test (KOEO):**

1. If using STAR tester or VOM, hook it up.
2. Key ON, do not start engine.
3. Activate Self-Test for 10 seconds (ground STI/latch button), then deactivate and activate again. The system is in Continuous Monitor mode.
4. Locate the suspected sensor or harness. Wiggle, tap, and move. Look for indication of fault stored in memory:
   - STAR—Red LED lights and/or continuous tone
   - MIL—CHECK ENGINE light
   - VOM—needle sweeps

**To wiggle test (ER):**

1. If using a STAR tester or VOM, hook it up.
2. If the KOEO test was just done, turn the key OFF for at least 10 seconds.
3. Start engine.

**Fig. 4-14.** In Continuous Monitor Test (EEC-IV only) you attempt to recreate fault while checking for codes. For example, tap MAF sensor while watching STAR tester.

4. Activate Self-Test for 10 seconds, then deactivate and activate again. The system is in Continuous Monitor mode. Keep engine running.
5. As in KOEO, locate the suspected sensor or harness. Wiggle, tap, and move. Look for indication of fault stored in memory:
   - STAR—Red LED lights and/or continuous tone
   - MIL—CHECK ENGINE light
   - VOM—needle sweeps



## 4.5 Switch Monitor Tests (MECS only)

The Switch Monitor test checks the input signals from each individual switch to the control module. You will activate each switch, one at a time, and observe the signal that tells how that switch is signalling the condition shown in Fig. 4-15, the Switch Monitor Test Chart.

- SML (Switch Monitor Lamp), an LED on the Adapter cable of the Super STAR II tester (see Fig. 4-12 above)
- Voltage on the VOM

**To switch monitor test:**

1. Engine off, allow to cool, all accessories OFF, transaxle in P or Neutral, foot off brake.
2. Deactivate Self-Test. Remove the STI ground or unlatch center button and turn OFF Super STAR II.

| QT 10 | Switch Monitor Test Chart | | | | | |
|---|---|---|---|---|---|---|
| **Switch** | **1.3L** | **1.6L** | **1.8L** | **2.2L** | **2.2L Turbo** | **Super Star II Tester LED or Analog VOM Indications** |
| Clutch Engage Switch/Neutral Gear Switch (CES/NGS) (MTX only) | X | X | X | X | X | LED on or less than 1.5V in gear and clutch pedal released |
| Manual Lever Position Switch (MLP) (ATX only) | X | X | X | X | X | LED on or less than 1.5V in P or N |
| Idle Switch (IDL) | X | X | X | X | X | LED on or less than 1.5V with accelerator pedal depressed |
| Brake On-Off Switch (BOO) | X | X | X MTX | X | X | LED on or less than 1.5V with brake pedal depressed (not fully) |
| Headlamps Switch (HLDT) | X | X | X | X | X | LED on or less than 1.5V with headlamp switch on |
| Blower Motor Switch (BLMT) | X | X | X | X | X | LED on or less than 1.5V with blower switch at 2nd or above position |
| A/C Switch (ACS) | X | X | X | X | X | LED on or less than 1.5V with A/C switch on and blower on |
| Defrost Switch (DEF) | X | X | X | X | X | LED on or less than 1.5V with defrost switch on |
| Coolant Temperature Switch (CTS) | X | X | X | X | X | LED on or less than 1.5V with cooling fan on |
| Wide Open Throttle Switch (WOT) | X | | X | | | LED off or 0V with accelerator pedal fully depressed |
| Knock Control (KC) | | | | | X | LED on or less than 1.5V while tapping on engine |

**Fig. 4-15.** MECS Switch Monitor Test chart.

3. Key ON.
4. Activate Self-Test. Ground the STI or turn ON Super STAR II, latch center button.
5. One at a time, activate a switch. For example, press the brake pedal. Look for:
   - LED ON, or
   - VOM less than 1.5v

## 4.6 Adaptive Mixture Self-Test Codes (EEC-IV only, 1991-on)

On some 1991 and later vehicles, during Quick Test you'll see Continuous Memory codes that identify signals from the oxygen sensor. These give you information about how the engine control system is regulating the air-fuel mixture and adapting to changes in engine condition (Ford calls it Adaptive Fuel).

Those of you familiar with Bosch procedures will see that this is another approach to testing the system's ability to adapt quickly to extreme variations in the air-fuel mixture. Where the Bosch tests often depend on reading engine-out exhaust with an exhaust gas analyzer, the Ford tests are built into the control module, reading exhaust gas through the oxygen sensor.

Look for two sets of codes that can alert you to problems of poor air-fuel mixtures.

1. Adaptive fuel offset at the rich limit: "This engine is still running lean even though I've shifted as far rich as I can go."
2. Lean limit: "This engine is still running rich even though I've shifted as far lean as I can go."

Most V-type engines have two oxygen sensors, one for each bank. Finding the signal in both sensors indicates the problem is common to all cylinders. If you find the signal in just one oxygen sensor, that narrows your troubleshooting to that bank of cylinders.

If you see adaptive fuel codes, the first question you want to ask is if the problem is in all cylinders or only one. With rich limit codes on SFI systems you can run a cylinder balance Self-Test to determine which cylinder is not getting fuel. Obviously, you cannot run this test with MPI, where several injectors are fired by the same control module signal.

To check for causes of lean limits on SFI systems, or for MPI systems see Causes of Limits below.

## 4.7 Cylinder Balance Self-Test (SFI only)

This Self-Test is automatically operated by the control module. It is much simpler than running cylinder balance manually, or even with an engine analyzer. It does not even require a tachometer.

To run a cylinder balance test, press and release the throttle within 2 minutes of the last ER Self-Test code. In the following 2 to 3 minutes with no action required by you, the control module does the following:

1. Commands a fixed duty cycle to the Throttle Air Bypass ISC, so that the ISC does not attempt to correct for changes in idle rpm, then stores this idle rpm figure for comparison purposes.
2. Shuts off fuel flow to one injector and stores the rpm figure for all cylinders minus that injector, then calculates the rpm drop for that cylinder.
3. Turns first injector back on, waits until the idle rpm steadies, and repeats the process for each other injector.
4. Determines from its memory the maximum drop of any cylinder.
5. Calculates the allowable tolerance between cylinders by taking a percentage (depends on the engine model) of the max rpm drop recorded. Example: Max rpm drop of 150 x 65% = 98 rpm. If all cylinders drop at least 98 rpm, they are all considered to be delivering equal power. You'll see code 90, PASS.
6. If one cylinder drops less than 98 rpm, that cylinder is weak, not contributing to the engine power. The code indicates the weak cylinder. Number 30 means cylinder #3. 10 means #1. 80 means #8.

You can repeat the cylinder balance test by pressing and releasing the accelerator within 2 minutes of the last code output. This time, the control module will use a smaller percentage to calculate the cylinder differences, further separating the weaker cylinders. Example: Max rpm drop of 150 rpm x 43% = 65 rpm.

- If all the rpm drops are greater than 65 rpm, code 90 indicates PASS.
- If #3 fails the first test and passes the second, it is firing, but weak, possibly caused by a clogged injector or injector/wiring harness resistance out of spec.

If you press and release the accelerator again as above, the third cylinder balance test will re-calculate at a lower percentage as the minimum rpm drop for any cylinder to pass this test. Example: Max rpm drop of 150 x 20% = 30 rpm.

- If code 30 shows with all three tests, #3 is probably dead.

**NOTE —**
The cylinder-balance test cannot find a bad injector because it looks for differences. It will not point to an injector that is not flowing any fuel. Check the appearance of the plug in the cylinder of a suspect injector. If it looks cleaner than the other plugs, the injector is probably not opening.

If the cylinder balance test reads code 90, PASS, a lean mixture is not the result of inadequate individual-cylinder injection of an SFI system. You need to check for other causes of a lean limit. See Fig. 4-16.

### Checking for Cause of Limits

Based on the limit codes observed earlier under Self-Test for all systems, whether MFI or SFI, the following could be causes of adaptive fuel reaching limits. You'll see in Chapter 11 how to check these.

10

| Self-Test Steps | | | | |
| --- | --- | --- | --- | --- |
| **1st test** | **2nd test** | **3rd test** | **Indication** | **Possible Causes** |
| 90 | X | X | Indicates a pass, all cylinders contributing equally | |
| 30 | 90 | X | Indicates a weak cylinder. Cylinder is firing, but not contributing as much as the others | • Partially clogged injector<br>• Injector/harness resistance out of specification |
| 30 | 30 | 90 | Same as above, but more severe | • Same as above, but more severe |
| 30 | 30 | 30 | Very weak or dead cylinder | • Open or shorted circuit<br>• Loss of injector drive signal<br>• Fully clogged injector |

**Fig. 4-16.** Typical cylinder balance Self-Test code outputs.

**Causes of rich limit (engine running too lean):**

1. Vacuum leaks: false air reaching cylinders with no matching fuel injection.
   - air induction system (the air-flow sensor, the soft rubber ducting to the throttle body, the throttle body itself, the intake manifold and gasket)
   - vacuum system (hoses for fuel pressure regulator, brake booster, Thermactor solenoid valves, Canister purge—all places indicated by the vacuum diagram on the VECI decal)
2. Low fuel pressure
3. MAP/BP sensor out of spec (Speed-density system)
4. Low VPWR voltage supplied to injectors
5. Canister-Purge solenoid stuck closed
6. Upstream air leak in Thermactor system

**Causes of lean limit (engine running too rich):**

1. Excess fuel pressure
2. Canister Purge will not hold vacuum for 20 seconds
3. MAP/BP sensor is out of spec (Speed density system)
4. Oxygen sensor fault: heater circuit or sensor contamination
5. Cooling, ignition, EGR if applicable
6. Injector flow test
7. Cylinder compression

## 4.8 No Codes Displayed

What if you do not see any codes at all? When you have nothing on the MIL or on the scan tool, you have a problem with the readout from the control module memory. This is rare, so I'll summarize the tests.

Perform this series of Tests. Refer to the proper circuit schematic and electrical test in **Chapter 12**. Check the following:

1. VREF voltage at Self-Test Connector to be 5v.
2. STI circuit continuity, using an ohmmeter across the two ends of the lead.
3. STO circuit continuity.
4. STO circuit for short to ground.
5. Power Relay always ON.
6. VPWR circuit for short to power.
7. MIL for always ON, or always OFF.

Fix any faults. Replace all connections and rerun Quick Test.

## 4.9 Clearing Memory Codes

After you've fixed faults and rerun your Quick Test, clear the Memory Codes. You might have been told that it's simple, just remove the negative battery cable, but wait. First, decide whether you want to clear Continuous Memory codes, or clear the KAM.

**To clear EEC-IV Continuous Memory codes:**

1. Run KOEO Self-Test as described previously.
2. When the codes begin to show, deactivate Self-Test (remove STI ground/unlatch button). Codes will be erased without erasing KAM.

**To erase MECS-I Continuous Memory codes:**

1. Disconnect battery cable and press brake for 5-10 seconds.

**To clear the KAM:**

1. Disconnect the negative battery cable for at least 5 minutes. This removes power from the control module and allows the KAM memory to decay. Do this after you have replaced some component of the system.

> **NOTE —**
> KAM stores the adaptive values for various components. Let's say a particular vehicle has adapted to tolerances in EGR, oxygen sensor, injectors, MAP/BP, TPS, MAF, and VAF. After clearing the KAM, you can expect driveability problems while the control module adapts—for 10 miles or more depending on the vehicle.

## 4.10 Checking Output State (EEC-IV only)

You can use this test to help you service actuators. You tell the control module to energize and de-energize most of the actuators, not one at a time, but all at once. Then you can check to see if, for example, the EVAP canister purge opens and closes correctly, or if the thermactor diverter works. If not, then you know you have to go further to check wiring or the component.

Check output states after you've observed all codes from KOEO and Continuous Memory. The engine is not running, and all code output has ended.

**To test output state:**

1. If not in Self-Test, activate it (ground STI/latch tester button).
2. Briefly press the throttle wide open and release. This energizes or sends signals to most of the actuators. This may also reveal some codes that didn't show before.

**NOTE —**
I know, I know, with a carburetor, you would never mash the throttle, engine off, to avoid pumping raw gas into the cylinders. But remember: fuel-injection systems have no accelerator pump, so you don't have to worry.

3. Again briefly press the throttle wide open and release. Now you have de-energized most of the actuators. Again, that may reveal some codes that didn't show before.

### 4.11 MECS-II

MECS-II ('93+) Engine Control Module provides considerably more diagnostic capabilities than MECS-I. The control module runs continuous checks of input signals. But it checks outputs only for three seconds when you request the check:

- Ignition ON
- Ground STI terminal of data-link connector

"00" indicates No Trouble Codes. Read codes by scan tool, Analog VOM, or flashing MIL on dash

### 4.12 4EAT Codes

Diagnostic Trouble Codes can usually be read by counting flashes of the Malfunction Indicator Light (MIL) when the control module is in Diagnostic Test Mode, 1991 and later 1.8L 4EAT and 1993 and later 2.0L 4EAT. To indicate trouble codes, some cars flash other dash indicator lamps:

- '93 and later 2.5L 4EAT - Overdrive Off Lamp (ODL)
- '91 and later 1.6L 4EAT - Manual Shift Lamp (MSL)

## 5. CONCLUSION

In this chapter, you've seen troubleshooting and diagnostics covering most Ford cars and trucks. Beginning with a series of Diagnostic Routines, you've seen how to use Quick Tests and other diagnostic procedures to track down problems in less time. You've seen the built-in test capabilities of the EEC and MECS-II systems. To see how to perform pinpoint tests and make further tests of fuel and ignition, go to the next chapter.