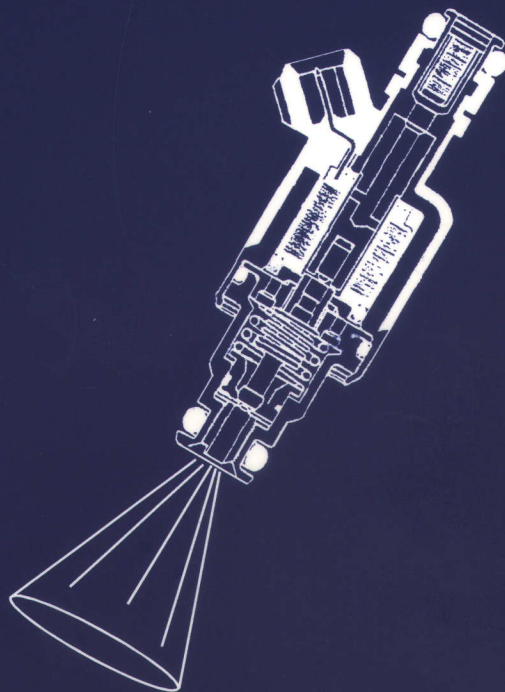
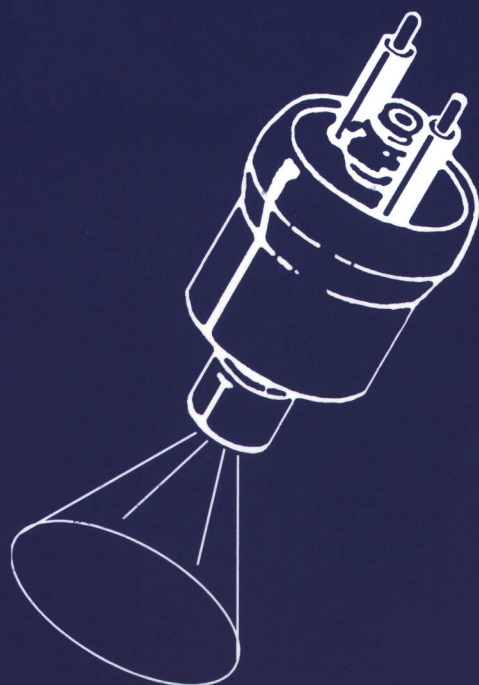


# Workshop Manual

## "BY" Models

### EFI Diagnostic GM




**VOLVO  
PENTA**

## Safety Warning

This Workshop Manual will alert you to certain procedures that must be done very carefully. If you ignore this information, you could...

- Injure yourself or people around you
- Injure the boat operator, boat passengers, or people around the boat
- Damage the Volvo Penta product or its systems

Understand the following symbols before proceeding:

 <b>Safety Warning</b>	Alerts you to the possibility of danger and identifies information that will help prevent injuries.
<b>Note</b>	Identifies information that will help prevent damage to machinery.
<b>Important</b>	Appears next to information that controls correct assembly and operation of the product.

This Workshop Manual is written for qualified, factory trained service technicians familiar with the use of Volvo Penta special tools.

This Workshop Manual tells you how to correctly maintain and service Volvo Penta products and systems. When correctly serviced, the Volvo Penta product will be reliable and safe to operate.

When Volvo Penta special tools are called for, use them. Where mentioned, the tools are required to perform the service procedure.

If you use service procedures or service tools that are not recommended in this manual, **YOU ALONE** must decide if your actions might injure people or damage the Volvo Penta product.

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**This Volvo Penta Workshop Manual is part of a set that  
covers the following Volvo Penta "BY" Models**

<b>Engine</b>	<b>Steering</b>	<b>Model Number</b>	<b>Transom Shield</b>	<b>Drive Unit</b>
<b>3.0 GS</b>	Manual	30GSMBYCCE	3868844	3868895 (1.97:1) SX-M
	Manual	30GSMBYCCE	3868844	3868896 (2.18:1) SX-M
	Manual	30GSMBYCCE	3868845	3868895 (1.97:1) SX-M
	Manual	30GSMBYCCE	3868845	3868896 (2.18:1) SX-M
	Power	30GSPBYCCE	3868844	3868895 (1.97:1) SX-M
	Power	30GSPBYCCE	3868844	3868896 (2.18:1) SX-M
	Power	30GSPBYCCE	3868845	3868895 (1.97:1) SX-M
	Power	30GSPBYCCE	3868845	3868896 (2.18:1) SX-M
<b>4.3 GL</b>	Power	43GLPBYC	3868844	3868892 (1.66:1) SX-M
	Power	43GLPBYC	3868844	3868893 (1.79:1) SX-M
	Power	43GLPBYC	3868844	3868894 (1.89:1) SX-M
	Power	43GLPBYC	3868844	3868913 (1.95:1) DP-SM
	Power	43GLPBYC	3868844	3868914 (2.32:1) DP-SM
	Power	43GLPBYC	3868846	3868892 (1.66:1) SX-M
	Power	43GLPBYC	3868846	3868893 (1.79:1) SX-M
	Power	43GLPBYC	3868846	3868894 (1.89:1) SX-M
	Power	43GLPBYC	3868846	3868913 (1.95:1) DP-SM
	Power	43GLPBYC	3868846	3868914 (2.32:1) DP-SM
<b>4.3 GS</b>	Power	43GSJBYA	—	3868694 PJX-C1
	Power	43GSPBYC	3868844	3868892 (1.66:1) SX-M
	Power	43GSPBYC	3868844	3868893 (1.79:1) SX-M
	Power	43GSPBYC	3868844	3868913 (1.95:1) DP-SM
	Power	43GSPBYC	3868844	3868914 (2.32:1) DP-SM
	Power	43GSPBYC	3868846	3868892 {1.66:1} SX-M
	Power	43GSPBYC	3868846	3868893 {1.79:1} SX-M
	Power	43GSPBYC	3868846	3868913 {1.95:1} DP-SM
<b>4.3 Gi</b>	Power	43GIJBYA	—	3868694 PJX-C1
	Power	43GIPBYCCE	3868844	3868892 (1.66:1) SX-M
	Power	43GIPBYCCE	3868844	3868893 (1.79:1) SX-M
	Power	43GIPBYCCE	3868844	3868913 (1.95:1) DP-SM
	Power	43GIPBYCCE	3868844	3868914 (2.32:1) DP-SM
	Power	43GIPBYCCE	3868846	3868892 (1.66:1) SX-M
	Power	43GIPBYCCE	3868846	3868893 (1.79:1) SX-M
	Power	43GIPBYCCE	3868846	3868913 (1.95:1) DP-SM
	Power	43GIPBYCCE	3868846	3868914 (2.32:1) DP-SM
	<b>5.0 GL</b>	Power	50GLPBYC	3868844
Power		50GLPBYC	3868844	3868890 (1.51:1) SX-M
Power		50GLPBYC	3868844	3868912 (1.78:1) DP-SM
Power		50GLPBYC	3868844	3868913 (1.95:1) DP-SM
Power		50GLPBYC	3868846	3868891 (1.60:1) SX-M
Power		50GLPBYC	3868846	3868890 (1.51:1) SX-M
Power		50GLPBYC	3868846	3868912 (1.78:1) DP-SM
Power		50GLPBYC	3868846	3868913 (1.95:1) DP-SM

**This *Volvo Penta* Workshop Manual is part of a set that  
covers the following *Volvo Penta* "BY" Models**

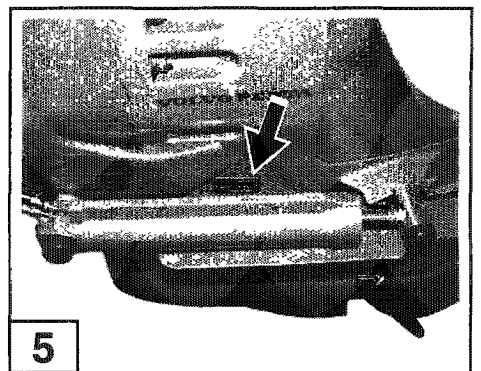
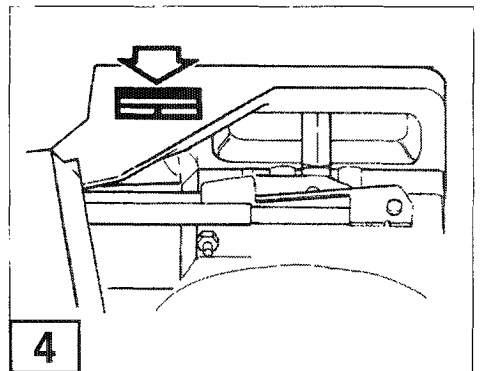
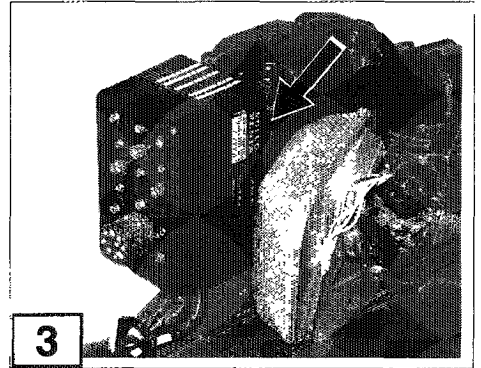
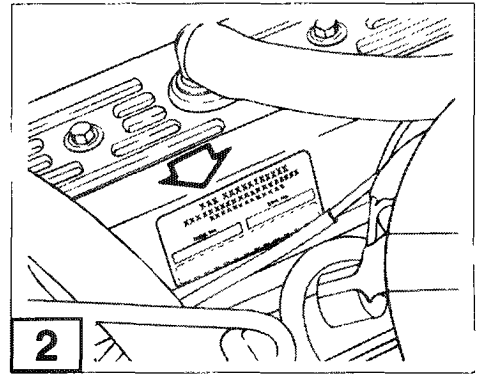
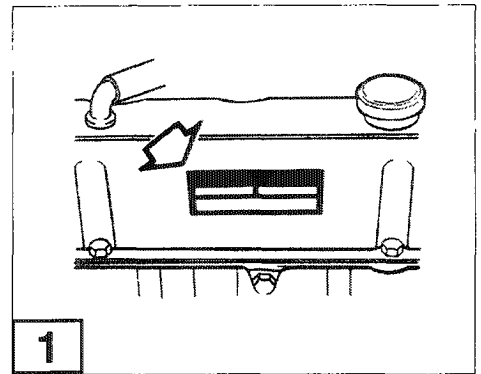
<b>Engine</b>	<b>Steering</b>	<b>Model Number</b>	<b>Transom Shield</b>	<b>Drive Unit</b>
<b>5.0 Gi</b>	Power	50GIPBYCCE	3868844	3868891 (1.60:1) SX-M
	Power	50GIPBYCCE	3868844	3868890 (1.51:1) SX-M
	Power	50GIPBYCCE	3868844	3868912 (1.78:1) DP-SM
	Power	50GIPBYCCE	3868844	3868913 (1.95:1) DP-SM
	Power	50GIPBYCCE	3868846	3868891 (1.60:1) SX-M
	Power	50GIPBYCCE	3868846	3868890 (1.51:1) SX-M
	Power	50GIPBYCCE	3868846	3868912 (1.78:1) DP-SM
	Power	50GIPBYCCE	3868846	3868913 (1.95:1) DP-SM
<b>5.7 GS</b>	Power	57GSPBYC	3868844	3868889 (1.43:1) SX-M
	Power	57GSPBYC	3868844	3868890 (1.51:1) SX-M
	Power	57GSPBYC	3868844	3868912 (1.78:1) DP-SM
	Power	57GSPBYC	3868844	3868913 (1.95:1) DP-SM
	Power	57GSPBYC	3868846	3868889 (1.43:1) SX-M
	Power	57GSPBYC	3868846	3868890 (1.51:1) SX-M
	Power	57GSPBYC	3868846	3868912 (1.78:1) DP-SM
	Power	57GSPBYC	3868846	3868913 (1.95:1) DP-SM
<b>5.7 GSi</b>	Power	57GSIPBYCCE	3868844	3868889 (1.43:1) SX-M
	Power	57GSIPBYCCE	3868844	3868912 (1.78:1) DP-SM
	Power	57GSIPBYCCE	3868844	3868913 (1.95:1) DP-SM
	Power	57GSIPBYCCE	3868846	3868889 (1.43:1) SX-M
	Power	57GSIPBYCCE	3868846	3868912 (1.78:1) DP-SM
	Power	57GSIPBYCCE	3868846	3868913 (1.95:1) DP-SM
<b>7.4 Gi</b>	Power	74GIPBYCCE	3868844	3868889 (1.43:1) SX-M
	Power	74GIPBYCCE	3868844	3868911 (1.68:1) DP-SM
	Power	74GIPBYCCE	3868844	3868912 (1.78:1) DP-SM
	Power	74GIPBYCCE	3868844	3868913 (1.95:1) DP-SM
	Power	74GIPBYCCE	3868846	3868889 (1.43:1) SX-M
	Power	74GIPBYCCE	3868846	3868911 (1.68:1) DP-SM
	Power	74GIPBYCCE	3868846	3868912 (1.78:1) DP-SM
	Power	74GIPBYCCE	3868846	3868913 (1.95:1) DP-SM
<b>7.4 GSi</b>	Power	74GSIPBYCCE	3868850	3868911 (1.68:1) DP-SM
	Power	74GSIPBYCCE	3868850	3868912 (1.78:1) DP-SM
	Power	74GSIPBYCCE	3868916	3868911 (1.68:1) DP-SM
	Power	74GSIPBYCCE	3868916	3868912 (1.78:1) DP-SM
<b>8.2 GSi</b>	Power	82GSIPBYCCE	3868850	3868911 (1.68:1) DP-SM
	Power	82GSIPBYOCE	3868850	3868912 (1.78:1) DP-SM
	Power	82GSIPBYCCE	3868916	3868911 (1.68:1) DP-SM
	Power	82GSIPBYCCE	3868916	3868912 (1.78:1) DP-SM
<b>DPX 385</b>	Xact	DPX385XBYDCE	3868289	3868637 (1.59:1) DPX-S1
	Xact	DPX385XBYDCE	3868289	3868638 (1.68:1) DPX-S1
	Xact	DPX385XBYDCE	3868289	3868639 (1.78:1) DPX-S1
<b>DPX 415</b>	Xact	DPX415XBYDCE	3868289	3868637 (1.59:1) DPX-S1
	Xact	DPX415XBYDCE	3868289	3868638 (1.68:1) DPX-S1
	Xact	DPX415XBYDCE	3868289	3868639 (1.78:1) DPX-S1

## Volvo Penta Model Identification

**Note** All sterndrive systems must be matched for either single or dual engine installations. Failure to properly match engine, transom bracket and sterndrive will result in poor boat performance, and risk or damage to the engine and or drive because of incorrect drive gear ratio.

The model identification is located on the engine valve cover, and **MUST** correspond with the transom bracket and sterndrive numbers as listed in this document.

- Engine Model Number **1** **2** **3**
- Transom Bracket Model Number **4**
- Sterndrive Model Number **5**



# General Information

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## Safety Warning

To reduce the chance of personal injury and / or property damage, the following cautions must be carefully observed.

Proper service and repair are important to the safety of the service technician and safe, reliable operation of all Electronic Fuel Injection (EFI) equipped engines. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality.

The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure or tool, which is not recommended by the manufacturer, must first determine that neither his safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or tool selected.

It is important to note that this manual contains various "Safety Warnings" and "Notes" that must be carefully observed in order to reduce the risk of personal injury during service or repair, or the possibility that improper service or repair may damage the engine or render it unsafe. It is also important to understand that these "Safety Warnings" and "Notes" are not exhaustive, because it's impossible to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

## Basic Knowledge / Tools Required \_\_\_\_\_

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. You should understand the meaning of voltage, ohms, and amps; the basic theories of electricity; what happens to an open, shorted or grounded wire; and be able to follow wiring diagrams.

To perform system diagnostics, several special tools and equipment are required. Become acquainted with the tools and their use before attempting to diagnose the system. Special tools which are required for system service are illustrated at the end of this section.

## Electrostatic Discharge Damage \_\_\_\_\_

Electronic components used in control systems are often designed to carry very low voltages, and are very susceptible to damage caused by electrostatic discharge. **It is possible for less than 100 volts of static electricity to cause damage to some electronic components.** By comparison, it takes as much as 4,000 volts for a person to feel the zap of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up.

Charging by induction occurs when a person with well-insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage; therefore, it's important to use care when handling and testing electronic components.

## Diagnostic Information \_\_\_\_\_

The diagnostic charts and function checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The charts are prepared with the assumption that the system functioned correctly at the time of assembly and that there are no multiple failures.

Engine control circuits contain many special design features not found in standard marine wiring. Electrical contacts are protected against environmental effects and proper splicing methods must be used when necessary. The proper operation of low amperage input / output circuits depends upon good continuity between circuit connectors.

It is important before component replacement and / or during normal troubleshooting procedures that a visual inspection of any questionable mating connector be performed. Mating surfaces should be properly formed, clean, and make good contact. Some typical causes of connector problems are listed below.

- Improperly formed contacts and / or connector housing
- Damaged contacts or housing due to improper engagement
- Corrosion, sealer or other contaminants on the contact mating surfaces
- Incomplete mating of the connector halves during initial assembly or during subsequent troubleshooting procedures
- Tendency for connectors to come apart due to vibration and / or temperature cycling
- Terminals not fully seated in the connector bodies
- Inadequate terminal crimps to the wire



## DLC Connector \_\_\_\_\_

The ECM can communicate a variety of information through the Data Link Connector (DLC) at the front of the engine. Stored information can be acquired using a scan tool or a code tool (CT). Step charts in the **Diagnoses** section incorporate procedures using the CT.

**Note** The marine DLC is a 10-pin connector; an automotive DLC is a 12-pin connector. Make sure the scan or code tool is an appropriate one for marine use.

## Code / Scan Tools \_\_\_\_\_

A variety of devices attach to the DLC to aid technician diagnostics. They range from inexpensive blinking lights (code tools) to sophisticated LCD / LED readouts (scan tools). Choose one that has been designed for marine applications, and best suits your needs and budget. The text in this manual has been written in terms of using a code tool (CT). If using a scan tool, follow the manufacturer's instructions.

## ECM Self-Diagnosis \_\_\_\_\_

The ECM performs a continual self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of diagnostic codes. The codes are two digit numbers that can range from 12 to 51. When a malfunction is detected by the ECM, a code is set.

## How Diagnostic Trouble Codes (DTC's) Are Set \_\_\_\_\_

The ECM is programmed to receive calibrated voltage signals from the sensors. The voltage signal from a sensor may range from as low as 0.1 volt to as high as 4.9 volts. The sensor voltage signal is calibrated for engine application. This would be the sensor's working parameter or "window." The ECM and sensors will be discussed further in the **ECM and Sensor** section.

If a sensor is within its working or acceptable parameters, the ECM will not detect a problem. When a sensor voltage signal falls out of this "window", or an open or short occurs in the wiring to the sensor, the ECM would not receive the "window" voltage for that sensor.

When the ECM does not receive the "window" voltage for a programmed length of time, a DTC will be stored. The Check Engine light (if so equipped) will be illuminated and a known default value will replace the sensed value to restore engine performance.

## Visual / Physical Inspection \_\_\_\_\_

**A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further steps.** Inspect all vacuum hoses for correct routing, pinches, cuts, or disconnects. Be sure to inspect hoses that are difficult to see. Inspect all the wires in the engine compartment for proper connections, burned or chafed spots, pinched wires, or contact with sharp edges or hot manifolds. This visual / physical inspection is very important. It must be done carefully and thoroughly.

## On-Board Diagnostic (OBD) System Check \_\_\_\_\_

After the visual / physical inspection, the OBD system check is the starting point for all diagnostic procedures. Refer to the **Diagnoses** section.

The correct procedure to diagnose a problem is to follow two basic steps:

1. **Are the on-board diagnostics working?** This is determined by performing the OBD system check. Since this is the starting point for the diagnostic procedures, always begin here. If the on-board diagnostics aren't working, the OBD system check will lead to a diagnostic chart in the **Diagnoses** section to correct the problem. If the on-board diagnostics are working correctly, the next step is:

2. **Is there a DTC stored?** If a DTC is stored, go directly to the numbered DTC chart in the **Diagnoses** section. This will determine if the fault is still present.

## Service Mode \_\_\_\_\_

When the CT is connected to the DLC, and the CT switch is in the "ON" position, the system will enter what is called Service Mode. In this mode the ECM will:

1. Display a DTC 12 by flashing the CT light (indicating the system is operating correctly).
2. Display any stored DTC's by flashing the CT light. Each DTC will be flashed three times, then DTC 12 will be flashed again.
3. Hold ignition timing at a fixed timing degree programmed into the ECM. This will allow base timing to be adjusted on distributor ignition engines.
4. Move the IAC valve to its fully extended position, blocking the idle air passage. This is important to remember, as an attempt to run the boat while in Service Mode will most likely result in an abnormally low idle speed.

## Reading Diagnostic Trouble Codes (DTC) \_\_\_\_\_

The provision for communicating with the ECM is the Data Link Connector (DLC). It is part of the EFI engine wiring harness, and is a 10-pin connector. It is used in the assembly plant to check engine operation before it leaves the plant. The DTC's stored in the ECM's memory can be read either through a scan tool (a hand-held diagnostic scanner plugged into the DLC), or by counting the number of flashes of the CT when in Service Mode.

The ignition and CT switches must be in the "OFF" position when connecting the CT to the DLC. Then turn the ignition switch to the "ON" position with the engine not running. At this point, the CT light should be on. Push the CT switch to the "ON" position and the light should flash DTC 12 three times consecutively (i.e. flash - pause - flash-flash - pause, then it would repeat two more times). DTC 12 indicates that the ECM's diagnostic system is operating. If DTC 12 is not indicated, a problem is present within the diagnostic system itself, and should be addressed by consulting the appropriate diagnostics chart in the **Diagnoses** section.

Following the output of DTC 12, the CT light will indicate a DTC three times if a DTC is present, or it will simply continue to output DTC 12. If more than one DTC has been stored in the ECM's memory, the DTC's will be displayed from the numerically lowest to the highest, with each DTC being displayed three times.

### Malfunction Light

This light is part of the diagnostic Code Tool (CT) and has the following functions:

- It informs the operator that a problem has occurred and that the boat should be taken in for service as soon as reasonably possible.
- It displays DTC's stored by the ECM which help the technician diagnose system problems.

When the CT is attached to the DLC with its switch in the "OFF" position, and the key in the "ON" position and the engine not running, the CT light will come "ON". When the engine is started, the light will turn "OFF". If the light remains "ON", the self-diagnostic system has detected a problem. If the problem goes away, the light will go out in most cases after 10 seconds, but a code will remain stored in the ECM.

When the light remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability problem, an EFI Diagnostic Circuit Check must be performed. These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

To retrieve a DTC, turn the key to the "ON" position with the engine not running. Push the CT switch to the "ON" position and the light should flash a Code 12 three times, and then any other Code(s) that are stored in the ECM memory.

### Intermittent Light

In the case of an "intermittent" problem, the CT bulb will light for 10 seconds and then go out. However, the corresponding code will be stored in the memory of the ECM. When unexpected codes appear during the code reading process, one can assume that these codes were set by an intermittent malfunction and could be helpful in diagnosing the system.

An intermittent DTC, if cleared, may or may not reset. If it's an intermittent failure, consult the **Diagnostic Aids** on the page facing the diagnostic code chart corresponding to the intermittent DTC. **Symptoms** also covers the topic of "intermittents". A physical inspection of the applicable sub-system most often will resolve the problem.

## Technician Clearing of DTC's \_\_\_\_\_

### Scan Tool Procedure

An electronic Scan Tool is the most desirable instrument for clearing codes. It is effective with all ECM variations, and will clear codes with the engine running. Scan Tools are available from a number of reputable manufacturers, however, make sure you use a **marine version**. Follow the Scan Tool manufacturer's operating instructions.

### Manual Procedure

**Note** When clearing DTC's, the battery must be fully charged and cranking RPM speed must be a minimum of 160 RPM. **The ability to clear DTC's is directly dependent on battery being fully charged and able to crank engine with adequate RPM.**

**Note** Some ECM's cannot be cleared with the manual procedure. If this is the case, use an electronic Scan Tool.

1. Turn ignition "OFF". Remove protective Data Link Connector (DLC) cover. Push diagnostic Code Tool (CT) switch to "OFF" position and attach to DLC.
2. Turn ignition switch to "ON", do not start engine.
3. Push CT switch to "ON" position.
4. To clear DTC's, disengage the remote control's shift function, then SLOWLY move the throttle from 0% (idle) to 100% (wide open throttle) and back to 0% (idle).
5. Push CT switch to "OFF" position. **If this step is not performed, the engine may not start and run.**
6. Turn ignition "OFF" for 20 seconds.
7. Start engine and run for at least 20 seconds.
8. Turn ignition switch "OFF" for at least 20 seconds.

9. Turn ignition switch to "ON", do not start engine. Push CT switch to "ON" position and **verify that DTC 12 is flashed**. Push CT switch to "OFF" position, turn ignition switch to "OFF" position, remove CT, and install DLC protective cover.

If original DTC's are still present, check "Note" at the beginning of the procedure and repeat the DTC clearing procedure.

If new DTC's are displayed, perform **On-Board Diagnostic (OBD)** system check.

## ECM Clearing of DTC's \_\_\_\_\_

The ECM will automatically clear DTC's if they have not re-occurred within 25 "power-ups". One "power-up" is defined as any time the engine, either cranking or running, enters Run Mode by exceeding 300 RPM for 16 seconds or more.

## Diagnosis of Driveability Concerns (With No DTC's Set) \_\_\_\_\_

If a driveability concern still exists after following the diagnostic circuit check and reviewing the **Symptoms** section, an out-of-range sensor may be suspected. Because of the unique design of the EFI system, failsafes have been incorporated into the ECM. A sensed value is replaced with a default value in the case of a sensor malfunction or sensor wiring problem. With this feature, limited engine performance is restored until the engine is repaired. A basic understanding of sensor operation is necessary to be able to diagnose an out-of-range sensor.

If a sensor is out of range, but still within the operating "window" of the ECM, the problem will go undetected by the ECM and may result in a driveability concern.

**Example:** coolant temperature is 150°, but the coolant sensor incorrectly reads 50°. This would cause the ECM to deliver more fuel than was actually needed and result in an overly rich, rough running condition. This condition would not have caused a DTC to set as the ECM interprets this as within its "range".

To identify a sensor which is out of range, unplug it while running the engine. After approximately 2 minutes, the diagnostic DTC for that sensor will set, illuminate the Check Engine or code tool light, and replace the sensed value with a default value. If at that point a noticeable performance improvement is observed, the DTC chart for that particular sensor should be followed to correct the problem.

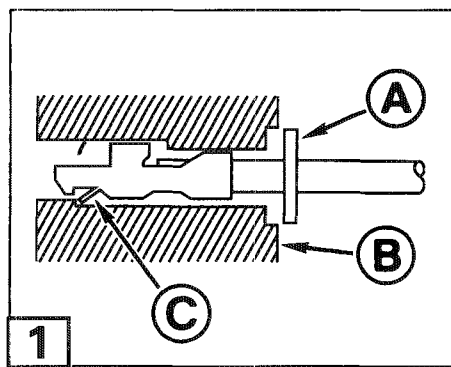
**Note** Be sure to clear each DTC after disconnecting and reconnecting each sensor. Failure to do so may result in a mis-diagnosis of the driveability concern.

## Wiring Connector Service \_\_\_\_\_

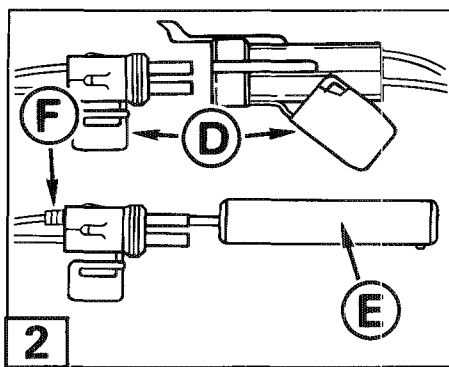
Most connectors in the engine compartment are protected against moisture and dirt which could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronics system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor or in the wiring harness may locate the open circuit condition. This should always be considered when an open circuit or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

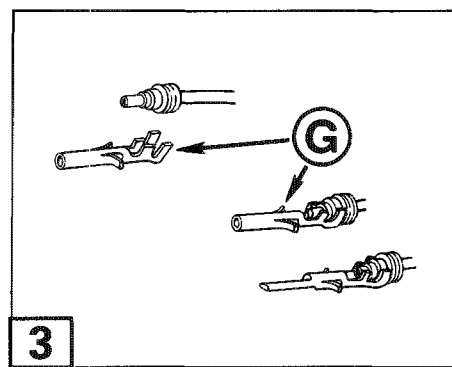
Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently. Replacement connectors and terminals are listed in the Parts Catalog.



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## Metri-Pack Series 150 Terminals \_\_\_\_\_

Some ECM harness connectors contain terminals called Metri-Pack. These are used at some of the sensors and the distributor connectors. Metri-Pack connectors require tools J 35689, BT-8518 or an equivalent to service them.

**1** Some Metri-Pack terminals are called "pull-to-seat". To remove the terminal, slide the seal **A** back on the wire. Insert a flat tool thru the back of the connector **B** to release the locking tang **C**, and push the wire out through the front of the connector. To install a terminal, the wire is first inserted through the one piece seal then out the front of the connector. The terminal is crimped on the wire, and the terminal pulled back into the connector to seat it in place.

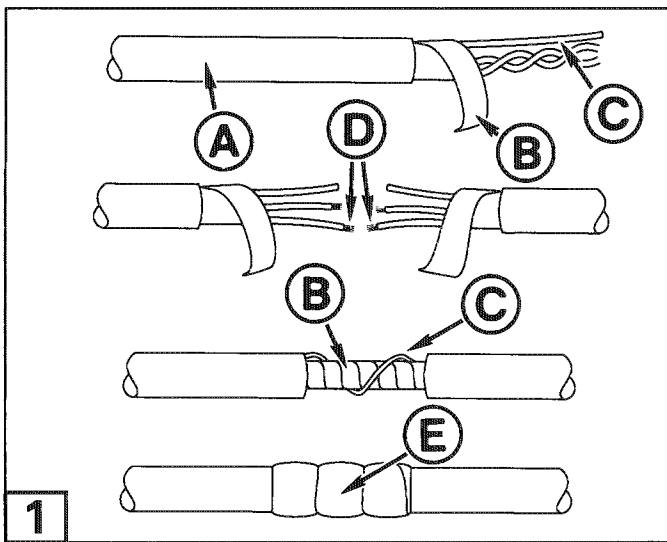
## Weather-Pack Terminals \_\_\_\_\_

**2** Some Weather-Pack terminals are called "push-to-seat". Weather-Pack connectors require tools J 28742, BT-8234-A or an equivalent to service them. These tools are used to remove pin and sleeve terminals. If terminal removal is attempted without using the special tool required, there is a good chance that the terminal will be bent or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

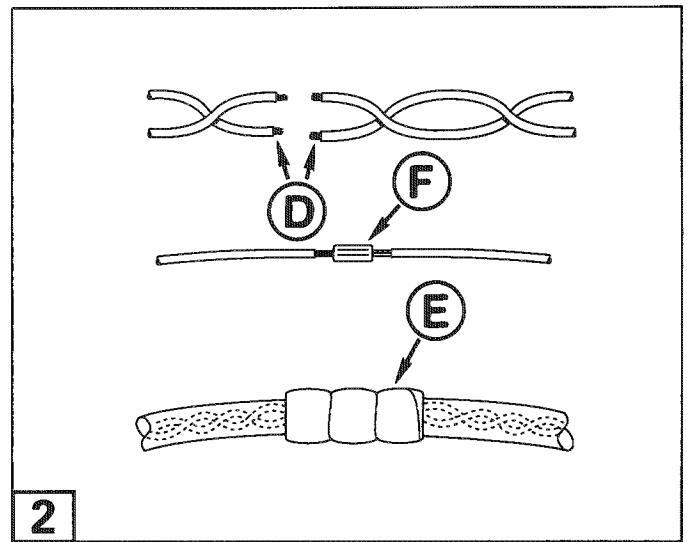
**2 3** To remove the terminal, pivot the connector retaining hinge **D** out of the way. Insert the specified removal tool **E** thru the front of the connector, and push the terminal and seal **F** out of the connector. To install a terminal, the wire is first inserted through the seal. The wire and seal are crimped to the terminal **G**. The terminal is then pushed back into the connector to seat and seal it in place. Make certain that the connectors are properly seated and all of the sealing rings are in place when closing the retaining hinge.

**2** The retaining hinge **D** provides a secondary locking feature for the connector. It improves the connectors reliability by retaining the terminals if the small terminal lock tangs are not positioned properly.

Weather-Pack connectors cannot be replaced with standard connectors. Instructions are provided with Weather-Pack connector and terminal packages.



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## Wiring Harness Service \_\_\_\_\_

When signal wires are spliced into a harness, use the same gauge wire with high temperature insulation only. With the low current and voltage levels found in the system, it's important that the best possible bond be made at all wire splices by soldering the splices.

### 1 Twisted / Shielded Cable Repair

Step 1. Remove outer jacket (A).

Step 2. Unwrap aluminum / mylar tape and ground (uninsulated) wire. Do not remove mylar tape (B), or ground wire (C).

Step 3. Untwist conductors. Strip insulation (D) as necessary.

Step 4. Splice wires using splice clips and rosin core solder. Wrap each splice to insulate.

Step 5. Wrap with mylar (B) and ground wire (C).

Step 6. Tape (E) over whole bundle to secure as before.

### 2 Twisted Lead Wire Repair

Step 1. Locate damaged wire. Remove insulation (D) as required. If shrink tube is to be used as an insulator, cut and slide shrink tube over damaged wire.

Step 2. Splice wire together using splice clip (F) and rosin core solder.

Step 3. Cover splice with electrical tape to insulate from other wires.

Step 4. Retwist as before and cover with electrical tape (E) to hold in place.

**Note** Use care when probing a connector or replacing connector terminals. It is possible to short between opposite terminals. If this happens, certain components can be damaged. Always use jumper wires with the corresponding mating terminals between connectors for circuit checking. **NEVER** probe through connector seals, wire insulation, secondary ignition wires, boots, nipples or covers. Microscopic damage or holes may result in eventual water intrusion, corrosion, and component or circuit failure.

## Service Tools Needed

For diagnosis the system requires a Code Tool (CT) or Scan Tool, inductive pick-up timing light, fuel pressure test gauge, tachometer, test light, ohmmeter, digital voltmeter with 10 megohms impedance, vacuum gauge and jumper wires. A test light or voltmeter must be used when specified in the procedures. For more complete information on the operation of these tools, consult the tool manufacturer's instructions.

### 3 High Impedance Multi-Meter (Digital Volt-Ohmmeter DVOM)

A digital voltmeter with a 10 megohms input impedance is used because this type of meter will not load down the circuit and result in faulty readings. Some circuits require accurate voltage readings because they have very high resistance.

### 4 Vacuum Pump With Gauge (20 In. Hg. Minimum)

Use the gauge to monitor engine manifold vacuum, and the hand pump to check vacuum controlled devices.

### 5 Unpowered Test Light

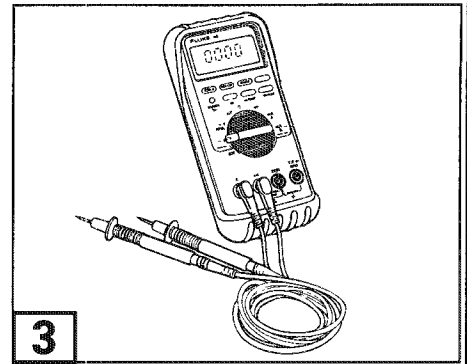
Used for checking wiring for complete circuits, shorts to ground, or voltage.

### 6 Tachometer

Must have inductive signal pick-up.

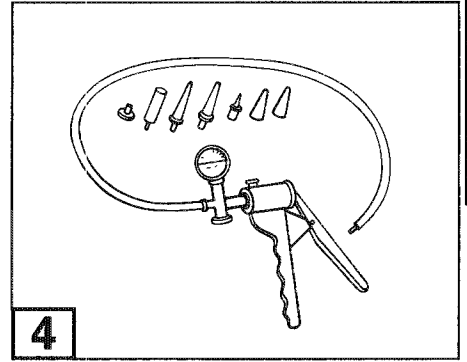
### 7 Metri-Pack Terminal Remover

Used for removing 150 series Metri-Pack "pull-to-seat" terminals from connectors. Refer to **Wiring Harness Service** in this section for removal procedure.



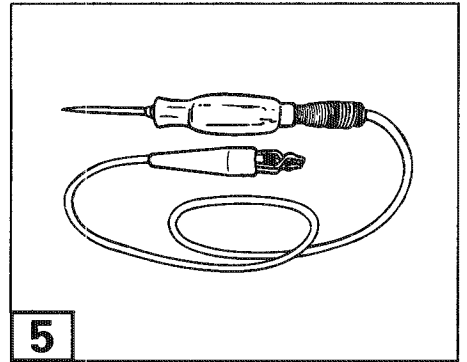
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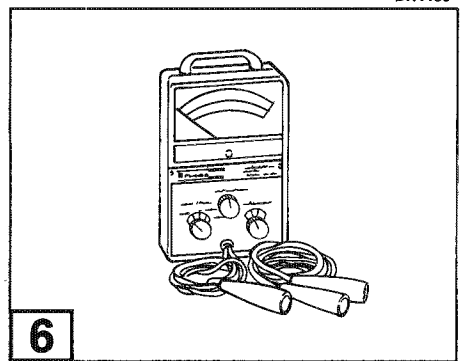
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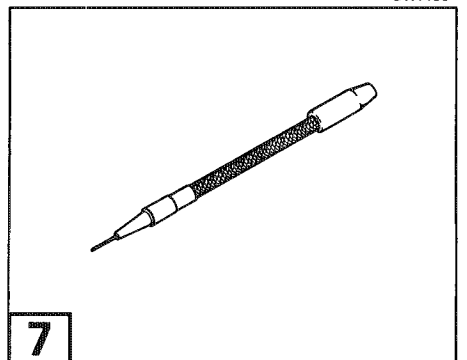
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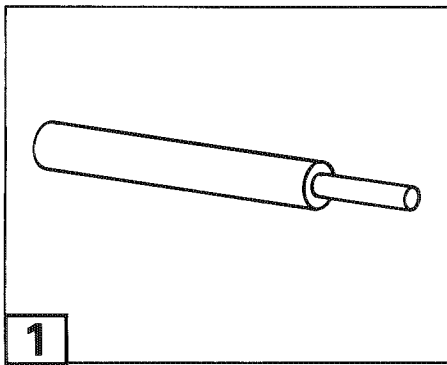
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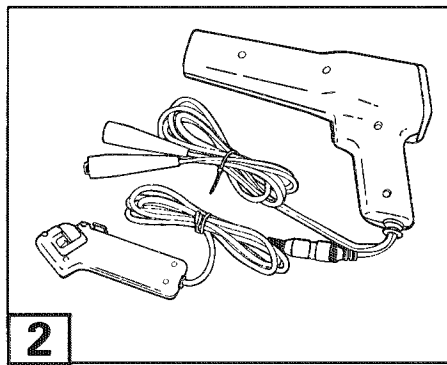
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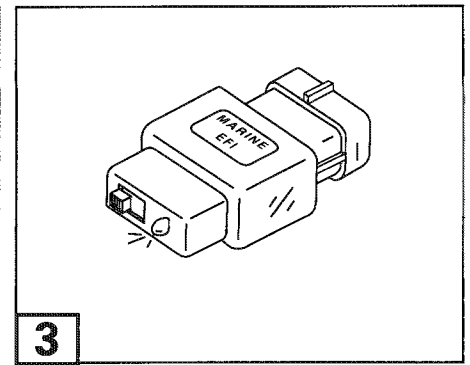
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**1 Weather Pack Terminal Remover**

Used for removing terminals from Weather Pack connectors. Refer to **Wiring Harness Service** in this section for removal procedure.

**2 Timing Light**

Must have inductive signal pickup

**3 Code Tool**

Small, inexpensive device that displays DTC's stored in the ECM by means of a flashing light. Cannot check sensor or circuit integrity, or provide other engine operational data. **Must be designed for marine use.**

**4 Fuel Pressure Gauge**

Used for checking fuel pump pressure and comparing injector pressure drop for equal fuel distribution.

**5 Injector Harness Test Light**

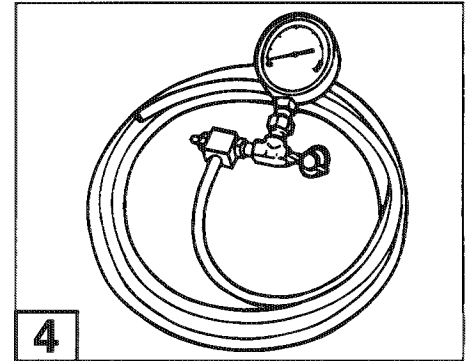
A specially designed light used to visually indicate injector electrical impulses from the ECM.

**6 Injector Tester (optional)**

Separately energizes each injector to compare for equal impulses over a constant time interval.

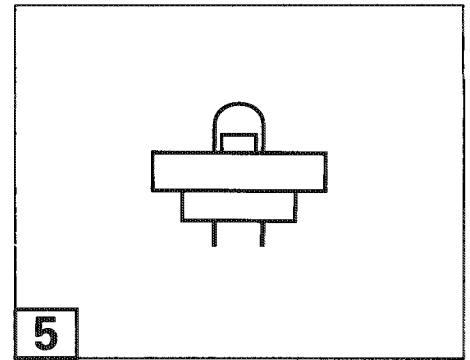
**7 Scan Tool (optional)**

Hand held electronic diagnostic tool that's used to determine EFI system problems. It displays numerous engine operating parameters, and is available from a number of reputable manufacturers. **Must be designed and encoded for marine use.**



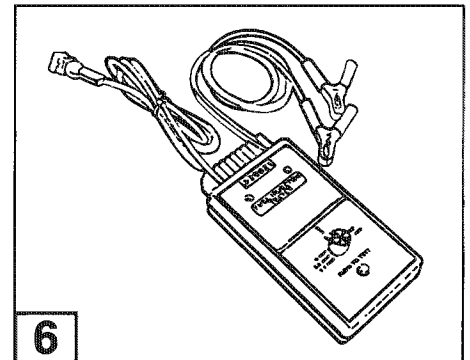
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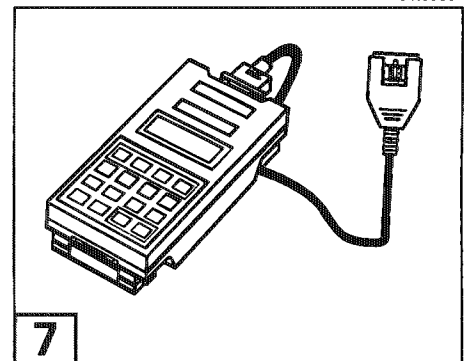
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## Section 2

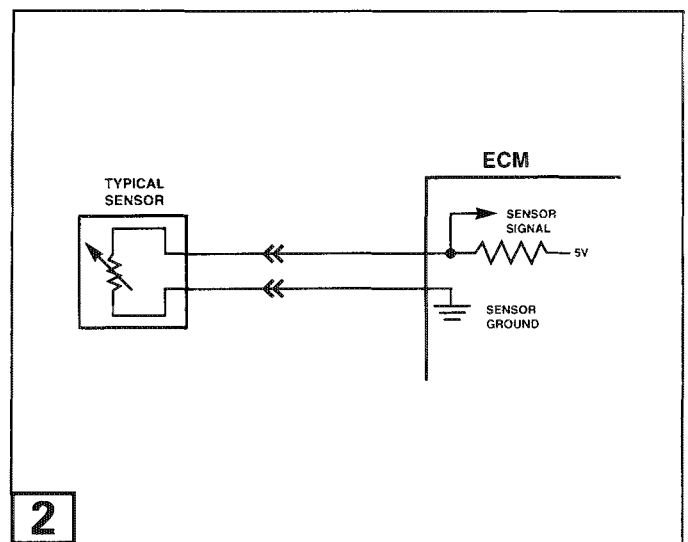
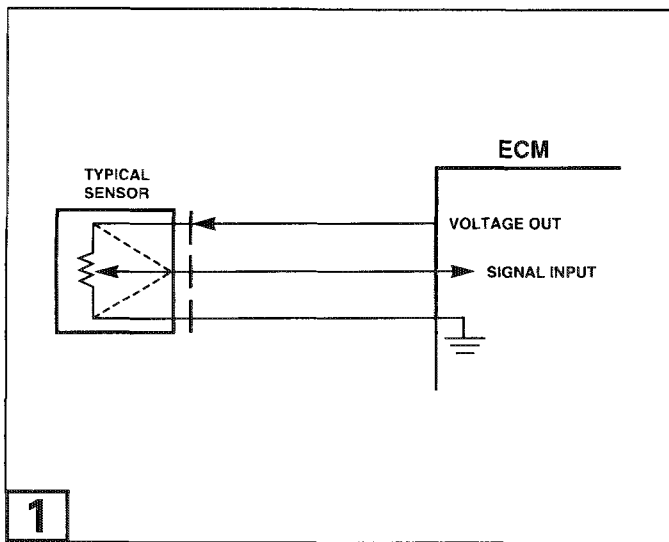
# Engine Control Module (ECM) and Sensors

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### Safety Warning

Before working on any part of the electrical system, read the section called Safety at the end of this manual.



## General Description

The Volvo Penta Electronic Fuel Injection (EFI) system is equipped with a computer that provides the operator with state-of-the-art fuel delivery and spark control. Computers use voltage to send and receive information as described below.

### Sensors and Voltage Signals

Voltage is electrical pressure. Voltage does not flow through circuits; instead, voltage causes current. Current does the real work in electrical circuits. It is current, the flow of electrically charged particles, that energizes solenoids, closes relays and lights lamps.

Besides causing currents in circuits, voltage can be used as a signal. Voltage signals can send information by changing levels, changing wave form (shape), or changing the speed at which the signal switches from one level to another. Computers use voltage signals to communicate with one another. The different sections inside computers also use voltage signals to talk to each other. There are two kinds of voltage signals, analog and digital. Both of these are used in computer systems.

### Three wire Sensors

1 All 3-wire sensors have a reference voltage, a ground and a variable "wiper." The lead coming off the "wiper" will be the signal to the Engine Control Module (ECM). As the wiper position changes, the signal voltage returned to the computer also changes.

### Two Wire Sensors

2 This sensor is basically a variable resistor in series with a fixed known resistor within the computer. By knowing the values of the input voltage and the voltage drop across the known resistor, the value of the variable resistor can be determined. The variable resistors that are commonly used are called thermistors. A thermistor's resistance varies with temperature.

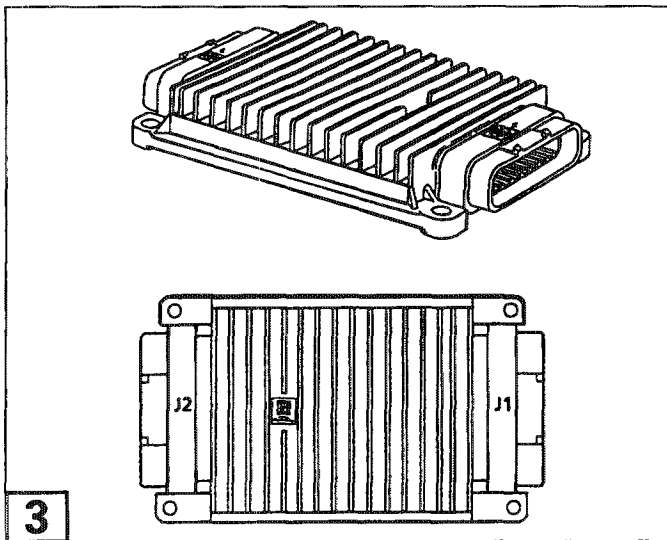
### Switch Types

Switched inputs to the computer (also known as discretes) can cause one bit to change, resulting in information being communicated to the computer. Switched inputs can come in two types; they are "pull-up" and "pull-down".

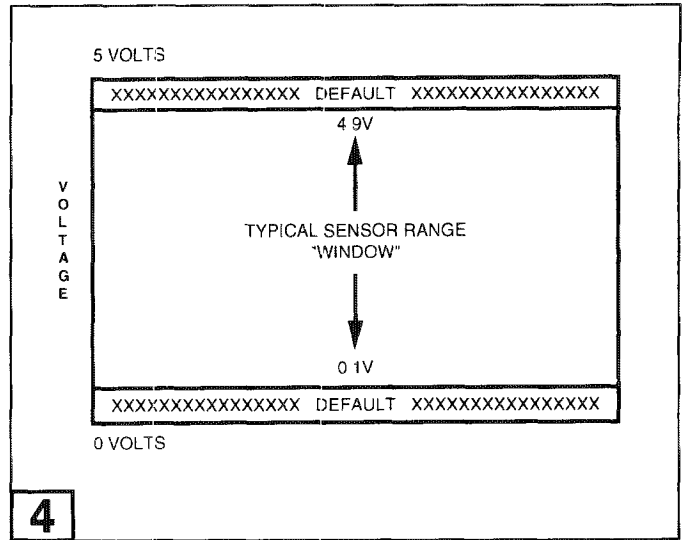
With a "pull-up" type switch, the ECM will sense a voltage when the switch is CLOSED. In the case of the "pull-down," the ECM "sees" the voltage when the switch is OPEN.

### Pulse Counters

For a computer to determine frequency information from a switched input, the computer must measure the time between voltage pulses. As a number of pulses are recorded in a set amount of time, the computer can calculate the frequency. The meaning of the frequency number can have any number of meanings to the computer.



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An example of a pulse counter type of input is the distributor reference pulse input. The computer can count a train of pulses, a given number of pulses per engine revolution. In this way, the computer can determine the RPM of the engine.

### Engine Control Module (ECM)

**3** The Engine Control Module (ECM) is the control center of the fuel injection system. It constantly monitors information from various sensors, and controls the systems that affect engine performance.

**4** The ECM also performs a diagnostic function check of the system. It can recognize operational problems and store a Diagnostic Trouble Code(s) (DTC) which identifies the problem area to aid the technician in making repairs. "Sensed" values must fall within the sensor 0.1 - 4.9V range. If the sensed value exceeds this range, either high or low, the ECM "defaults" to predetermined values set in the factory ECM programming.

#### ECM Function

The ECM supplies 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, the use of a 10 megohms or greater input impedance digital voltmeter is required to assure accurate voltage readings.

### Memory

There are three types of memory storage within the ECM: ROM, RAM and EEPROM.

#### ROM

Read Only Memory (ROM) is a permanent memory that is physically soldered to the circuit boards within the ECM. The ROM contains the overall control programs. Once the ROM is programmed, it cannot be changed. ROM memory is non-erasable, and does not need power to be retained.

#### RAM

Random Access Memory (RAM) is the microprocessor "scratch pad." The processor can write into, or read from, this memory as needed. This memory is erasable and needs a constant supply of voltage to be retained. During normal engine operation, acquired DTC's are stored in RAM memory.

#### EEPROM

Electronic Erasable Programmable Read Only Memory (EEPROM) is the portion of the ECM that contains the different engine calibration information that is specific to each application. Upon engine shut-off, DTC's are stored to the EEPROM from RAM. DTC's will remain in the EEPROM even if B+ voltage is subsequently lost (i.e. battery removed, master switch turned off, etc.).

## Speed Density System

The Volvo Penta Electronic Fuel Injection (EFI) system is a speed and air density system. The system is based on "speed density" fuel management.

Sensors provide the ECM with the basic information for the fuel management portion of its operation. Signals to the ECM establish the engine speed and air density factors.

### Speed

The engine speed signal comes from the Ignition Control (IC) module inside the distributor to the ECM on the (IC) reference high circuit. The ECM uses this information to determine the "speed" or RPM factor for fuel and ignition management.

### Density

One sensor contributes to air density data, the Manifold Absolute Pressure (MAP) sensor.

The Manifold Absolute Pressure (MAP) sensor is a 3-wire sensor that monitors the changes in intake manifold pressure which results from changes in engine load. These pressure changes are supplied to the ECM in the form of electrical signals.

As intake manifold pressure increases, vacuum decreases. The air density in the intake manifold also increases, and additional fuel is required.

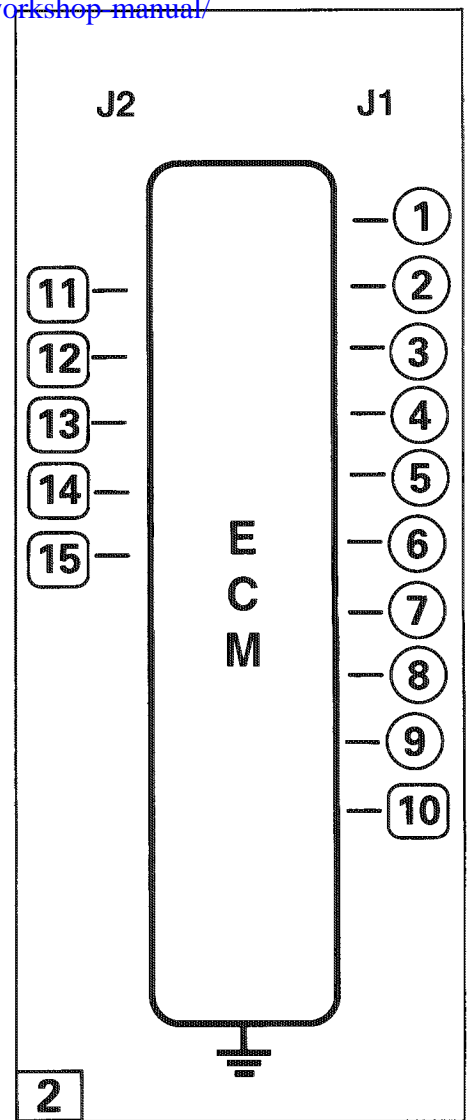
The MAP sensor sends this pressure information to the ECM, and the ECM increases the amount of fuel injected by increasing the injector pulse width. As manifold pressure decreases, vacuum increases, and the amount of fuel is decreased.

These two inputs MAP and RPM are the major determinants of the air/fuel mixture delivered by the fuel injection system.

The remaining sensors and switches provide electrical inputs to the ECM which are used for modification of the air / fuel mixture, as well as for other ECM control functions, such as Idle Air Control (IAC).

### ECM Inputs / Sensor Descriptions

**1** This illustration shows the sensors, switches, and other inputs that supply data used by the ECM to control its various systems. The following sections provide a brief description of each.



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- ① Battery 12V
- ② Ignition 12V
- ③ TP Sensor
- ④ MAP Sensor
- ⑤ ECT Sensor
- ⑥ IAT Sensor
- ⑦ Knock Sensor
- ⑧ Diagnostic Enable
- ⑨ Sensor V-REF (5 Volts)
- ⑩ S.L.O.W. Switches
- ⑪ Ignition Control
- ⑫ Fuel Pump Relay
- ⑬ IAC Motor
- ⑭ Serial Data
- ⑮ Fuel Injectors