

T444E
DIESEL ENGINE / VEHICLE
DIAGNOSTIC MANUAL
FOR
INTERNATIONAL® TRUCKS
EGES-125-1
May, 1997.

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 - (BARO) BAROMETRIC PRESSURE SENSOR
 - (BRAKE) BRAKE SWITCH/RELAY CIRCUITS
 - (CMP) CAMSHAFT POSITION SENSOR
 - (DCUATA) DCUATA DATA COMMUNICATION LINKS
 - (EBP) EXHAUST BACK PRESSURE SENSOR
 - (ECI) ENGINE CRANK INHIBIT
 - (ECI) ENGINE COOLANT LEVEL SYSTEM (ENGINE PROTECTION)
 - (ECM) ELECTRONIC CONTROL MODULE SELF DIAGNOSTICS
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 - (EOT) ENGINE OIL TEMPERATURE SENSOR
 - (EPR) EXHAUST BACK PRESSURE REGULATOR
 - (GPC) GLOW PLUG CONTROL
 - (IAT) INTAKE AIR TEMPERATURE SENSOR
 - (ICP) INJECTION CONTROL PRESSURE SENSOR
 - (10M PWR) INJECTOR DRIVER MODULE POWER CIRCUITS
 - (INJ) INJECTOR DRIVE CIRCUITS
 - (IPR) INJECTION PRESSURE REGULATOR
 - (KAM PWR) KEEP ALIVE MEMORY POWER
 - (MAP) MANIFOLD ABSOLUTE PRESSURE SENSOR
 - (SCCS) SPEED CONTROL COMMAND SWITCHES AND PTO CONTROLS
 - (STI/EWL) SELF TEST INPUT SWITCH AND ENGINE WARNING LIGHT
 - (TACH) TACHOMETER INPUT CIRCUITS
 - (TSA) TWO SPEED AXLE CIRCUIT
 - (V REF) VOLTAGE REFERENCE CIRCUITS
 - (VPM) VEHICLE PERSONALITY MODULE FUEU HOUR METERS AND ODOMETER
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This manual is part of a series of manuals intended to assist service technicians in maintaining International® Engines in accordance with the latest technical advancements.

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T 444E DIESEL ENGINES

<u>Form No.*</u>	<u>Description</u>
EGES-120	T 444E Engine Service Manual
EGES-125	T 444E Diesel Engine / Vehicle Diagnostic Manual
EGED-130	T 444E Hard Start / No Start & Performance Engine Diagnostics Form
EGED-135	T 444E Electronic Control System Diagnostic Form
1 171 674 R1	T 444E Engine Operation and Maintenance Manual (Prior to 1997)
1171 715 R1	T 444E Engine Operation and Maintenance Manual 1997 Model Year

* - Manual number specified with latest revision will be furnished.

FOREWORD

SERVICE DIAGNOSIS

Service diagnosis is a systematic procedure of investigation to be followed in order to locate and correct an engine problem. The engine is first considered as a complete unit in its specific application and then the problem is localized to components or systems; intake, exhaust, cooling, lubrication or injection. Testing procedures will then help analyze the source of the problem.

PREREQUISITES FOR EFFECTIVE DIAGNOSIS:

1. Knowledge of the principles of operation for both the engine and application systems.
2. Knowledge to perform and understand all procedures in the diagnostic and service manuals.
3. Availability of and the ability to use gauges and diagnostic test equipment.
4. Have available the current information for the engine application.

Although the cause of an engine failure may be apparent, very often the real cause is not found until a repeat failure occurs. This can be prevented if specific diagnostic action is taken prior to, during and after engine disassembly and during engine reassemble.

It is also very important that specific diagnostic tests follow engine reassembly prior to and after the engine is placed back into service.

Identification of the symptoms which lead to engine failure is the result of proper service diagnosis. Effective service diagnosis requires use of the following references:

1. Appropriate Diesel Engine Service Manual.
2. Hard Start / No Start & Performance Engine Diagnostics.
3. Electronic Diagnostics
4. Service Bulletins.

This manual is arranged in sections, with the pages numbered consecutively in each section. Any photos or artist renderings are also numbered consecutively in each section. Included at the top of each page is the Section Title, Section Number and Page Number. The bottom center of each page will show the manual Form Number (i.e. EGES-125).

NOTE: A dash and a numeral (-1) indicates the number of times the basic manual has been completely revised.

An index arranged according to sections will be found at the beginning of this manual.

The diagram illustrates the layout of a page within a rectangular border. At the top left, the text "SECTION TITLE" is followed by a right-pointing arrow and the word "GENERAL". A horizontal line extends from the end of "GENERAL" across the page. At the top right, the text "Section 1" is above "Page 1". To the right of the page, two arrows point to the right edge: the top one is labeled "SECTION NO." and the bottom one is labeled "PAGE NO.". In the center of the page, the word "EXAMPLE" is written in large, bold, capital letters. At the bottom left, the text "FORM NO." is followed by a right-pointing arrow and "EGES-125-1". A horizontal line extends from the end of "EGES-125-1" across the page.

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FUEL SYSTEM DESCRIPTION

The T 444E fuel system consists of three major sub-systems:

- Fuel Supply System.
- Injection Control Pressure System.
- Fuel Injector.

These sub-systems work together to inject pressurized fuel into the combustion chambers. The function of the fuel supply system is to deliver fuel to the injectors. The injection control pressure system supplies the injectors with high pressure lube oil.

The fuel injectors use the pressure from the lube oil to pressurize the fuel and inject the fuel into the combustion chambers.

The function of the fuel supply system is to deliver fuel from the fuel tank(s) to the injectors. The components involved in this task are:

- Fuel Lines
- Fuel Strainer
- Transfer Fuel Pump
- Fuel Filter/Water Separator
- Fuel Pressure Regulator Valve

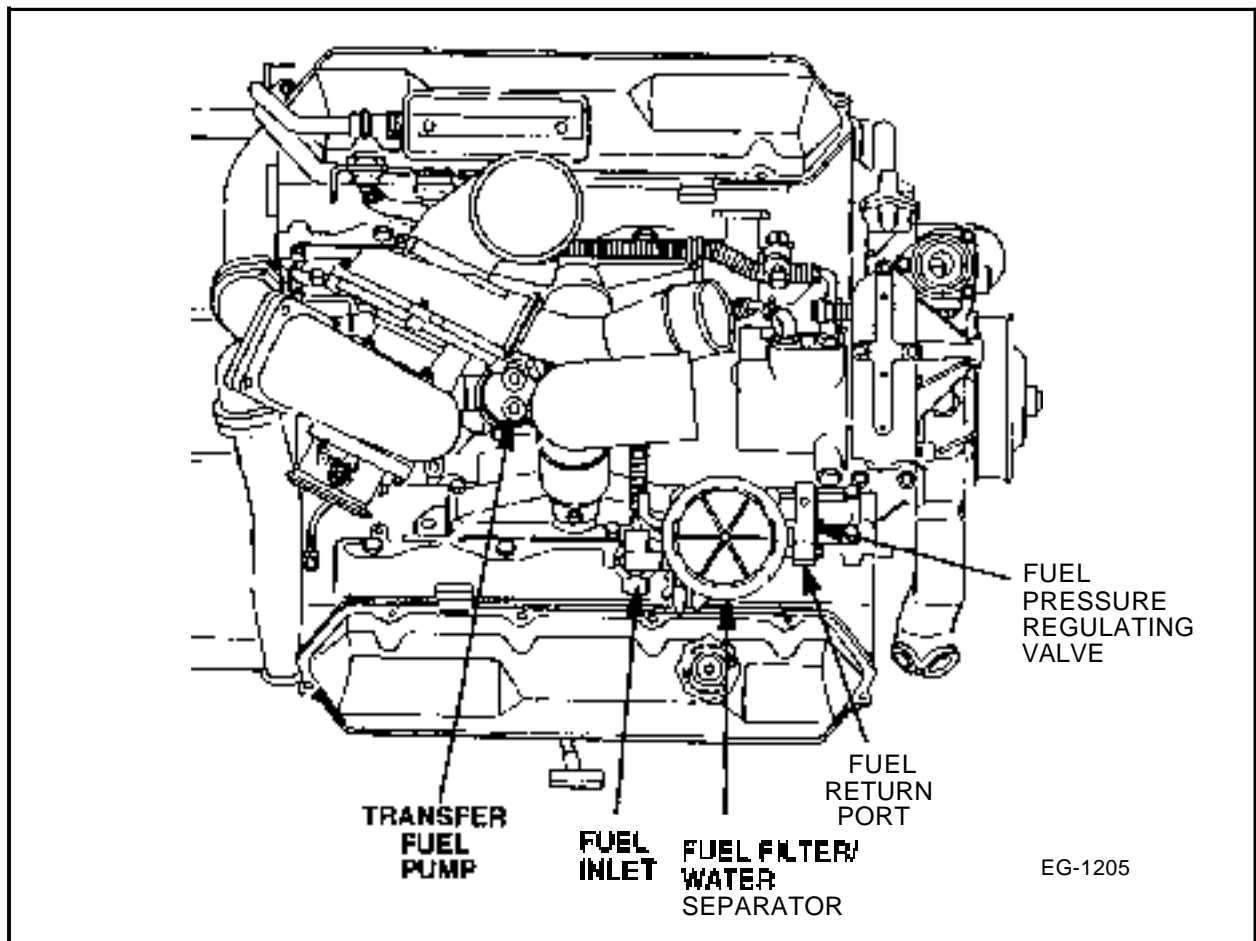


Figure 1.1-1. - Component Locations

FUEL SUPPLY SYSTEM

FUEL SYSTEM DESCRIPTION (Continued)

FUEL SUPPLY PUMP

The fuel transfer pump on the T 444E engine is a camshaft driven two stage diaphragm/piston pump mounted in the engine "V". Refer to Figure 1.1-2.

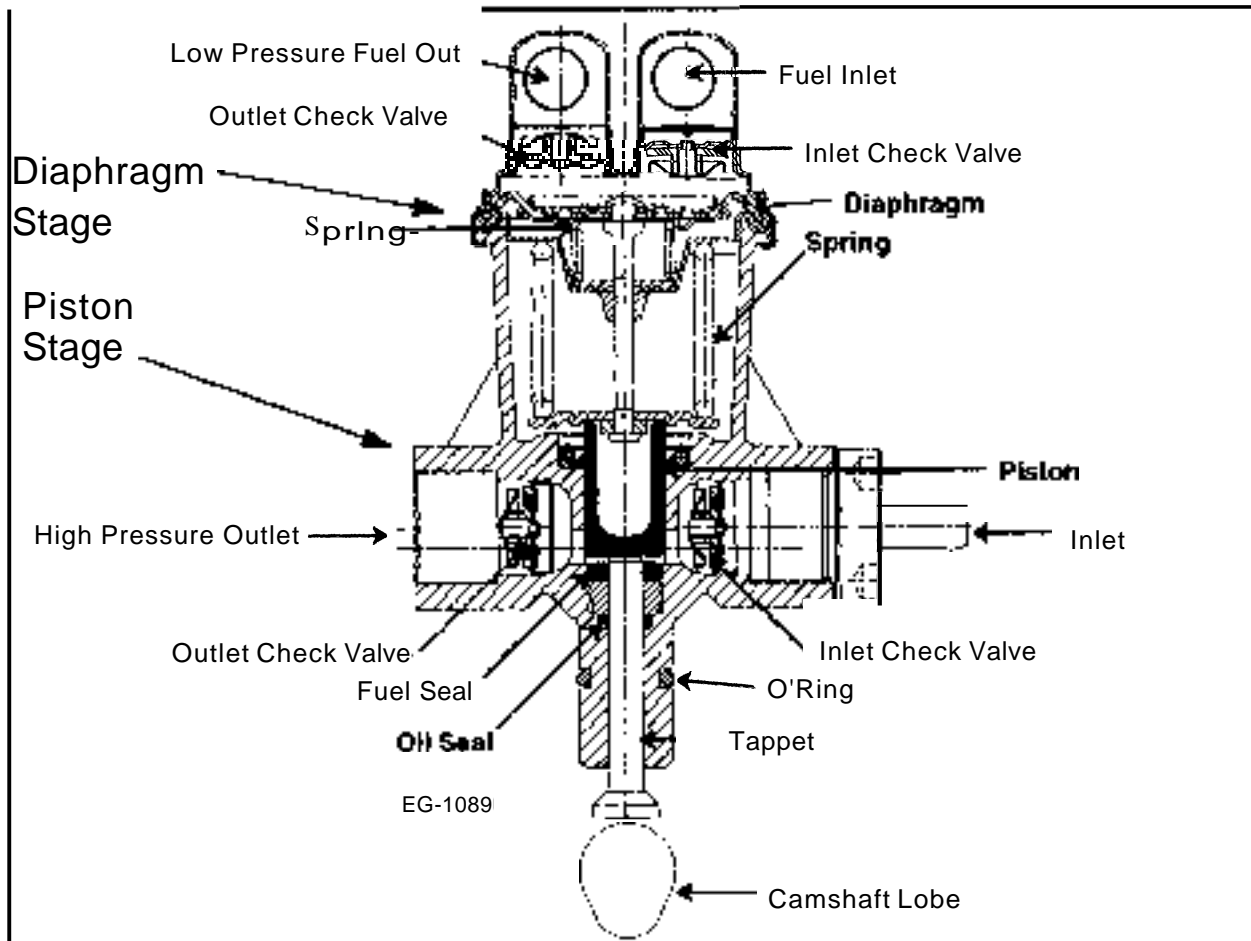


Figure 1.1-2. - Tandem Fuel Supply Pump

FUEL SYSTEM OPERATION

The diaphragm stage of the tandem lift pump draws fuel from the tank and through the fuel strainer. Pressurized fuel 4 to 6 psi (28 to 41 kPa) from the diaphragm stage is supplied to the fuel filter. Air trapped in the filter is vented back to the tank through an orifice in the regulator block mounted on the filter. The orifice is protected from plugging by a wire mesh screen located inside the filter housing.

Fuel in the filter housing passes through the filter element to a standpipe in the center of the filter assembly. Clean fuel is then routed to the inlet of the piston stage of the tandem pump.

The piston stage of the tandem pump raises fuel

pressure from 4 psi to 40 psi (28 to 276 kPa) to insure proper filling of the injectors. Fuel from this stage is divided through steel lines to the back of each cylinder head. These lines supply fuel to a gallery drilled in each cylinder head which intersects each injector bore in the cylinder head. Figure 1.1-3.

Return fuel from the two fuel galleries is routed through hoses, of a special rubber compound, from the front of each head to the pressure regulator located on the side of the filter housing. These hoses provide flexibility in the fuel system by absorbing and smoothing pressure pulses from the piston stage of the pump.

INJECTION CONTROL SYSTEM OPERATION

(Refer to Figure 1.2-1)

The T 444E system utilizes a hydraulically actuated injector to pressurize fuel inside the injector. The hydraulic fluid used to actuate the injector is engine oil.

Oil is drawn from the oil pan thru the pickup tube by the engine oil pump. The engine oil pump is a gerotor type pump driven by the crankshaft. Oil is fed through passages in the front cover to an oil reservoir mounted on top of the front cover.

The reservoir makes available a constant supply of oil to a high pressure hydraulic pump mounted in the engine "V". The high pressure pump is a gear driven seven plunger swash plate pump. High pressure oil is delivered by the high pressure pump to oil galleries machined into the cylinder heads, drilled intersecting passages supply high pressure oil to the injector.

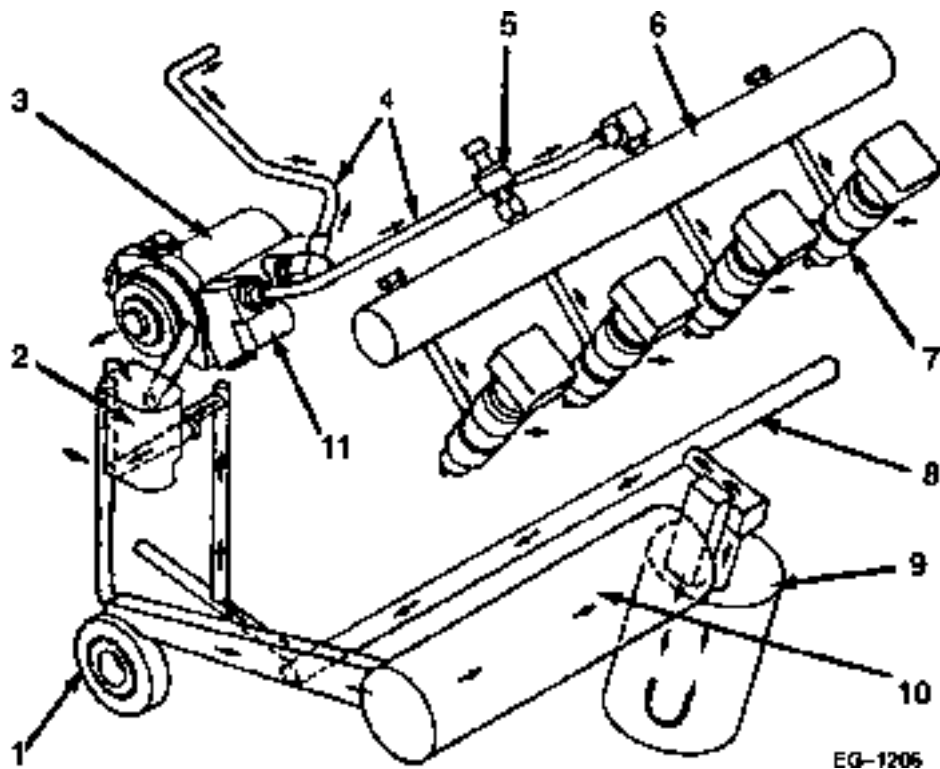


Figure 1.2-1 - Injector Oil System

1. Oil Pump
2. Reservoir (Located On Top of Front Cover)
3. High Pressure Pump
4. High Pressure Hoses
5. Injection Control Pressure Sensor
6. Cylinder Head High Pressure Rail
7. Injector (8)
8. Gallery (Crankcase)
9. Oil Filter
10. Oil Cooler
11. Injection Control Pressure Regulator

INJECTION PRESSURE CONTROL

The injection control pressure system (Figure 1.2-2) is a closed loop operating system. The system consists of the (ECM) Electronic Control Module, (ICP) Injection Control Pressure Sensor and the (IPR) Injection Pressure Regulator valve. The ECM is programmed with an injection pressure control strategy which determines the correct injection control pressure at each engine operat-

ing condition. The ECM receives a 0-5 volt d.c. analog feedback signal from the ICP sensor located in the high pressure oil supply gallery on the left cylinder head that indicates Injection Control Pressure information. The ECM processes this signal and controls Injection Control Pressure by controlling the ground to the IPR regulating valve.

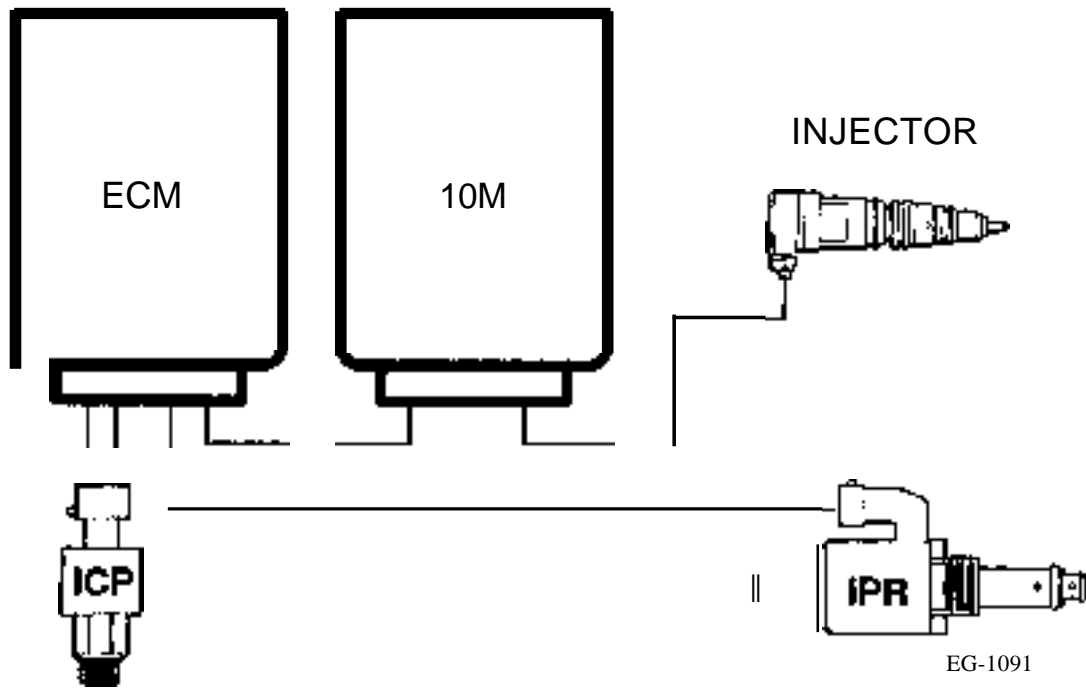


Figure 1.2-2 - Injection Control System

IPR VALVE OPERATION

The Injection Pressure Regulator valve is a pulse width modulated valve operating at 400 Hz. The pulse width is modulated from a duty cycle of 0 to 50% to control ICP pressure from 500 to 3000 psi (3.4 to 20 mPa). The regulator valve is mounted

in the high pressure pump and achieves injection control pressure regulation by dumping excess oil through a (shuttle) spool valve into the front cover and back to sump.

IPR VALVE OPERATION (Continued)

Figure 1.2-3 illustrates the IPR valve in the Engine Off state. The spool valve is held closed (to

the right) by the return spring and the drain ports are closed.

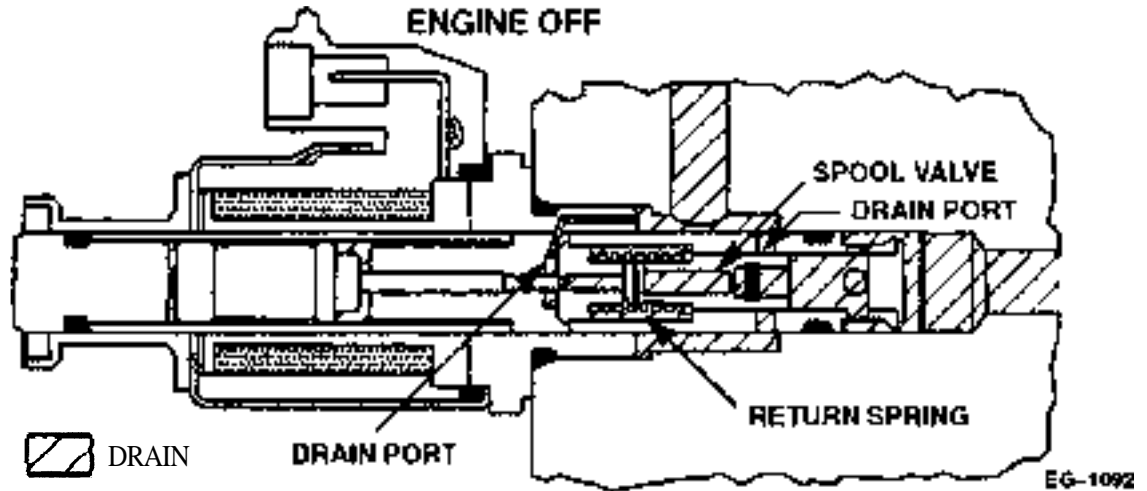


Figure 1.2-3 - Engine Off

Figure 1.2-4 illustrates the IPR valve in the Engine Cranking state. The ECM signals the IPR valve to close which directs all the oil to flow into

the oil supply galleries to build oil pressure as quickly as possible to start the engine.

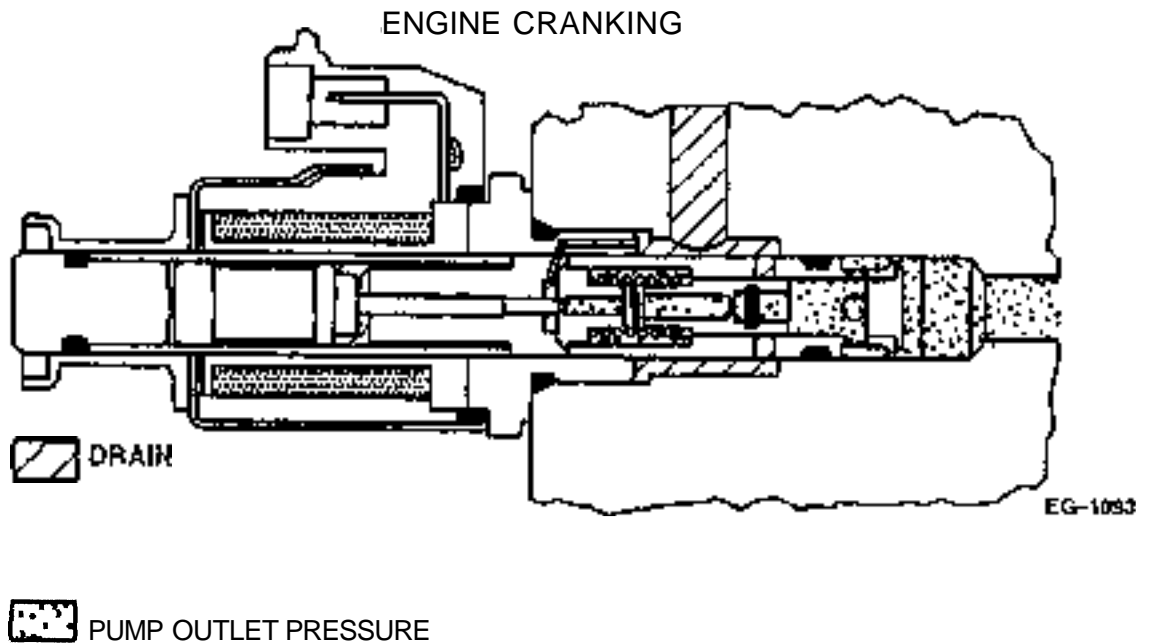


Figure 1.2-4- Engine Cranking

IPR VALVE OPERATION (Continued)

Figure 1.2-5 illustrates the IPR valve in the Engine Running state. The ECM pressure regulating signal determines the magnetic field strength of the IPR valve solenoid. The magnetic field pulls the poppet to the left as shown in Figure 1.2-5. This action allows the pump outlet pressure that is on the spool valve to move the spool valve to the new position of the poppet. Poppet movement allows a small amount of oil to enter the spool chamber through the spool valve control

orifice and filter.

Spool chamber oil pressure is regulated by the ECM by controlling the poppet position. The spool responds to pressure changes in the spool chamber by changing position to maintain a balance of pressure on each side of the spool. Spool valve position determines the desired injection control pressure by bleeding off oil from the pump outlet to the drain port.

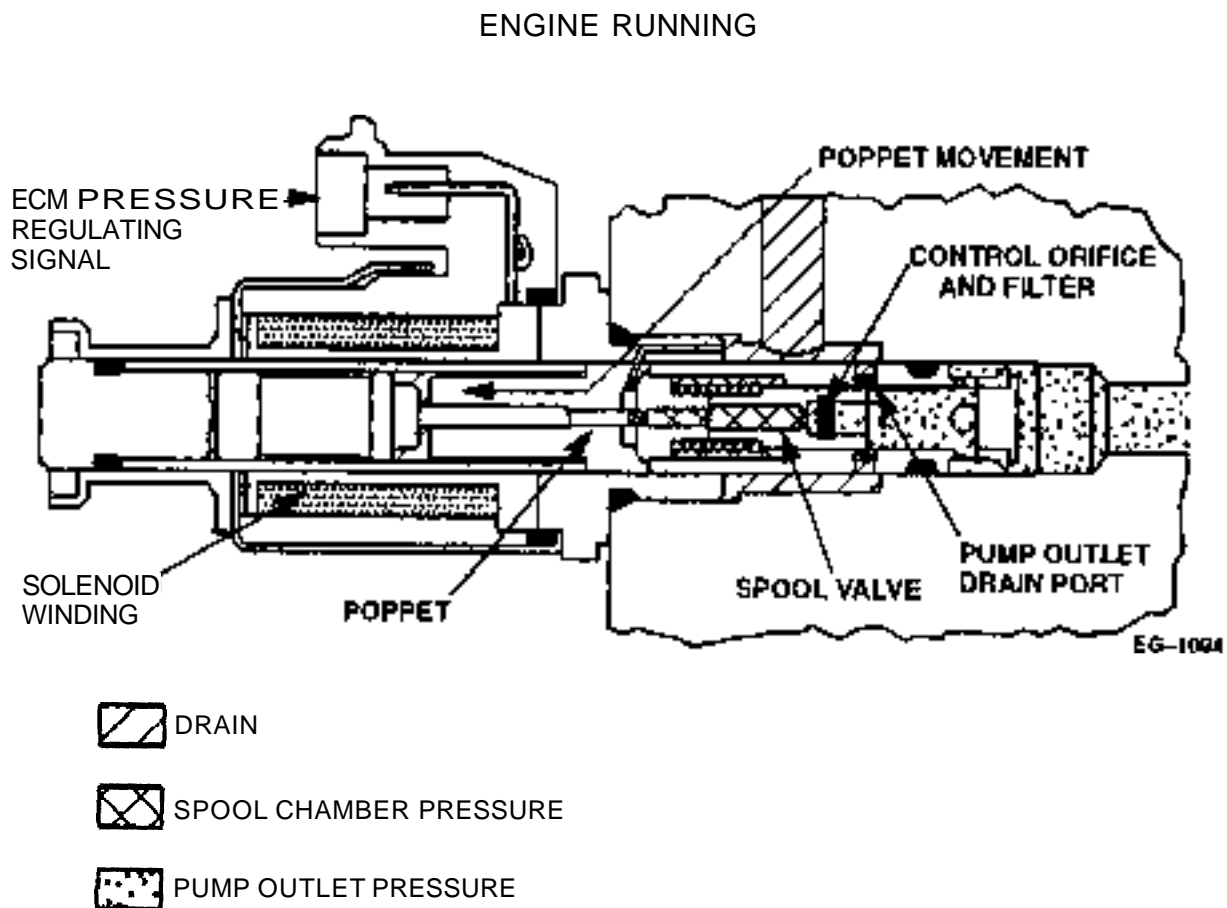


Figure 1.2-5 - Engine Running

INJECTOR OPERATION

INJECTOR OPERATION

When an injector is energized, (Figure 1.3-1.) the poppet valve is opened by an electronic solenoid mounted on the injector. Oil pressure is allowed to flow into the injector and act on the amplifier

piston. When injection is ended the pressure on top of the amplifier piston is vented by the poppet valve thru the top portion of the injector and directed by the oil troughs mounted on the injector to a push tube hole for return to the oil sump.

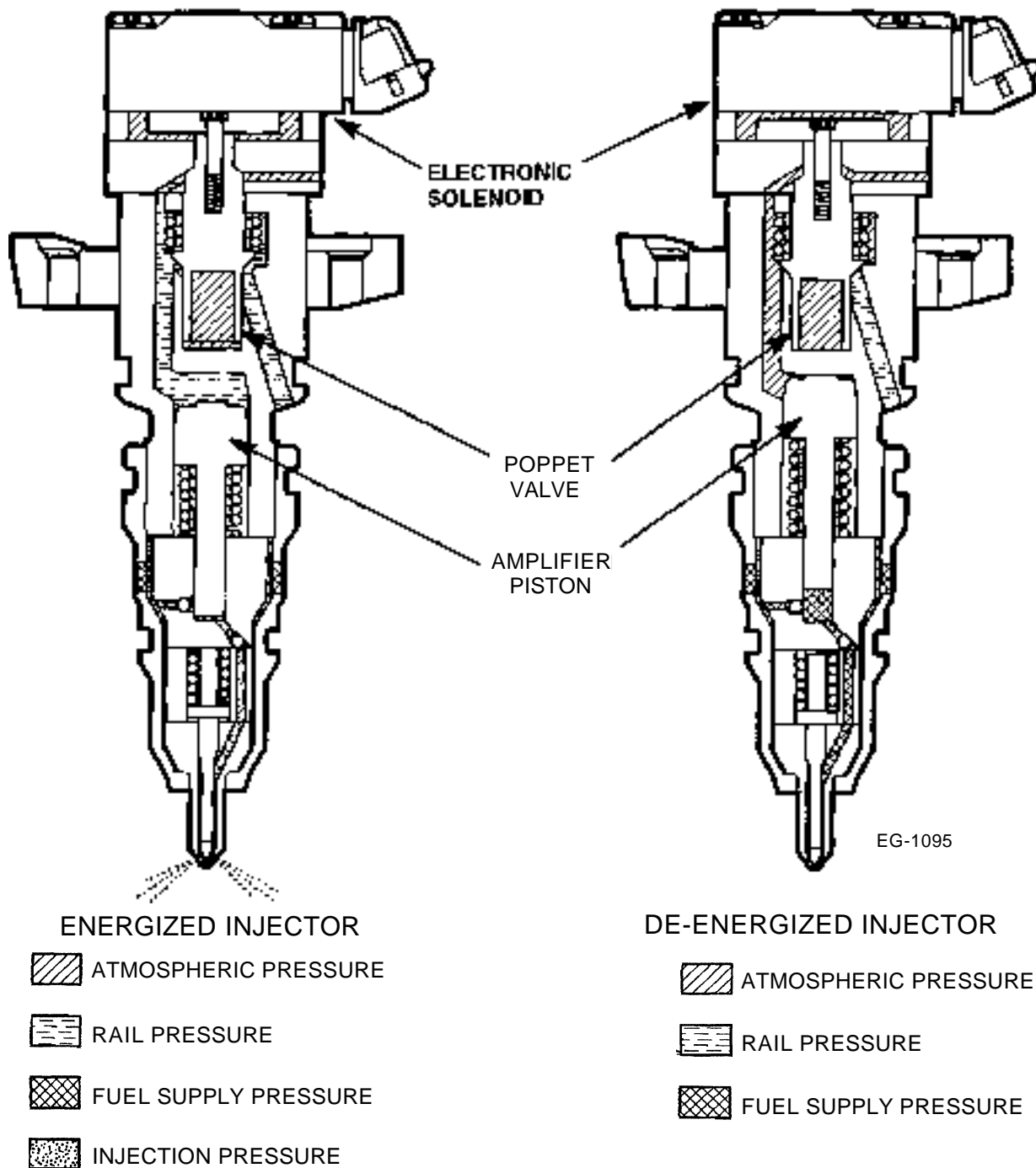


Figure 1.3-1. - Energized vs. De-energized Injector

EXHAUST BACK PRESSURE DEVICE (Optional)

DESCRIPTION

The Exhaust Back Pressure device (Figure 1.4-1.) is a mechanism which applies a restriction to the flow of exhaust gas exiting the turbocharger. The increased restriction created by the closure of the butterfly valve increases exhaust back pressure and causes the engine to work harder to force the exhaust gases out of the turbocharger. This results in more heat transferred from the engine to the coolant which allows the cab in the vehicle to receive more heat in a short amount of time.

OPERATION

The exhaust back pressure device is located on the turbocharger pedestal and consists of the following components:

1. Exhaust Back Pressure Regulator (EPR).
2. Actuator Piston
3. Butterfly valve.

The Exhaust Back Pressure device is controlled by the Electronic Control Module (ECM). The ECM

senses Engine Coolant Temperature and Intake Air Temperature (Figure 1.4-2.) to determine when the exhaust back pressure (butterfly valve closure) is required.

Engine oil pressure is present on one side of the regulator valve while the engine is running. When coolant and intake air temperatures are low, the ECM signals the regulator valve to open which allows engine oil pressure to push on the actuator piston causing the butterfly valve to close. The ECM receives exhaust back pressure information from the exhaust back pressure sensor and controls the position of the butterfly valve.

When the engine reaches operating temperature, the ECM will signal the regulator valve to fully close, cutting off engine oil pressure to the actuator piston. The actuator piston will retract due to spring pressure causing the butterfly valve to fully open and remove the exhaust restriction.

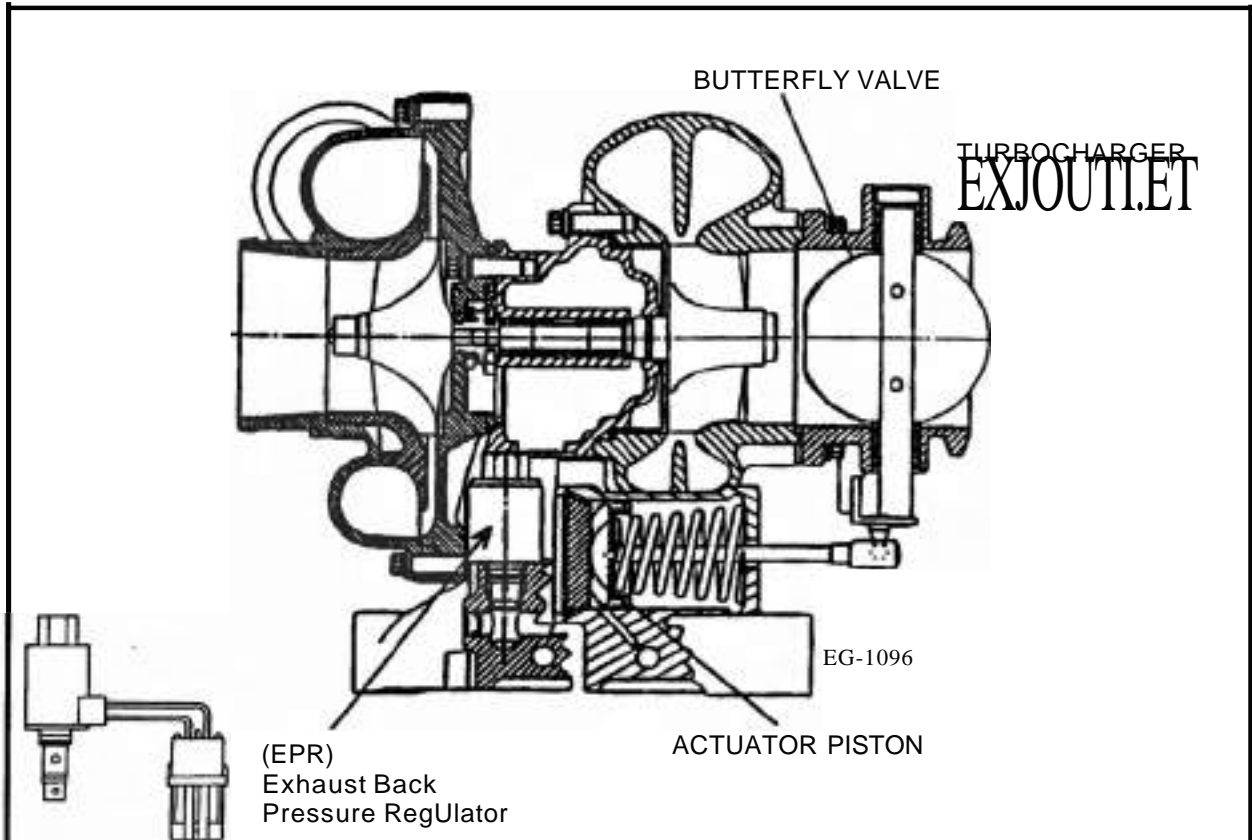


Figure 1.4-1. - Exhaust Back Pressure Device

EXHAUST BACK PRESSURE DEVICE

EXHAUST BACK PRESSURE DEVICE (Continued)

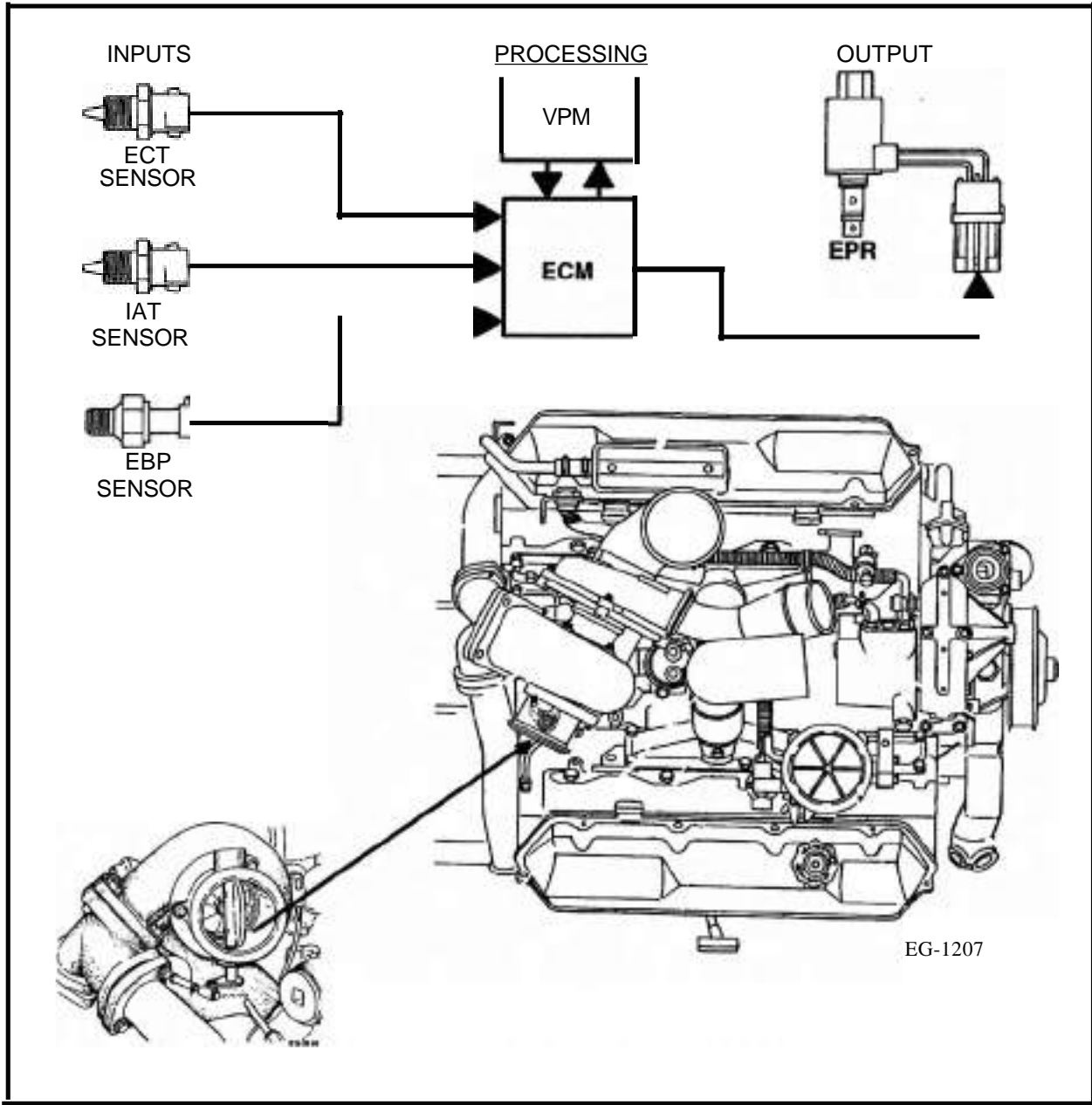


Figure 1.4-2. - Exhaust Back Pressure Device Location and Function

OPERATION AND FUNCTION

The Electronic Control Module (ECM) (Figure 1.5-1.) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM is also able to monitor and control vehicle features such as cruise control, transmission control, starter engagement etc.

To understand how the ECM functions and how it can monitor input signals and exert control over the actuators it is necessary to view the four primary functions of the ECM.

ECM Functions

- Reference Voltage Regulator
- Input Conditioners
 - AMP
 - AID Converter
- Microcomputer
 - Processor
 - Memory
- Output Drivers
 - Grounding Transistors

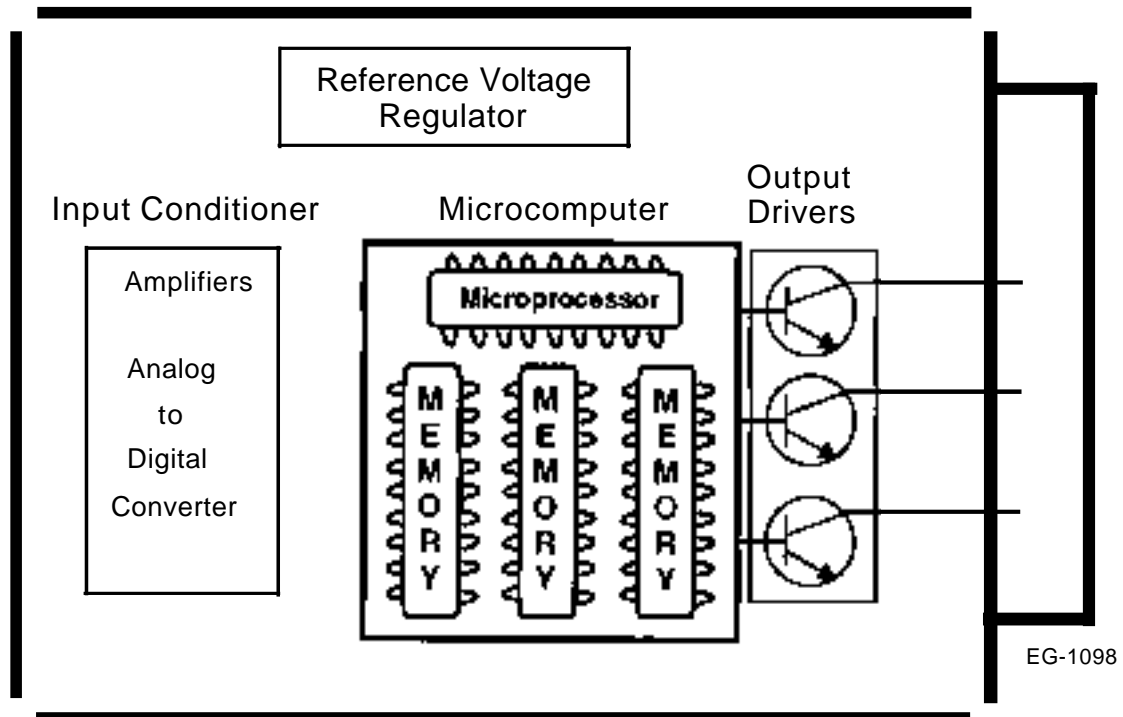


Figure 1.5-1. - Electronic Control Module

ELECTRONIC CONTROL MODULE

OPERATION AND FUNCTION (Continued)

I. VOLTAGE REFERENCE

The ECM supplies a 5 volt reference signal to many of the input sensors in the control system. On most circuits the ECM compares the regulated 5 volts sent to the sensors by the modified returned signal and is able to determine temperature, pressure, speed, position and many

other variables that are important to engine and vehicle functions. This 5 volt signal is current limited by a current limiting resistor in the event of an external dead short to ground.

For some sensors, like CMP (Camshaft Position), the 5 volts signal is a power source that powers up the circuitry in the sensor.

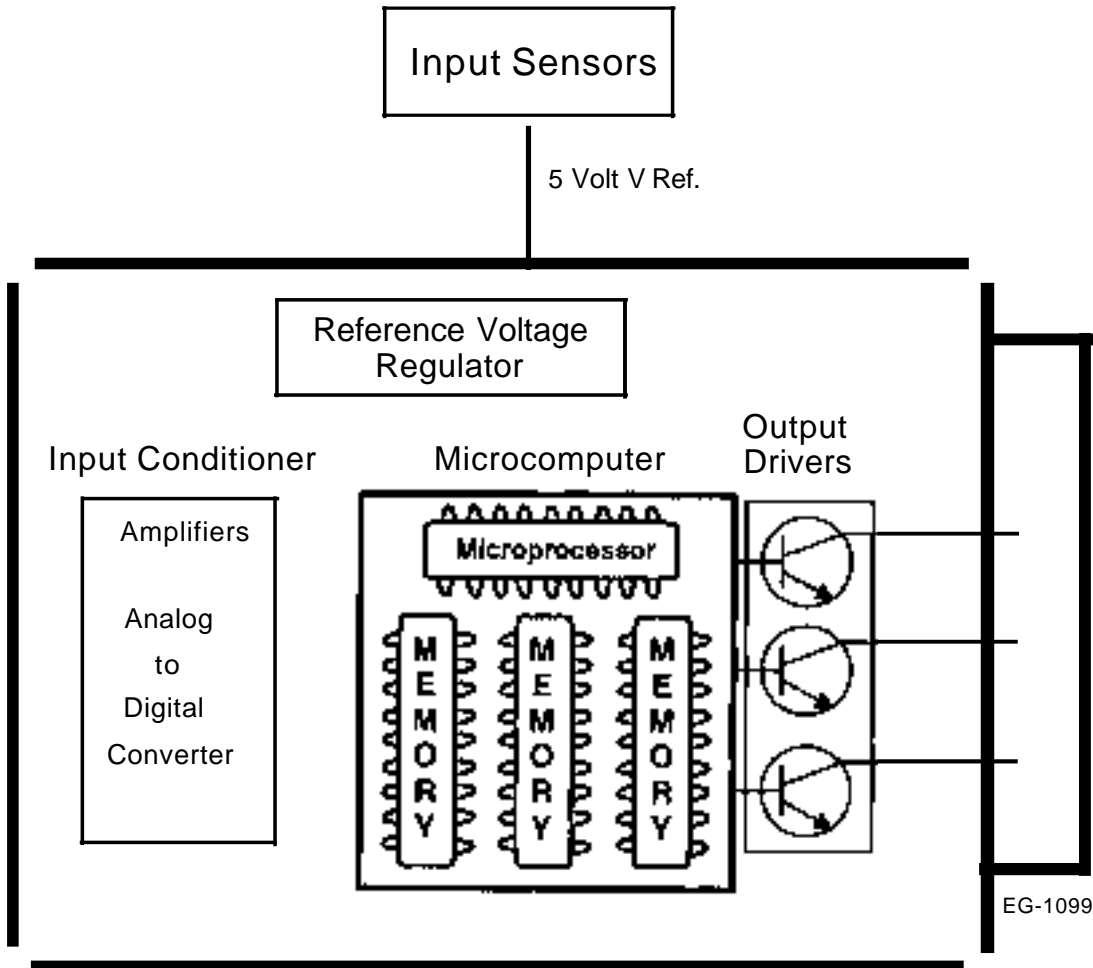


Figure 1.5-2. - Electronic Control Module 5 Volt Reference

OPERATION AND FUNCTION (Continued)

II. SIGNAL CONDITIONER

It conditions the input signals for the internal microprocessor (Figure 1.5-3.). This enables the microprocessor to interpret the signals. Signal

conditioning usually consists of converting analog signals to digital signals, squaring up sine wave signals or amplifying low intensity signals to a level the ECM microprocessor can process.

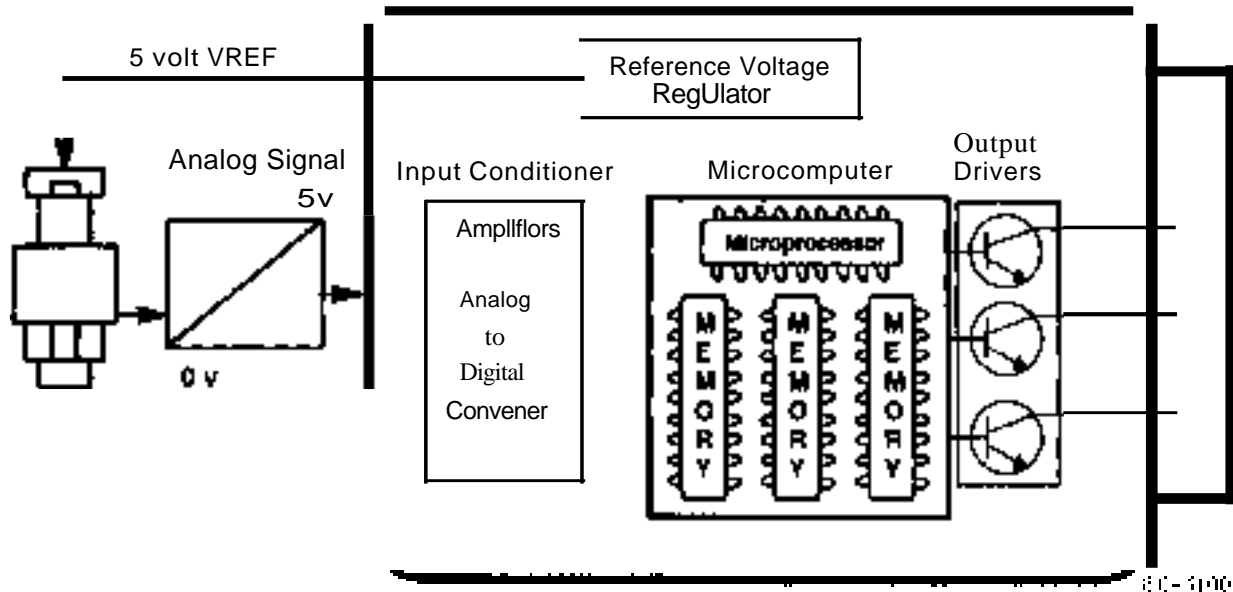


Figure 1.5-3. - Electronic Control Module Signal Conditioning

III. MICROPROCESSOR

The ECM contains an internal microprocessor. The processor stores operating instructions (control strategies) and tables of values (calibration parameters). It compares these stored instructions and values to sensed input values to determine the correct operating strategy for any given engine condition. Calculations in the ECM occur at two different levels or speeds referred to as the foreground and the background calculations. These calculations are performed on a continuous closed loop basis.

The foreground calculations occur at a much faster rate than the background calculations. These are normally the more critical functions to engine operation or they occur at a faster rate. Such as engine speed control. Back-

ground calculations are normally things that occur at a slower pace such as engine temperature.

Diagnostic strategies (instructions) are also programmed into the ECM. Some instructions cause inputs or outputs to be monitored on a continuous basis and will flag a code that will be set, other strategies will instruct the ECM to perform certain tests upon operator demand.

The ECM's microprocessor is equipped with three types of memory Random Access Memory (RAM), Read Only Memory (ROM) and Keep Alive Memory (KAM) (Figure 1.5-4.). They allow the processor to store the necessary instructions, calibration tables and input values to control the engine.

ELECTRONIC CONTROL MODULE

OPERATION AND FUNCTION (Continued)

ROM:

Read Only Memory is the memory where calibration tables and operating strategies are stored. Information in the ROM is permanent. It can not be changed or lost by turning the engine off or disconnecting the batteries.

RAM:

Random Access Memory is a temporary storage memory for current events such as current engine temperature or current speed, pedal position etc. It is the memory to which information is temporarily stored so that it can be compared to the information in the ROM. Unlike the Rom memory, the RAM is lost every time the key is turned off or when power is interrupted to the ECM.

KAM:

Keep Alive Memory is a permanent memory. It is used to store diagnostic faults (codes). Adaptive strategies (temporary operating instructions) can also be written to it in event of a system failure or as a compensation for component wear. Uninterrupted power must be supplied from the battery to the ECM on a continuous basis to keep KAM memory alive. All information in KAM is lost if the ECM has a total power loss such as when the batteries are disconnected.

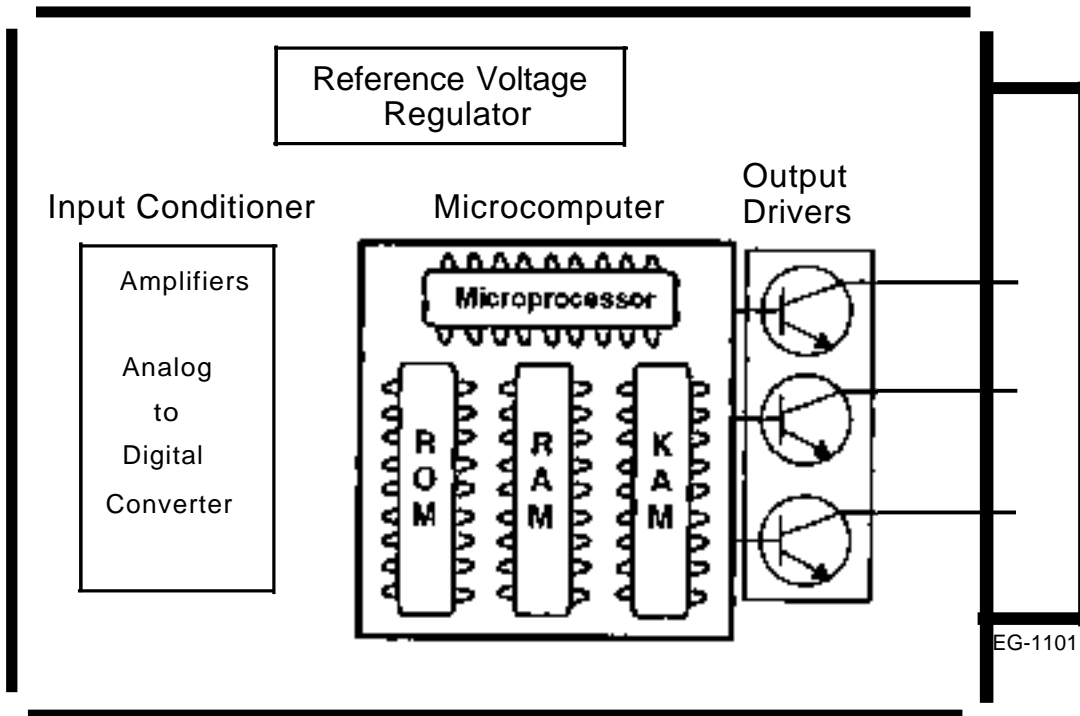


Figure 1.5-4. - Electronic Control Module Microprocessor Memory

OPERATION AND FUNCTION (Continued)

ACTUATOR CONTROL

The ECM controls the actuators by applying a (low level) signal to the base of the transistor output drivers (Figure 1.5-5.). These drivers, when switched on, will complete the ground circuit of each actuator.

The actuators are controlled either thru a duty cycle (0/0 time on/off), or controlled thru a controlled pulse width or simply just switched on or off as determined by the type of actuator being controlled.

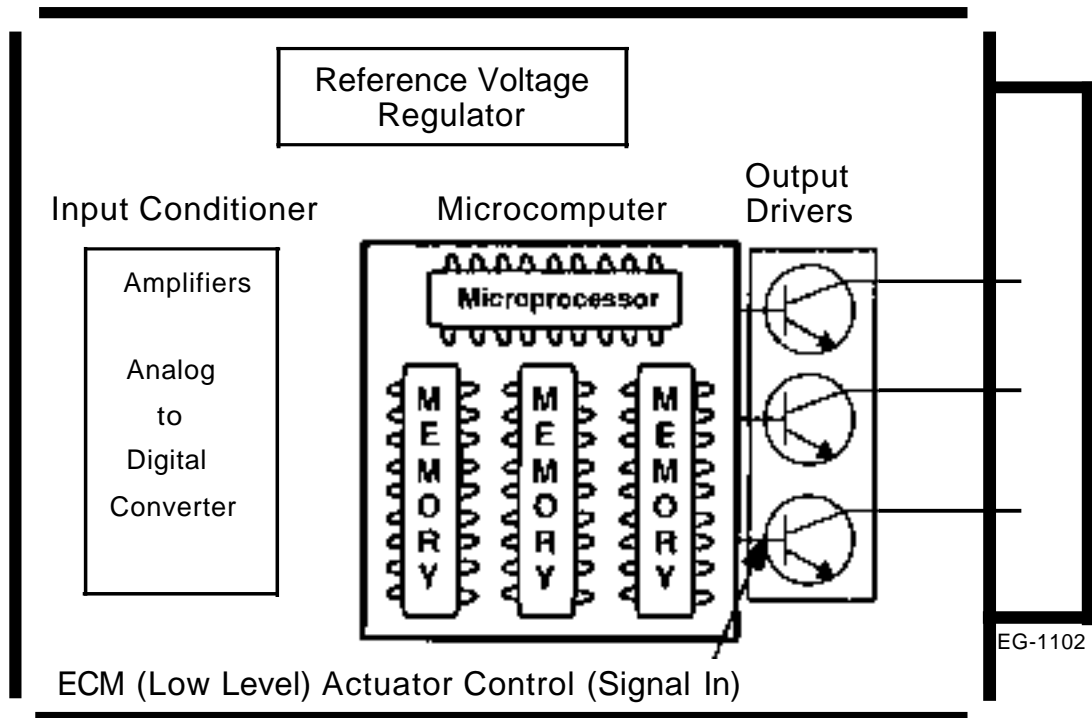


Figure 1.5-5. - Electronic Control Module Actuator Control

INJECTION DRIVER MODULE FUNCTIONS

The Injection Driver Module (10M) is a device that performs four major functions.

- I. Electronic Distributor for the injectors.
The Electronic Control Module (ECM) senses the piston position of cylinder #1 from the output signal of the Camshaft Position Sensor (CMP) which is located on the engine front cover. The CMP sensor is a Hall effect sensor which looks for a narrow vane on the timing sensor disk (Figure 1.6-1.). The disk is precisely mounted

and indexed on the camshaft gear in a relationship that identifies the position of #1 piston.

The ECM uses this signal to determine the correct injector firing sequence. The Cylinder Identification (CI) line carries the injector firing sequence information to the 10M.

The 10M receives a Fuel Demand Command Signal (FOGS) signal from the ECM to control injector timing and the quantity of fuel that is delivered by each injector.

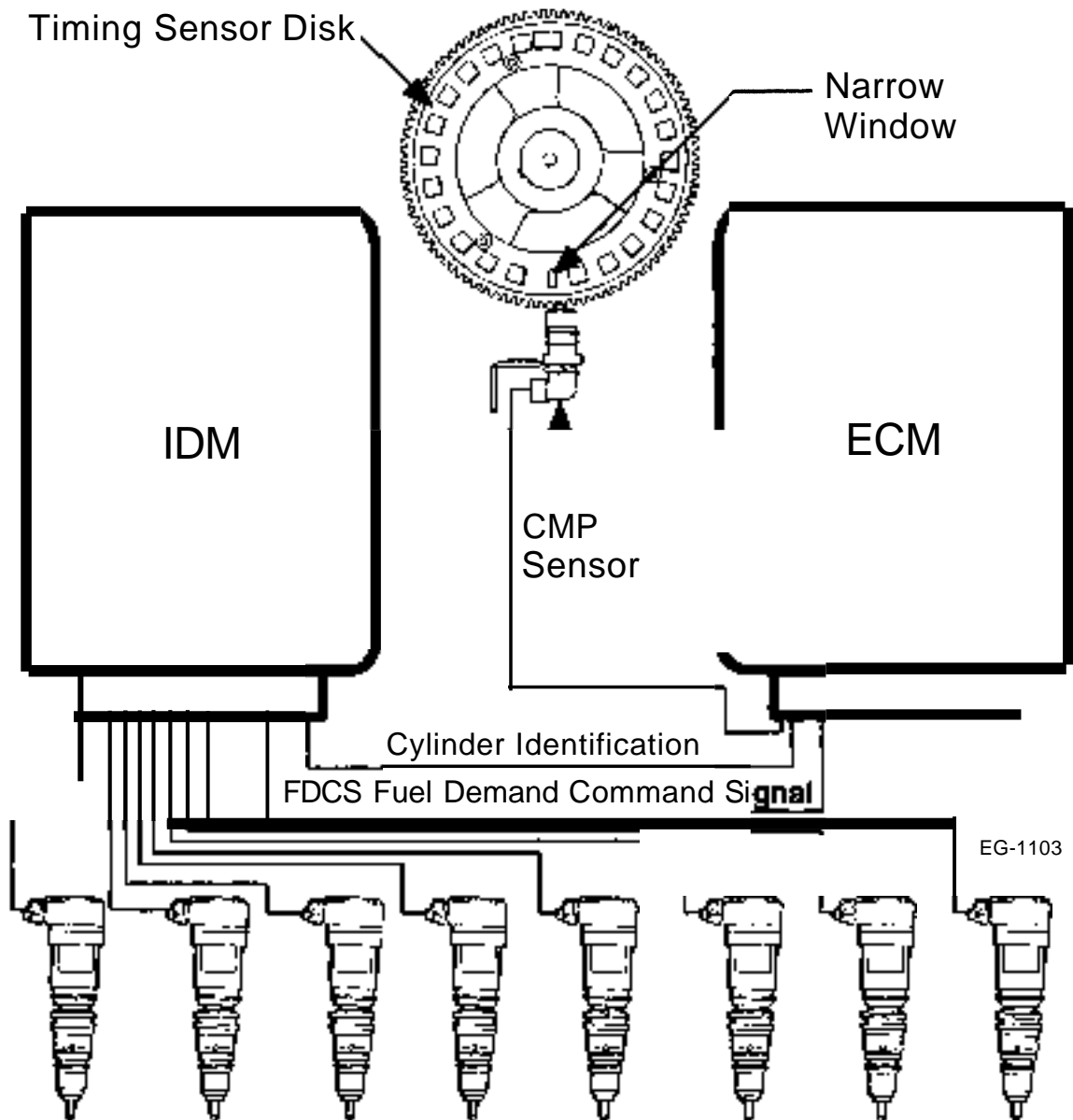


Figure 1.6-1. -Injector Driver Module (Distributor)

INJECTOR DRIVER MODULE

INJECTOR DRIVER MODULE FUNCTIONS - (Continued)

U. Power Source for the injectors.

The 10M supplies a constant 115 +volt d.c. supply to all injectors. The 115 volt d.c. supply is created in the 10M by making and breaking a 12 volt source across a coil internal to the IDM, the

same principle is used on automotive coils. The resultant 115 + volts created by the collapsed field is stored in capacitors until used by the injectors.

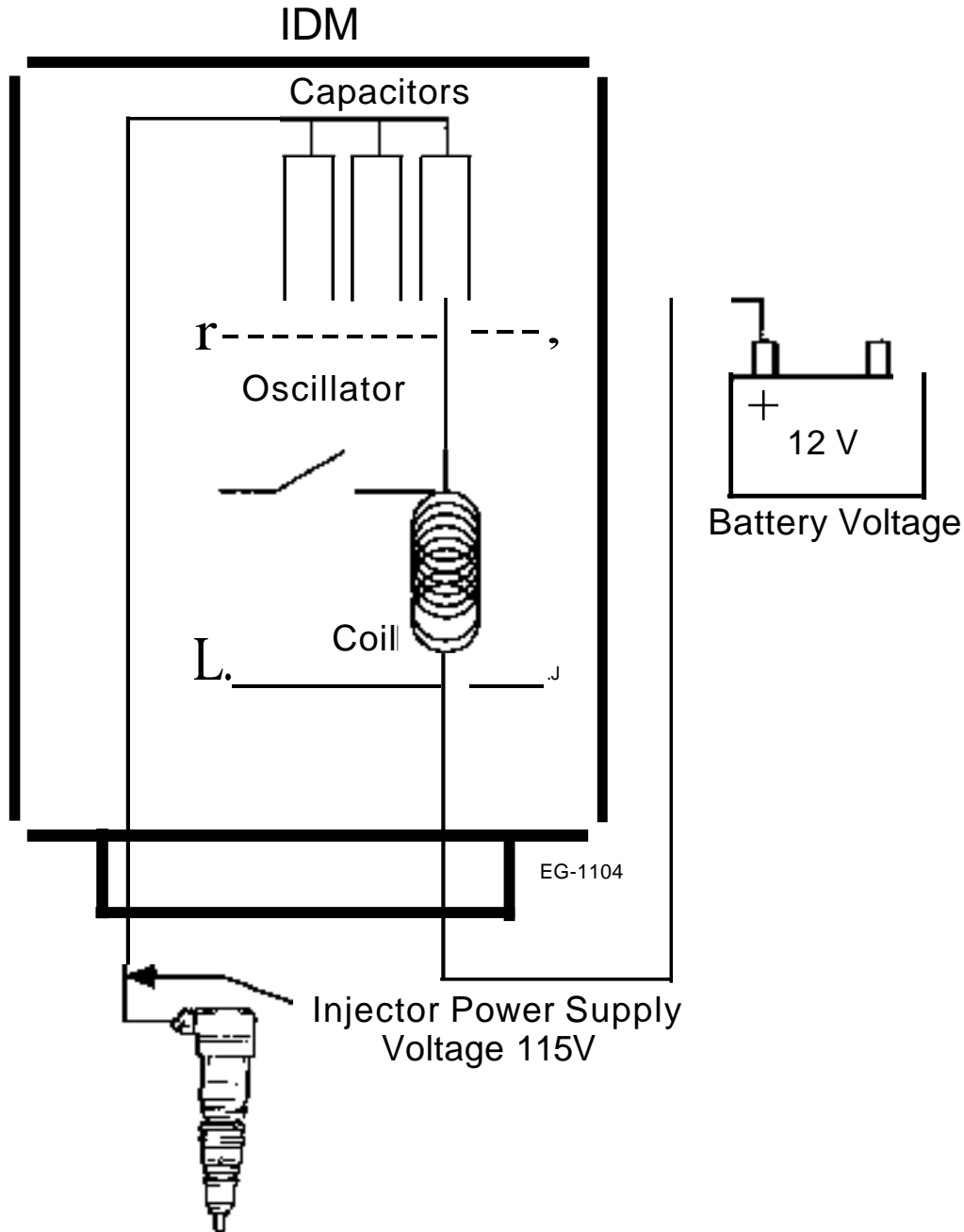


Figure 1.6-2. - Injector Driver Module (Power Source)

INJECTOR DRIVER MODULE FUNCTIONS - (Continued)

III. Output Driver for the injectors

The 10M controls when the injector is turned on and how long the injector is turned on by closing the circuit to ground by the use of output driver transistors. Each injector has an individual out-

put driver in the 10M. The processor in the 10M selects the correct firing sequence, the ECM through the FOCS signal controls the timing of when the injection starts and the duration of how long the injector is open.

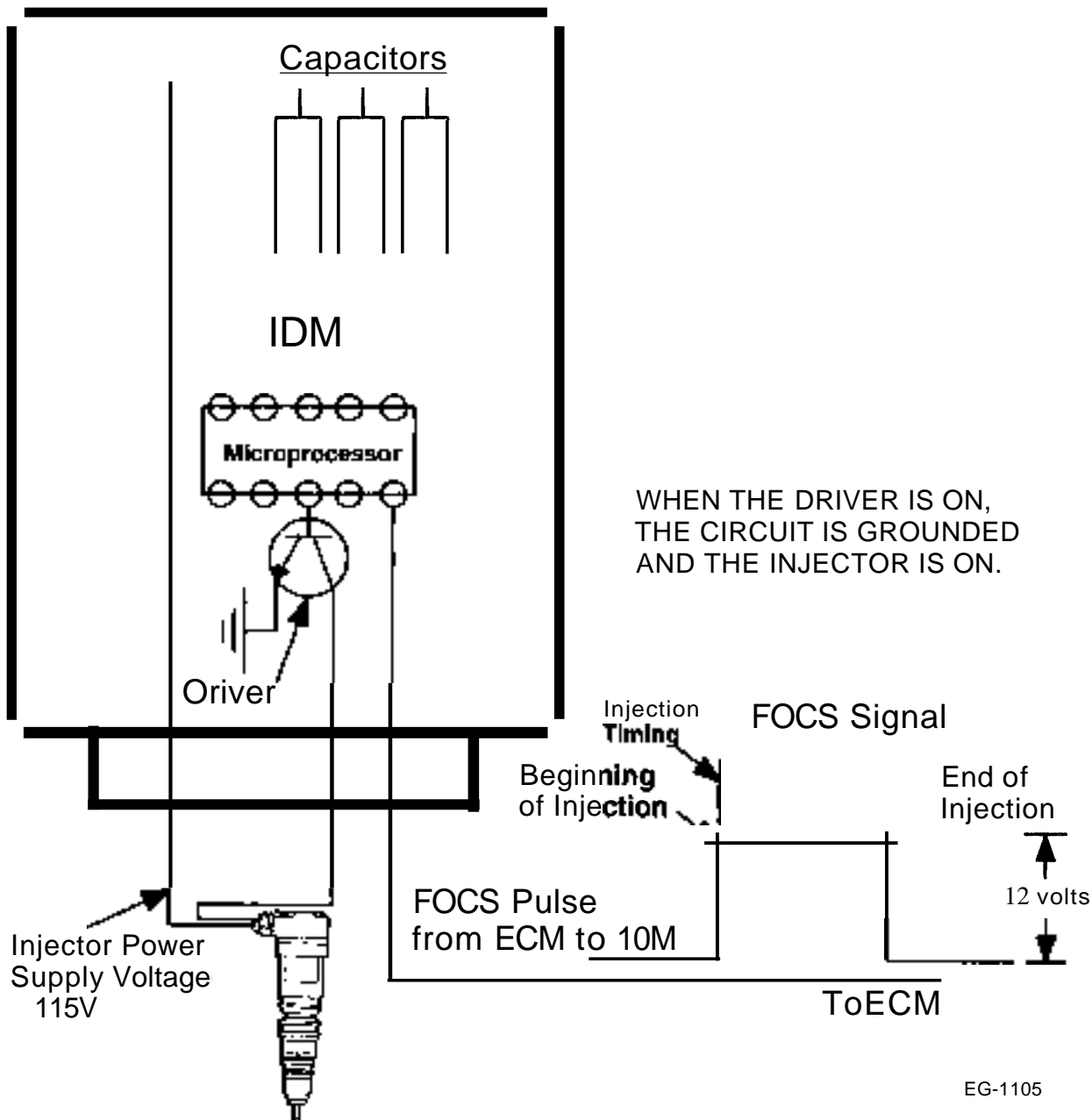


Figure 1.6-3. - Injector Driver Module (Output Driver)

INJECTOR DRIVER MODULE

INJECTOR DRIVER MODULE FUNCTIONS - (Continued)

IV Performs diagnostics for itself and the injectors. The 10M is capable of identifying if an injector is drawing too much current or too little current and sends a fault code to the ECM that can be accessed by the technician. This code

can be used to identify potential problems in either the wiring harness or injector. The 10M also performs self diagnostic checks that can set a code to indicate that the 10M has failed and needs to be replaced.

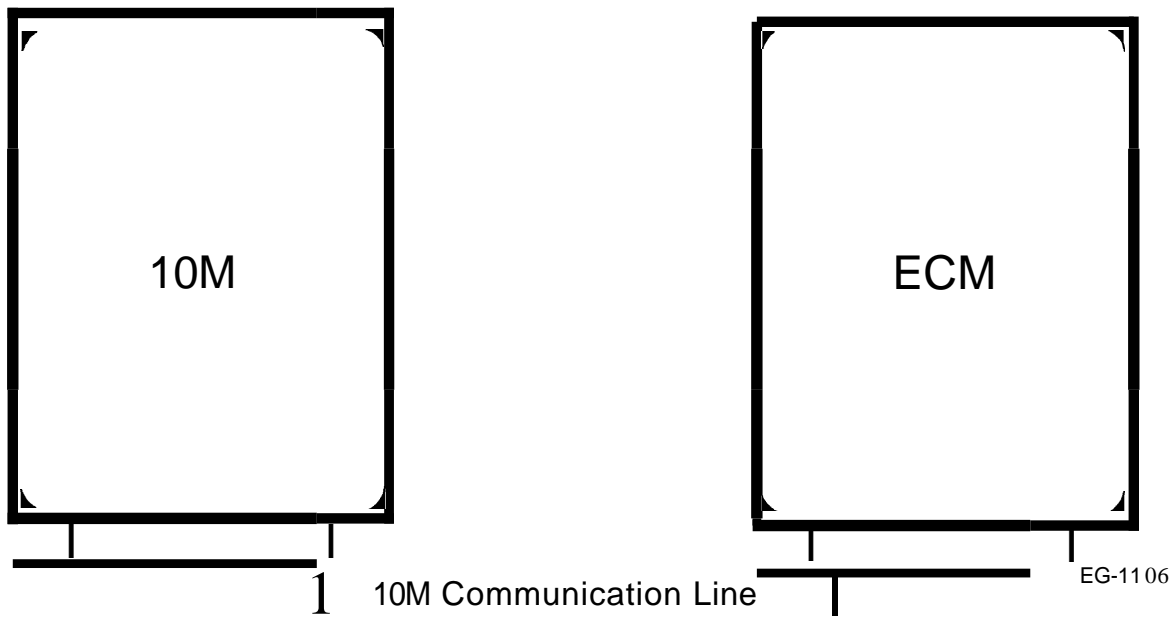


Figure 1.6-4. - Injector Driver Module Diagnostic Communication

INPUT SIGNALS

Engine and vehicle sensors transmit input signals to the Electronic Control Module (ECM) (Figure 1.7-1.) by either:

- ◆ Controlling a reference voltage to produce an analog or digital signal.
- ◆ Generating a signal voltage.
- ◆ Switching a 12 volt signal.

start 5 volts regulated supplied by the ECM. A voltage regulator supplies the reference voltage (V_{ref}) to these sensors. This voltage is changed by the sensor and the signal is relayed back to the ECM. The ECM, by comparing the V_{ref} to the returned signal can check it's internal programmed tables to determine the value of the variable being measured.

REFERENCE VOLTAGE SENSORS

Reference voltage sensors are supplied with a con-

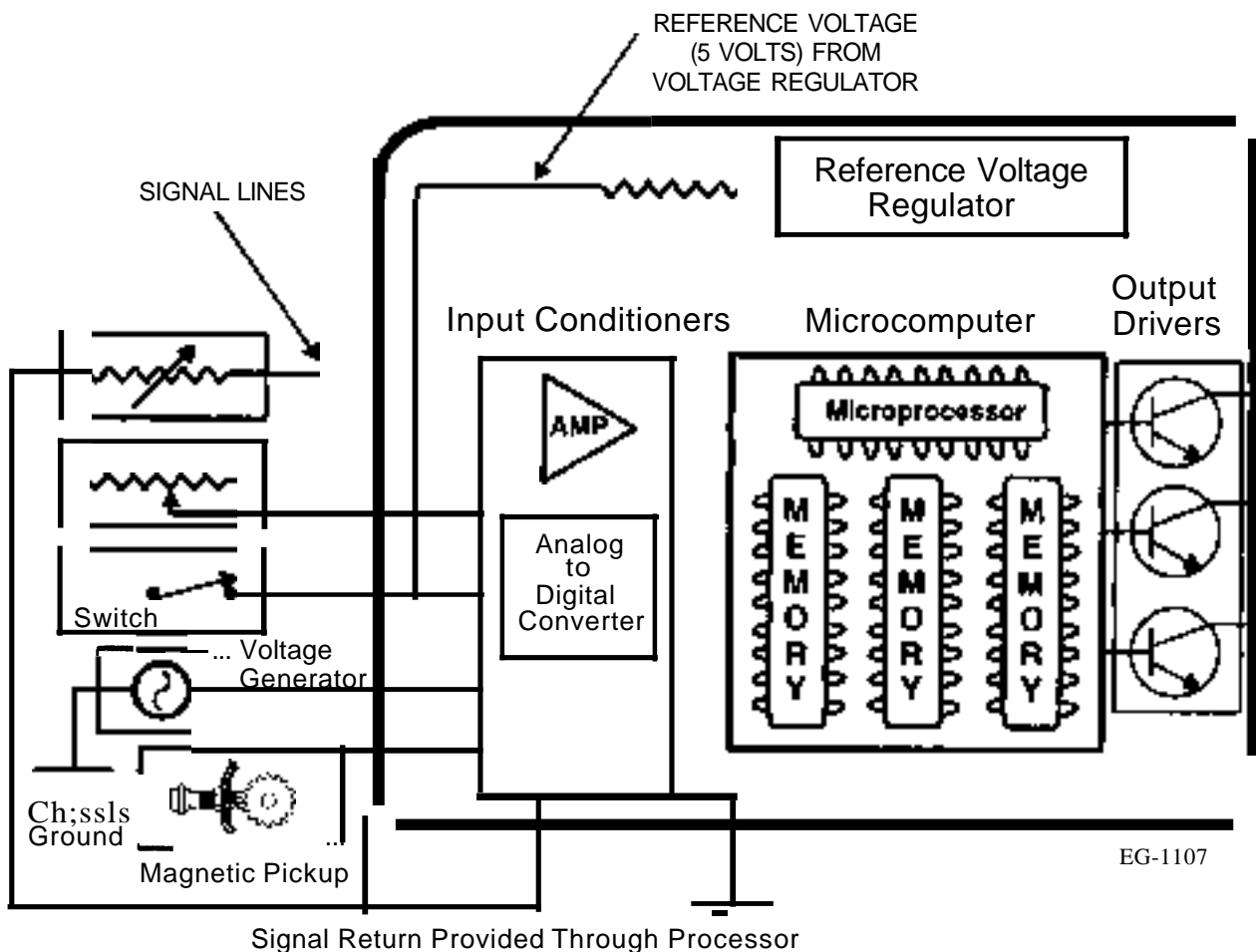


Figure 1.7-1. - Types of Input Signals

SENSOR OPERATION

TYPES OF SENSORS

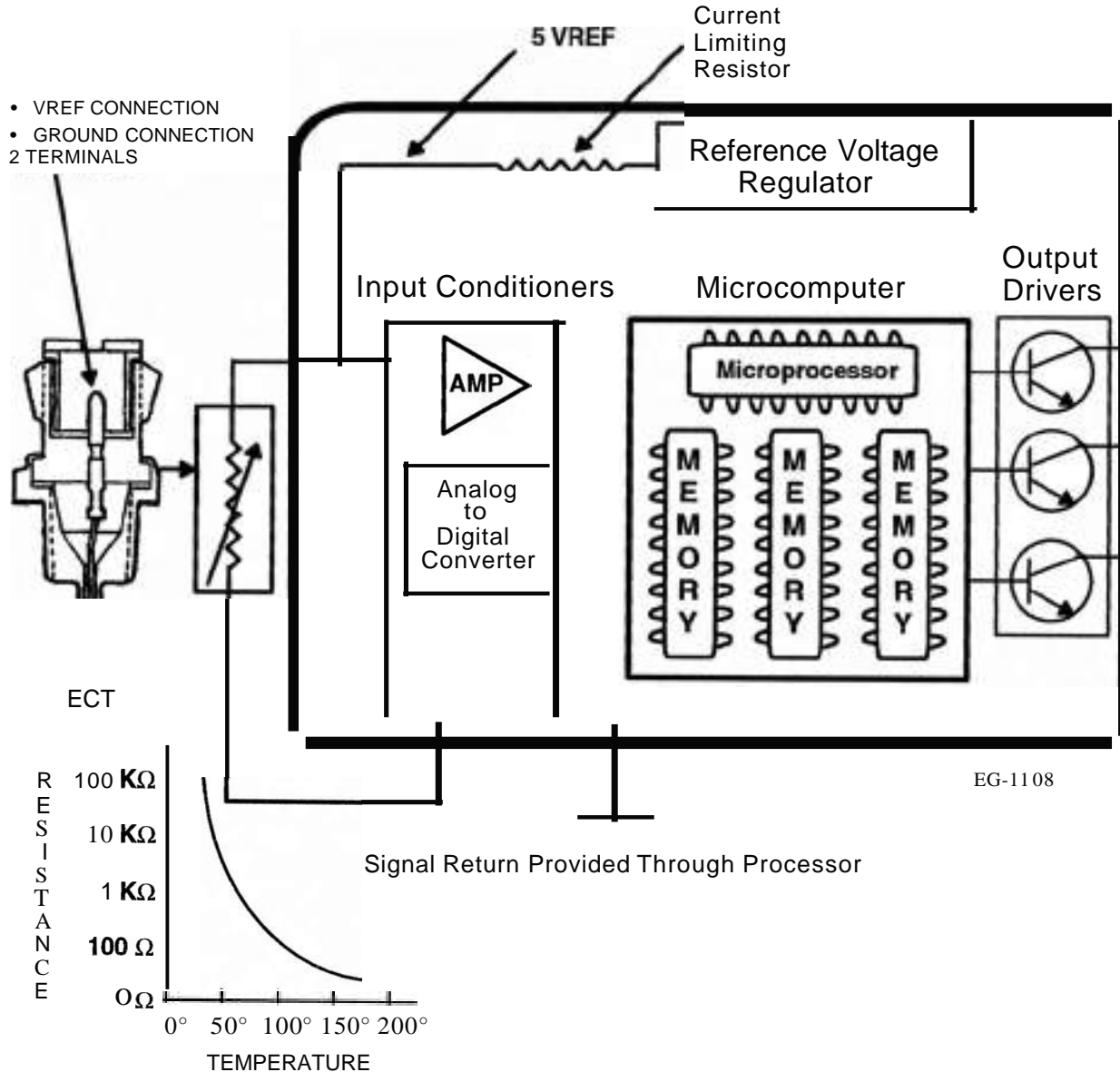
THERMISTOR

A thermistor is a type of sensor which changes its electrical resistance with temperature. The electrical resistance of the thermistor decreases as temperature increases and increases as temperature decreases. The thermistor in conjunction with a current limiting resistor in the ECM (Figure 1.7-2.) forms a voltage divider network that provides a voltage signal that indicates temperature. The top half of the voltage divider is the current limiting resistor

internal to the ECM. A thermistor sensor has two electrical connections, signal return and ground. The output of a thermistor sensor is not linear.

Examples:

- EaT Engine Oil Temperature
- ECT Engine Coolant Temperature Sensor
- (AT Intake Temperature Sensor



The chart indicates resistance of a thermistor decreases as temperature increases. Output of thermistor is not linear.

Figure 1.7-2. - Thermistor Engine Coolant Temperature (ECT)

TYPES OF SENSORS (Continued)

POTENTIOMETER

A potentiometer (Figure 1.7-3.) is a variable voltage divider used to sense the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion. The voltage

on the wiper changes at each point along the resistive material. This voltage is proportional to the amount of mechanical movement.

Example:

APS Accelerator Position Sensor

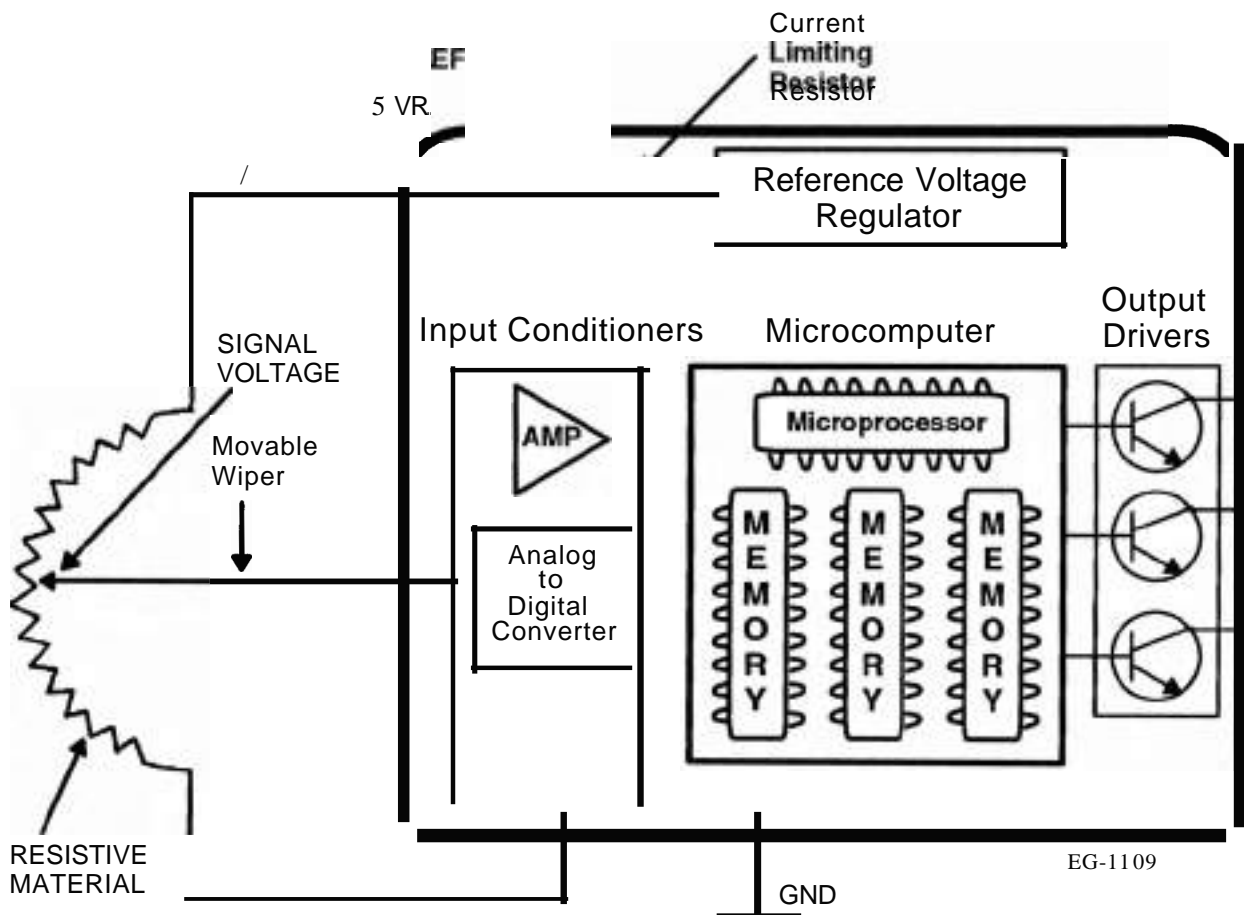


Figure 1.7-3. - Potentiometer (Variable Resistance Voltage Divider)

SENSOR OPERATION

TYPES OF SENSORS (Continued)

VARIABLE CAPACITANCE SENSOR

Variable capacitance sensors are used to measure pressure. The pressure which is to be measured is applied to a ceramic material. The pressure forces the ceramic to move closer to a thin metal disk. This action causes the capacitance of the sensor to change which creates a frequency that corresponds to a pressure. The internal circuitry of the sensor converts that frequency into a linear analog voltage that indicates pressure. The thicker the ceramic

disk the more pressure that sensor can measure. A variable capacitance sensor has three connections: Vref, signal and ground. Refer to Figure 1.7-4.

Examples:

- EOP Engine Oil Pressure Sensor
- ESP Exhaust Back Pressure Sensor
- ICP Injection Control Pressure Sensor

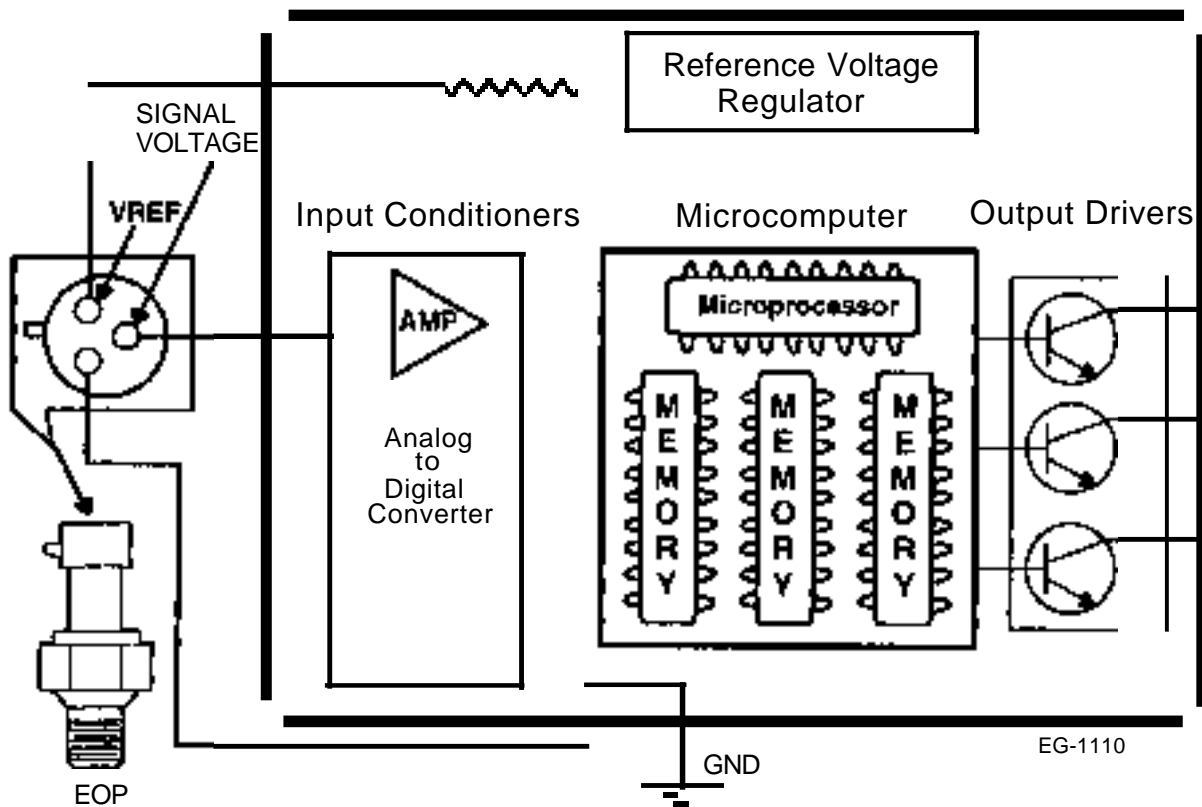


Figure 1.7-4. - Variable Capacitance Sensor (Exhaust Back Pressure Sensor)

TYPES OF SENSORS (Continued)

HALL EFFECT SENSOR

The Hall Effect sensor is an electronic device which generates a voltage signal controlled by the presence, absence or strength of a magnetic field.

The Camshaft Position sensor is an example of a Hall Effect device. It contains a transducer, permanent magnet, signal conditioner and a switching transistor. The sensor's permanent magnet applies a magnetic field around the transducer as shown in Figure 1.7-5. The sensor's transducer senses the strength of the magnetic field which is controlled by the vanes and windows (located on the rotating timing sensor disk) as they pass the sensor.

A voltage signal is generated by the Hall Effect device each time a window passes the device. The signal is filtered and conditioned by the signal conditioner.

The conditioned signal is applied to the switching transistor's base which causes the transistor to switch on and ground the 12 volt line from the ECM. The ECM no longer senses the 12 volt reference signal.

Each time a vane passes the Hall Effect device no signal is generated. This action causes the transistor to shut off and causes the ECM to see its 12 volt reference signal.

This switching action allows the ECM to determine crankshaft position and engine speed which is required by the ECM to control engine operating parameters such as injector timing and injection duration.

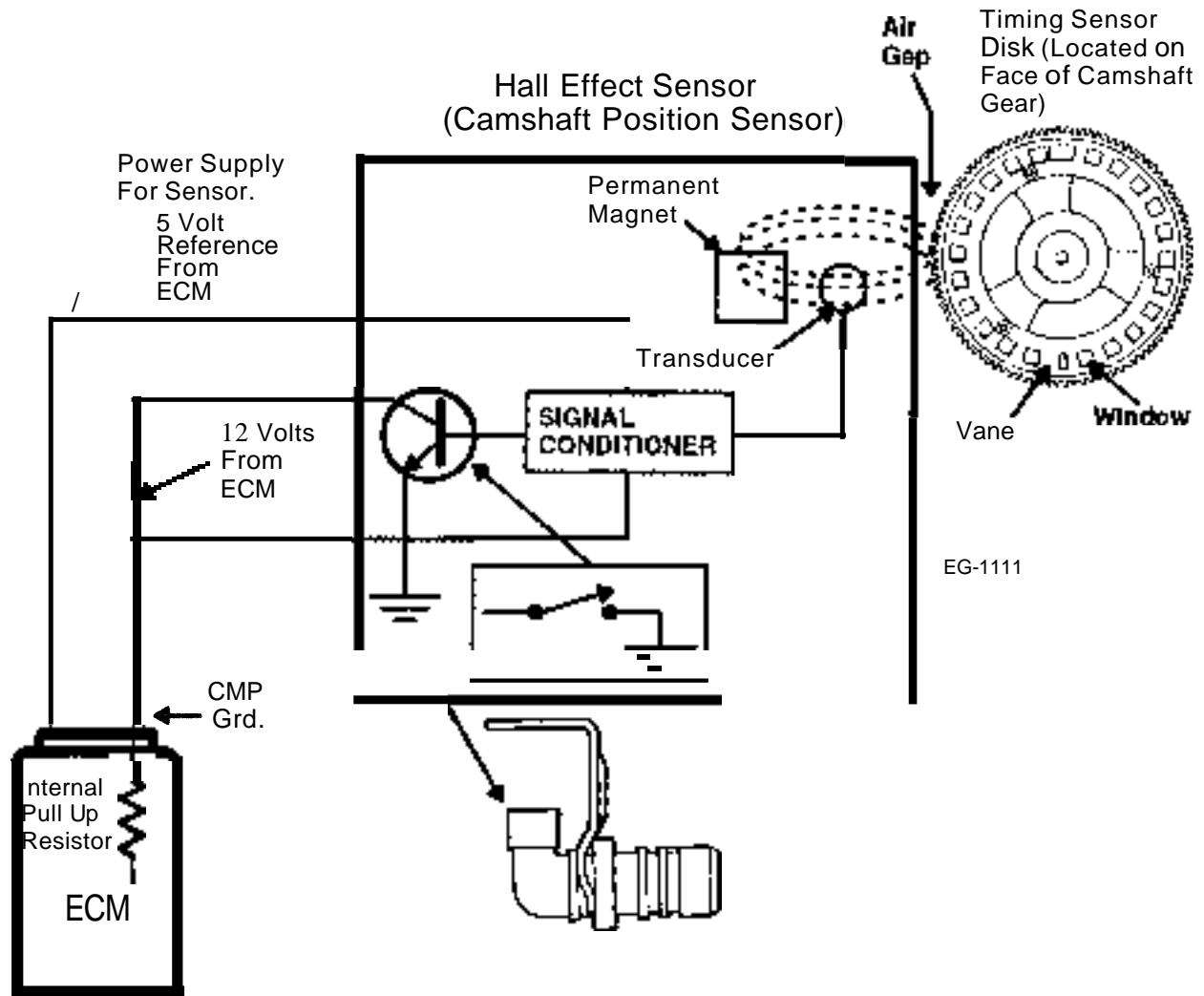


Figure 1.7-5. Hall Effect Sensor (Camshaft Position Sensor)

SENSOR OPERATION

TYPES OF SENSORS (Continued)

SWITCH SENSORS

Switch sensors are used to indicate position, levels or pressures. The signal of a switch sensor is a digital signal created by either opening or closing a switch. The on or off signal can indicate position as in the case of a clutch switch, level as in the case of a coolant level switch or pressure as in the case of a low oil pressure switch. A switch sensor can be either a voltage input type switch or a grounding type switch. A voltage input style switch will supply the ECM with a voltage when closed. A grounding type switch is wired in series with a current limiting resistor in the ECM and will cause a zero voltage

signal when closed (grounding the circuit). A switch sensor normally has two connectors signal return (Grd) and the signal. A switch sensor is considered a low speed digital input. Refer to Figure 1.7-6.

Examples:

- IVS Idle Validation Switch
- BNO Brake Normally Open
- BNC Brake Normally Closed
- CLS Coolant Level Switch
- DDS Driveline Disengagement Switch

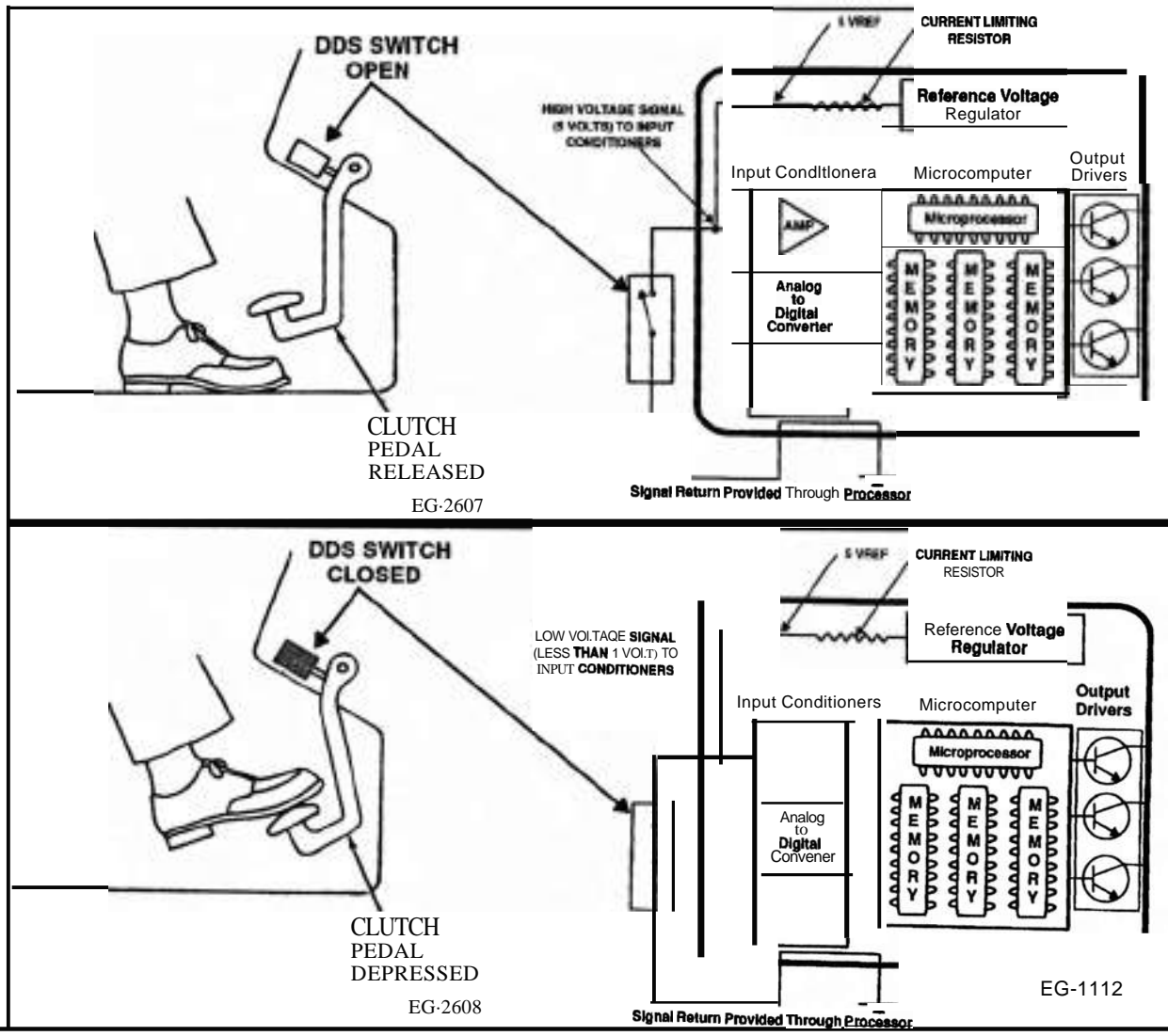


Figure 1.7-6. - Driveline Disengagement Switch (DDS)

TYPES OF SENSORS (Continued)

MAGNETIC PICKUP

A magnetic pickup is a sensor used to generate an alternating frequency that indicates speed. Magnetic pickups normally have a two wire connection for signal return and ground. A magnetic pickup is constructed with a permanent magnetic core surrounded by a wire coil. The signal frequency is gen-

erated by the rotation of gear teeth which make and break the magnetic field created by the magnet. Refer to Figure 1.7-7.

Examples

VSS Vehicle Speed Sensor

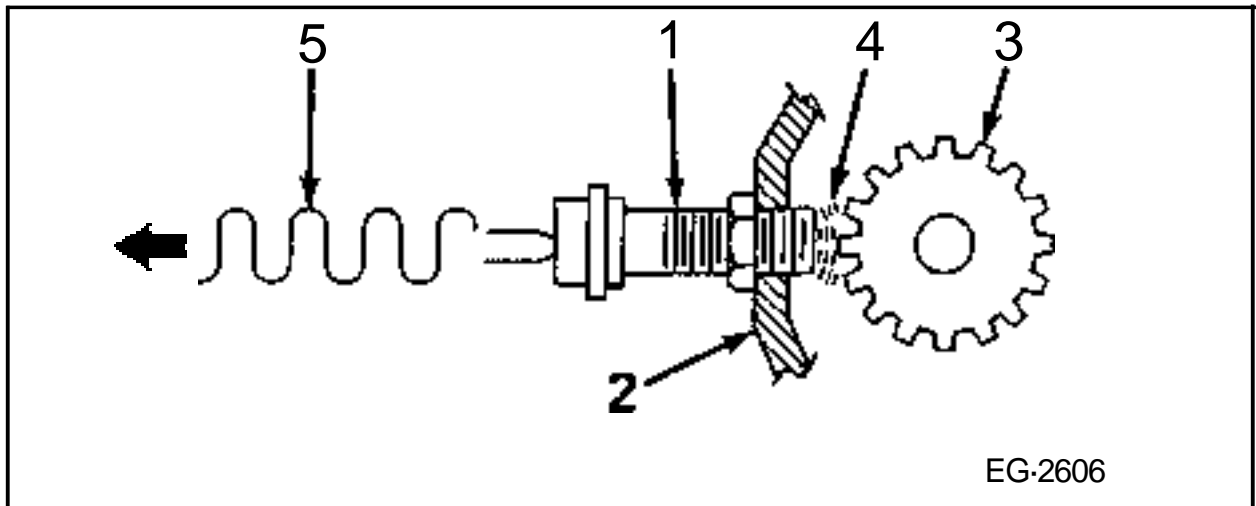


Figure 1.7-7. - Magnetic Pickup (Vehicle Speed Sensor)

- | | |
|------------------------------|---------------------------|
| 1. Magnetic Pickup Sensor | 4. Permanent Magnet Field |
| 2. Transmission Case | 5. Output Signal |
| 3. 16 Tooth Speedometer Gear | |

STANDARD FEATURES

ELECTRONIC GOVERNOR CONTROL

The T 444E is fully electronically governed over all operating ranges.

COLD IDLE ADVANCE

This feature provides an increase in engine cold idle speed of up to 875 rpm (normal idle 700 rpm) for a faster warm up to nominal operating temperature. This is accomplished through the electronic control module monitoring the engine coolant temperature sensor input and adjusting injector operation as required. Low idle speed is increased proportionally when the engine's coolant temperature is below 158°F (70°C) (700rpm) to 14°F (-10°C) (875 rpm maximum).

COLD AMBIENT PROTECTION SYSTEM (CAP)

This feature is built into the engine control system software to aid engine warm up and to maintain engine temperature during extended idle periods in cold weather.

The CAP feature slowly ramps up engine idle speed (after 5 minutes of idle time) to a preset engine rpm when the intake air temperature is below 32° F (0° C) and coolant temperature is below 158 ° F (70 ° C). This system is programmed to return engine idle speed back to normal idle when the vehicle operator decides to operate the vehicle or engage the PTO.

GLOW PLUG ASSISTED START

This feature increases engine startability in cold weather. The glow plugs are controlled by the Electronic Control Module which monitors engine temperature. "A WAIT TO START" lamp is included to inform the operator when the engine is ready for cranking.

AMERICAN TRUCKING ASSOCIATION DATA LINK PROVISIONS

The T 444E is equipped with an American Trucking Association (ATA) data link connector that allows communication between the electronic engine control system and the Pro-Link 9000 Electronic Service Tool (EST).

The data link provides communication capabilities for:

- Engine parameter data transmission.
- Diagnostics and troubleshooting.
- Customer programming.
- Production line programming of vehicle features.
- Field programming.

SERVICE DIAGNOSTICS

The electronic service tool provides means for obtaining diagnostic information using the ATA data link. The recommended electronic service tool is the Pro-Link® 9000 with an International cartridge. Sensor, actuator, electronic component and engine system faults can be detected by the ECM and be diagnosed by the EST.

The engine control system also provides service diagnostic information via flash codes emitted using the engine warning lamp. The service literature is indexed according to the flash codes.

ELECTRONIC SPEEDOMETER AND TACHOMETER PROVISIONS

The engine control system calibrates vehicle speed using pulses/mile. Dip switches no longer need to be changed when components affecting speed calibration are changed. The new speed calibration information can be programmed through the Electronic Service Tool.

ENGINE OVER TEMPERATURE PROTECTION SYSTEM (COOLANT TEMPERATURE COMPENSATION)

This system reduces fuel delivery when the engine coolant temperature is above the cooling system design target value. Fueling is reduced proportionally to the extent the design limit is exceeded. The reduction is calibrated to a maximum of 200/0 before standard engine warning and/or optional warning! shutdown systems engage. If this feature is activated, a fault code is stored in the Electronic Control Module's memory to explain low power complaints.

This feature may be omitted on emergency vehicle applications that require 100% power on demand.

VEHICLE FEATURES

STANDARD FEATURES (Continued)

EVENT LOGGING SYSTEM

This system records if the engine was operated beyond maximum rpm, over heated (coolant temperature), low on coolant and/or experienced low oil pressure. This information is stored in the ECM memory and may be accessed through the use of the EST.

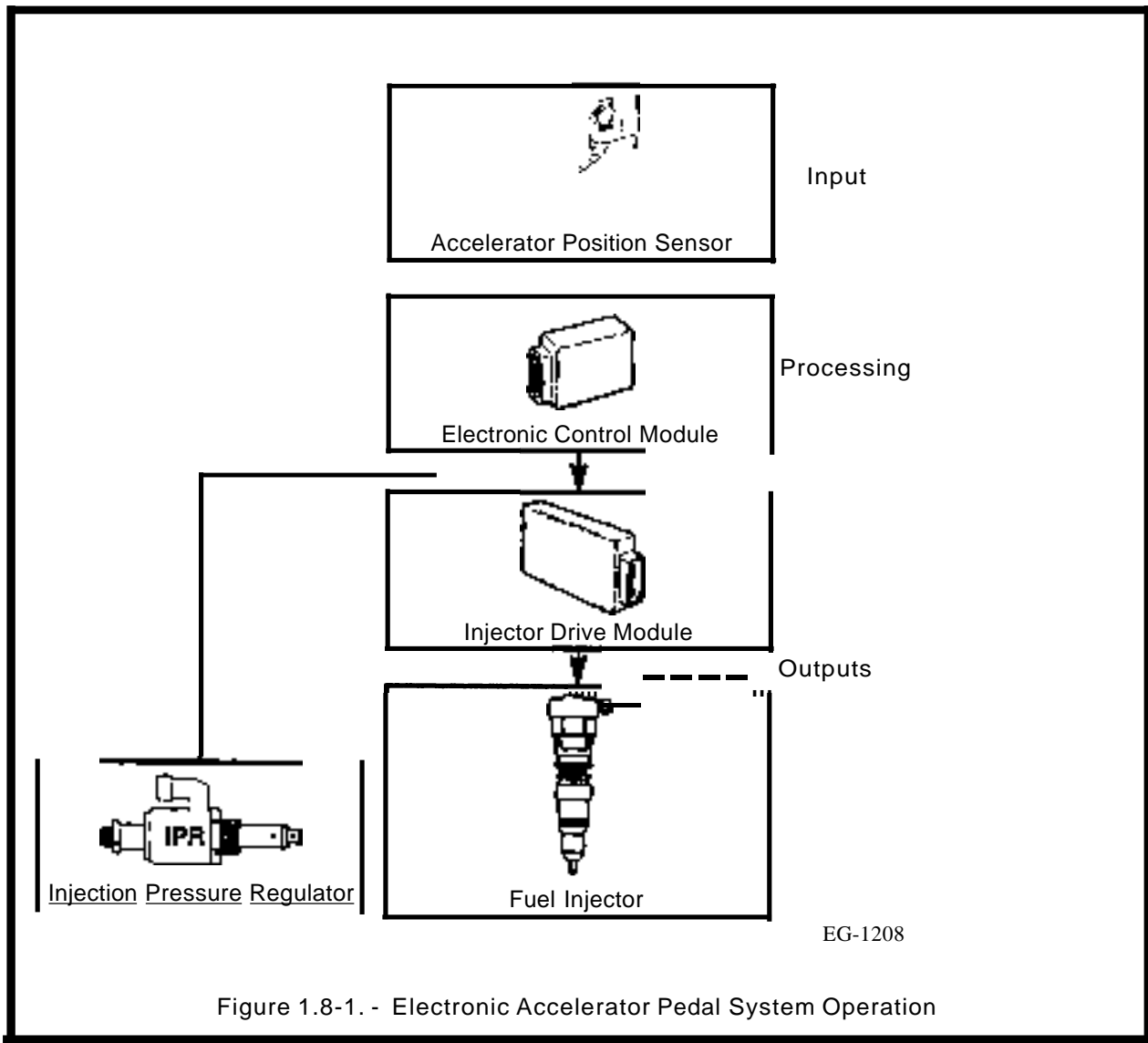
Power Take-Off (PTO) options with automatic transmissions. Engine Crank Inhibit is available as an optional feature with a manual transmission and a clutch switch.

ENGINE CRANK INHIBIT

This system will not allow the engine to crank unless the automatic transmission is in neutral and will not allow the starter to engage while the engine is running. It also facilitates the use of cruise control and

ELECTRONIC ACCELERATOR PEDAL

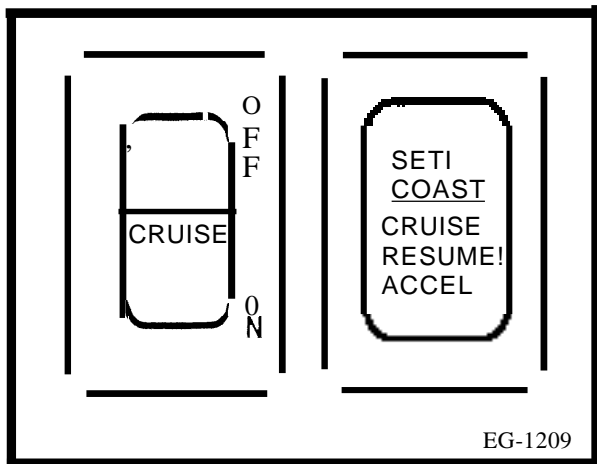
This feature eliminates the mechanical linkage used with conventional accelerator pedals. An accelerator position sensor within the accelerator pedal assembly provides the ECM with a signal representing the driver's demand for power.



OPTIONAL FEATURES

CRUISE CONTROL

This feature provides vehicle speed using automotive style set/coast, resume/accel, on, off switches. Speed control is disabled when the brake is applied, the clutch pedal is depressed or an automatic transmission is placed in neutral. The accelerator pedal can be used to provide a speed increase from the cruise speed selected.



Cruise Control Switches.

THROTTLE CONTROL FOR PTO OPERATION

The T 444E is compatible with both stationary and mobile PTO applications. Remote and in-cab throttle control locations are available. Also, the throttle control feature can be used as an electronic hand throttle.

ROAD SPEED LIMITING/GOVERNOR

This feature limits vehicle speed to an owner/operator programmable maximum speed.

EXHAUST BACK PRESSURE ENGINE WARM-UP SYSTEM

With this feature, a butterfly valve is placed in the exhaust stream at the turbo exhaust outlet. When the ambient and engine coolant temperatures are low, the valve restricts exhaust flow. The increased engine load increases the heat transferred to the cooling system. This, in turn, increases the amount of heat available to warm the vehicle interior. The ex-

haust back pressure engine warm-up system is especially desirable in bus applications.

BODY EQUIPMENT MANUFACTURERS PROVISIONS

Additional circuits and connector junction blocks are provided in the cab. The circuits include provisions for:

- Remote engine speed control.
- Remote PTO (engine speed) control commands.
- Additional power and control (protection) circuits for after manufacture add-on equipment.

The standard electrical system will provide breakout connector access to the speed control circuits.

ENGINE WARNING SYSTEM

This system illuminates the red "Stop Engine" lamp and actuates a buzzer when warning thresholds for coolant temperature, engine coolant level and/or engine oil pressure (low) are exceeded.

ELECTRONIC IDLE SHUTDOWN TIMER

This is an optional feature which provides engine shutdown after a 5 minute idle time has been exceeded.

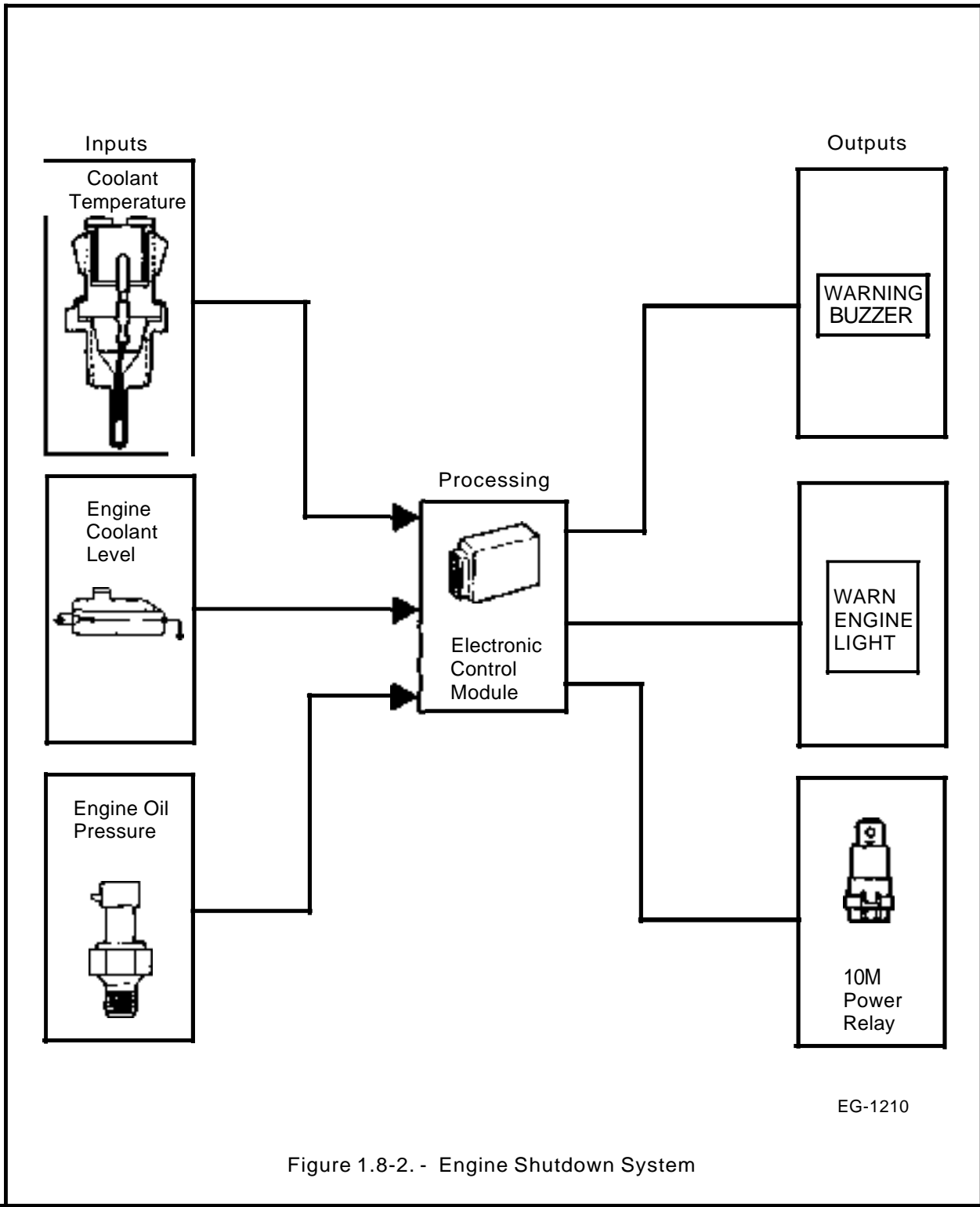
ENGINE SHUTDOWN SYSTEM (FIGURE 1.8-2.)

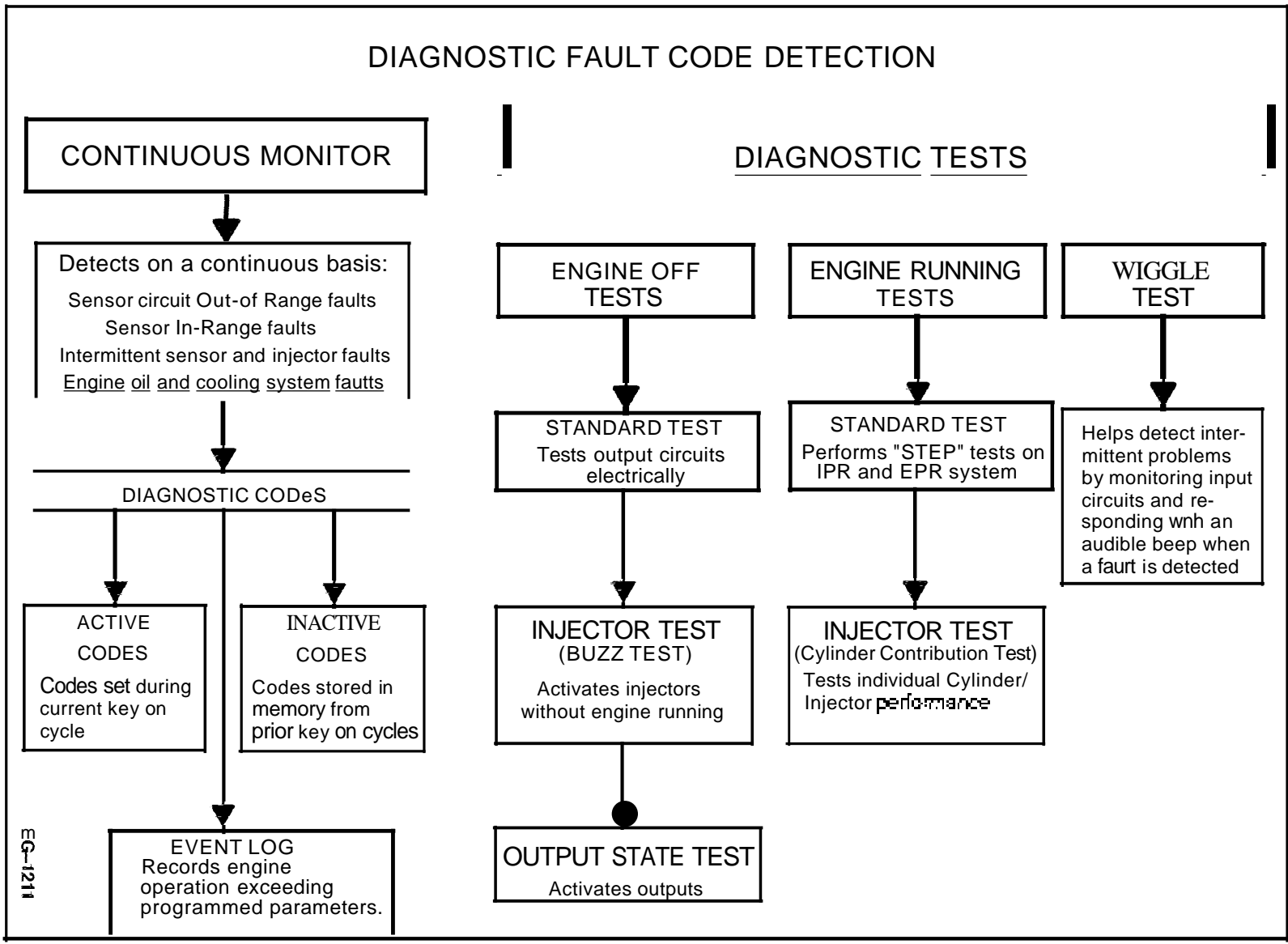
This system shuts down the engine after 30 seconds of operation beyond critical threshold values for coolant temperature, oil pressure and/or engine coolant level. The above mentioned warning system is included with this shutdown system. The engine may be restarted after shutdown, if it is mechanically capable of starting.

VEHICLE FEATURES

OPTIONAL FEATURES (Continued)

ENGINE SHUTDOWN SYSTEM-(Continued)





DIAGNOSTIC SOFTWARE

SELF TEST OPERATION

CONTINUOUS SELF TEST

CONTINUOUS MONITOR

Diagnostics are performed by the Electronic Control Module (ECM) continuously to detect out of range, rationality and system faults.

During the time that the key is "ON", if an input signal is "Out of Range" meaning the signal is either greater or lesser than what the signal range should be during normal operation, the ECM will record a "Fault". It will also monitor the operation of systems and will determine if the system is working within a normal range. If the ECM detects that a system falls outside a predetermined range, it will record and flag a fault.

During normal engine operation, the ECM automatically performs several tests to detect faults. When it has detected a fault, the ECM often invokes a fault management strategy to allow continued, though sometimes degraded, vehicle operation.

A "Fault" is an indication of a malfunction measured or monitored electronically. Sometimes "Faults" are referred to as "Codes."

"Codes" are three digit numbers assigned to Faults to indicate the source of the malfunction. Most Codes will indicate the source and the "Mode" of failure. The "Failure Mode" will indicate the signal reading, IE.; "Out of Range High", "Out of Range Low" or in Range fault.

During operation of the truck with the engine running, the Vehicle Personality Module (VPM) memory will record "EVENT ENGINE HOURS". This is the monitoring of engine operation exceeding programmed parameters. The standard Engine Event is Overspeed of the engine, referred to as Over RPM and excess coolant temperature. To retrieve information on Engine Events, it will be necessary to access them with the Electronic Service Tool.

If the engine is equipped with the optional engine warning/shutdown system, low oil pressure, and low coolant level operation, will also be monitored and recorded as "EVENT ENGINE HOURS".

OPERATOR ON DEMAND TESTS ENGINE OFF

STANDARD TEST (ENGINE OFF)

"Engine Off Tests" are "Standard Tests" performed by the ECM. These tests are commanded by the operator using the Electronic Service Tool (EST) or

using the Self Test Input (STI) push-button switch. Since Injector Driver Module (10M) faults are not stored in the ECM, it will be necessary to perform a self test to transmit faults from the 10M to the ECM.

To use the EST access the Engine menu and select Diagnostic Tests. Then select Engine Off Tests. Depressing the Enter key will initiate the test.

To use the STI diagnostic push-button switch, depress the switch and hold in, while turning the ignition switch to the "ON" position. Release the STI button after the key is in the "ON" position. Do not start the engine.

When the operator signals the test to begin, the ECM will perform internal tests of its processing components and internal memory.

It will automatically proceed to Output Circuit Check (OCC). This will operate the ECM output circuits. It will measure each individual circuit's response. The following circuits are checked by the ECM during the test:

1. Cylinder identification
2. Exhaust Pressure Regulator
3. Engine Crank Inhibit (relay)
4. Glow Plug Control (relay)
5. Injector Driver Module (relay)
6. Glow Plug Light
7. Fuel Demand Command Signal
- B. Injection Pressure Regulator
9. Engine to Transmission Data Line (EDL relay).

The ECM will monitor the outputs and test the operation of the output signals and actuators. If a circuit fails the test, a fault code will be logged.

When the test is complete, the EST will display any faults that were found during the test. If the STI diagnostic switch was used, the faults will be transmitted as "Flash Codes," using the Oil Warning and Engine Warning lights.

The fault codes are read by counting the number of light flashes. The following sequence occurs:

1. The "Oil/Water" light will flash one time. This indicates the beginning of Active fault codes.
2. The "WARN ENGINE" light will flash repeatedly signaling the active fault codes. All codes are three digits. The number of flashes should be counted in sequence.

DIAGNOSTIC SOFTWARE

SELF TEST OPERATION

OPERATOR ON DEMAND TESTS ENGINE OFF (Continued)

STANDARD TEST (Continued)

- At the end of each digit of the code there will be a short pause. Three flashes and a pause indicates the number 3. The code 232 will be sent as two flashes, (a pause), three flashes, (a pause), and two flashes.

If there is more than one code being sent, the "OILWATER" light will flash once indicating the beginning of another active fault code. The code 111 indicates "NO FAULTS".

If no further Active fault codes exist, the "OILWATER" light will flash twice, indicating the beginning of "INACTIVE CODES". The "WARN ENGINE" light will then flash the "INACTIVE CODE"(s) present. If several "INACTIVE CODES" are present, the "OILWATER" light will flash once between each of the fault codes.

When all of the stored fault codes have been sent, the "OILWATER" light will flash three times indicating "END OF MESSAGE".

If it is necessary to repeat transmission of fault codes, press the STI button and all stored codes will be retransmitted as described previously.

INJECTOR "BUZZ" TEST (ENGINE OFF)

The purpose of the Engine Off Injector "BUZZ" Test is to diagnose electrical problems with the fuel delivery components. This test can only be accessed with the EST and only after an "Engine Off Test" or Self Test has been performed.

NOTE: BEFORE RUNNING THIS TEST, FAULT CODES SHOULD BE ACCESSED, NOTED AND ERASED. THIS WILL ALLOW THE FAULTS FOUND IN THIS TEST TO BE DISPLAYED AS "ACTIVE CODES"

During the test, the ECM will signal the 10M to activate the injectors in numerical order 1 thru 8. The IDM will monitor each injector's electrical circuit operation. The IDM will send feedback signals to the ECM which indicate the status of injector performance and electrical circuit operation. If an electronic component in the fuel system fails the param-

eters of the test, an inactive fault code will be logged and transmitted to the EST at the end of the test.

NOTE: THE TECHNICIAN CAN MONITOR INJECTOR OPERATION BY LISTENING TO THE SOUND EACH INJECTOR PRODUCES AS IT IS ACTIVATED BY THE 10M, HOWEVER, IN A HARD START/NO START CONDITION WHERE THE OIL MAY BE VERY COLDTHICK INJECTORS MAY NOT BE AUDIBLE.

If the faults were not erased before this test, the faults found during this test will be displayed as "INACTIVE CODES".

To read these fault codes, access the "Diagnostic Codes" menu and read both Active and Inactive codes.

OUTPUT STATE TEST (ENGINE OFF)

The purpose of the Output State Test is to diagnose the operation of the output signals and actuators. This test can only be performed by using the Electronic Service Tool.

To run this test, select the Output State Test from the EST Engine Off Test menu. The test consists of two modes of operation:

- Toggling outputs from high to low.
- Toggling outputs from low to high.

When in the "OUTPUTS ARE LOW" mode the ECM will pull down the output voltage to their low state. This will actuate the output components that are controlled by the ECM grounding the circuits. During this test "OUTPUTS ARE LOW" will be displayed on the screen.

When in the "OUTPUTS ARE HIGH" mode the ECM will pull up the output voltage to their high state. This will actuate the output components that are controlled by the ECM energizing the control circuits. During this test "OUTPUTS ARE HIGH" will be displayed on the screen.

During this test, the output of the circuit in question can be monitored with a DVOM. The DVOM will measure a "High or Low" voltage state condition as the outputs are toggled. The actual voltage will vary with the circuit tested.

DIAGNOSTIC SOFTWARE SELF TEST OPERATION

OPERATOR ON DEMAND TESTS ENGINE OFF TEST (Continued)

OUTPUT STATE TEST (ENGINE OFF) (Continued)

NOTE 1: THE EST WILL ONLY DISPLAY "OUTPUTS ARE HIGH" OR "OUTPUTS ARE LOW". IT WILL NOT DISPLAY ANY VOLTAGES ETC. A DVOM IS REQUIRED TO MONITOR THE SUSPECTED PROBLEM CIRCUIT OR ACTUATOR.

NOTE 2: FAULTS WILL NOT BE SET DURING THIS TEST.

This following actuators and signals are toggled high and low during the test:

- a. Injector Driver Module Enable Relay
- b. Cylinder Identification
- c. Fuel Demand Command Signal (FDCS)
- d. Exhaust Pressure Regulator
- e. Injection Pressure Regulator
- f. Engine Crank Inhibit Relay
- g. Engine Data Link (EDL) Relay
- h. Oil Warning Light
- i. Warn Engine Light
- j. Glow Plug Lamp
- k. Glow Plug Relay

OPERATOR ON DEMAND TESTS ENGINE RUNNING

STANDARD TEST (ENGINE RUNNING)

The Self Test (Engine Running) checks the operation of the following actuators:

1. Injection Pressure Regulator (IPR)
2. Exhaust Back Pressure Regulator (EPR)

During the test, the ECM commands the IPR and the EPR actuators through a pre-programmed testing sequence to determine if the actuators are performing as expected. The ECM monitors the feedback signal values from the injection control pressure and exhaust back pressure sensors and compares those values to the expected values. At the end of the test, the ECM will return the engine to the normal operating mode and transmit any fault codes which may have been set during the test.

This test can only be performed by using the Electronic Service Tool.

PROCEDURE

NOTE: ENGINE COOLANT TEMPERATURE MUST BE 160° F, BATTERY VOLTAGE MUST BE HIGHER THAN 12.5 VOLTS AND NO VEHICLE SPEED SENSOR (VSS) SIGNAL SHOULD BE PRESENT DURING THIS TEST. IF ACTIVE FAULT CODES ARE PRESENT, THEY MUST BE REPAIRED AND CLEARED PRIOR TO RUNNING THIS **TEST**.

1. Select "Engine Running Test" from the "Diagnostic Test" menu in the EST.
2. Press "ENTER" to begin test. The ECM will begin to raise the engine idle speed to a predetermined value. It will then command the IPR valve to set the injection control pressure to rated speed pressure. If the performance of the IPR is acceptable, the ECM will control the IPR valve to reduce the pressure in steps while continuing to monitor the performance of the injection control pressure system.

At the completion of the IPR test, the ECM will conduct a similar test on the EPR valve. When testing is completed, normal engine operation is restored and fault codes will be transmitted as described previously.

INJECTOR TEST "CYLINDER CONTRIBUTION" (ENGINE RUNNING)

The Injector Test is designed to detect problems with injection and combustion events. During the test the ECM will control fuel delivery and determine each cylinder's power contribution. If a cylinder is not performing satisfactorily, a fault code will be set.

This test can only be performed by using the Electronic Service Tool.

PROCEDURE

NOTE: THE ENGINE RUNNING SELF TEST MUST BE PERFORMED FIRST IN ORDER TO GAIN ACCESS TO THE INJECTOR (ENGINE RUNNING) TEST IN THE EST.

1. Select Injector Test from the Engine Running Test menu.

DIAGNOSTIC SOFTWARE

SELF TEST OPERATION

OPERATOR ON DEMAND TESTS (ENGINE RUNNING)

INJECTOR TEST (ENGINE RUNNING) (Continued)

PROCEDURE (Continued)

2. The ECM will increase the normal amount of fuel delivery (overfuel) to the injector/cylinder being tested and monitor the reduction of fuel required to operate the remaining injectors to maintain engine speed. If there is no reduction in fuel delivery to the other cylinders the ECM will set a fault code identifying the non-contributing cylinder.

When testing is completed, normal engine operation is restored and fault codes will be transmitted.

OPERATOR ON DEMAND TESTS

WIGGLE TEST

The purpose of the Wiggle Test is to troubleshoot intermittent connections at sensors and actuators. It may be performed with the engine off or running. The Electronic Service Tool is used to monitor the following circuits during the Wiggle Test.

- a. Accelerator Position Sensor (APS)
- b. Intake Air Temperature Sensor (IAT)

- c. Camshaft Position Sensor (CMP)
- d. Data Communication Link
- e. Exhaust Back Pressure (optional)
- f. Engine Coolant Temperature
- g. Engine Oil Pressure (optional)
- h. Injection Control Pressure
- i. Manifold Absolute Pressure
- j. Remote Accelerator Pedal Sensor
- k. Engine Oil Temperature
- l. Barometric Pressure Sensor (BARD)

PROCEDURE

1. Select the Wiggle Test from the "Diagnostic Test" menu in the EST. Press the "ENTER" key to begin test.
2. The technician should wiggle connectors and wires at all suspected problem points. The EST will "BEEP" if circuit continuity is broken. It will display all faults found during the test.

SECTION 2 MECHANICAL DIAGNOSTICS

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INTRODUCTION

No doubt almost any mechanical problem can be accurately diagnosed under ideal conditions. But what really matters is whether accurate diagnosis can become the norm under everyday conditions. Much of the long term success and acceptance of an engine is actually determined by the efficiency of thousands of shop foremen and technicians.

The purpose of engine diagnostic forms are to provide the customer with satisfaction as well as assist the technician in troubleshooting the T 444E Diesel Engine. Diagnostic forms provide a guide to finding problems quickly and easily and to avoid unnecessary repairs and expense. Engine diagnostic forms should not remain buried in a book in the shop foreman's service library. They should be taken right to the job and used to provide a systematic and time saving method of diagnosing engine problems.

Engine diagnostic forms begin with the basics progressing to the tests that are more difficult. This leads the technician in a path of diagnosis to check the more common problems first and proceed to the less likely. The form should be followed in sequence, starting at test number one (1) and continuing through to the final test. The order of the tests should be followed because some components depend on the function of other components for proper operation. Performing the tests out of order could cause an incorrect conclusion.

Two diagnostic forms are required to properly diagnose the T 444E engine. The first form, **Hard Start/No Start and Performance Engine Diagnostics**, guides the technician through Hard Start or No Start conditions in which the engine does not start or is difficult to start. The Performance Engine Diagnostics portion guides the technician through conditions in which the engine is running with some type of performance problem. An example would be a low power complaint. Illustrations when applicable, are located on the reverse side of the form. They show the location of test points and how to hook up test equipment at each point.

The second form, **Electronic Control System Diagnostics**, lists all engine and vehicle related fault codes on the front side. A circuit index adjacent to each fault code is provided to assist the technician to quickly refer to the appropriate section of the manual for each fault code. Fault code descriptions, comments and probable causes are listed for each fault code listed. This information will allow the technician to understand what the fault code is and the problem associated with it.

The reverse side of this form contains a schematic wiring diagram of the T 444E engine and truck mounted electronic controls. In addition, a chart is supplied which describes the Electronic Control Module's (60 pin) expected signal values under specified conditions. The chart will enable the experienced technician to quickly identify and repair the problem.

DIAGNOSTIC FORMS

INSTRUCTIONS

-IMPORTANT-

BEFORE ATTEMPTING TO PERFORM ANY OF THE DIAGNOSTIC PROCEDURES, IT IS IMPORTANT TO FILL IN THE INFORMATION REQUESTED AT THE TOP OF THE DIAGNOSTIC FORM(S). PROPER INFORMATION IS REQUIRED.

The DATE, MILES and HOURS are important information for warranty purposes.

The ENGINE SERIAL NUMBER AND VEHICLE IDENTIFICATION NUMBER (VIN) are important information for ordering parts and referencing service information. The ENGINE SERIAL NUMBER is located on a machined pad next to the rear of oil cooler on the engine block. The VIN is stamped on the manufacturer's identification plate located on the chassis.

The ENGINE HORSEPOWER/EMISSIONS INFORMATION and ENGINE FAMILY RATING CODE (EFRC) is important information to determine if the engine is the correct horsepower for the application and if the VPM (Vehicle Personality Module) is calibrated to the correct horsepower and emissions level. The ENGINE HORSEPOWER/EMISSIONS INFORMATION is located on the emission label located on the right valve cover. The ENGINE FAMILY RATING CODE can only be accessed with the EST (Electronic Service Tool).

To read the EFRC:

1. Select ENGINE MENU and press "ENTER".
2. Select CALIBRATION DATA MENU and press "ENTER".
3. Select ENGRANS SELECT MENU and press "ENTER".
4. Scroll to the ENGINE RATING CODE and it will be displayed on the EST. (Refer to Diagnostic Tool Section for operating the EST.)

The MECHANIC and UNIT number is useful information for reference only.

Date:	Miles:	Hours:	Mechanic:	Complaint:
Eng. Sn.	VIN		Unit #	
Eng. HP	EFAC.:	Ambient Temp.	Coolant Temp..	
Hard Start/No start Diagnostics			Performance Diagnostics	

INSTRUCTIONS (Continued)

INSTRUCTIONS FOR ENGINE DIAGNOSTIC FORMS

RECORD THE TEST DATA IN THE "ACTUAL" BOX (FIGURE 2.1-1.) ON THE HARD START NO START & PERFORMANCE ENGINE DIAGNOSTICS FORM. IF THERE ARE ANY DIFFERENCES BETWEEN THE "SPECIFICATION" BOX AND THE "ACTUAL" BOX, CORRECT AS NECESSARY AND REPEAT THE CHECKS. RETAIN THIS INFORMATION FOR FUTURE OPERATING ANALYSIS.

Diagnostic form numbers EGED-13Q-1 and EGED-135-1 are available in pads of 50 sheets from:

Navistar International Transportation Corporation
Printing, Procurement and Distribution
4956 Wayne Road
Battle Creek, Michigan 49017

FROM FORM EGED-13Q-1

8. EST TOOL-DATA LIST

- Select and enter the following data as the first three lines in a custom data list
- Monitor the data while cranking the engine for 20 seconds minimum

Data	Spec.	Actual
Bat. voltage	7 volts min.	
Eng. RPM	100 RPM min.	
ICP pressure	800 PSI min.	

- If voltage is low, proceed to Test 9a.
- If no RPM is noted, recheck fault codes and proceed to Test 9b.
- If Icp pressure is low, refer to Test 10.

Figure 2.1-1. - Diagnostic Form (Example)

*. Manual number specified with latest revision will be furnished.

INTRODUCTION

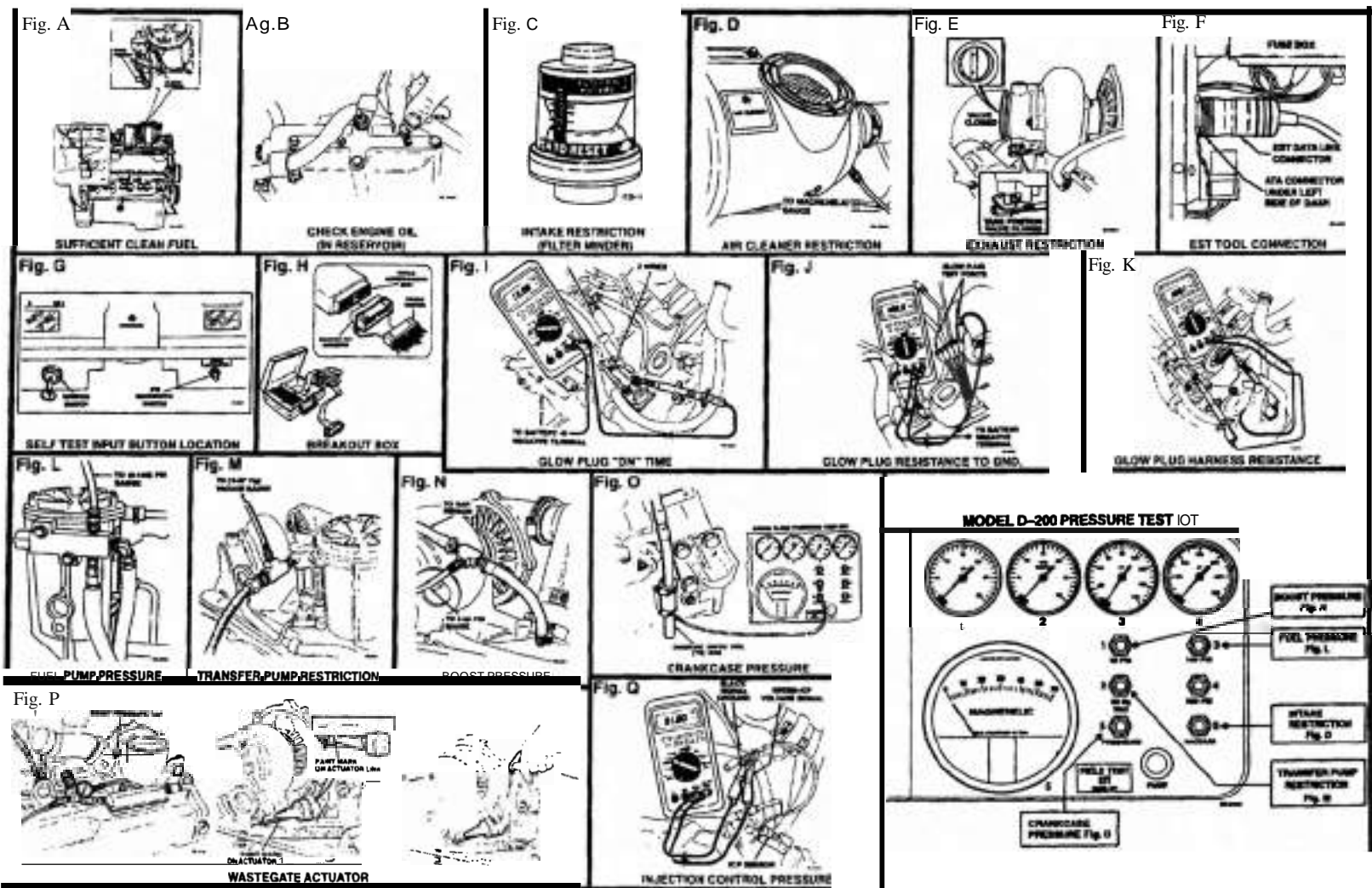
The following pages have supporting information and instructions for the combined Hard Start/No Start and Performance diagnostic form. Each section has detailed instructions on how to perform each test and how to use any specialized equipment.

7448E DIESEL ENGINE HARD START / NO START AND PERFORMANCE ENGINE DIAGNOSTICS		Date: _____ Eng. SN: _____ Eng. HP: _____		Miles: _____ VIN: _____ EPCV: _____	Years: _____ MOR E: _____ ECR Version #: _____	Technician: _____ Ambient Temp.: _____	Vehicle P/N: _____ Turbocharger P/N: _____ Exhaust A/F: _____ Coolant Temp.: _____	Compress: _____ Work Order #: _____ Date: _____																																																															
1. SUFFICIENT CLEAN FUEL REFER TO FIGURE A ON REVERSE SIDE		2. VISUAL INSPECTION		3. CHECK ENGINE OIL LEVEL REFER TO FIGURE 4 ON REVERSE SIDE		4. INTAKE/EXHAUST RESTRICTION REFER TO FIGURES C & E ON REVERSE SIDE		5. EST TOOL-FAULT CODES REFER TO FIGURE F ON REVERSE SIDE																																																															
<ul style="list-style-type: none"> Check at tanks, drain samples from fuel lines and delivery engine. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____	<ul style="list-style-type: none"> Check for contaminants (fuel, coolant) Correct Grade/Viscosity Miles/Hours on oil, correct level Check level in reservoir. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____	<ul style="list-style-type: none"> Select and enter the following data as the first 3 lines in - custom data list Monitor the data while cranking the engine for 20 seconds minimum. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Item</th><th>Spec</th><th>Actual</th></tr> <tr><td>Bal. Voltage</td><td>7 Volts min</td><td>_____</td></tr> <tr><td>Eng RPM</td><td>130 RPM min</td><td>_____</td></tr> <tr><td>ICP Pressure</td><td>1800 psi min</td><td>_____</td></tr> </table>		Item	Spec	Actual	Bal. Voltage	7 Volts min	_____	Eng RPM	130 RPM min	_____	ICP Pressure	1800 psi min	_____	<ul style="list-style-type: none"> Check while cranking the engine Measure with DVOM Breakout box pins 57+ & 40- <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Instrument</th><th>Spec</th><th>Actual</th></tr> <tr><td>DVOM</td><td>7 volts minimum</td><td>_____</td></tr> <tr><td>DVOM</td><td>57+ & 40-</td><td>_____</td></tr> </table>		Instrument	Spec	Actual	DVOM	7 volts minimum	_____	DVOM	57+ & 40-	_____	<ul style="list-style-type: none"> Minimum 130 RPM engine cranking speed for 20 seconds. Breakout box pins 34+ & 46- with Fluke - <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Instrument</th><th>Spec</th><th>Actual</th></tr> <tr><td>Fluke 88</td><td>130 RPM minimum</td><td>_____</td></tr> <tr><td>Fluke 88</td><td>34+ & 46-</td><td>_____</td></tr> </table>		Instrument	Spec	Actual	Fluke 88	130 RPM minimum	_____	Fluke 88	34+ & 46-	_____	<ul style="list-style-type: none"> Check for contaminants (fuel, coolant) Correct Grade/Viscosity Miles/Hours on oil, correct level Check level in reservoir. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____	<ul style="list-style-type: none"> Check at tanks, drain sample from fuel lines and delivery engine. Correct Grade/Viscosity <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____	<ul style="list-style-type: none"> Check for contaminants (fuel, coolant) Correct Grade/Viscosity Miles/Hours on oil, correct level Check level in reservoir. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____	<ul style="list-style-type: none"> Check for contaminants (fuel, coolant) Correct Grade/Viscosity Miles/Hours on oil, correct level Check level in reservoir. <table border="1" style="width:100%; border-collapse: collapse;"> <tr><th>Method</th><th>Check</th></tr> <tr><td>Visual</td><td>_____</td></tr> </table>		Method	Check	Visual	_____
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PERFORM TESTS IN SHADED AREAS IF EST TOOL IS NOT AVAILABLE OR ATA CODES ARE NOT TRANSMITTED
EGED-150-1 Rev 1997 © BENTLEY INTERNATIONAL TRANSPORTATION CORPORATION

HARD START/NO START DIAGNOSTICS

HARD START/NO START & PERFORMANCE DIAGNOSTIC: OIRM EGED-30- (REAR SIDE)



EGED-30-

Printed In the United States of America

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
SUFFICIENT CLEAN FUEL

FROM FORM EGED-13Q-1

1. SUFFICIENT CLEAN FUEL

- Check at tank(s), drain sample from fuel filter while cranking engine.

Method	Check
Visual	

PURPOSE

To determine if the fuel system is getting sufficient clean fuel to start and operate the engine.

TEST PROCEDURE

1. Route a hose from the fuel drain tube (Figure 2.2-1.) to a clear container and open the drain.
2. Crank the engine and observe the fuel flowing into the container. Stop cranking the engine when the container is half full.

Fuel flow out of the drain tube should be a steady stream. Insufficient flow could indicate fuel supply or fuel system problem.

3. Inspect fuel in container. It must be clean and free of air, contaminants, water, icing or clouding. The fuel should be straw colored. Fuel dyed red or blue indicates an off-highway fuel.
4. Check fuel odor for the presence of other fuels such as gasoline or kerosene.

If engine oil is present in the fuel, it may indicate an injector "O" ring leak and subsequent loss of injection control pressure. If that is suspected, check the injection control pressure during engine cranking. Use the Electronic Service Tool (EST) or follow the procedure outlined in Test 9C on the Hard Start/No Start diagnostic form.

NOTE: SOME SEDIMENT AND WATER MAY BE PRESENT IN THE FUEL SAMPLE IF THE FUEL FILTER HAS NOT BEEN SERVICED OR DRAINED FOR A PROLONGED PERIOD OF TIME. A SECOND SAMPLE MAY BE REQUIRED TO DETERMINE FUEL QUALITY.

LOW OR NO FUEL POSSIBLE CAUSES

- No fuel in tank.
- If equipped with an in line fuel valve, it could be shut off.
- Fuel supply line from tank(s) could be broken or crimped.
- Fuel could be waxed or jelled (most likely in cold weather with #2 fuel), the pickup tube in tank could be clogged or cracked. If there is excessive water in the tank, it could freeze preventing the fuel from being drawn to the engine.
- If the vehicle is equipped with supplemental filters or water separators, check for plugged filters or leakage that could allow the fuel system to draw air.
- Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in the fuel may indicate that the tank and fuel system may need to be flushed and cleaned.

TOOLS REQUIRED

Clear container approximately 1 quart.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
SUFFICIENT CLEAN FUEL (Continued)

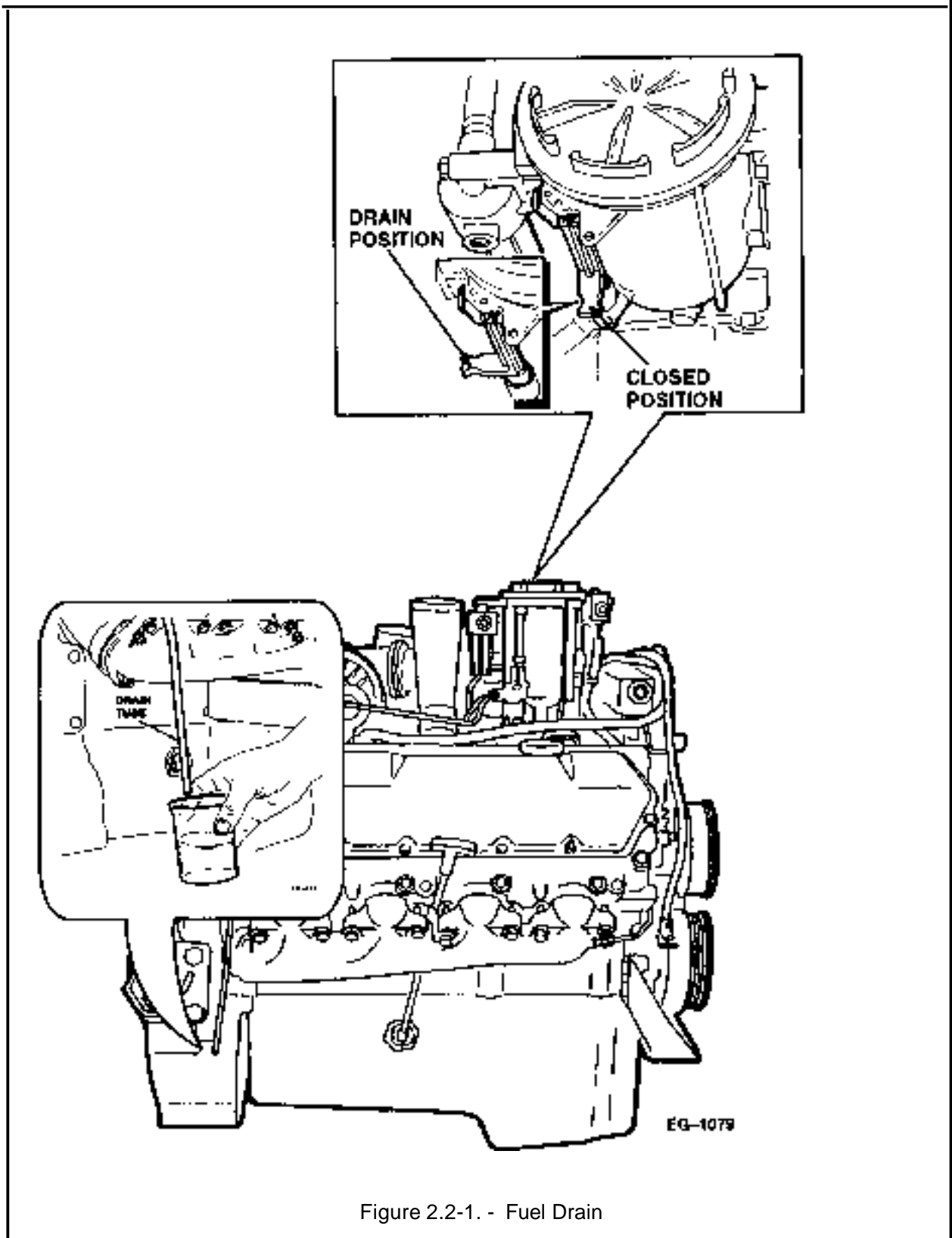


Figure 2.2-1. - Fuel Drain

T 444E ENGINE
VISUAL INSPECTION

FROM FORM EGED-13Q-1

2. VISUAL INSPECTION				
Fuel	Oil	Coolant	Electrical	Air
Method		Check		
Visual				

PURPOSE

Visual inspection to check the general condition of the engine and to look for obvious causes of hard or no start conditions.

TEST PROCEDURE

1. Inspect entire fuel system for leaks including tank and lines. Inspect fuel lines for damage (kinks and bends).
2. Check high pressure oil lines and high pressure pump in engine "V" for major oil leaks.
3. Inspect entire cooling system, (coolant level in reservoir, hoses, water pump and radiator) for coolant leaks. Check for residue which may have been caused from prior leakage.
4. Inspect engine wiring harness for correct routing and insure that no rubbing or chaffing has occurred. Inspect the in-line Deutsch 31 way connector on the engine. Check connections to sensors, relays, actuators and control modules. Inspect battery cable connections for corrosion. Check the fuses at the battery. All connections should be seated and in good condition, free from damage and corrosion.

POSSIBLE CAUSES

- Loose or leaking fuel supply lines could cause fuel system to lose prime.
- Kinked or blocked fuel supply lines will create restriction to fuel flow.
- Massive fuel or oil leaks may contribute to no start conditions.
- Coolant leaks could indicate serious engine problems.
- Electronic connectors may be damaged or not installed properly causing a no start condition.

NOTE: THE CAMSHAFT POSITION (CMP) SENSOR AND THE INJECTION PRESSURE REGULATOR (IPR) VALVE ARE THE TWO MOST CRITICAL ELECTRONIC COMPONENTS TO INSPECT WHEN THE ENGINE FAILS TO START.

TOOLS REQUIRED

Inspection light

T 444E ENGINE
CHECK ENGINE OIL LEVEL

FROM FORM EGED-130-1

3. CHECK ENGINE OIL LEVEL

- Check for contaminants (fuel, coolant)
- Correct grade/viscosity
- Miles/Hours on oil, correct level
- Check level in reservoir

Method	Check
Visual	

PURPOSE

To determine if the crankcase and oil reservoir contain engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly.

TEST PROCEDURE

1. Park vehicle on level ground. Check oil level with oil level gauge. If there is no oil or very little oil in the crankcase the fuel injectors will not operate.

If the oil level on the gauge is over full, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, it will have a fuel odor.

2. Inspect oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity for the temperature (environment) the vehicle is operating in. Single weight or 15W 40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become thicker) and will make engine cranking more difficult and starting less reliable at temperatures below freezing. Refer to the lube oil chart in the operator's or service manual for the correct oil selection for temperature conditions.
4. The oil level in the oil reservoir should be checked. Remove the inspection plug in top of reservoir (Figure 2.2-2.) to check oil level. Normal oil level is within 1/2 inch below the top of the reservoir. (If the engine has not been operated for some time, oil in the reservoir may drain into the crankcase. The engine may start hard or start and not continue to run.) Filling the res-

ervoir will allow the system to prime faster facilitating starting.

If the oil level in the reservoir becomes low while the vehicle is parked for a short period of time, it is due to a leaking check valve in the high pressure pump.

If oil level in the reservoir drops while cranking the engine, it indicates that no oil is being pumped to the reservoir.

POSSIBLE CAUSES

- Oil level low - Oil leak, oil consumption, incorrect servicing.
- Oil level high - Incorrect servicing, fuel dilution from lift pump or defective injector "O" rings.
- Oil Contamination with Coolant - Oil Cooler, head gasket, porosity, (accessories i.e. water cooled air compressors.)
- Low reservoir level- Engine built dry (not pressured lubed), prolonged period of not running, leaking check valve in high pressure pump.

TOOLS REQUIRED

1/4" drive ratchet or breaker bar to remove inspection plug.

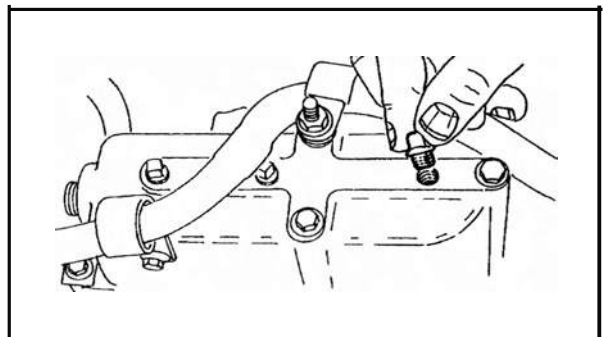


Figure 2.2-2. - Checking Oil Level in Reservoir

T 444E ENGINE
INTAKE/EXHAUST RESTRICTION

FROM FORM EGED-13Q-1

4. INTAKE/EXHAUST RESTRICTION

- Inspect air filter and ducts
- Inspect exhaust system
- Inspect exhaust back pressure device

Method	Check
Visual	

PURPOSE

Visual inspection to determine if an intake or exhaust restriction is contributing to a no start or hard start condition.

NOTE: A HIGH INTAKE OR EXHAUST RESTRICTION MAY CAUSE A CONSIDERABLE AMOUNT OF BLACK OR BLUE SMOKE WHEN STARTING THE ENGINE.

VISUALLY INSPECT:

1. Air cleaner inlet and ducting to assure that it is not restricted or collapsed.
2. Air cleaner housing, filter element and gaskets for proper installation.
3. Filter minder to assure intake restriction is below the "RED" markings. When the filter element reaches maximum allowable restriction, the yellow indicator reaches the top of window and automatically locks in this position.

NOTE: REFER TO PERFORMANCE DIAGNOSTICS SECTION 2.3 FOR DETAILED AIR CLEANER RESTRICTION INFORMATION.

4. Exhaust system for damaged or restricted pipes.
5. Exhaust back pressure device bell crank (If equipped) (Figure 2.2-3.) during cranking and assure it is not closing. If the tang is positioned as shown in Figure 2.2-3., the exhaust (butterfly) valve is closed.

POSSIBLE CAUSES

- Snow, plastic bags or other foreign material may restrict air flow at the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been inadvertently left in the intake system.
- The exhaust back pressure device may be closing during cranking or stuck closed.
- The tailpipe or muffler may have been damaged or collapsed.

TOOLS REQUIRED

None

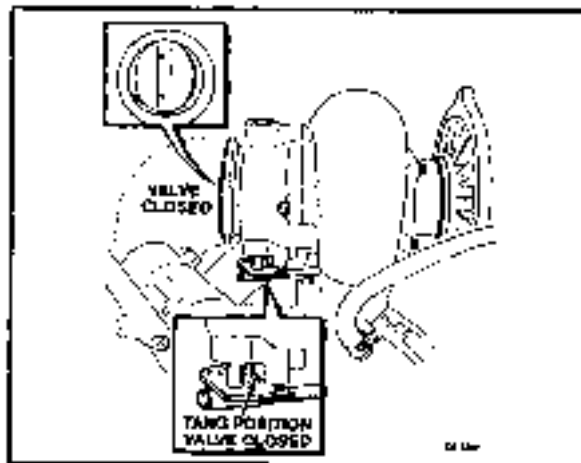


Figure 2.2-3. - Exhaust Back Pressure Valve Closed

T 444E ENGINE
EST TOOL-FAULT CODES

FROM FORM EGED-13Q-1

5. EST TOOL-FAULT CODES

- Install Electronic Service Tool

Active

Inactive

PURPOSE

To determine if the Electronic Control Module (ECM) has detected any fault conditions that would cause a hard or no start condition.

TEST PROCEDURE

NOTE: TURN ALL ACCESSORIES AND THE IGNITION OFF, BEFORE CONNECTING EST TOOL TO ATA DIAGNOSTIC CONNECTOR.

Connect the Electronic Service Tool (EST) to the American Trucking Association (ATA) diagnostic

connector. The connector is located on the lower left kick panel (Figure 2.2-4.) inside the cab. The screen of the reader should light up as soon as the tool is plugged in.

NOTE: THE ATA CONNECTOR SUPPLIES POWER TO OPERATE THE EST. THE EST WILL AUTOMATICALLY POWER UP AS SOON AS IT IS PLUGGED INTO THE ATA CONNECTOR. THE POWER CORD IS NOT REQUIRED AND IS FOR USE ONLY WHEN READING NON-VOLATILE MEMORY.

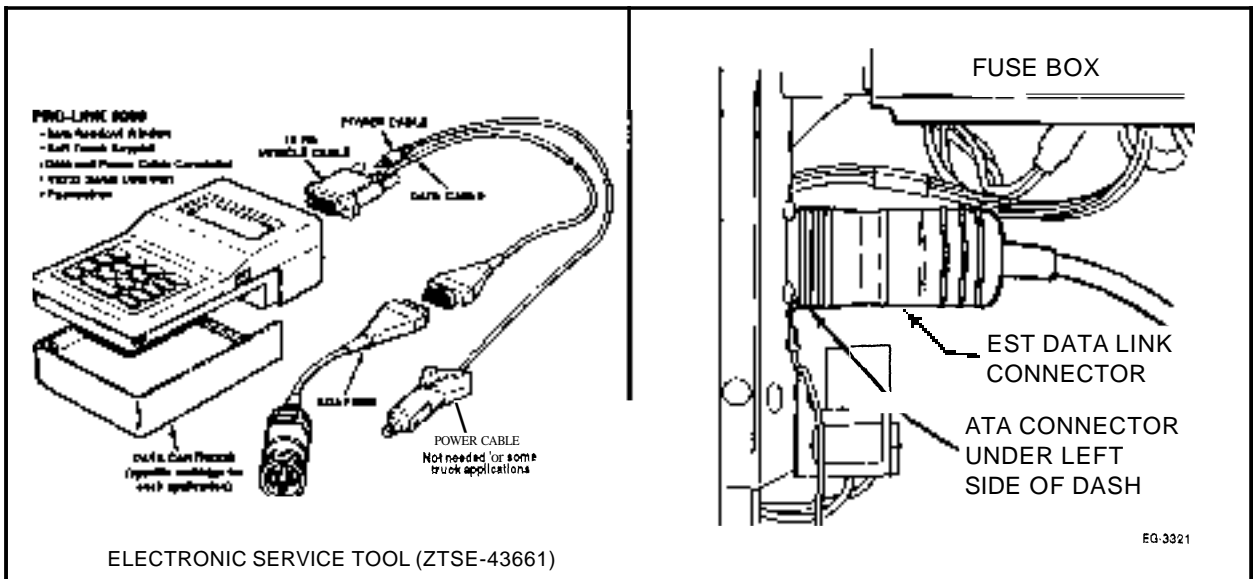


Figure 2.2-4. - Electronic Service Tool/ATA Connector Location

Turn the ignition switch to the "ON" position, but do not start the engine. This will allow the EST to receive data from the electronic control components on the truck. If no data is received, press "ENTER" to retry. The information received will be data showing the current status of the engine.

To access the fault codes press the "FUNC" key to switch to the main menu.

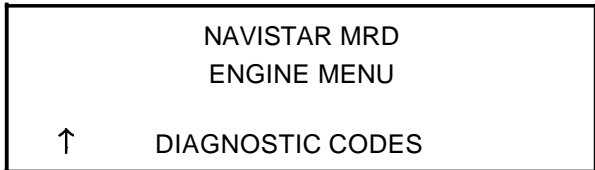
NAVISTAR MRD
SELECT DESIRED
MENU
[ENGINE] ← PRO-LINK

From the main menu select "ENGINE" by pressing the "←" key. This will cause the brackets to be placed around the "ENGINE" selection. Then press "ENTER".

HARD START/NO START DIAGNOSTICS

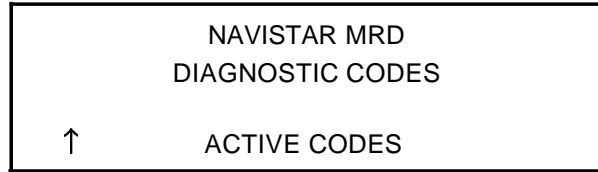
T 444E ENGINE
EST TOOL-FAULT CODES (Continued)

From the next menu select "DIAGNOSTIC CODES". The selection will have the "I↓" symbol on the screen. This means there are other selections available. By pressing the "↓" key the other selections will display on the screen. Press "↓" key until "DIAGNOSTIC CODES" appears on the screen.

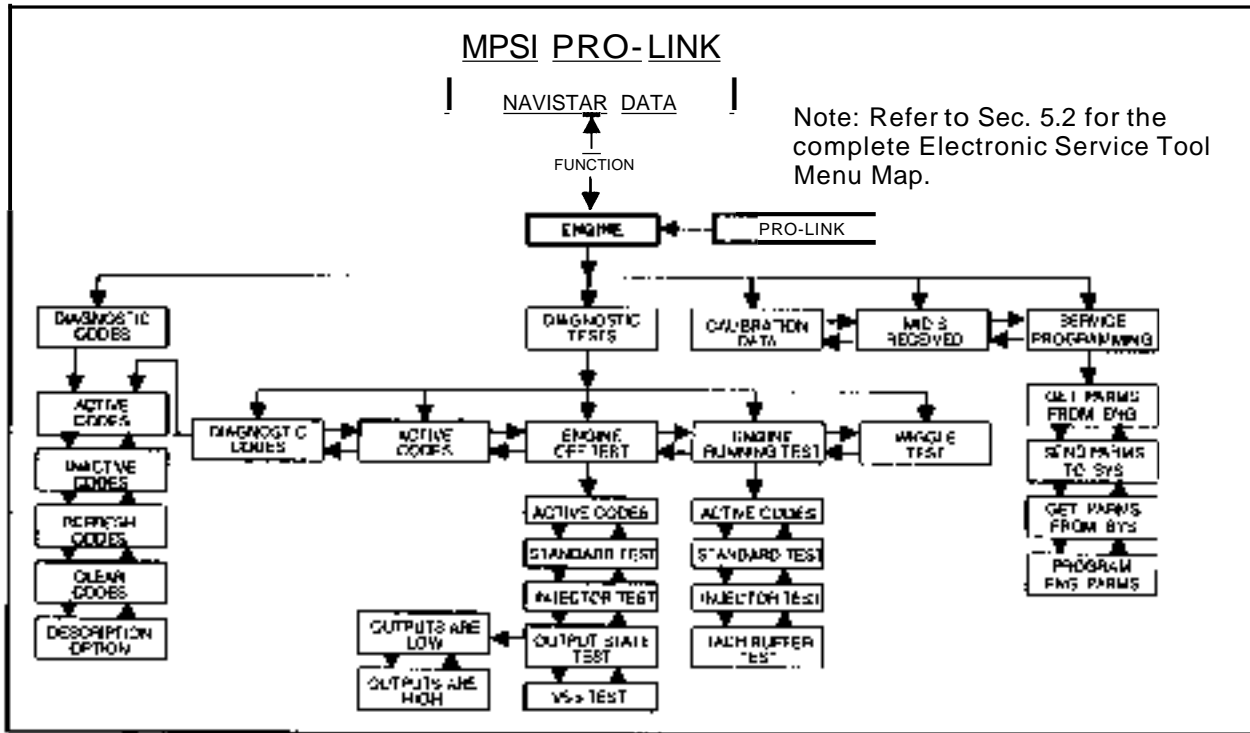


Next press "ENTER". This causes the EST to enter the diagnostic codes section. From this point, diagnostic codes can be accessed.

The first option that will appear is "ACTIVE CODES". By selecting this option, the fault codes that are currently occurring or that have occurred since the last key off cycle will be displayed.



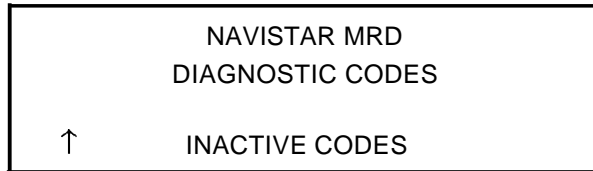
Press "ENTER". If there are any "Active Codes", the first one will appear on the screen along with a description of the code. If there are any additional codes "Active" the "↑↓" symbol will appear on the screen. Press "↓" key to access additional codes. If there are not any codes "Active", "NO ACTIVE CODES" will appear on the screen.



T 444E ENGINE

EST TOOL-FAULT CODES (Continued)

To access "Inactive Codes" press the "FUNC" key. This will access the last prior menu selection. Then press the "↓" key to select "INACTIVE CODES". Press the "ENTER" key.



Inactive codes are faults that have occurred prior to the last key off cycle and are now stored in memory. An "Active Code" will become an "Inactive" code if the key is shut off.

Record all fault codes that are found. If there are any fault codes found, refer to Electronic Control System Diagnostics, Section 3.5.

NOTE: ALL CURRENT FAULT CODES MUST BE REPAIRED AND (CLEARED), BEFORE PRO-

CEEDING WITH FURTHER DIAGNOSTIC TESTING.

POSSIBLE CAUSES

Electronic Control Module (ECM) detectable faults which will cause a hard or no start condition are:

- Camshaft Position (CMP) sensor faults.
- Injection Pressure Regulator (IPR) output circuit check fault.
- Fuel Demand Command Signal (FDCS) and Cylinder Identification (CI) output circuit check faults.

TOOLS REQUIRED

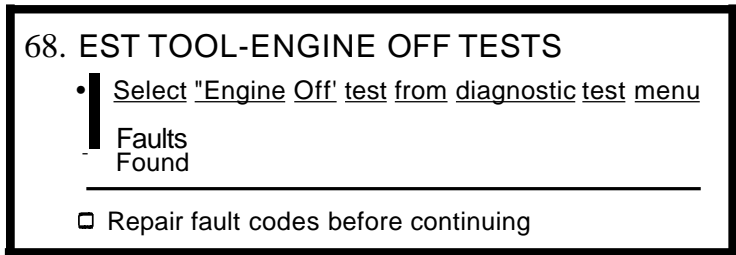
PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to Electronic Diagnostic form EGED-135-1 and fault code diagnosis.

T 444E ENGINE
EST TOOL-ENGINE OFF TESTS

FROM FORM EGED-130-1



PURPOSE

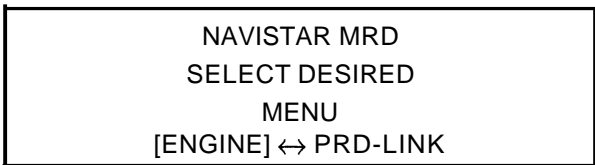
To determine if there are any electrical malfunctions that can be detected by the Electronic Control Module (ECM) during an on demand self test.

TEST PROCEDURE

NOTE: ACCESS "DIAGNOSTIC CODES" MENU IN EST AND CLEAR ALL FAULT CODES BEFORE PERFORMING ENGINE OFF TESTS.

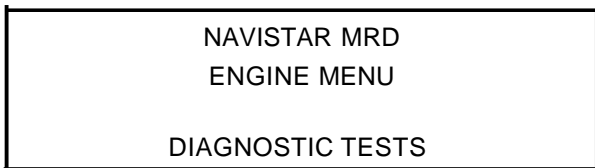
Access the "ENGINE OFF TESTS" in the "DIAGNOSTIC TESTS" section of the Electronic Service Tool (EST).

Press the "FUNC" key repeatedly, until the main menu appears on the screen.

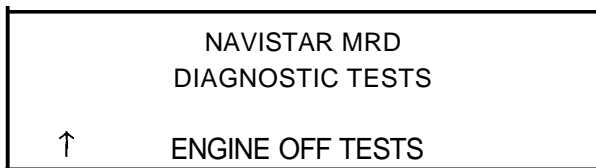


Move the brackets to engine selection by pressing the "←" key, then press "ENTER"

Next select the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "DIAGNOSTIC TESTS" is shown on the screen. Press "ENTER" to make this selection.



Press the "↓" key, until the "ENGINE OFF TESTS" is shown on the screen. At this point, press "ENTER"



After the "ENTER" key is pressed, the EST will command the ECM to perform a [(OCC) Output Circuit Check] self test. During this test, the ECM will test the electrical continuity of the output circuits.

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press "ENTER" and the faults will be displayed. If there is more than one fault that was found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults.

NOTE 1: IF FAULT CODES WERE NOT CLEARED BEFORE RUNNING ENGINE OFF TESTS, ALL 10M FAULTS AND ASSOCIATED CODES RECORDED DURING THE TEST WILL BE STORED AS "INACTIVE" CODES BY THE EST. TO READ THE CODES, ACCESS THE "INACTIVE" CODE MENU.

NOTE 2: THE PROGRAM IN THE EST WILL ONLY ALLOW THE ENGINE OFF TESTS MENU TO BE ACCESSED ONCE. TO REPEAT ENGINE OFF TESTS, SELECT "STANDARD TEST" TO RERUN THE ENGINE OFF TESTS.

POSSIBLE CAUSES

- Defective electrical components or circuitry.
- Injection Pressure Regulator (IPR) output circuit check fault.
- Fuel Demand Command Signal (FOGS) and Cylinder Identification (GI) output circuit check faults.

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS


If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

T 444E ENGINE
EST-INJECTOR "BUZZ TEST"

FROM FORM EGED-13Q-1

6b. EST-INJECTOR "BUZZ TEST"

- Select "Injector Test" from "The Engine Off Tests" menu



□ See Electronic Diagnostic Form for Codes

PURPOSE

To determine if the injectors are electronically functioning correctly, by energizing each injector in a programmed sequence. The Electronic Control Module (ECM) and Injector Drive Module (IDM) will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

TEST PROCEDURE

NOTE 1: ACCESS "DIAGNOSTIC CODES" MENU IN EST AND CLEAR ALL FAULT CODES.

NOTE 2: ENGINE OFF TEST MUST BE PERFORMED FIRST IN ORDER TO ACCESS THE INJECTOR "BUZZ" TEST.

After the "Engine Off Test" has been completed, press the "↓" key to access the "INJECTOR TEST". If the tool is not on a menu screen, i.e. displaying of fault codes etc., press the "FUNC" key. This will access the "DIAGNOSTIC TESTS" menu. Press "ENTER" to begin the test.

NAVISTAR MRD
DIAGNOSTIC TESTS

↑ INJECTOR TEST

During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector(s) by listening for the absence of the solenoid clicking sound.

NOTE: IF FAULT CODES WERE CLEARED BEFORE THE INJECTOR "BUZZ" TEST, FAULT CODES DISPLAYED WILL BE ACTUAL FAULTS FOUND DURING THE TEST. IF CODES WERE NOT CLEARED BEFORE TESTING, ACCESS "INACTIVE" FAULT CODES FROM DIAGNOSTIC CODES MENU TO RETRIEVE FAULTS FOUND DURING THIS TEST.

At the completion of the Injector Test, any faults that have been detected will be displayed. If there is more than one fault the "↑↓" symbol will be displayed. These additional faults can be accessed by pressing the "↓" key.

Record any faults found and refer to the Electronic Control System Diagnostics, Section 3.5.

POSSIBLE CAUSES

- Bad wiring harness connection at injector solenoid.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s).
- Defective IDM.

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

T 444E ENGINE
STI-BUTTON FLASH CODES

FROM FORM EGED-13Q-1

7. STI-BUTTON FLASH CODES

- Depress and hold "Engine Diagnostics" switch, then turn the ignition switch to the "ON" position.

Faults Found

Refer to Electronic Diagnostic form,
if fault code(s) set

PURPOSE

To read faults detected by the Electronic Control Module (ECM), if the Electronic Service Tool (EST) is not available or the EST cannot receive "Self Test Input" data due to communications or component failures.

The Self Test Input (STI) switch is located on the vehicle dashboard (Figure 2.2-5.) labeled "ENGINE DIAGNOSTICS". Depressing the STI switch on the dash while turning the ignition switch to the "ON" position, will signal the ECM to start the Self Test Input diagnostics to check output circuits. If any faults are detected, the ECM will flash the "WARN ENGINE" light to indicate which faults have been detected.

NOTE: SELF TEST INPUT DIAGNOSTICS WILL NOT FLASH VPM FAULT CODES.

TEST PROCEDURE

Depress and hold the STI switch (located on vehicle dash). Turn the ignition switch to the "ON" position. Do Not Start The Engine. The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the red "OILWATER" light and amber "WARN ENGINE" light to signal the fault codes.

NOTE: FAULT CODES CAN BE ACCESSED AT ANYTIME BY TURNING THE IGNITION SWITCH TO THE "ON" POSITION (DO NOT START ENGINE) AND DEPRESSING THE STI SWITCH.

To read the fault codes it will be necessary to count the number of times the "ENGINE WARN" light flashes. The following sequence of events occur each time the STI switch is depressed to obtain the fault codes:

1. The "OILWATER" light will flash one time to indicate the beginning of Active fault codes.

2. The "WARN ENGINE" light will flash repeatedly signaling the active fault codes.

NOTE: All FAULT CODES ARE THREE DIGITS AND CODE 111 INDICATES "NO FAULTS" HAVE BEEN DETECTED.

3. Count the number of flashes in sequence. At the end of each digit of the code there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes a pause, and two flashes a pause would indicate the code 232. If there is more than one fault code, the "OILWATER" light will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the "OILWATER" light will flash twice to indicate the beginning of INACTIVE codes. Count the number of flashes from the "WARN ENGINE" light. If there is more than one inactive code, the "OILWATER" light will flash once in-between each fault code.

After all codes have been sent, the "OILWATER" light will flash three times indicating "END OF MESSAGE".

To repeat transmission of fault codes, depress the "ENGINE DIAGNOSTICS" switch which will signal the ECM to resend all stored fault codes.

If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

POSSIBLE CAUSES

- Electronic component or circuitry failures.

TOOLS REQUIRED

None.

T 444E ENGINE
STI BUTTON-FLASH CODES (Continued)

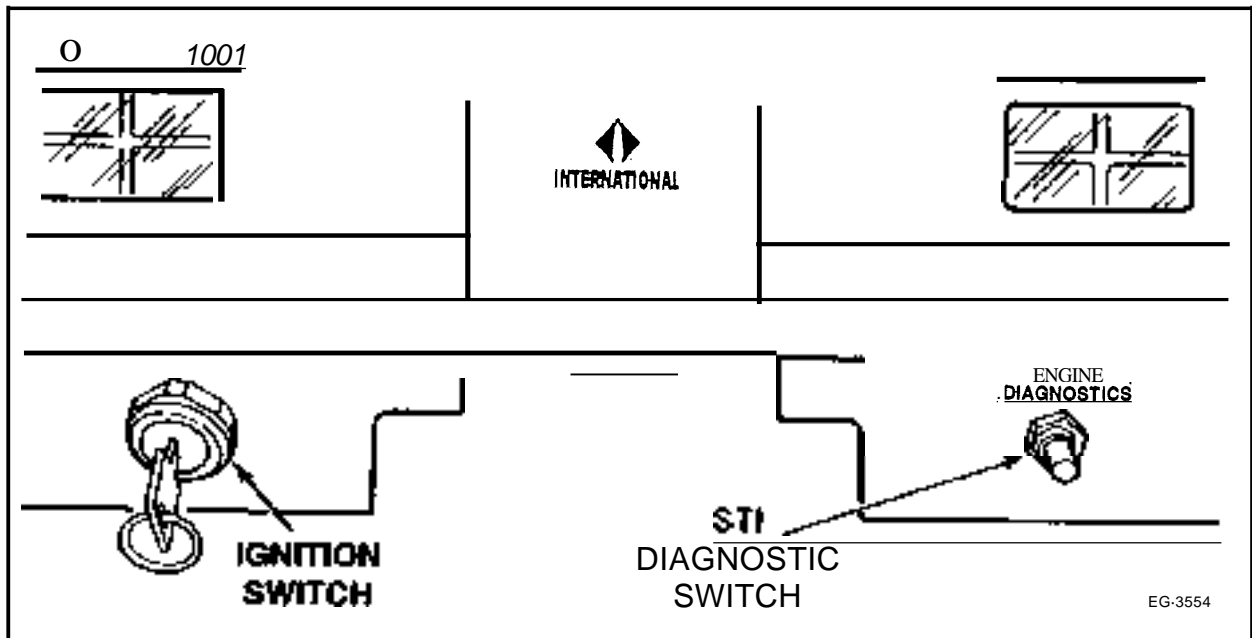


Figure 2.2-5. - Self Test Input (STI) Diagnostic Switch Location on Vehicle Dash

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
EST TOOL-DATA LIST

FROM FORM EGED-13Q-1

8. EST TOOL-DATA LIST

- Select and enter the following data as the first three lines in a custom data list
- Monitor the data while cranking the engine for 20 seconds minimum

Data	Spec.	Actual
Bat. voltage	7 volts min.	
Eng. RPM	130 RPM min.	
ICP pressure	800 PSI min.	

- If voltage is low, proceed to Test 9a.
- If no RPM is noted, recheck fault codes and proceed to Test 9b.
- If ICP pressure is low, refer to diagnostic manual EGES-125-1 for system leakage tests

PURPOSE

To determine if the components needed for starting are operating within specifications.

TEST PROCEDURE

IMPORTANT NOTE

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

To measure engine cranking speed, battery voltage, and Injection Control Pressure (ICP), it may be possible to read the data on the Electronic Service Tool (EST), "DATA LIST", while the engine is cranking. If the voltage drops below 7 volts while cranking, the EST tool will "RESET" back to start-up. If this happens, the tool cannot be used to perform this test. Refer to Test 9, "Testing Voltage, RPM and ICP individually"

NOTE: TURN ALL ACCESSORIES AND THE IGNITION OFF, BEFORE CONNECTING EST TOOL TO ATA DIAGNOSTIC CONNECTOR.

Connect the EST tool to the American Trucking Association (ATA) diagnostic connector. The connector is located on the lower left kick panel inside the cab. The screen of the reader should light up as soon as the tool is plugged in.

Turn the ignition switch to the "ON" position. Do not start the engine. This will allow the EST to receive data from the electronic control components on the truck. If no data is received press "ENTER" to retry. The information received will be data indicating the current status of the engine.

RATED HP	190
RATED RPM	2300
ACTIVE CODES	NO
INACTIVE CODES	NO

Press the "↓" key until "BAIT VOLTS" appears on the screen. Continue to press the "↓" key until "SATT VOLTS", is at the top of the screen. Pressing the number "1" key, a block dot will appear on line number one.(I).

BATIVOLTS	12.5
ENG. OIL TEMP	75 F
AMBIENT AIR	75 F
COOLANT TEMP	75 F

This will "Freeze the "BATT VOLTS" on line one. Now press the "↓" key until "ENGINE RPM" appears on the second line of the screen. Press the number "2" key to freeze "ENGINE RPM" on line two of the screen.

BATTVOLTS	12.5
ENGINE RPM	0
BOOST PSI	0
BARO IN Hg.	14.4

Continue to press the "↓" key until "INJ CNTL PSI" is on the third line. Then press the number "3" key to freeze "INJ CNTL PSI" on line three.

EGES-125-1

T 444E ENGINE

EST TOOL-DATA LIST (Continued)

|	BATIVOLTS	12.5
|	ENGINE RPM	0
|	INJ CNTL PSI	0
	FUELGAUHR	0.3

The EST is now ready to read the data needed. Crank the engine while observing the data on the screen. If the EST recycles to the entry screen or shuts down, it will be necessary to measure the values separately. If this is required continue on to steps 9A through 9C. Record the data on the diagnostic form.

The battery voltage must be 7 or more volts. If the voltage to the Electronic Control Module (ECM) drops below 7 volts, the ECM will not remain powered up. If the ECM is not receiving power via the ECM relay, the engine cannot be started.

Engine cranking RPM must be sufficient to generate the required Injection Control Pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

A "0" RPM indication on the Electronic Service Tool (EST) during engine cranking, indicates the ECM may not be receiving a signal from the Camshaft Position (CMP) sensor. Refer to CMP sensor diagnostics in Section 3.5 Electronic Control System Diagnostics.

If the CMP sensor is inoperative, it must be repaired before continuing. The ECM will not allow the Injector Pressure Regulator (IPR) valve to fully activate without a CMP signal.

If injection control pressure is low, remove the inspection plug in top of the oil reservoir and recheck the oil level. (If the engine has not been operated for some time, the oil may have drained into the crankcase.) If oil level is low, fill the reservoir. If the oil level in the reservoir continues to decline, the engine may not be pumping oil to the reservoir.

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

POSSIBLE CAUSES

- Low battery voltage. Due to "faulty" batteries, high resistance at battery cable connections or in the wiring to the ECM.
- Defective ECM power relay.

- Blown 15A inline fuse (located in battery box) which supplies battery power (voltage) to ECM.
- Blown fuse F5 at ECM power relay control terminal 86.
- Low cranking RPM. May be caused by electrical system malfunctions, incorrect oil or extended oil change intervals in cold ambient temperatures.
- No engine RPM indication on EST while cranking the engine. CMP sensor or faulty circuitry to the ECM may cause this condition. Recheck for fault codes after cranking engine. (Refer to Test 5 or 7).
- A defective high pressure oil pump or pump drive will prevent proper injection control pressure. A defective Injection Pressure Regulator (IPR), or electronic controls for the regulator will cause low injection control pressure.

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

- Starting system diagnostics. Refer to Electrical section CTS-511 0 of the Truck Service Manual.
- Low voltage at ECM. Refer to Electronic Control Module Power Supply (ECM PWR) in (Section 3.5) Electronic Control System Diagnostics.
- No Engine RPM indication during engine cranking. Refer to CMP sensor diagnostics in Electronic Control System Diagnostics Section 3.5.
- No Injection Control Pressure. Refer to Injection Control Pressure (ICP) sensor, IPR valve diagnostics in Electronic Control System Diagnostics Section 3.5.
- No injection control pressure and no electronic faults. - Refer to Test 9C.
- If ICP pressure is low, refer to High Pressure Leakage Tests on page NO TAG.

T 444E ENGINE
ECM VOLTAGE

FROM FORM EGED-13Q-1

9a. ECM VOLTAGE

- Check while cranking engine
- Measure with DVOM
- Breakout box pins 57+ & 40-

Instrument	Spec.	Actual
DVOM 57+ & 40-	7 volts minimum	

D If voltage is low, refer to ECM diagnostics

PURPOSE

To determine if there is sufficient voltage and current to operate the Electronic Control Module (ECM) and Injector Drive Module (IDM). The ECM and IDM require 7 volts minimum to operate and drive the injectors. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

TESTS MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

VOLTAGE MEASUREMENT AT BATTERY

1. Connect a DVOM (Digital Volt Ohm Meter) across the battery terminals.
2. Turn all accessories off and turn the ignition switch to the "ON" position.
3. Wait for the glow plug system to cycle, then crank the engine.

Record the lowest voltage obtained during engine cranking. If the voltage is below 7 volts, the 10M and ECM power relays may be resetting due to the lack of voltage and current from the batteries or a problem exists in the starting system.

If voltage is within specification, perform Voltage Measurement At The ECM Relay.

VOLTAGE MEASUREMENT AT THE ECM RELAY

The ECM power relay is located (Refer to Section 7, Vehicle and Component Illustrations) on the

engine cowl and mounted on a bracket over the IDM.

1. Connect a DVOM (+ lead) to terminal 87{ wire 97AR) of the ECM relay and the (-lead) to battery ground.
2. Turn all accessories off and turn the ignition switch to the "ON" position.
3. Wait for the glow plug system to cycle, then crank the engine.
4. Observe and record voltage while engine is cranking.

If no voltage is present at terminal 87(wire 97AR), refer to Electronic Control Module Power Supply (ECM PWR) in (Section 3.5) Electronic Control System Diagnostics. If voltage is 7 or more volts, proceed with voltage check using the breakout box.

VOLTAGE MEASUREMENT AT ECM WITH BREAKOUT BOX (FIGURE 2.2-6.)

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.
2. Remove the 60 way connector from the ECM. Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

T 444E ENGINE
ECM VOLTAGE (Continued)

VOLTAGE MEASUREMENT AT ECM
WITH BREAKOUT BOX (Continued)

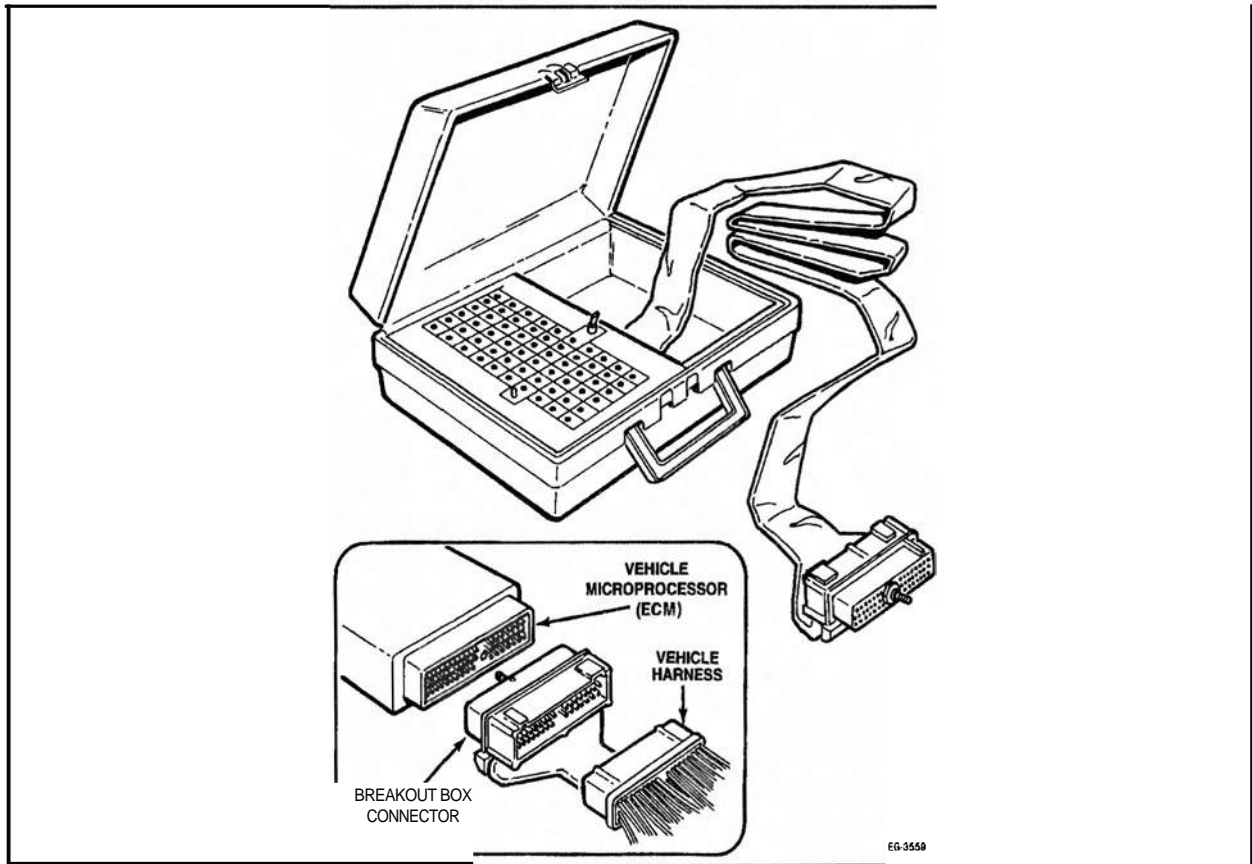


Figure 2.2-6. - Breakout Box (ZTSE-4346)

4. Connect the positive lead of the voltmeter to terminal 57 and the negative lead to terminal 40 on the breakout box.
5. Turn the ignition switch to the "ON" position. Wait for the glow plug system to cycle, then crank the engine. Record the lowest voltage observed while cranking engine.
6. If voltage is lower than 7 volts, repair the ECM power feed circuit. Refer to Electronic Control Module Power Supply (ECM PWR) in (Section 3.5) Electronic Control System Diagnostics.

POSSIBLE CAUSES

- Low battery voltage. Due to "faulty" batteries,

high resistance at battery cable connections or defective starter.

- Low or no battery voltage to the ECM. - May be due to high resistance or an open circuit in the power feed circuit to the ECM or its power relay. The ECM power circuit fuse, F5, may be open or the ECM power relay may be defective.

TOOLS REQUIRED

DVOM and breakout box.

SUPPLEMENTAL DIAGNOSTICS

- Refer to Electronic Control Module Power Supply (ECM PWR) in (Section 3.5) Electronic Control System Diagnostics.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
ENGINE CRANKING RPM

FROM FORM EGED-13Q-1

9b. ENGINE CRANKING RPM

- Minimum 130 RPM engine cranking speed for 20 seconds.
- Breakout box pins 34+ & 46- with Fluke 88

Instrument	Spec.	Actual
Fluke 88 34+ & 46-	130 RPM minimum	

c If no RPM is noted, recheck fault codes

PURPOSE

To determine if engine cranking speed is high enough to start the engine. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

Engine cranking RPM must be sufficient to generate the required Injection Control Pressure to operate the fuel injectors and to create enough compression heat to ignite the fuel.

A "0" RPM indication on the Electronic Service Tool (EST) during engine cranking, may indicate the ECM is not receiving a signal from the Camshaft Position (CMP) sensor. Refer to CMP sensor diagnostics, in Electronic Control System Diagnostics, Section 3.5.

If the CMP sensor is inoperative, it must be repaired before continuing. The ECM will not allow the Injector Pressure Regulator (IPR) valve to fully activate without a CMP signal.

CHECKING CRANKING RPM WITH BREAKOUT BOX

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.
2. Remove the 60 way connector from the Electronic Control Module (ECM). Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

4. Connect the (+ lead) of the Fluke 88 to terminal 34 and the (-lead) to terminal 46. Select the DC voltage scale and press the "RPM" button.
5. Crank the engine while observing the Fluke 88. A minimum of 130 RPM is necessary to start the engine.
6. Record cranking engine RPM on diagnostic form.

NOTE: IF NO ENGINE RPM IS MEASURED WITH THE FLUKE 88, CHECK FOR ADDITIONAL FAULT CODES. REFER TO TESTS 5 & 7 AND ELECTRONIC CONTROL SYSTEM DIAGNOSTICS SECTION 3.5, FOR CAMSHAFT POSITION (CMP) SENSOR DIAGNOSTICS.

POSSIBLE CAUSES

- Low cranking RPM. Starting system electrical malfunctions. Incorrect oil type or extended oil change intervals in cold ambient temperature conditions.
- No engine RPM. Poor connection at CMP sensor wiring harness connector, wiring harness to sensor open or shorted or CMP sensor is defective.

TOOLS REQUIRED

Fluke 88 DVOM (ZTSE-4357) and breakout box (ZTSE-4346).

SUPPLEMENTAL DIAGNOSTICS

- Refer to CMP sensor diagnostics, in Electronic Control System Diagnostics, Section 3.5.

T 444E ENGINE
INJECTION CONTROL PRESSURE

FROM FORM EGED-13D-1

9c. INJECTION CONTROL PRESSURE

- Check during engine cranking. (min. 130 RPM)
- Measure with w/breakout box pins 27+ and 46 - or breakout "tee" signal (green) & ground (black)

Instrument	Spec.	Actual
DVOM 27+ & 46-	1 to 4 volts	

○ If less than 1 volt, recheck oil level in reservoir.
If ICP pressure is low, refer to diagnostic manual EGES-125-1 for system leakage tests.

PURPOSE

To determine if the injection control pressure system is supplying sufficient oil pressure to start and operate the engine. This is an alternate method to be used if the Electronic Service Tool (EST) is unavailable or fails to function properly. Insufficient electrical power from the batteries or an electronic failure may inhibit the EST from receiving diagnostic data.

TEST PROCEDURE

MEASURING INJECTION CONTROL PRESSURE USING BREAKOUT BOX (FIGURE 2.2-7.)

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.
2. Remove the 60 way connector from the ECM.

Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.

3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.
4. Connect the positive lead of the DVOM to terminal 27 and the negative lead to terminal 46.
5. Crank the engine while observing the DVOM and record the injection control pressure voltage signal on diagnostic fonn. If Injection Control Pressure (ICP) pressure is low, refer to High Pressure Leakage Tests.

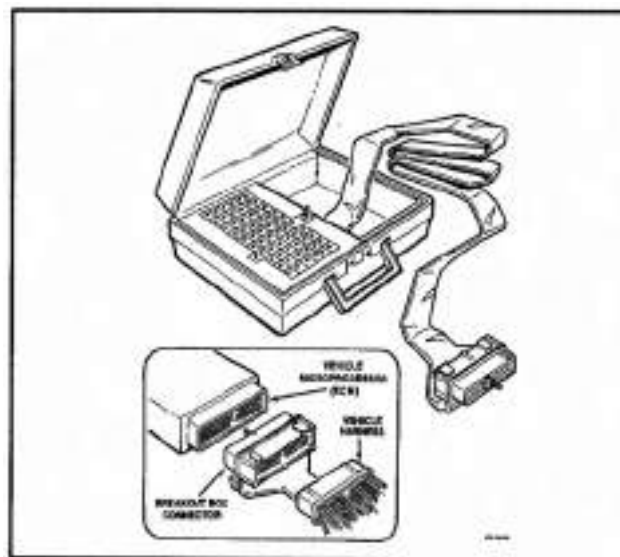


Figure 2.2-7. - Breakout Box (ZTSE-4346)

HARD START/NO START DIAGNOSTICS

T 444E ENGINE

INJECTION CONTROL PRESSURE - Continued

ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING (BREAK-OUT "TEE")

1. Remove engine harness connector at ICP sensor.
2. Connect the breakout "TEE" to the removed engine harness connector and the ICP sensor.
3. Connect DVOM leads (+Green, -Black) to the

breakout "TEE" as shown in Figure 2.2-8.

4. Crank engine and observe DVOM voltage reading. Record reading on diagnostic form. If voltage is low, recheck oil level in reservoir to confirm the reservoir contains a sufficient supply of oil to enable the injection control system to function properly. If oil level is ok, proceed to High Pressure Leakage tests.

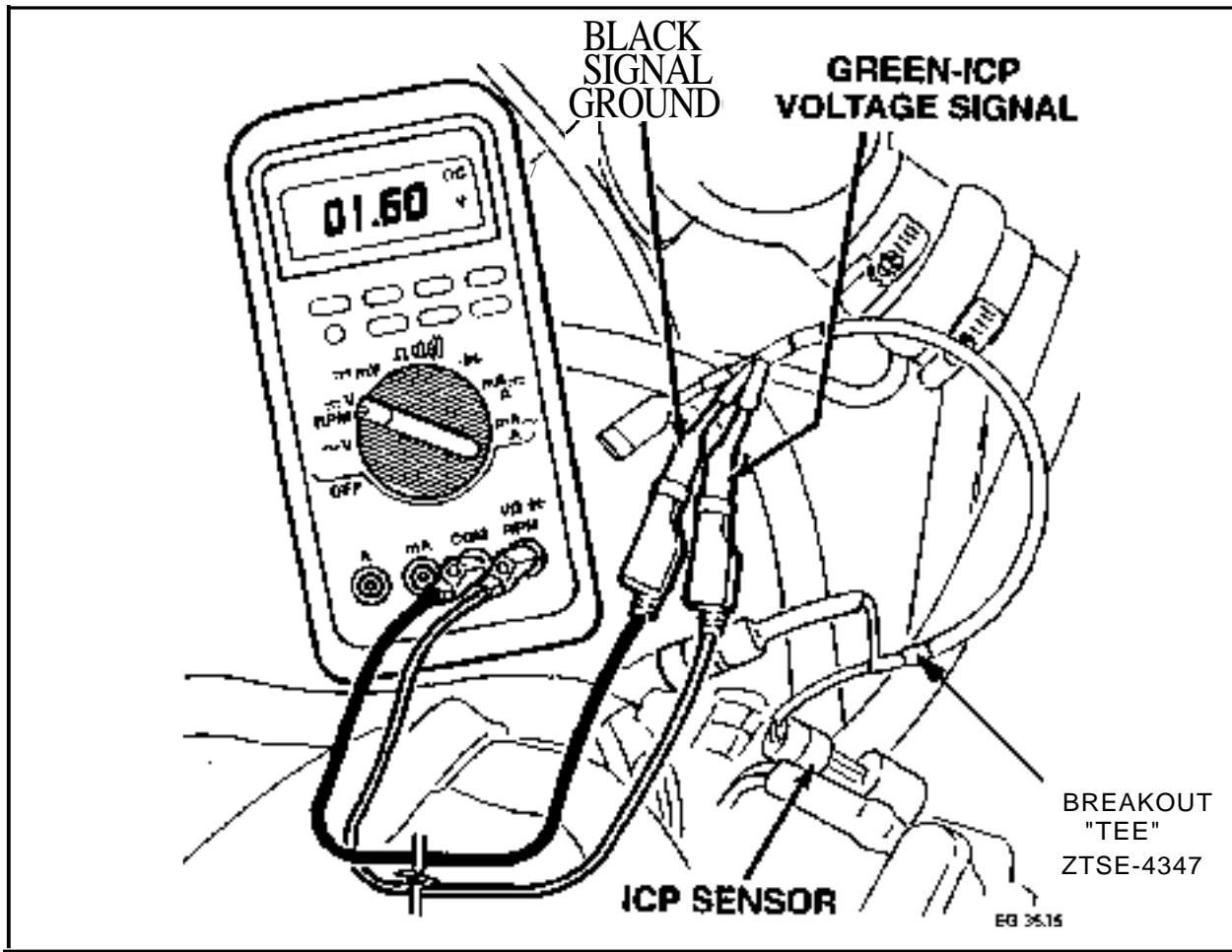


Figure 2.2-8. - Injection Control Pressure.

T 444E ENGINE HIGH PRESSURE LEAKAGE TESTS

ISOLATE RIGHT CYLINDER HEAD

Remove high pressure hose from the right cylinder head (Figure 2.2-9.). Use an Aero Equip size 6 flare plug and install into the high pressure hose to block it off. Crank the engine and monitor the Injection Control Pressure (ICP) signal.

CAUTION THE ENGINE MAY START!

If the engine fails to start, refer to procedure on Isolating Left Cylinder Head. If the engine starts or the ICP pressure is now within specifications, the injection control pressure leak has been isolated to the right cylinder head.

1. Remove flare plug from the high pressure supply hose and reconnect hose to right cylinder head.
2. Remove valve cover on right cylinder head.
3. Crank the engine and inspect the injector body and bore area for leakage. If no leakage is detected, perform ICP Leakage Test page 25.

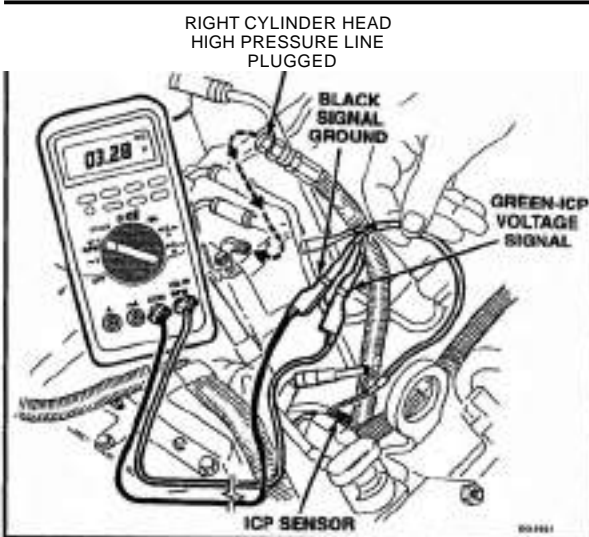


Figure 2.2-9. - Isolating Right Cylinder Head

ISOLATE LEFT CYLINDER HEAD

Remove the plug (from previous step) in the right cylinder head high pressure hose and reconnect hose to cylinder head. Remove the high pressure hose from the left cylinder head. Remove the ICP sensor and assemble it to the ICP adapter. Install the ICP sensor/adaptor onto the high pressure hose (Figure 2.2-10.). Crank the engine and monitor the ICP signal.

NOTE: If the ICP pressure is not within specification proceed to IPR and High Pressure Pump Test page 24.

If the engine starts, or the ICP pressure is now within specifications, the injection control pressure leak has been isolated to the left cylinder head. Reattach the left side high pressure hose. Remove left valve cover and crank the engine. Inspect the injector body and bore area for oil leakage. If no leakage is detected, perform ICP Leakage Test page 25.

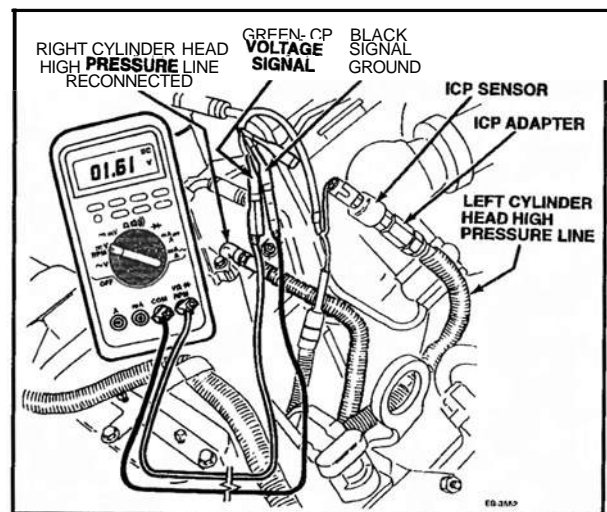


Figure 2.2-10. - Isolating Left Cylinder Head

HARD START/NO START DIAGNOSTICS

T 444E ENGINE

HIGH PRESSURE LEAKAGE TESTS (Continued)

IPR AND HIGH PRESS PUMP TEST

If injection control pressure is still low after isolating both cylinder heads, leave the ICP sensor adapter in the left hose and reinstall the flare plug to block the right high pressure hose (Figure 2.2-11.) and crank the engine. This has effectively deadheaded

the high pressure pump. If pressure is still not developed, inspect the IPR (Injection Pressure Regulator) valve for debris and/or replace with a known good valve and retest. If pressure is still low, check the high pressure pump and drive gear. The gear may be loose or the pump may be defective.

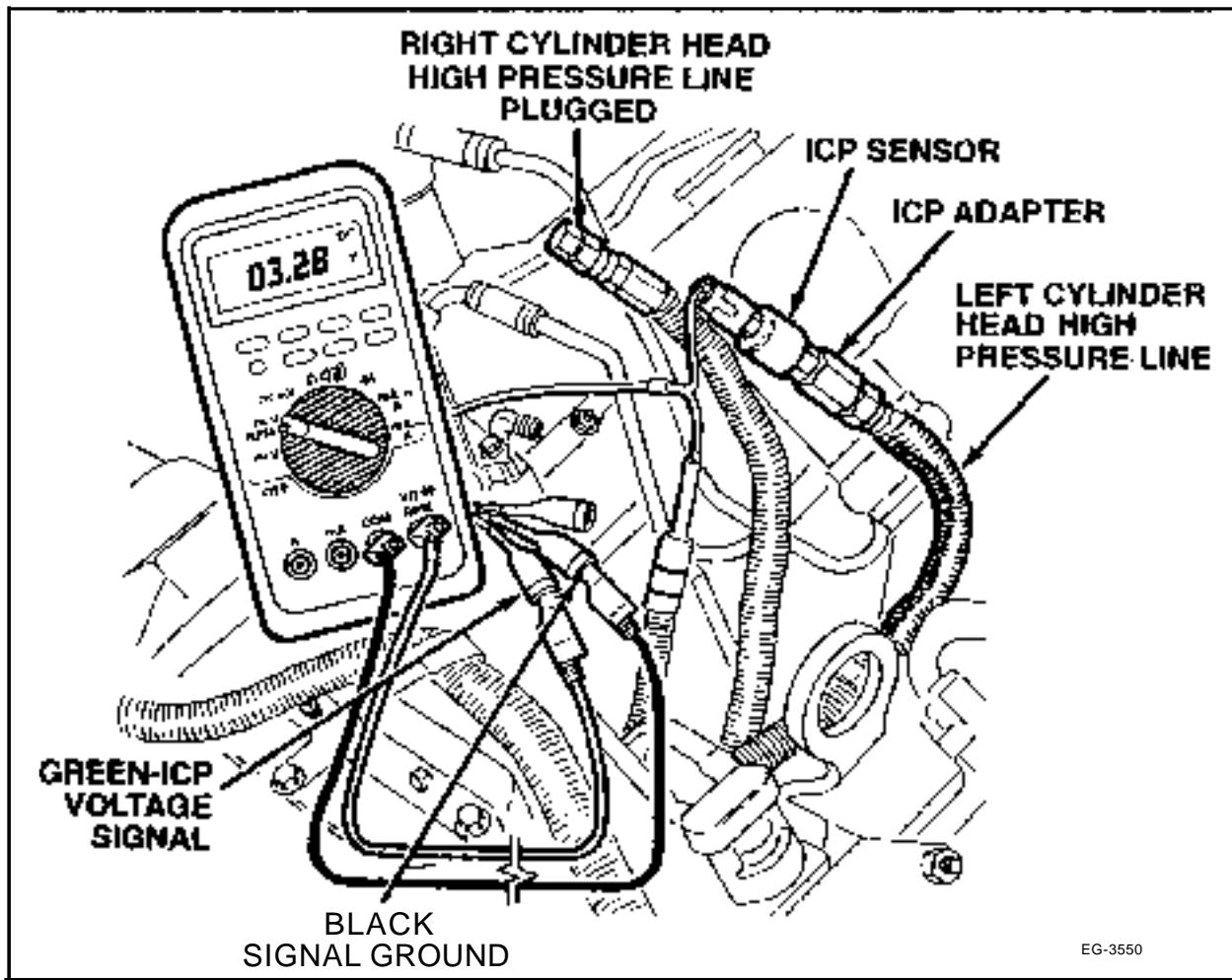


Figure 2.2-11.-IPR and High Pressure Pump Test

T 444E ENGINE ICP LEAKAGE TEST

1. Reconnect all high pressure oil lines disconnected in the process of isolating the cylinder head which is causing a loss of ICP pressure.
2. Remove the high pressure supply line of the suspect leaking cylinder head at the high pressure pump Figure 2.2-12..
3. Connect a regulated air supply Figure 2.2-13. to the high pressure supply oil line removed in the previous step.
4. Apply 100 psi of pressure from the regulated air source and inspect for leakage around the injectors.
5. With the fuel lines removed from the fuel regulator block, inspect for oil leakage out of each of the disconnected fuel lines. If oil is seeping out of the disconnected fuel lines remove all injectors in the cylinder head being tested and inspect injectors for worn "O" rings or obvious damage.

If leakage is observed at an injector, remove and inspect injector for obvious damage or worn "O" rings.

If no leakage is present, perform Injector "Buzz" test with air pressure still applied. Observe oil discharge from each of the injectors. Oil discharge should be equal from all injectors. If excess oil is discharged from an injector(s), the injector(s) may be defective.

If it is difficult to determine which injector(s) are leaking remove air supply and regulator from the high pressure oil supply hose and:

- A. Connect an automotive cylinder leak tester to the high pressure supply hose and apply air pressure via the cylinder leak tester.
- B. Conduct an Injector "Buzz" test and observe the percent cylinder leakage while each injector is activated. Remove and inspect injectors which exhibit a greater amount of leakage compared to the others.
- C. If none of the injectors indicate an excessive amount of leakage, remove all injectors. Inspect all "O" rings for wear and damage. All "O" rings should be replaced.

If oil was entering the fuel system, drain fuel tanks and dispose of the contaminated fuel properly.

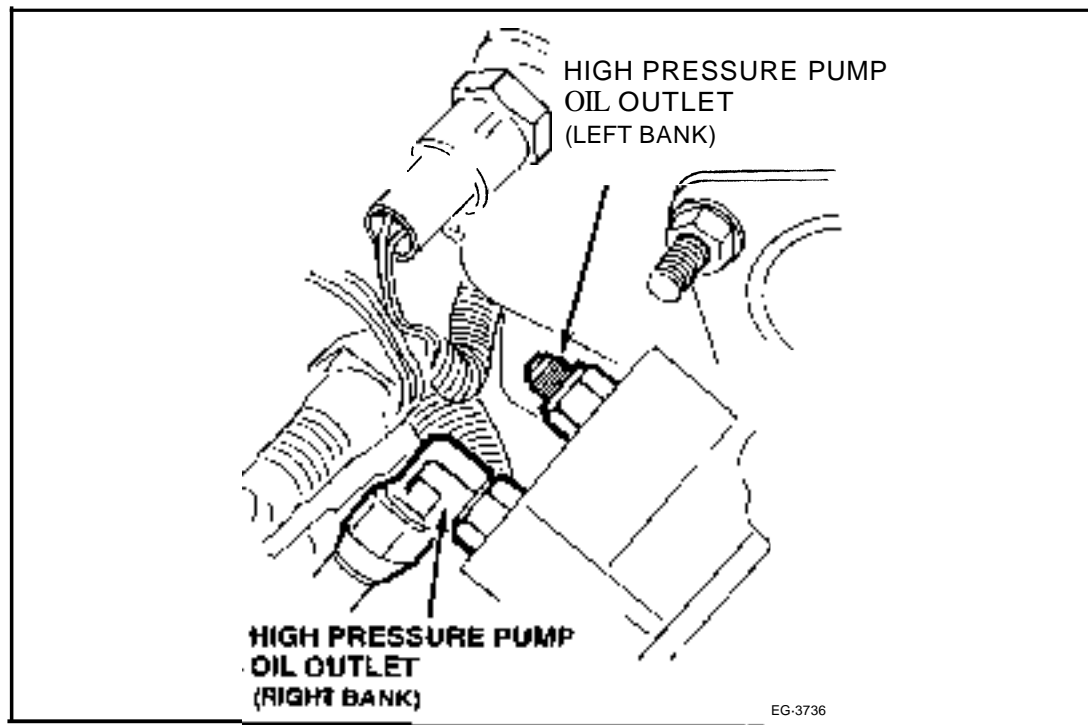


Figure 2.2-12. - High Pressure Pump Oil Outlet Locations

T 444E ENGINE
ICP LEAKAGE TEST (Continued)

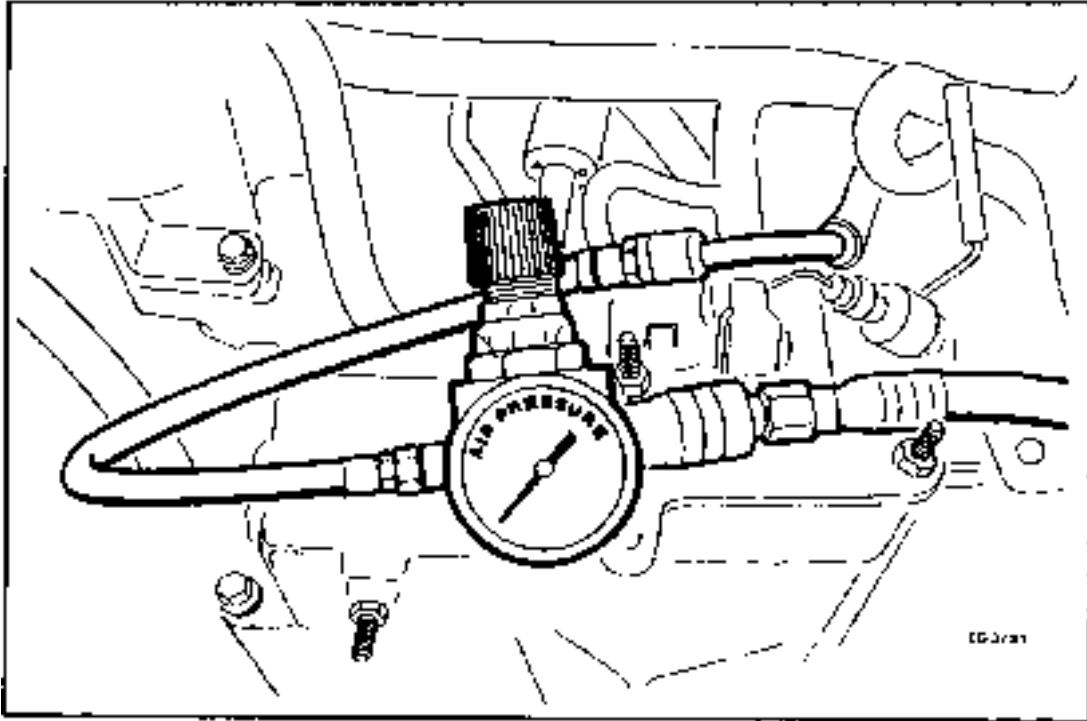


Figure 2.2-13. -ICP Leakage Test

POSSIBLE CAUSES:

Low injection pressure (voltage) indicates the injectors are not receiving sufficient oil pressure to properly operate the fuel injectors. This may be caused by:

- No oil in engine.
- Oil reservoir leak down (possibly through high pressure pump check valve).
- Defective high pressure pump
- Injector "O" ring leak.
- Injector body leak.
- IPR valve stuck open.
- Pump drive gear loose or damaged.

TOOLS REQUIRED:

DVOM, ICP sensor breakout "T" (ZTSE-4347), rep adapter and an Aero Equip size 6 flare plug.

SUPPLEMENTAL DIAGNOSTICS

- Camshaft Position (CMP) sensor diagnostics, in Electronic Control System Diagnostics, Section 3.5.

T 444E ENGINE
FUEL PUMP PRESSURE

FROM FORM EGED-130-1

10. FUEL PUMP PRESSURE

- Measure at regulator block
- Minimum 130 RPM cranking speed for 20 seconds

Instrument	Spec.	Actual
0-160 PSI Gauge	20 PSI minimum	

○ If pressure is low, replace fuel filter and retest.

PURPOSE

To determine if fuel pressure is sufficient to start and operate the engine.

NOTE: IF THE FUEL FILTER IS EQUIPPED WITH A WATER-IN-FUEL PROBE, CHECK WITH VEHICLE OPERATOR TO DETERMINE IF THE WATER-IN-FUEL LAMP HAS BEEN ILLUMINATED DURING VEHICLE OPERATION.

TEST PROCEDURE

1. Remove 1/8" pipe plug located on the fuel regulator block (Figure 2.2-14.). Install 1/8 inch (3 mm) pipe fitting in place of the pipe plug.

2. Connect a line from the fitting to the 0-160 PSI gauge of the Model D-200 Pressure Test Kit.
3. Measure fuel pressure by cranking engine for 20 seconds and observing maximum pressure. Record pressure on diagnostic form and compare to specifications. If fuel pressure is low, change the fuel filter and retest.

NOTE: IT MAY TAKE A NUMBER OF CRANK CYCLES TO PURGE THE AIR OUT OF THE FUEL SYSTEM.

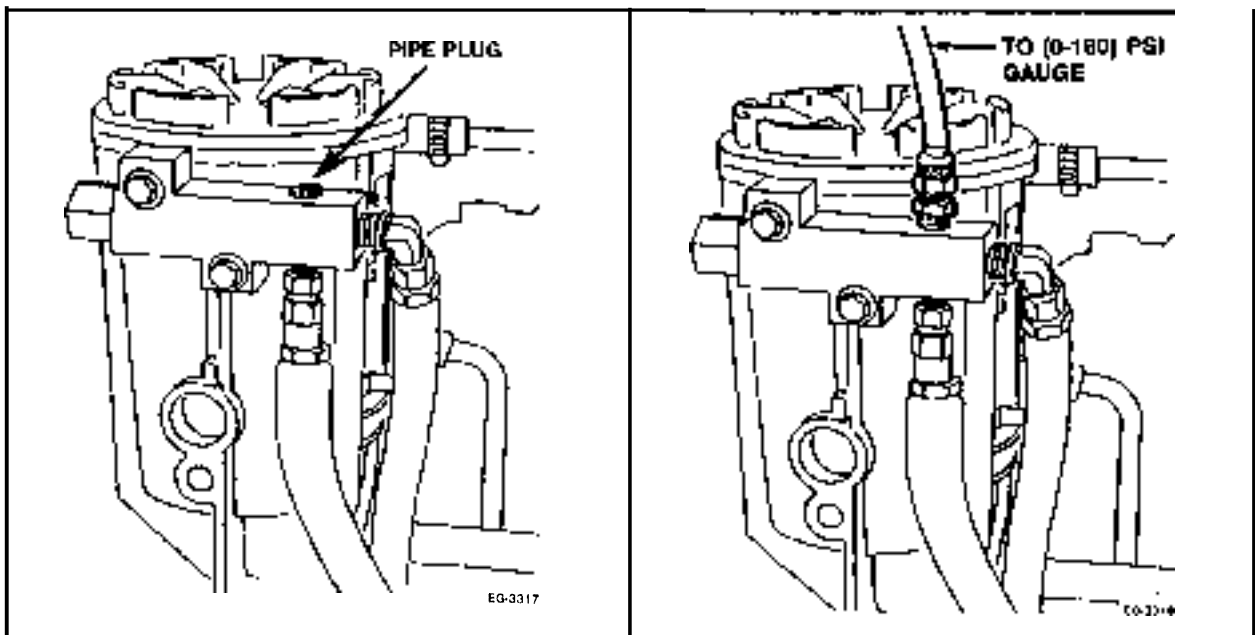


Figure 2.2-14. - Fuel Transfer Pump Pressure Check

T 444E ENGINE

FUEL PUMP PRESSURE (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Change filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.

- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Model D-200 Pressure Test Kit (ZTSE-2239) (0 to 160 PSI fuel pressure gauge), appropriate line with 1/8" NPT fitting.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
GLOW PLUG SYSTEM

FROM FORM EGED-13Q-1

11. GLOW PLUG SYSTEM Relay Operation

- Install a voltmeter to the glow plug feed terminal (terminal w/2 wires)
- Turn key to "ON" position, measure "ON" time.
- Verify sufficient glow plug "ON" time using voltmeter to verify glow plugs are receiving the required voltage within the specified time.

(Dependent upon coolant temperature, battery voltage and altitude)

	Spec.	Actual
Relay On Time	10 - 120 seconds	
Voltage	9 - 12 Volts	

(Relay may not cycle on, if engine is at operating temperature)

GLOW PLUG OPERATION

- Remove all glow plug/injector connectors.
- Measure glow plug resistance to Bat. Grd.
- Measure GP harness resistance to relay.

Glow Plug Number	Plug to Ground .1 to 6 Ohms	Harness to Relay < 1 Ohm
#1		
#3		
#5		
#7		
#2		
#4		
#6		
#8		

PURPOSE

To determine if the glow plug system is operating sufficiently to start a cold engine.

TEST PROCEDURE:

GLOW PLUG "ON" TIME

Connect a DVOM (Figure 2.2-15.) to the glow plug feed terminal (terminal with 2 wires) on the glow plug relay. The DVOM will verify that the glow plugs

are receiving the required voltage (9-12v) for the specified amount of time. Turn the ignition key to the "ON" position. **DO NOT ATTEMPT TO START ENGINE.** Note the time in seconds from when the ignition key is turned "ON" until the glow plug relay de-energizes (0 volts indication on the DVOM).

NOTE: GLOW PLUG "ON" TIME WILL BE AFFECTED BY ENGINE COOLANT TEMPERATURE, BATTERY CONDITION AND VEHICLE ALTITUDE.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
GLOW PLUG SYSTEM (Continued)

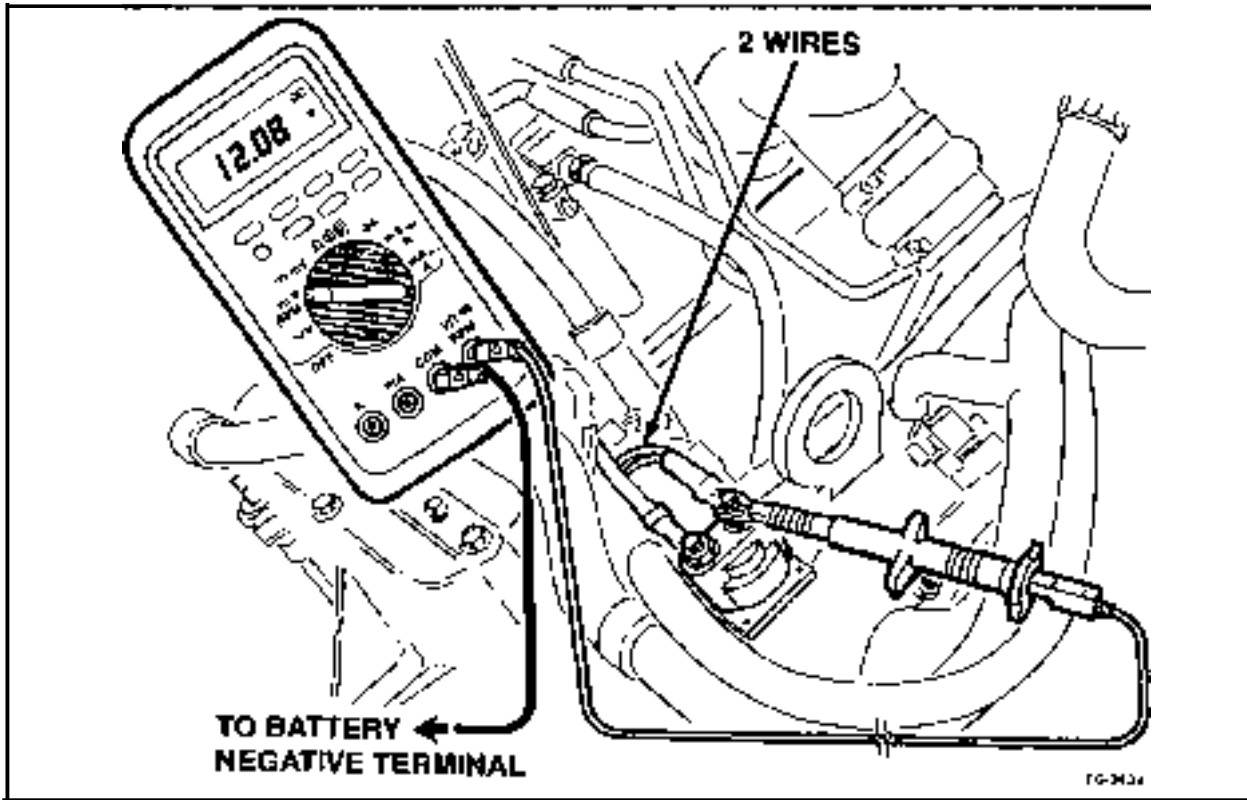


Figure 2.2-15. - Measuring Glow Plug/Relay "ON" Time

If no voltage is present, check for voltage at the other large terminal of the glow plug relay. If no voltage present, refer to glow plug system diagnostics in Electronic Control System Diagnostics, Section 3.5.

POSSIBLE CAUSES

Insufficient glow plug on time will not allow enough heat to accumulate in the combustion chamber to easily facilitate starting. If the glow plug system "ON" time does not meet specifications the problem may be:

- Poor ground connection.
- Defective glow plug relay.
- ECM in default
- ECM defective.
- Faulty wire harness connection.

T 444E ENGINE GLOW PLUG SYSTEM (Continued)

TEST PROCEDURE:

GLOW PLUG RESISTANCE TO GRD. (BATTERY (-) TERMINAL)

Disconnect the (4) glow plug/injector harness connectors from the valve cover gasket (harness).

NOTE: INCORRECT MEASUREMENTS WILL RESULT, IF ALL GLOW PLUG/INJECTOR HARNESS CONNECTORS ARE NOT DISCONNECTED.

Connect pigtail tool to each valve cover harness connector (Figure 2.2-16.) to measure glow plug resistance to (ground) battery negative terminal. Record resistance measurements on diagnostic form. A resistance measurement of .1 to 6 ohms indicates a good glow plug.

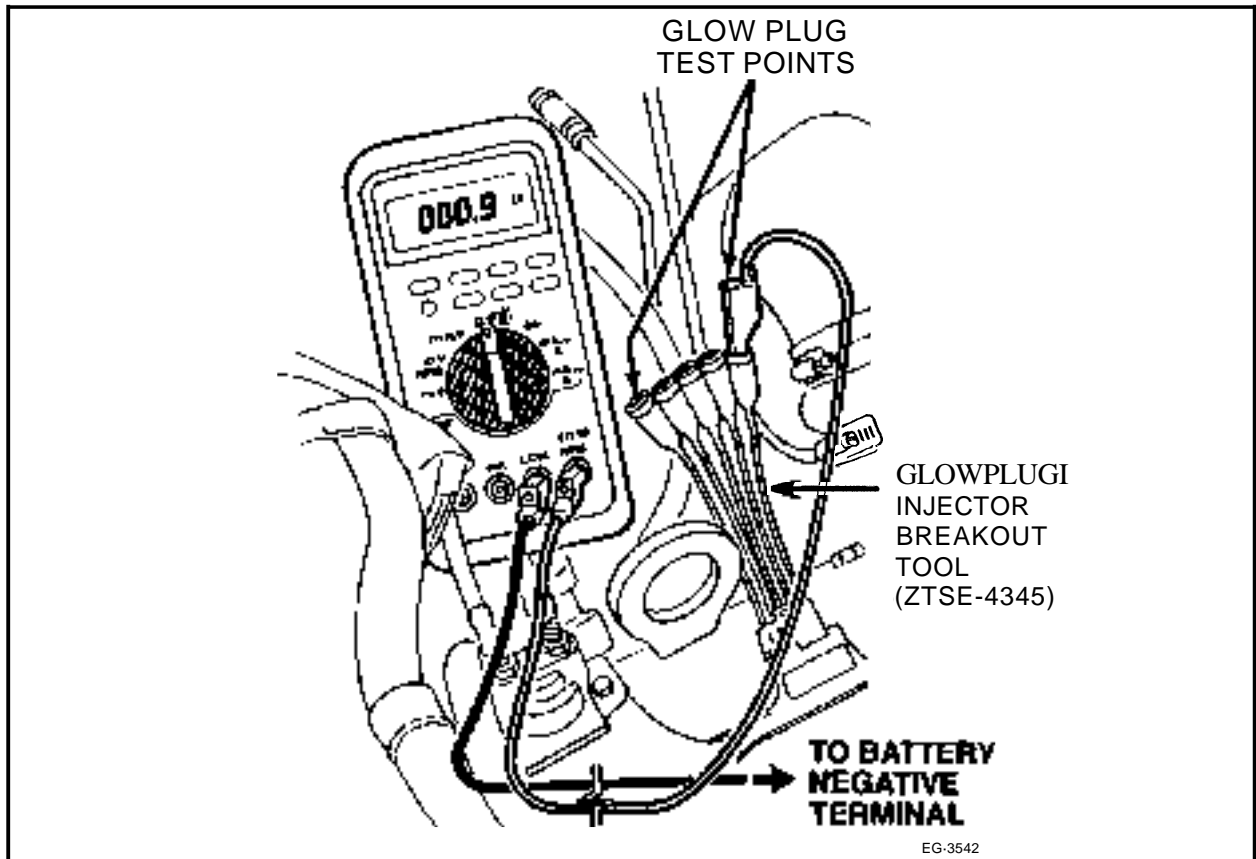


Figure 2.2-16. - Measuring Glow Plug Resistance to Gnd.

If the glow plug resistance to ground is high the most likely causes are:

- Open UVC (under valve cover) harness.
- Open glow plug.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE

GLOW PLUG SYSTEM (Continued)

TEST PROCEDURE:

GLOW PLUG HARNESS RESISTANCE TO RELAY

Measure resistance from the engine harness connector to the glow plug feed terminal (Figure 2.2-17.) on the glow plug relay.

NOTE: INCORRECT MEASUREMENTS WILL RESULT, IF ALL GLOW PLUG/INJECTOR HARNESS CONNECTORS ARE NOT DISCONNECTED.

TOOLS REQUIRED

DVOM, Glow Plug/Injector Breakout Tool (ZTSE-4345) and Stop Watch or equivalent.

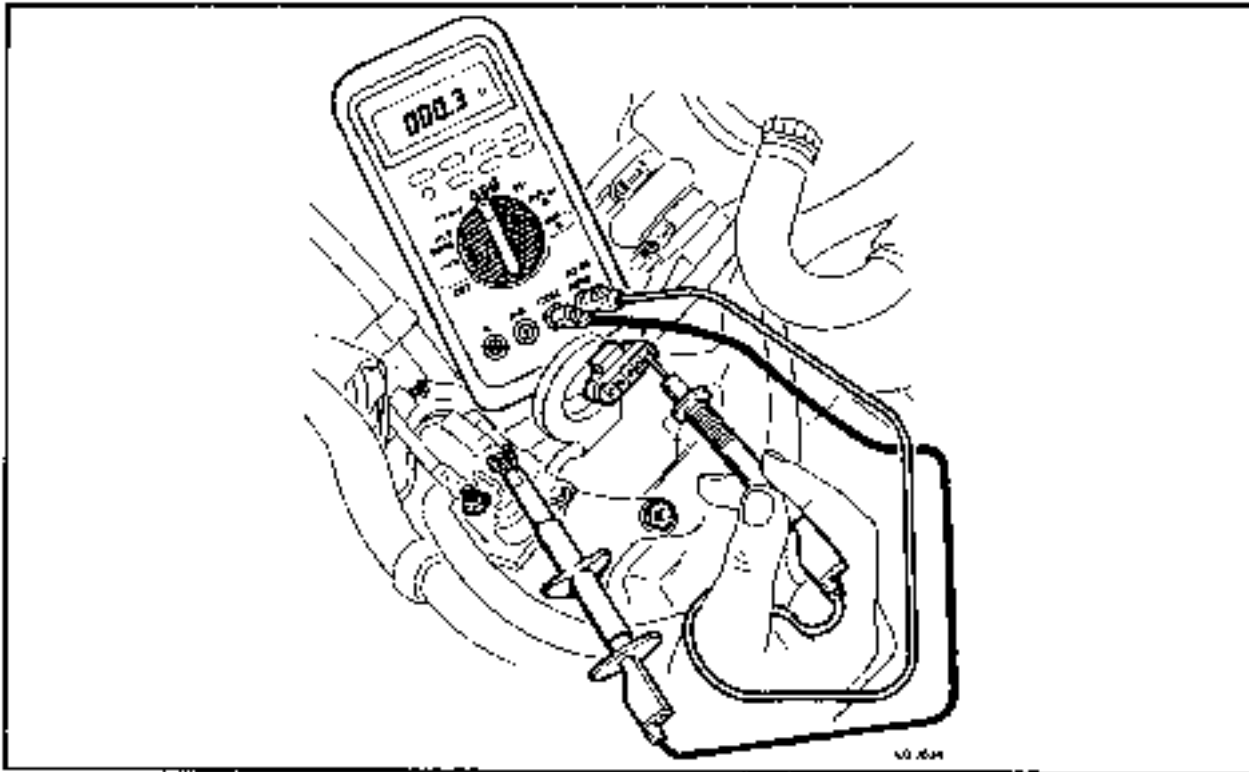


Figure 2.2-17. - Measuring Glow Plug Harness Resistance to Relay

T 444E ENGINE
CHECK ENGINE OIL LEVEL

FROM FORM EGED-130-1

1. CHECK ENGINE OIL LEVEL

- Check for contaminants (fuel, coolant)
- Correct grade/Viscosity

Method	Check
Visual	

○ If idle quality is poor after extended running, refer to Test 14

PURPOSE

To determine if the crankcase and oil reservoir contain engine oil of sufficient quantity and quality to enable the injection control pressure system to function properly.

TEST PROCEDURE

1. Park vehicle on level ground. Check oil level with oil level gauge. If there is no oil or very little oil in the crankcase the fuel injectors will not operate.

If the oil level on the gauge is over full, it is possible the engine was incorrectly serviced or fuel is diluting the oil and filling the crankcase. If a substantial amount of fuel is in the oil, it will have a fuel odor.

2. Inspect oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.
3. Check service records for correct oil type and viscosity for the temperature (environment) the vehicle is operating in. Single weight or 15W40 oil is not recommended for cold ambient temperatures. Oil that has had extended drain intervals will have increased viscosity (become

thicker) and will make engine cranking more difficult and starting less reliable at temperatures below freezing. Refer to lube oil chart in the operator's or service manual for the correct oil selection for temperature conditions.

4. Check oil level in reservoir. Figure 2.3-1.

POSSIBLE CAUSES

- Oil level low Oil leak, oil consumption, incorrect servicing.
- Oil level high Incorrect servicing, fuel dilution from lift pump or defective injector "O" rings.
- Oil Contamination with Coolant Oil Cooler, head gasket, porosity, (accessories i.e. water cooled air compressors.)
- Low reservoir level Engine built dry (not pressured lubed), prolonged period of not running, leaking check valve in high pressure pump.

TOOLS REQUIRED

1/4" drive ratchet or breaker bar to remove inspection plug.

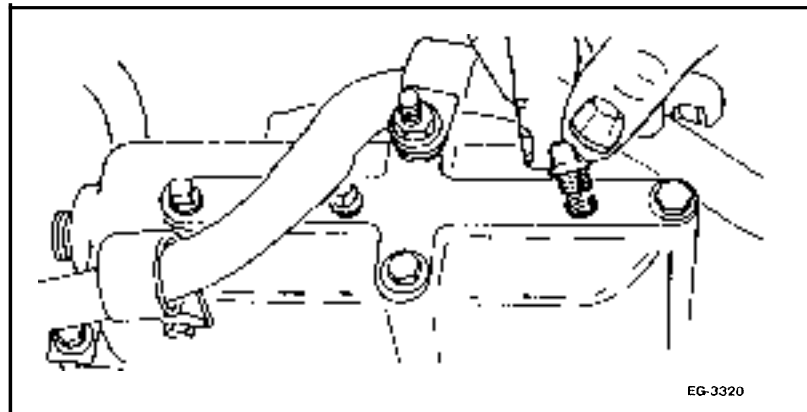


Figure 2.3-1. Checking Oil Level in Reservoir

PERFORMANCE DIAGNOSTICS

T 444E ENGINE
SUFFICIENT CLEAN FUEL

FROM FORM EGED-130-1

2. SUFFICIENT CLEAN FUEL

- Check at tank(s), drain sample from fuel filter while cranking engine.

Method	Check
Visual	

PURPOSE

To determine if the fuel system is getting sufficient clean fuel to start and operate the engine.

TEST PROCEDURE

1. Route a hose from the fuel drain tube (Figure 2.3-2.) to a clear container and open the drain.
2. Crank the engine and observe the fuel flowing into the container. Stop cranking the engine when the container is half full.

Fuel flow out of the drain tube should be a steady stream. Insufficient flow could indicate fuel supply or fuel system problem.

3. Inspect fuel in container. It must be clean and free of air, contaminants, water, icing or clouding. The fuel should be straw colored. Fuel dyed red or blue indicates an off highway fuel.
4. Check fuel odor for the presence of other fuels such as gasoline or kerosene.

If engine oil is present in the fuel, it may indicate an injector "O" ring leak and subsequent loss of injection control pressure. If that is suspected, check injection control pressure during engine cranking. Use the Electronic Service Tool (EST) or follow procedure outlined in Test 9C.

NOTE: SOME SEDIMENT AND WATER MAY BE PRESENT IN THE FUEL SAMPLE IF THE FUEL FILTER HAS NOT BEEN SERVICED OR DRAINED FOR A PROLONGED PERIOD OF TIME. A SECOND SAMPLE MAY BE REQUIRED TO DETERMINE FUEL QUALITY.

LOW OR NO FUEL POSSIBLE CAUSES

- No fuel in tank.
- If equipped with a inline fuel valve, it could be shut off.
- Fuel supply line from tank(s) could be broken or crimped.
- Fuel could be waxed or jelled (most likely in cold weather with #2 fuel), the pickup tube in tank could be clogged or cracked. If there is excessive water in the tank, it could freeze preventing the fuel from being drawn to the engine.

If the vehicle is equipped with supplemental filters or water separators, check for plugged filters or leakage that could allow the engine to draw air.

Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures. Excessive water or contaminants in fuel may indicate that the tank and fuel system may need to be flushed and cleaned.

TOOLS REQUIRED

Clear container approximately 1 quart.

T 444E ENGINE
SUFFICIENT CLEAN FUEL (Continued)

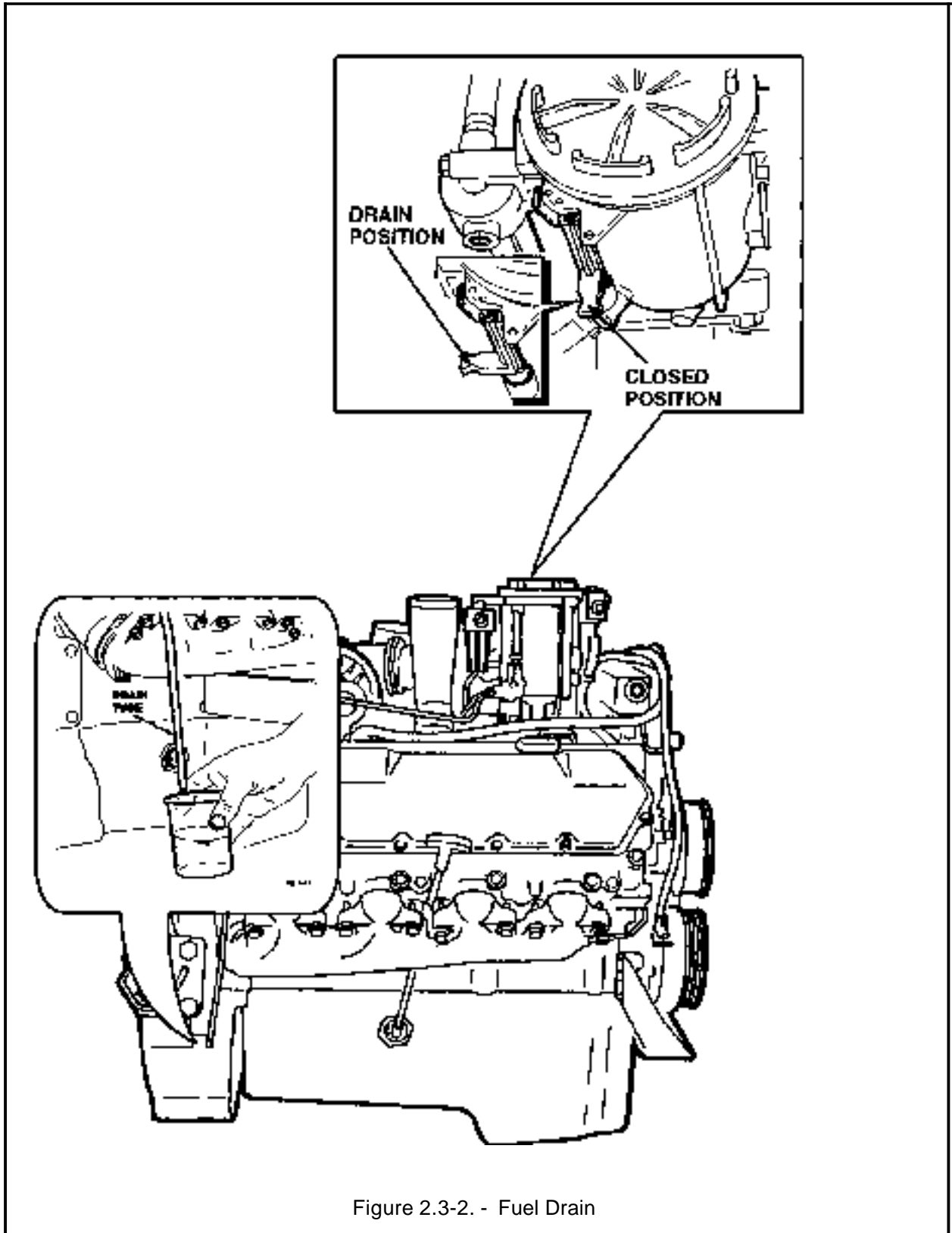


Figure 2.3-2. - Fuel Drain

PERFORMANCE DIAGNOSTICS

T 444E ENGINE EST-TOOL FAULT CODES

FROM FORM EGED-130-1

3. EST-TOOL FAULT CODES

- Install Electronic Service Tool

Active

Inactive

- ▣ See Electronic Diagnostic form for codes

PURPOSE

To determine if the Electronic Control Module (ECM) has detected any fault conditions that would cause an engine performance problem.

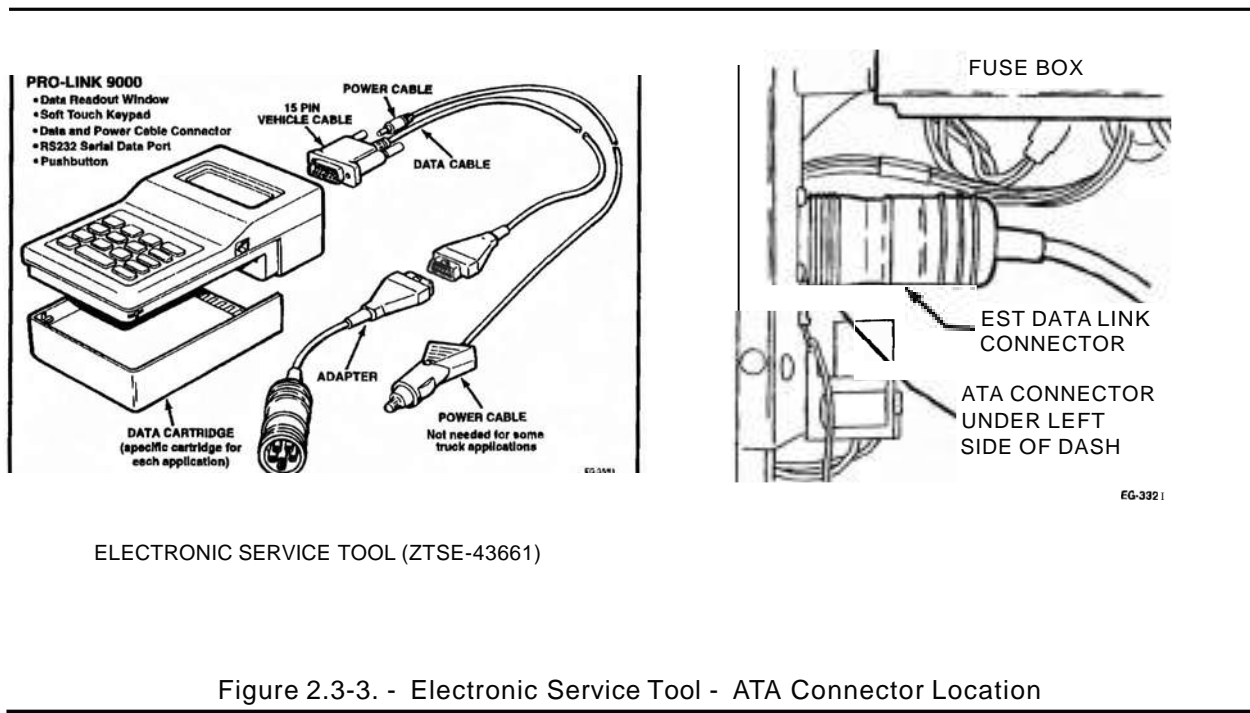
TEST PROCEDURE

NOTE: TURN ALL ACCESSORIES AND THE IGNITION OFF, BEFORE CONNECTING EST TOOL TO ATA DIAGNOSTIC CONNECTOR.

Connect the Electronic Service Tool (EST) to the American Trucking Association (ATA) diagnostic connector. The connector is located on the lower left kick panel (Figure 2.3-3.) inside the cab.

NOTE: THE ATA CONNECTOR SUPPLIES POWER TO OPERATE THE EST. THE EST WILL AUTOMATICALLY POWER UP AS SOON AS IT IS PLUGGED INTO THE ATA CONNECTOR. THE POWER CORD IS NOT REQUIRED AND IS FOR USE ONLY WHEN READING NON-VOLATILE MEMORY.

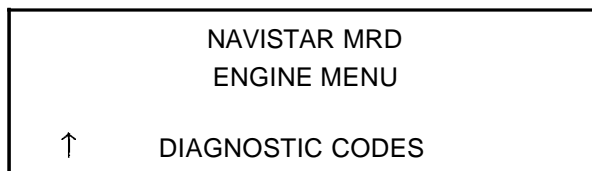
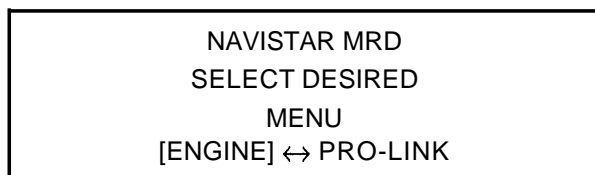
Turn the ignition switch to the "ON" position, but do not start the engine. This will allow the EST to receive data from the electronic control components on the truck. If no data is received, press "ENTER" to retry. The information received will be data showing the current status of the engine.



T 44E ENGINE EST TOOL-FAULT CODES (Continued)

To access the fault codes press the "FUNC" key to switch to the main menu.

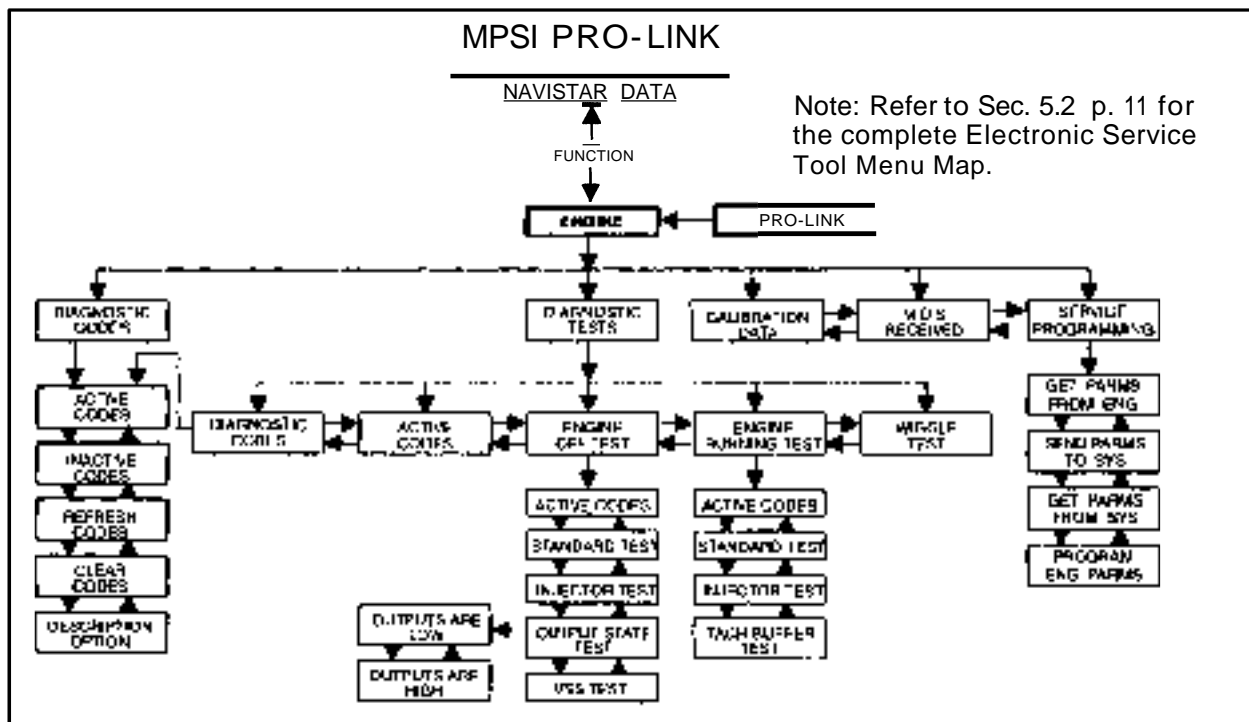
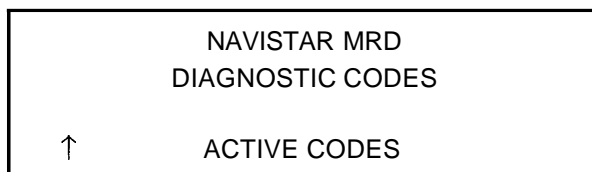
the diagnostic codes section. From this point, diagnostic codes can be accessed.



From the main menu select "ENGINE" by pressing the "←" key. This will cause the brackets to be placed around the "ENGINE" selection. Then press "ENTER".

The first option that will appear is "ACTIVE CODES". By selecting this option, the fault codes that have occurred during this key "ON" cycle will be displayed. Press "ENTER". If there are any "Active Codes", the first one will appear on the screen along with a description of the code. If there are any additional codes "Active" the "t↓" symbol will appear on the screen. Press "↓" key to access additional codes. If there are not any codes "Active", "NO ACTIVE CODES" will appear on the screen.

From the next menu select "DIAGNOSTIC CODES". The selection will have the "i↓" symbol on the screen. This means there are other selections available. By pressing the "↓" key the other selections will display on the screen. Press "↓" until "DIAGNOSTIC CODES" appears on the screen. Next press "ENTER". This causes the EST to enter

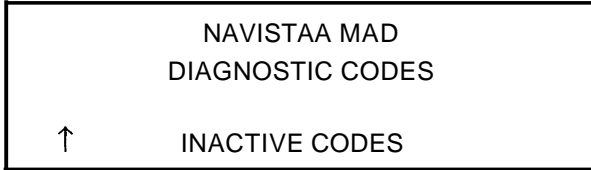


PERFORMANCE DIAGNOSTICS

T 444E ENGINE

EST TOOL-FAULT CODES (Continued)

To access "Inactive Codes" press the "FUNC" key. This will access the last prior selection. Then press the "↓" key to select "INACTIVE CODES" Press the "ENTER" key.



Inactive codes are faults that have occurred *in* the past, and are now stored in memory. An "Active Code" will become an "Inactive" code if the key is shut off even if the malfunction no longer exists (such as an intermittent problem).

Record all fault codes that are found. If there are any fault codes found, refer to "Electronic Control System Diagnostics" section of the manual.

NOTE: ALL CURRENT FAULT CODES MUST BE REPAIRED (CLEARED), BEFORE PROCEEDING WITH FURTHER DIAGNOSTIC TESTING.

POSSIBLE CAUSES

Electronic malfunctions which can be detected by the ECM on a continuous monitor basis.

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to Electronic Diagnostic form EGED-135-1 and fault code diagnosis.

T 444E ENGINE
EST TOOL-ENGINE OFF TESTS

FROM FORM EGED-13Q-1

4a. EST TOOL-ENGINE OFF TESTS

- Select "Engine Off" test or "Self Test" from diagnostic test menu

Faults
Found

- ☐ See Electronic Diagnostic form for codes

PURPOSE

To determine if there are any electrical malfunctions that can be detected by the Electronic Control Module (ECM) during an on demand self test.

TEST PROCEDURE

NOTE: ACCESS "DIAGNOSTIC CODES" MENU IN EST AND CLEAR ALL FAULT CODES BEFORE PERFORMING ENGINE OFF TESTS.

Access the "ENGINE OFF TESTS" in the "DIAGNOSTIC TESTS" section of the Electronic Service Tool (EST).

Press the "FUNC" key repeatedly, until the main menu appears on the screen.

NAVISTAR MRD
SELECT DESIRED
MENU
[ENGINE] ↔ PRO-LINK

Move the brackets to engine selection by pressing the "←" key, then press "ENTER"

Next select the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "DIAGNOSTIC TESTS" is shown on the screen. Press "ENTER" to make this selection.

NAVISTAR MRD
ENGINE MENU

↑ DIAGNOSTIC TESTS

Press the "↓" key, until the "ENGINE OFF TESTS" is shown on the screen. At this point, press "ENTER"

NAVISTAR MRD
DIAGNOSTIC TESTS

i ENGINE OFF TESTS

After the "ENTER" key is pressed, the EST will command the ECM to perform a self test.

When the test is complete, the screen will display the number of faults found in the self test. If there are any additional faults found, press "ENTER" and the faults will be displayed. If there is more than one fault that was found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults.

NOTE 1: IF FAULT CODES WERE NOT CLEARED BEFORE RUNNING ENGINE OFF TESTS, ALL 10M FAULTS AND ASSOCIATED CODES RECORDED DURING THE TEST WILL BE STORED AS "INACTIVE" CODES BY THE EST. TO READ THE CODES, ACCESS THE "INACTIVE" CODE MENU.

NOTE 2: THE PROGRAM IN THE EST WILL ONLY ALLOW THE ENGINE OFF TESTS MENU TO BE ACCESSED ONCE. TO REPEAT ENGINE OFF TESTS, SELECT "SELF TEST" TO RERUN THE ENGINE OFF TESTS.

POSSIBLE CAUSES

- Defective electrical components or circuitry.
- Injection Pressure Regulator (IPR) output circuit check fault.
- Fuel Demand Command Signal (FOCS) and Cylinder Identification (CI) output circuit check faults.

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE
EST-INJECTOR "BUZZ TEST"

FROM FORM EGED-130-1

4b. EST-INJECTOR "BUZZ TEST"

NOTE: Engine Off Test must be performed first in order to gain access to the Injector "Buzz Test"

- Select "Injector Test" from diagnostic test menu

	Faults								
I	Found	|							

☐ See Electronic Diagnostic form for codes

PURPOSE

To determine if the injectors are electronically functioning correctly, by energizing each injector in a programmed sequence. The Electronic Control Module (ECM) and Injector Drive Module (IDM) will monitor this test and transmit fault codes if any injector(s) or electrical circuitry are not functioning properly.

TEST PROCEDURE

NOTE 1: ACCESS "DIAGNOSTIC CODES" MENU IN EST AND CLEAR ALL FAULT CODES.

NOTE 2: ENGINE OFF TEST MUST BE PERFORMED FIRST IN ORDER TO ACCESS THE INJECTOR "BUZZ" TEST.

After the "Engine Off Tests" have been completed, press the "↓" key to access the "INJECTOR TEST". If the tool is not on a menu screen, i.e. displaying of fault codes etc., press the "FUNC" key. This will access the "DIAGNOSTIC TESTS" menu. Press "ENTER" to begin the test.

NAVISTAR MRD
DIAGNOSTIC TESTS

↑

INJECTOR TEST

During this test, the injector solenoids will produce an audible clicking sound when actuated. It is possible to detect a malfunctioning injector(s) by listening for the absence of the solenoid clicking sound.

NOTE: IF FAULT CODES WERE CLEARED BEFORE THE INJECTOR "BUZZ" TEST, FAULT CODES DISPLAYED WILL BE ACTUAL FAULTS FOUND DURING THE TEST. IF CODES WERE NOT CLEARED BEFORE TESTING, ACCESS "INACTIVE" FAULT CODES FROM EST MENU TO RETRIEVE FAULTS FOUND DURING THIS TEST.

At the completion of the Injector Test, any faults that have been detected will be displayed. If there is more than one fault the "↑↓" symbol will be displayed. These additional faults can be accessed by pressing the "↓" key.

Record any faults found and refer to the Electronic Control System Diagnostics, Section 3.5.

POSSIBLE CAUSES

- Bad wiring harness connection at injector solenoid.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s).
- Defective IDM.

TOOLS REQUIRED

PRC-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

T 444E ENGINE
STI BUTTON-FLASH CODES

FROM FORM EGED-130-1

5. STI BUITON-FLASH CODES

- Depress and hold "Engine Diagnostics" switch, then turn the ignition switch to the "ON" position.

Faults Found	
--------------	--

Refer to Electronic Diagnostic form if fault code(s) set

PURPOSE

To read faults detected by the Electronic Control Module (ECM), if the Electronic Service Tool (EST) is not available or the EST cannot receive "Self Test Input" data due to communications or component failures.

The Self Test Input (STI) switch is located on the vehicle dashboard (Figure 2.3-4.) and is identified as the "ENGINE DIAGNOSTICS" switch. Depressing the STI switch on the vehicle dashboard while turning the ignition switch to the "ON" position, will signal the ECM to start the Self Test Input diagnostics to check output circuits. If any faults are detected, the ECM will flash the "WARN ENGINE" light to indicate which faults have been detected.

NOTE: SELF TEST INPUT DIAGNOSTICS WILL NOT FLASH VPM FAULT CODES.

TEST PROCEDURE

Depress and hold the STI switch (located on vehicle dash). Turn the ignition switch to the "ON" position. Do Not Start The Engine. The ECM will begin to perform the self test to check the output circuits.

When the test is completed, the ECM will flash the "OILWATER" and "WARN ENGINE" lights to signal the fault codes.

NOTE: FAULT CODES CAN BE ACCESSED AT ANYTIME BY DEPRESSING AND HOLDING THE STI SWITCH WHILE TURNING THE IGNITION SWITCH TO THE "ON" POSITION. (DO NOT START ENGINE.)

To read the fault codes it will be necessary to count the number of times the "ENGINE WARN" light flashes. The following sequence of events occur each time the STI switch is depressed to obtain the fault codes:

1. The "OILWATER" light will flash onetime to indicate the beginning of Active fault codes.

2. The "WARN ENGINE" light will flash repeatedly signaling the active fault codes.

NOTE: ALL FAULT CODES ARE THREE DIGITS AND CODE 111 INDICATES "NO FAULTS" HAVE BEEN DETECTED.

3. Count the number of flashes in sequence. At the end of each digit of the code there will be a short pause. Three flashes and a pause would indicate the number 3. Therefore, two flashes, a pause, three flashes a pause, and two flashes a pause would indicate the code 232. If there is more than one fault code, the "OILWATER" light will flash once indicating the beginning of another active fault code.

After all the active codes have been flashed, the "OILWATER" light will flash twice to indicate the beginning of INACTIVE codes. Count the number of flashes from the "WARN ENGINE" light. If there is more than one inactive code, the "OILWATER" light will flash once in-between each fault code.

After all codes have been sent, the "OILWATER" light will flash three times indicating "END OF MESSAGE".

To repeat transmission of fault codes, depress the "ENGINE DIAGNOSTICS" switch which will signal the ECM to resend all stored fault codes.

If fault codes are set, refer to Electronic Diagnostic Form EGED-135-1 and fault code diagnosis.

POSSIBLE CAUSES

- Electronic component or circuitry failures.

TOOLS REQUIRED

None.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE
STI BUTTON-FLASH CODES (Continued)

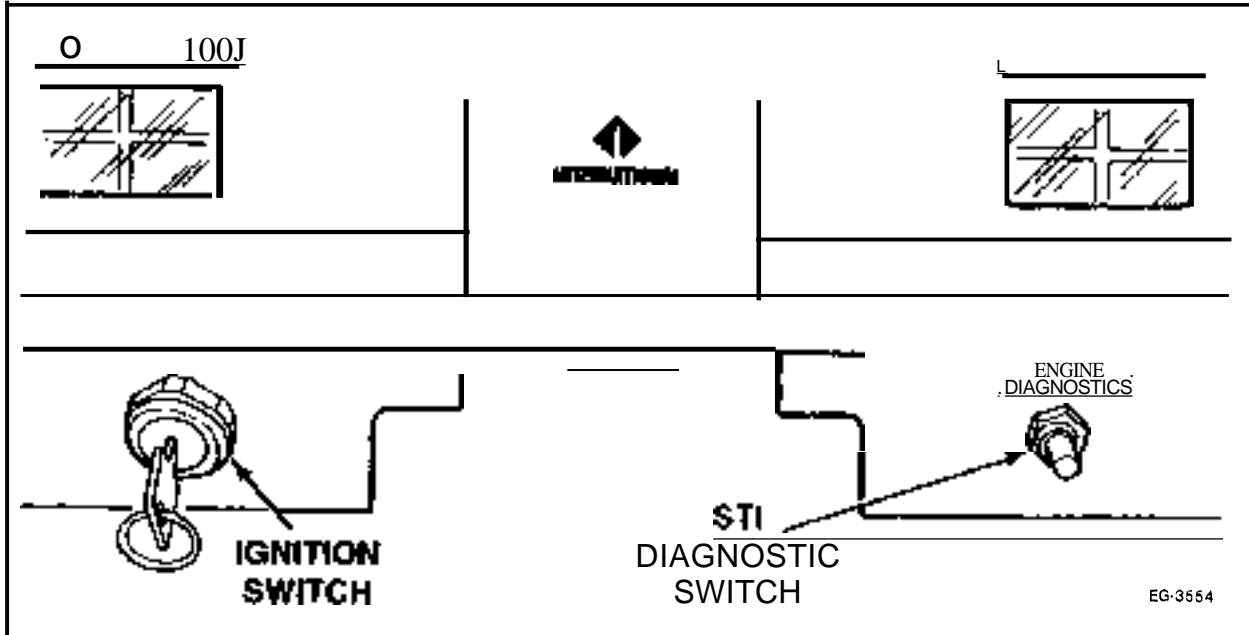


Figure 2.3-4. - Self Test Input (STI) Diagnostic Switch Location on Vehicle Dash

T 444E ENGINE
INTAKE RESTRICTION

FROM FORM EGED-13Q-1

6. INTAKE RESTRICTION

- Check filter minder if equipped
(If yellow band is latched @ 25"H2O, replace filter)
- Measure at High idle & no load
- Use manometer or magnehelic gauge

Instrument	Spec.	Actual
Filter Minder	25 " H2O	
Manometer or Magnehelic Gauge	12.5 " H2O Max..	

PURPOSE

To determine if an intake/air cleaner restriction exists. Often a low power and poor fuel economy complaint is simply due to a dirty air cleaner element. In this test, the gauge is inserted in the air cleaner housing. As the air cleaner element accumulates dirt, restriction to airflow increases. If restriction exceeds specifications, replace the air cleaner element or elements.

NOTE: A HIGH INTAKE RESTRICTION MAY CAUSE A CONSIDERABLE AMOUNT OF BLACK OR BLUE SMOKE WHEN STARTING THE ENGINE.

INSPECT AIR INTAKE RESTRICTION INDICATOR

1. Refer to appropriate "Operation and Maintenance Manual" "Air Cleaner Restriction Gauge and Indicator", for detailed information.

NOTE: THE AIR CLEANER IS TO BE REPLACED WHEN THE RESTRICTION REACHES THE MAXIMUM ALLOWABLE LIMIT. THE RESTRICTION CAN BE MEASURED BY A SERVICE INDICATOR, WATER MANOMETER OR MAGNEHELIC GAUGE.

2. Inspect the element(s) for damaged gaskets or dents. If they exhibit either they should be replaced.

SINGLE ELEMENT AIR CLEANER

Measure air cleaner restriction as follows:

1. Attach the restriction test gauge (Figure 2.3-5.) at air cleaner housing tap location.
2. Run engine at high idle RPM.
3. Replace the air cleaner element when the test gauge shows a restriction greater than 12.5 in. H2O (3.13 kPa).

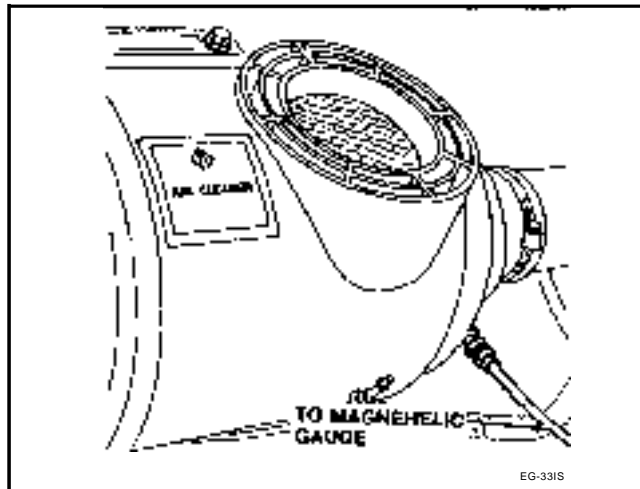


Figure 2.3-5. - Restriction Test Location

PERFORMANCE DIAGNOSTICS

T 444E ENGINE

INTAKE RESTRICTION (Continued)

NOTE 1: THE TRUE MAXIMUM AIR CLEANER RESTRICTION CAN ONLY BE OBTAINED WHEN OPERATING THE ENGINE AT FULL LOAD AND RATED SPEED. THE VEHICLE MOUNTED INDICATOR OR VACUUM GAUGE WILL SENSE MAXIMUM RESTRICTION. WHEN 25 IN. H₂O (6.22 KPA) IS SENSED ON THE VEHICLE MOUNTED GAUGES, REPLACE THE AIR CLEANER ELEMENT. FOR CONVENIENCE, AIR CLEANER RESTRICTION CAN BE MEASURED AT HIGH IDLE (NO LOAD); HOWEVER, THE ELEMENT MUST BE REPLACED WHEN 12.5 IN. H₂O (3.13 KPA) IS MEASURED.

NOTE 2: HIGH AIR CLEANER RESTRICTION CAN CAUSE TURBOCHARGER SEALS TO UNSEAT, CAUSING OIL TO BE DRAWN THROUGH SEALS AND INTO THE ENGINE.

DUAL ELEMENT CLEANER

The dual element air cleaner provides a large primary (outer) filter element and an optional small secondary (inner) filter element. The secondary element should be used in dusty environments.

The dual element air cleaner assembly air cleaner restriction connection (Figures 2.3- 6. and 7.) is 10-

located between the primary and the secondary element in the bottom of the air cleaner housing. This arrangement allows only the primary (outer) element to be sensed by the restriction indicator or dash mounted vacuum gauge. THE INNER ELEMENT IS NOT RECORDED ON THE RESTRICTION INDICATOR OR DASH MOUNTED **VACUUM GAUGE**.

To determine inner element restriction use the:

Visual Check Procedure

Visually inspect the restriction indicator built into the inner element or inner element retaining nut.

NOTE: TWO DIFFERENT INDICATORS ARE THE RESULT OF TWO DIFFERENT SUPPLIERS. REPLACE THE ELEMENT WHEN THE GREEN DOT DISAPPEARS FROM THE ELEMENT OR FROM THE WINDOW IN THE RETAINING NUT.

IMPORTANT

EACH SUPPLIER'S RETAINING NUT REQUIRES A DIFFERENT TORQUE. REFER TO FIGURES 2.3- 6. AND 7.

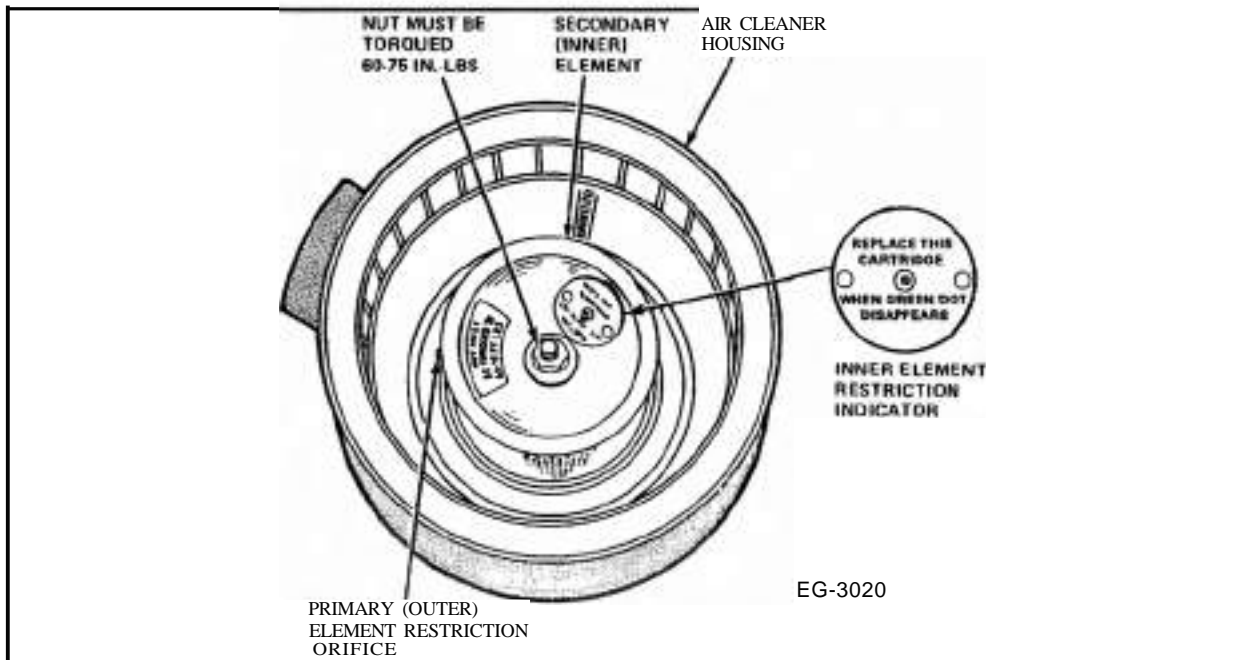


Figure 2.3-6. - Dual Element Air Cleaner With Indicator in End Cap

T 444E ENGINE INTAKE RESTRICTION (Continued)

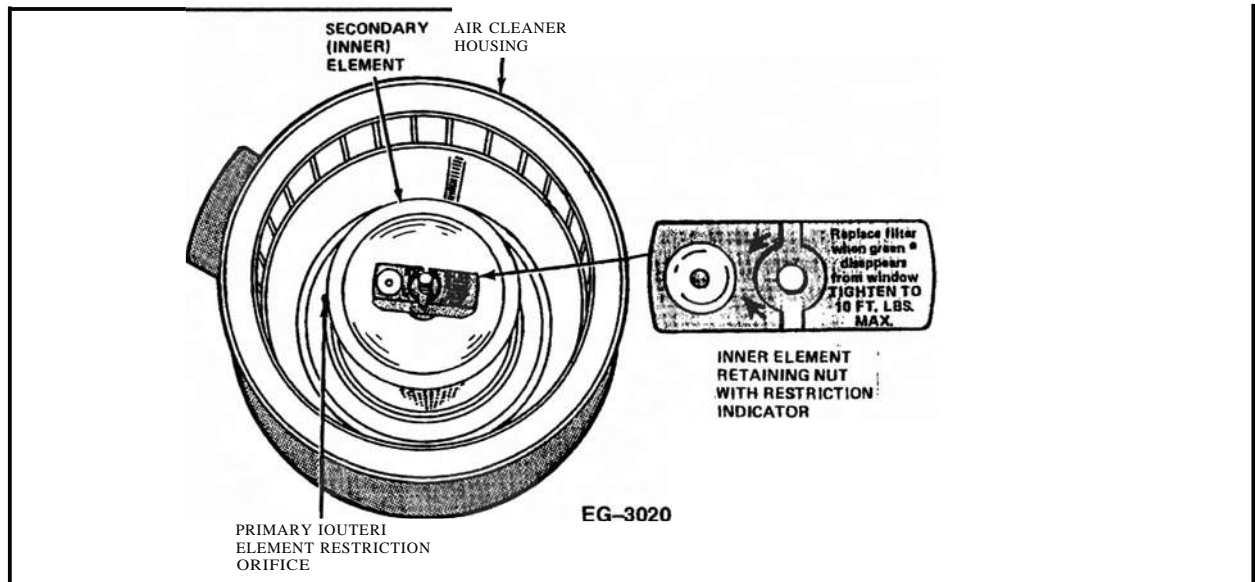


Figure 2.3-7. - Dual Element Air Cleaner Retaining Nut Indicator

POSSIBLE CAUSES

- Dirty air cleaner element.
- Snow, plastic bags or other foreign material may restrict air flow at the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been inadvertently left in the intake system.

TOOLS REQUIRED

Model 0-200 Pressure Test Kit (ZTSE-2239), manehelic gauge or water manometer.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE EXHAUST RESTRICTION

FROM FORM EGED-130-1

7. EXHAUST RESTRICTION

- Visually inspect exhaust system for damage
- Check if EBP device is closing at High idle
With breakout box pins 49+ and 46 - or "TEE"
Green + and Black - (If so equipped)
- Measure at High idle

Instrument	Spec.	Actual
DVOM	< 2.0 Volts	

PURPOSE

To determine if a restriction exists in the exhaust system which would cause an engine performance problem.

VISUAL INSPECTION

1. Visually inspect entire exhaust system for obvious physical damage.
2. If exhaust system damage is not present, start engine and warm to operating temperature.

3. Run engine at high idle with no load.

4. The exhaust back pressure valve should be open. {Figure 2.3-8.} illustrates position of tang on bellcrank of the back pressure device when the exhaust back pressure (butterfly) valve is open. (If so equipped)

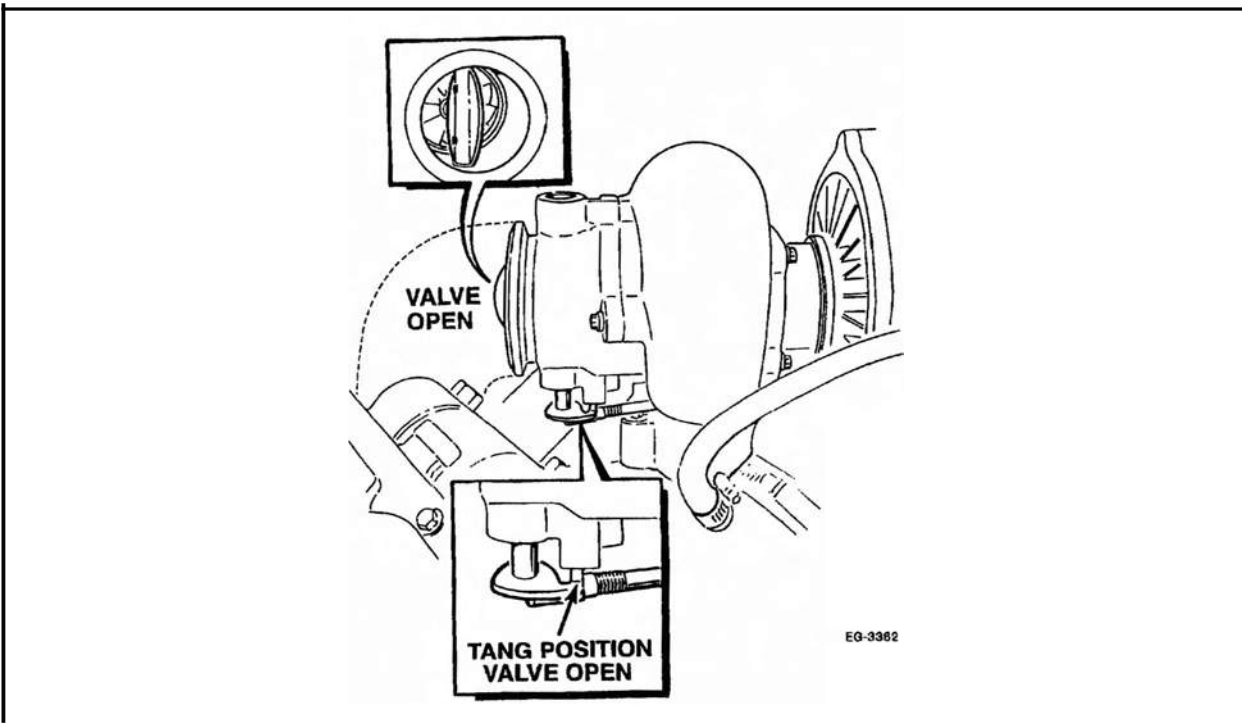


Figure 2.3-8. - Checking Position of Exhaust Back Pressure {butterfly} Valve At High Idle

T 444E ENGINE
EXHAUST RESTRICTION (Continued)

TEST PROCEDURE

1. If the suspected exhaust restriction is not visually evident, an exhaust back pressure measurement is necessary. Install the breakout box or "T" (Figure 2.3-9.) in line with the ESP sensor which will allow access to the back pressure voltage signal.

NOTE: APPLY PARKING BRAKE AND INSURE THE TRANSMISSION IS IN NEUTRAL.

2. Measure exhaust back pressure (voltage) at high idle engine speed. Record voltage and compare to voltage specification on diagnostic form.

POSSIBLE CAUSES

- Closed Exhaust Back Pressure device.
- Collapsed tailpipe
- Clogged catalytic converter. (If so equipped)
- Damaged muffler.

TOOLS REQUIRED

DVOM and sensor breakout "T" (ZTSE-4347), or breakout box (ZTSE-4346).

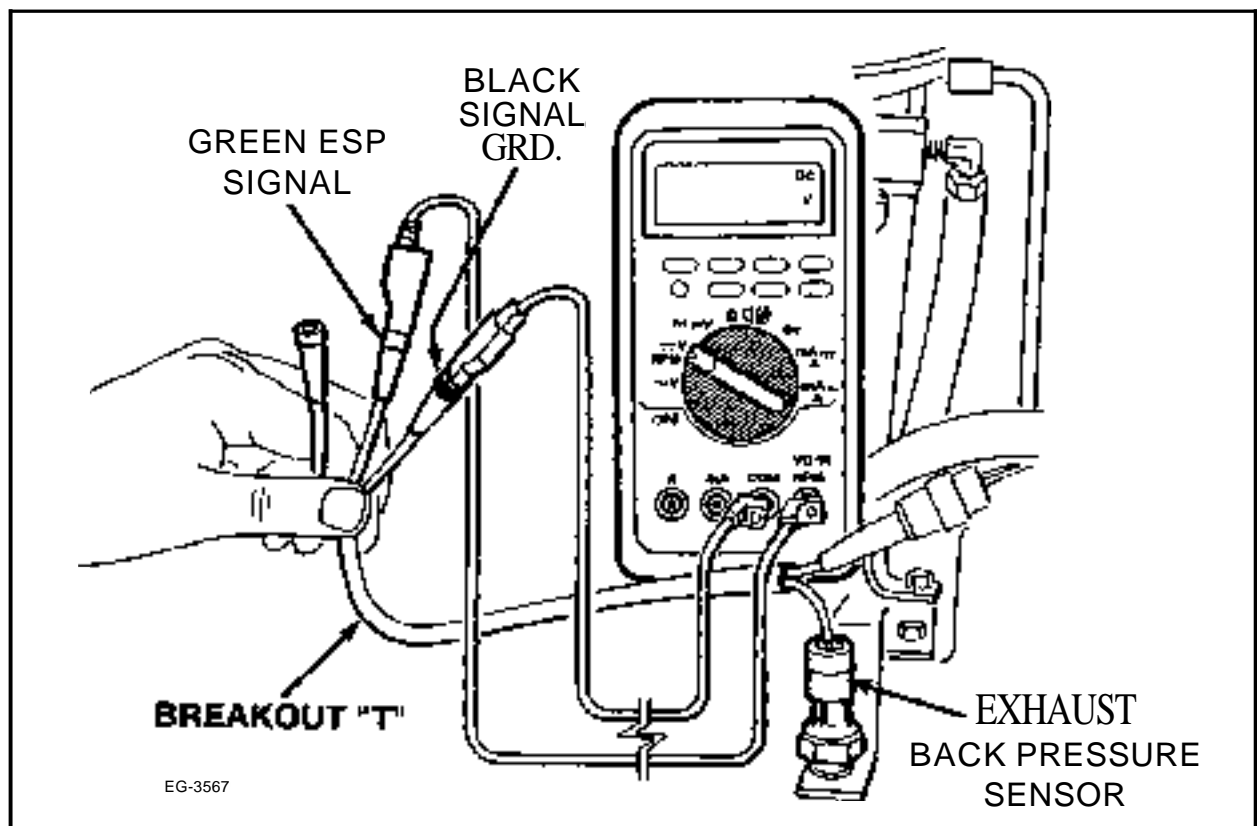


Figure 2.3-9. - Measuring Exhaust Back Pressure (Voltage)

PERFORMANCE DIAGNOSTICS

T 444E ENGINE
FUEL PRESSURE HIGH IDLE

FROM FORM EGED-130-1

8. FUEL PRESSURE HIGH IDLE

- Measure at regulator block.

Instrument	Spec.	Actual
0-160 PSI Gauge	30-65 PSI @ High idle	

○ If pressure is low, replace filter and retest.
If pressure still low, perform test 10B.

PURPOSE

To determine if fuel pressure is sufficient to correctly operate the engine.

TEST PROCEDURE

NOTE: IF FUEL FILTER IS EQUIPPED WITH A WATER-IN-FUEL PROBE, CHECK WITH VEHICLE OPERATOR TO DETERMINE IF THE WATER-IN-FUEL LAMP HAS BEEN ILLUMINATED DURING VEHICLE OPERATION.

1. Remove 1/8" pipe plug located on the fuel regulator block. (Figure 2.3-10.) Install 1/8 inch (3 mm) pipe fitting in place of the pipe plug.
2. Connect a line (Figure 2.3-10.) from the fitting to the 0-160 PSI gauge of the Model D-200 Pressure Test Kit (ZTSE-2239). Start engine

and run at low idle to check for fuel leaks in line to pressure gauge.

NOTE: BLEED AIR FROM THE FUEL LINE TO INSURE AN ACCURATE READING.

3. Measure fuel pressure at high idle and record on diagnostic form. If pressure is not within specifications, replace fuel filter and recheck fuel pressure at high idle.

NOTE: IT MAY TAKE A NUMBER OF CRANK CYCLES TO PURGE THE AIR OUT OF THE FUEL SYSTEM AFTER REPLACING THE FUEL FILTER.

If fuel pressure remains low after replacing the filter, perform Transfer Pump Restriction Test 10B.

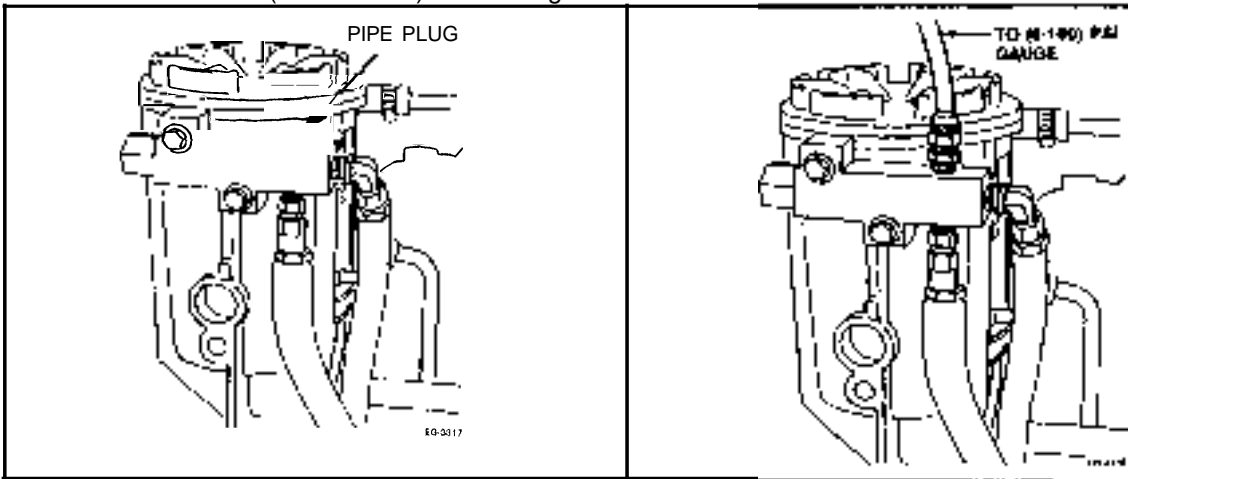


Figure 2.3-10. - Fuel Pressure Tap Location

T 444E ENGINE

FUEL PRESSURE HIGH IDLE (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.

- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Model 0-200 Pressure Test Kit (ZTSE-2239) (0 to 160 PSI fuel pressure gauge), appropriate line with 1/8" NPT fitting.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE
EST-ENGINE RUNNING TEST

FROM FORM EGED-130-1

9a. EST-ENGINE RUNNING TEST

- Select "Engine Running" test from the diagnostic test menu.

Faults Found

Refer to Electronic Diagnostic form if fault code(s) set

PURPOSE

To verify the engine's electronic sensors and actuators are operating properly within their specified operating ranges. The Electronic Service Tool (EST) is used to signal the Electronic Control Module (ECM) to perform the "Engine Running Test". The ECM will exercise the actuators and monitor sensor feedback signals. If a sensor or actuator problem exists, the ECM will transmit fault code(s) to the EST.

TEST PROCEDURE

IMPORTANT

APPLY PARKING BRAKE AND INSURE THE TRANSMISSION IS IN NEUTRAL BEFORE RUNNING TEST.

1. Start and run engine until it reaches 160° F minimum.

NOTE: ENGINE MUST BE AT LEAST 160° F TO ALLOW THE ECM TO PERFORM AN ACCURATE TEST OF THE ENGINE SENSORS AND ACTUATORS. IF ENGINE COOLANT TEMPERATURE IS BELOW SELF TEST RANGE, THE EST TOOL WILL DISPLAY AN "ECT OUT OF SELF TEST RANGE" MESSAGE.

2. Access the "Engine Running Test" from the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "ENGINE RUNNING TEST" appears on the screen. Then press the "ENTER" key.

NAVISTAR MRD
DIAGNOSTIC TESTS

↑
ENGINE RUNNING TEST

The ECM will then conduct the "Engine Running Test". It will command the engine to accelerate to a pre-determined engine RPM and operate the Injection Pressure Regulator (IPR) valve. If engine is equipped with the optional exhaust back pressure device, the ECM will also operate the Exhaust Back Pressure Regulator (EPR) Valve during this test.

The ECM will measure the effects of actuator movement via the sensors. At the completion of the test, the EST screen will display "00 FAULTS", if no faults were detected. If EST indicates faults have been detected, press the "ENTER" key to display the fault codes. Record fault codes and refer to the Electronic Diagnostic form EGED-135-1 for fault codes which were detected.

POSSIBLE CAUSES

- Defective or inoperative sensors or actuators.
- Open or shorted wiring harness to sensors or actuators.
- Loose or corroded engine wiring harness connections at sensor or actuators.

T 444E ENGINE
EST TOOL-INJECTOR TEST

FROM FORM EGED-130-1

9b. EST TOOL-INJECTOR TEST
(CYLINDER CONTRIBUTION)

- Select "Injector Test" from "Engine Running" test menu

Faults Found

Refer to Electronic Diagnostic form if fault code(s) set.

PURPOSE

To verify that all power cylinders are contributing equally.

TEST PROCEDURE

NOTE: THE "ENGINE RUNNING TEST" MUST BE PERFORMED FIRST TO ACCESS THE INJECTOR TEST.

After the "Engine Running Test" has been completed, press the "↓" key from the "ENGINE RUNNING TEST" screen to access the "INJECTOR TEST". Then press the "ENTER" key.

DIAGNOSTIC TESTS
ENGINE RUNNING TESTS

t INJECTOR TEST

NOTE: THE ENGINE WILL RUN ROUGH DURING THE TEST.

The Electronic Service Tool (EST) will signal the Electronic Control Module (ECM) to actuate each

injector in a programmed sequence and then measure power cylinder performance.

At the completion of the test, the EST screen will display "00 FAULTS", if no injector faults occurred. If EST indicates faults have been detected, press the "ENTER" key to display the fault codes. Record fault codes and refer to the Electronic Diagnostic form EGED-135-1 for fault codes which were detected.

POSSIBLE CAUSES

- Broken compression rings, leaking or bent valves, bent push rods or connecting rods.
- Open or shorted engine wiring harness to injector(s).
- Defective injector solenoid(s)

TOOLS REQUIRED

PRO-LINK 9000 (ZTSE-43661)

SUPPLEMENTAL DIAGNOSTICS

Refer to Section 3.5 Electronic Control System Diagnostics.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE FUEL PRESSURE (FULL LOAD)

FROM FORM EGED-13Q-1

10a. FUEL PRESSURE (FULL LOAD)

- Measure at regulator block.
- Measure at full load rated speed.

Instrument	Spec.	Actual
0-160 PSI Gauge	30-65 PSI @ Full load	

○ If pressure is low, replace fuel filter and retest.
If pressure still low, perform Test 10B.

NOTE: FUEL PRESSURE (FULL LOAD AND BOOST PRESSURE ARE "ROAD TESTS". THEY MAY BE PERFORMED AT THE SAME TIME.

PURPOSE

To determine if fuel pressure is sufficient to correctly operate the engine at full load operating condition.

and run at low idle to check for fuel leaks in line to pressure gauge.

NOTE: IF FUEL FILTER IS EQUIPPED WITH A WATER-IN-FUEL PROBE, CHECK WITH VEHICLE OPERATOR TO DETERMINE IF THE WATER-IN-FUEL LAMP HAS BEEN ILLUMINATED DURING VEHICLE OPERATION.

NOTE: BLEED AIR FROM THE FUEL LINE TO INSURE AN ACCURATE READING.

TEST PROCEDURE

NOTE: FUEL PRESSURE MUST BE TAKEN AT FULL LOAD. FUEL PRESSURE MAY BE SUFFICIENT AT HIGH IDLE, BUT MAY BE UNSATISFACTORY AT FULL LOAD OPERATING CONDITIONS.

IMPORTANT

TO MEASURE FUEL PRESSURE AT FULL LOAD, VEHICLE MUST BE DRIVEN ON THE ROAD IN THE HIGHEST GEAR (POSSIBLE) AND ACCELERATOR PEDAL DEPRESSED TO THE FLOOR (FULL DEPRESSION) OF THE CAB. IF A VEHICLE DYNAMOMETER IS AVAILABLE, OPERATE VEHICLE AT FULL RATED LOAD AND SPEED.

1. Remove 1/8" pipe plug located on the fuel regu.. Jatar block. (Figure 2.3-11.) Install 1/8 inch (3 mm) pipe fitting in place of the pipe plug.
2. Connect a line (Figure 2.3-11.) from the fitting to the 0-160 PSI gauge of the Model D-200 Pressure Test Kit (ZTSE-2239). Start engine

3. Measure fuel pressure at full load and record on diagnostic form. If pressure is not within specifications, replace fuel filter and re-check fuel pressure.

T 444E ENGINE

FUEL PRESSURE (FULL LOAD) (Continued)

NOTE: IT MAY TAKE A NUMBER OF CRANK CYCLES TO PURGE THE AIR OUT OF THE FUEL SYSTEM AFTER REPLACING THE FUEL FILTER.

If fuel pressure remains low after replacing the filter, perform Transfer Pump Restriction Test 10B.

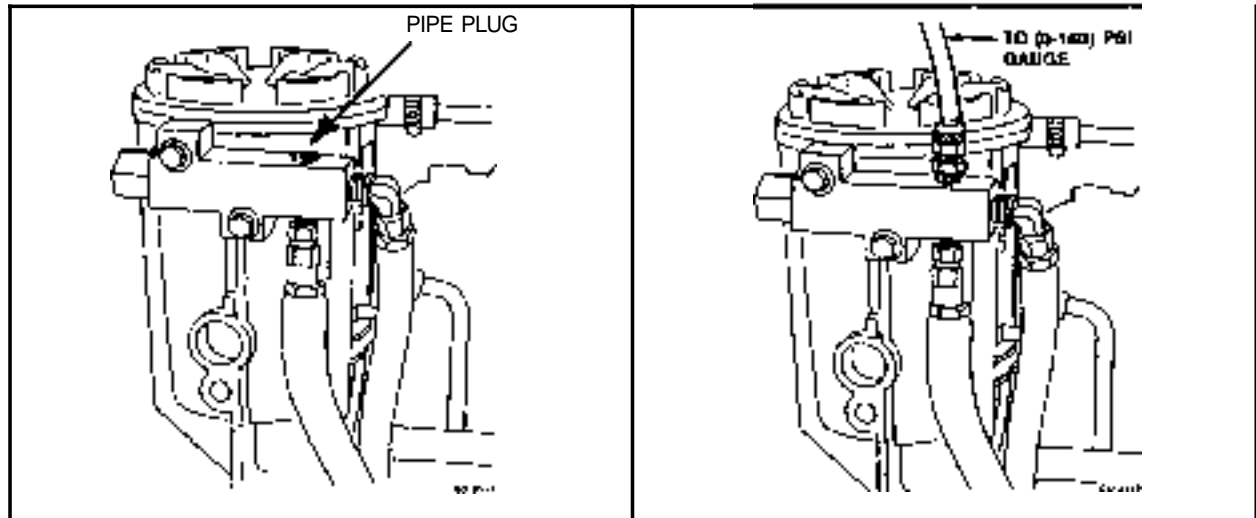


Figure 2.3-11. - Fuel Pressure Tap Location

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel

system could cause air to be ingested into the system and cause low fuel pressure.

- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Model 0-200 Pressure Test Kit (ZTSE-2239) (0 to 160 PSI fuel pressure gauge), appropriate line with 1/8" NPT fitting.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE TRANSFER PUMP RESTRICTION

FROM FORM EGED-130-1

10b. TRANSFER PUMP RESTRICTION

- Measure at fuel pump inlet
- Measure at High idle

Instrument	Spec.	Actual
0-30" Hg. Vacuum Gauge	<6" Hg.	

- If restriction is high, check for blockage between pump and fuel tank.
- If restriction is within spec., check for sticking regulator valve or debris.

TRANSFER PUMP RESTRICTION

PURPOSE

To determine if excessive restriction to fuel flow exists from the engine fuel inlet line to the fuel tank(s).

TEST PROCEDURE

1. Connect a tee between the fuel filter inlet and fuel supply line. (Figure 2.3-12.) Connect a line from the tee to the 0-30" Hg. vacuum gauge of the D-200 Pressure Test Kit (ZTSE-2239).

2. Measure fuel inlet restriction at high idle and record reading on diagnostic form.
3. If restriction exceeds 6 in. Hg., locate the restriction on the suction side of the fuel system and correct.

NOTE: IF FUEL INLET RESTRICTION IS WITHIN SPECIFICATIONS, REFER TO FUEL REGULATOR VALVE REMOVAL AND INSPECTION ON PAGE 24.

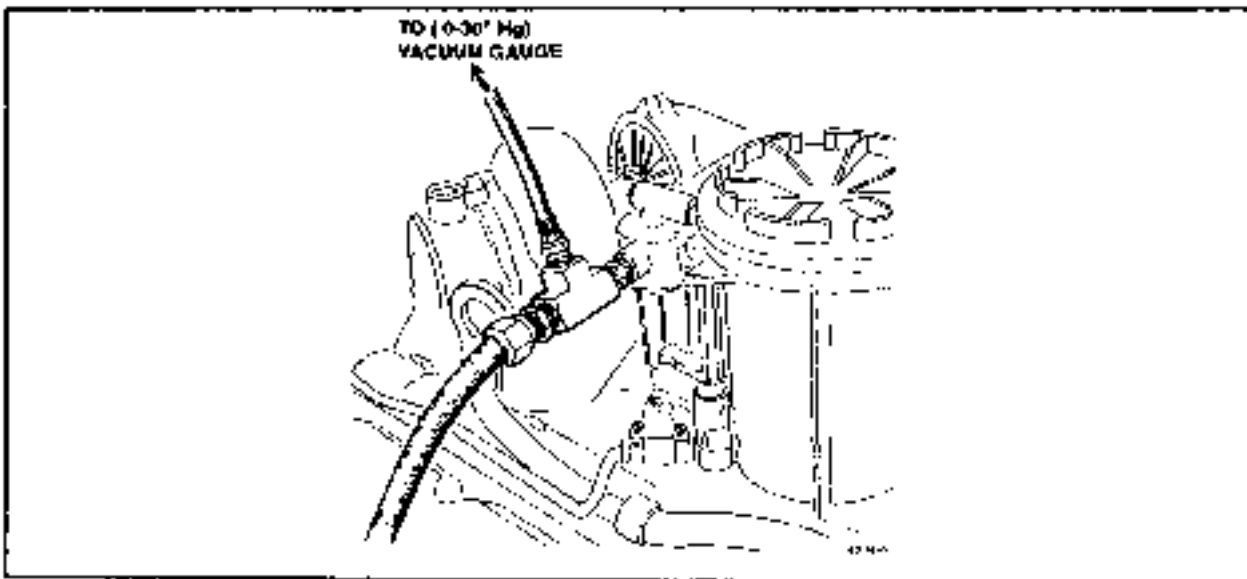


Figure 2.3-12. - Transfer Pump Restriction

T 444E ENGINE

TRANSFER PUMP RESTRICTION (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Replace filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.

- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

Model 0-200 Pressure Test Kit (ZTSE-2239) (0 to 30" Hg. vacuum gauge), "T" fitting, and appropriate fuel lines.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE

FUEL REGULATOR VALVE REMOVAL AND INSPECTION

FUEL REGULATOR VALVE REMOVAL AND INSPECTION.

1. Remove fuel return line from adapter fitting on fuel regulator block. (Figure 2.3-13.)
2. Remove the fuel line adapter fitting with "O" ring.
3. Use needle nose pliers to remove the fuel regulator spring and valve from the regulator.
4. Inspect fuel regulator valve seating surface for damage and insure spring is not broken.
5. Inspect inside of regulator block for dirt or debris that could restrict the flow of fuel past the regulator valve.

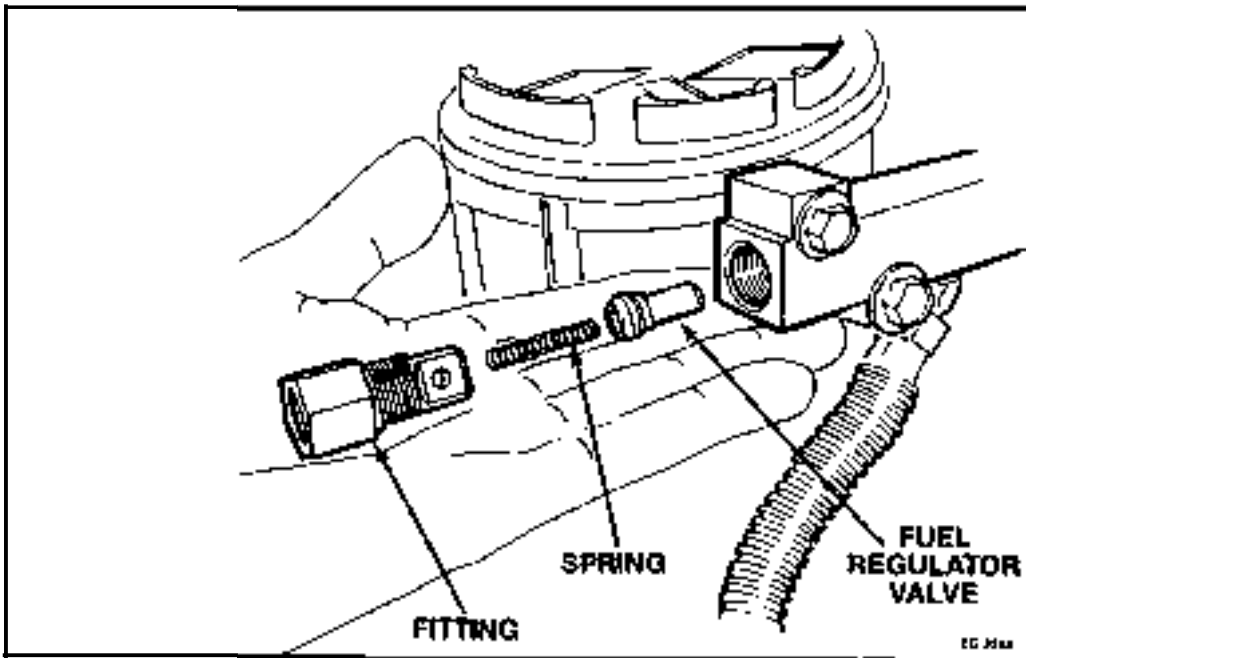


Figure 2.3-13. - Fuel Regulator Valve Removal and Inspection

T 444E ENGINE
BOOST PRESSURE

FROM FORM EGED-130-1

11. BOOST PRESSURE

- Monitor boost pressure and engine RPM with the EST tool in data list mode, or use dash tach and 0-30 PSI gauge and "T" if EST tool is not available
- Measure pressure at full load rated speed

Spec.	|	Actual
PSI @ RPM		

NOTE: BOOST PRESSURE AND FUEL PRESSURE (FULL LOAD) ARE "ROAD TESTS". THEY MAY BE PERFORMED AT THE SAME TIME.

PURPOSE

To determine if the engine can develop sufficient boost to obtain specific power.

TEST PROCEDURE

NOTE: TURN ALL ACCESSORIES AND THE IGNITION OFF, BEFORE CONNECTING EST TOOL TO ATA DIAGNOSTIC CONNECTOR.

1. Connect EST to the ATA connector.
2. Turn the ignition switch to the "ON" position.
3. Access the data list and press the "↓" key until "BOOST PSI" is displayed on the screen.

BATT VOLTS	12.5
ENGINE RPM	0
BOOST PSI	0
BARO IN Hg.	14.4

4. Drive vehicle on road till engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor.

NOTE: DRIVING THE VEHICLE UP HILL OR FULLY LOADED WILL FACILITATE EFFORTS OF REACHING THE PROPER ENGINE LOADING AT SPECIFIED ENGINE SPEEDS.

5. Record intake manifold boost at specified engine speeds.

ALTERNATE TEST PROCEDURE

1. Install a tee into the MAP (Manifold Absolute Pressure) sensor line that comes from the intake manifold. (Figure 2.3-14.)

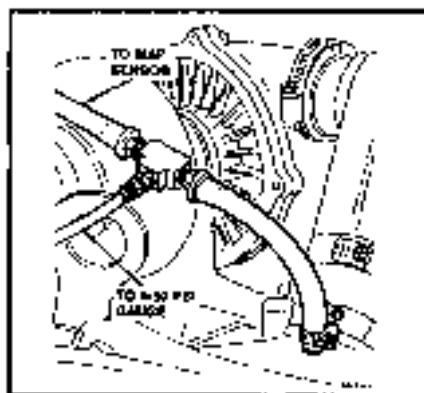


Figure 2.3-14. - Boost Pressure Tap Location

NOTE: MAP SENSOR MUST NOT BE DISCONNECTED DURING TEST.

2. Temporarily install the 0-200 Pressure Test Kit (ZTSE-2239) in the cab of the vehicle. Connect a line to the 0 to 30 PSI gauge and route it to the "T" so it is not crimped or in contact with a hot engine surface.

PERFORMANCE DIAGNOSTICS

T 444E ENGINE

BOOST PRESSURE (Continued)

3. Drive vehicle on road until engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor.

NOTE: DRIVING THE VEHICLE UP HILL OR FULLY LOADED WILL FACILITATE EFFORTS OF REACHING THE PROPER ENGINE LOADING AT SPECIFIED ENGINE SPEEDS.

5. Record intake manifold boost at specified engine speeds.

NOTE: IF BOOST PRESSURE IS WITHIN SPECIFICATIONS, THE ENGINE IS FUNCTIONING PROPERLY. THERE MAY BE CHASSIS OR APPLICATION CONCERNS.

POSSIBLE CAUSES:

- Restricted intake or exhaust.
- Low fuel pressure.
- Low injection control pressure.
- Control system faults
- Defective injectors.
- Defective Turbocharger
- Base engine failure

T 444E ENGINE
CRANKCASE PRESSURE

FROM FORM EGED-130-1

12. CRANKCASE PRESSURE

- Measure at road draft tube with orifice restrictor tool (ZTSE-4146)
- Measure at High idle no load RPM.

Instrument	Spec.	Actual
0 to 60" H ₂ O Magnehelic	< 6" H ₂ O	

PURPOSE

To measure power cylinder condition.

TEST PROCEDURE

1. Park vehicle on level ground.
2. Insure breather tube is free of dirt.
3. Insure engine oil level is not above the full mark and the dipstick is securely in place.
4. Connect a line from the restrictor tool (Figure 2.3-15) to a water manometer or to the pressure side of the magnehelic gauge on the 0-200 Pressure Test Kit (ZTSE-2239). **NOTE:** Install a quick connect plug in the vacuum port of the gauge to vent it to atmosphere. (Make sure that the magnehelic gauge has been zeroed)
5. Run engine to attain normal engine operating temperature before measuring crankcase pressure.
6. Perform engine crankcase pressure test with engine at high idle (no load) RPM. Allow the gauge reading to stabilize before taking the pressure reading.

7. Record crankcase pressure on diagnostic form.

IMPORTANT

DO NOT PLUG THE BREATHER TUBE DURING THE CRANKCASE PRESSURE TEST AS RESTRICTING THE TUBE CAN CAUSE CRANKSHAFT AND TURBOCHARGER SEALS TO LEAK.

POSSIBLE CAUSES:

- Dirt entering air induction system. (Check system for leaks.)
- Broken or worn compression rings
- Leaking or bent valves
- Turbocharger boost pressure entering crankcase.
- Air from air compressor leaking into crankcase.

TOOLS REQUIRED

Orifice restriction tool (ZTSE-4146) and water manometer or 0-200 Pressure Test Kit (ZTSE-2239)

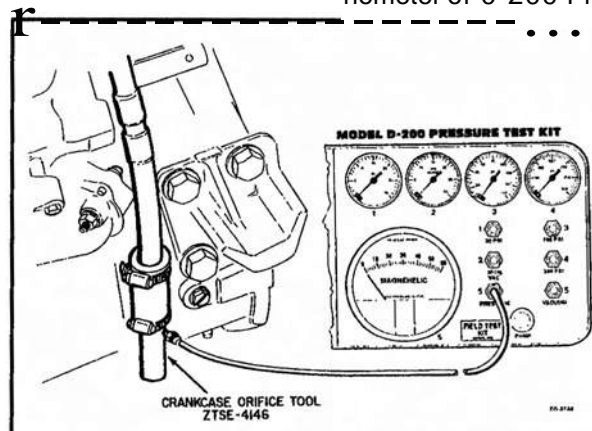


Figure 2.3-15. - Crankcase Pressure Test

PERFORMANCE DIAGNOSTICS

T 444E ENGINE WASTEGATE ACTUATOR TEST

FROM FORM EGED-13Q-1

13. WASTEGATE ACTUATOR TEST		
<ul style="list-style-type: none">• Apply regulated air to actuator• Inspect for leakage• Inspect actuator for movement		
Instrument	Spec.	Actual
0 to 60 PSI Gauge	17-19 PSI	

PURPOSE

To determine operation of actuator in conjunction with turbocharger operation.

TEST PROCEDURE

1. Remove actuator boost line from turbo compressor housing and connect an air regulator with a 0-60 PSI gauge to the actuator boost line. Figure 2.3-16.

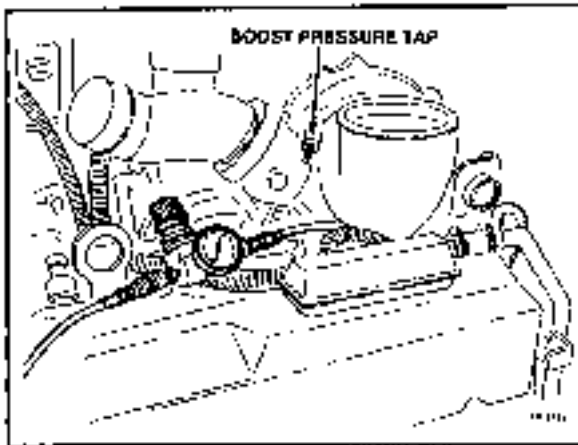


Figure 2.3-16. - Boost Pressure Tap Location and Air Regulator Connection

2. Mark actuator (link) shaft with paint pen. Figure 2.3-17.

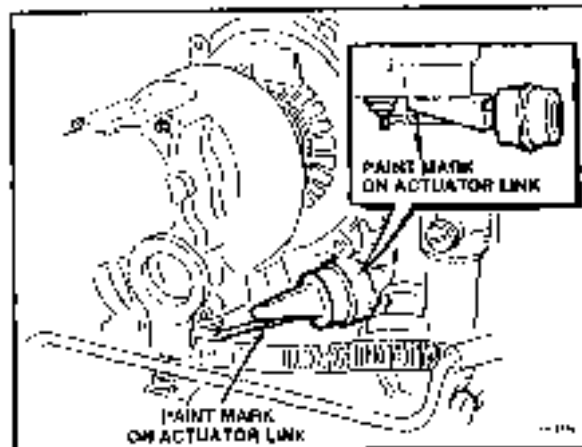


Figure 2.3-17. - Paint Mark Location on Actuator Link

3. Spray leak detector Figure 2.3-18. around the actuator housing and slowly apply air pressure to the actuator. Actuator (shaft) movement (indicated by position of paint mark) should begin to occur between 17-19 psi.

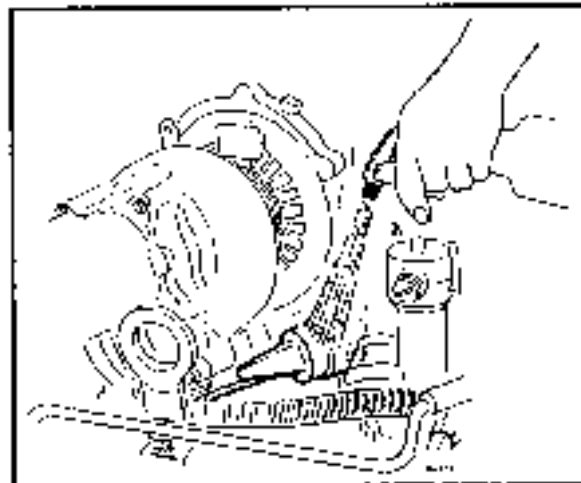


Figure 2.3-18. - Checking Actuator for Leaks

If a significant amount of actuator shaft movement occurs and no air leaks are detected at actuator housing, actuator is OK. If little or no shaft movement occurs or air leaks are present at the actuator housing, the turbocharger must be removed from

T 444E ENGINE

WASTEGATE ACTUATOR TEST(Continued)

engine. Refer to engine service manual for further wastegate diagnosis.

POSSIBLE CAUSES

- Sticky flapper valve

- Ruptured actuator diaphragm
- Leaky canister
- Leaky hose to actuator

TOOLS REQUIRED

Air pressure regulator, **0-60** psi gauge and paint marker. (Alternative: Dial indicator)

PERFORMANCE DIAGNOSTICS

T 444E ENGINE

INJECTION CONTROL PRESSURE TEST (OIL AERATION-POOR IDLE QUALITY)

FROM FORM EGED-130-1

**14. INJECTION CONTROL PRESSURE
(Oil Aeration-Poor idle quality)**

NOTE: TEST SHOULD BE PERFORMED AFTER ENGINE HAS BEEN RUN UNDER LOAD.

- Hold engine speed at high idle for 60 seconds.
- Monitor ICP pressure with EST data list or
- Measure at breakout box pins 27+ & 46- or Breakout "Tee" green and black -

Instrument	Spec.	Actual
EST	PSI	
DVOM (27+ ,46-)	Volts @ High Idle	

○ If ICP signal increases above 1040 PSI or 1.6 volts, change oil and retest.

PURPOSE

To determine if engine lube oil is being aerated and causing poor idle quality.

TEST PROCEDURE

IMPORTANT

IF ENGINE OIL IS AERATING, IT MAY CAUSE THE ENGINE TO IDLE ERRATICALLY. TO DETERMINE IF OIL IS BEING AERATED, PERFORM THIS TEST AFTER ENGINE HAS BEEN RUN UNDER A LOAD.

NOTE: TURN ALL ACCESSORIES AND THE IGNITION OFF, BEFORE CONNECTING EST TOOL TO ATA DIAGNOSTIC CONNECTOR.

1. Connect the Electronic Service Tool (EST) to the American Trucking Association (ATA) data link connector. (Figure 2.3-19.)
2. Start the engine and bring it to operating temperature.

NOTE: APPLY PARKING BRAKE AND INSURE THE TRANSMISSION IS IN NEUTRAL.

3. Press the "↓" key on the EST until "INJ CNTL PSI" appears on the screen.

BATT VOLTS	12.5
ENGINE RPM	0
INJ CNTL PSI	0
FUEL GAL/HR	0.3

4. Operate engine at high idle and monitor (ICP) Injection Control Pressure for 60 seconds on the EST.

Normal ICP pressure is 1000-1040 PSI. If ICP pressure does not stabilize below 1100 PSI and continues to rise while high idle speed is maintained, engine lube oil may be aerated. If this condition occurs, change oil and filter, then repeat ICP test.

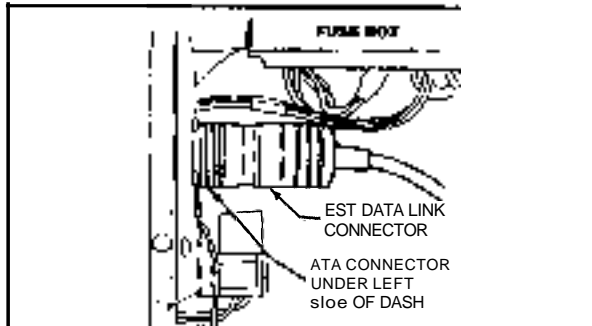


Figure 2.3-19. - ATA Connector Location

T 444E ENGINE

INJECTION CONTROL PRESSURE (OIL AERATION-POOR IDLE QUALITY) (Continued)

ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING (BREAK-OUT "TEE")

1. Remove engine harness connector at ICP sensor.
2. Connect the breakout "TEE" to the removed engine harness connector and the ICP sensor.
3. Connect DVOM leads (+Green, -Black) to the breakout "TEE" as shown in (Figure 2.3-20.)
4. Start the engine and bring it to operating temperature.
5. Operate engine at high idle and monitor (ICP) voltage for 60 seconds. Normal ICP voltage is between 1.2 to 1.6 volts. If the ICP signal voltage continues to rise as high idle speed is maintained, the engine lube oil may be aerated. Change oil and filter, then repeat ICP test at high idle.

TOOLS REQUIRED

DVOM and breakout sensor "T", (ZTSE-4347)

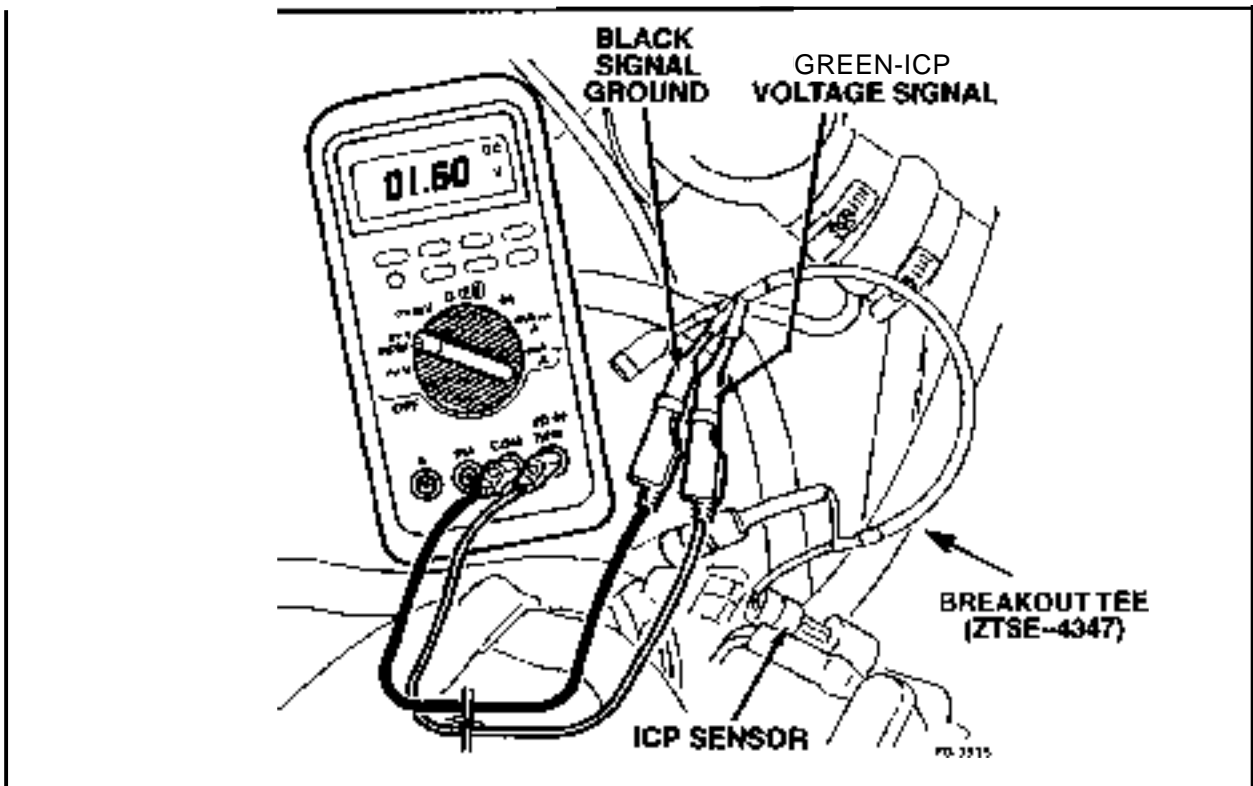


Figure 2.3-20. - Measuring Injection Control Pressure Using "Breakout Tee"

PERFORMANCE DIAGNOSTICS

T 444E ENGINE

INJECTION CONTROL PRESSURE (OIL AERATION-POOR IDLE QUALITY) (Continued)

ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING BREAKOUT BOX

1. Connect breakout box at ECM. (Figure 2.3-21.)
2. Connect DVOM to breakout box terminal #s (+27, -46).
3. Start the engine and bring it to operating temperature.
4. Operate engine at high idle and monitor (ICP) voltage for 60 seconds. Normal ICP voltage is between 1.2 to 1.6 volts. If the ICP signal voltage continues to rise as high idle speed is maintained, the engine lube oil may be aerated. Change oil and filter, then repeat ICP test at high idle.

TOOLS REQUIRED

DVOM and breakout box (ZTSE-4346).

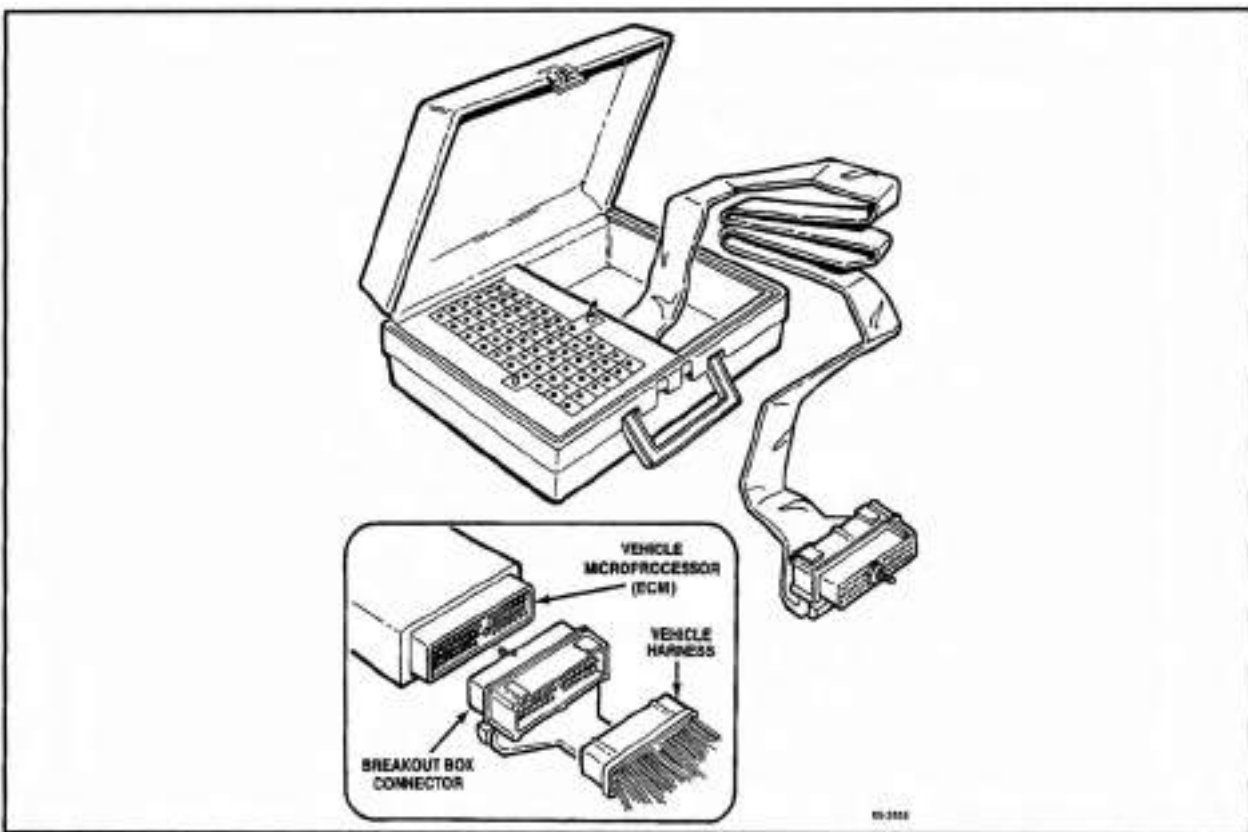


Figure 2.3-21. - Breakout Box (ZTSE-4346)

POSSIBLE CAUSES:

- Extended oil drain intervals. The anti-foam additives in the oil may be depleted from severe use or extended oil drain intervals.
- Wrong oil type or grade of oil.

PERFORMANCE SPECIFICATIONS

T 444E1160 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2600
6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2600 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 23DoF (11 DOC) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1160 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A160C
Engine rating	160 BHP @ 2600 RPM
Engine Family Rating Code (EFRC)	2111
Injector Part Number Original Equipment	1 816 187 C2/C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 824 703 C91 84
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 824 704 C91 84
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2600 + 50
High Idle Speed - RPM with automatic transmission	..... 2600 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	"..... Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1160 HP @ 2600 RPM
[California 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	. . . . . 20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O•• (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2600 6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2600 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
--	--------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

--Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A175F
Engine rating	175 BHP @ 2600 RPM
Engine Family Rating Code (EFRC)	2151
Injector Part Number Original Equipment	1 816 187 C2/C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 824 703 C91 84
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 824 704 C91 84
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2600 + 50
High Idle Speed - RPM with automatic transmission	2600 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	""

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H ₂ O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	..... 25 in. H ₂ O (6.25 kPa)

Fuel Pressure [Minimum]*	20 psi (138 kPa)
--------------------------	------------------

Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
---------------------------------------	-------------------------------

Crankcase Pressure [Maximum]*	{Requires Stabilized	6.0 in. H ₂ O** (2.0 kPa)
	Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2600
	6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H ₂ O (6.7 kPa)
---	------------------------------------

Smoke Level Max* - Bosch Number	1.3 @ 2600 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
--	--------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
------------------------------------	--------------------

Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

1**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2600 RPM
[California 1994 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A175C
Engine rating	175 BHP @ 2600 RPM
Engine Family Rating Code (EFRC)	2121
Injector Part Number Original Equipment	1 816187 C2/C3
Injection Timing	Not-Adjustable
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 824 703 C91 84
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 824 704 C91 84
High Idle Speed - RPM with manual transmission	2600 + 50
High Idle Speed - RPM with automatic transmission	..... 2600 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2600 RPM
[California 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H ₂ O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H ₂ O (6.25 kPa)

Fuel Pressure [Minimum]*	20 psi (138 kPa)
--------------------------	------------------

Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
---------------------------------	-------------------------------

Crankcase Pressure [Maximum]*	(Requires Stabilized	6.0 in. H ₂ O** (2.0 kPa)
	Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2600
	6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H ₂ O (6.7 kPa)
---	------------------------------------

Smoke Level Max* - Bosch Number	1.3 @ 2600 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
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Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A190F
Engine rating	190 BHP @ 2600 RPM
Engine Family Rating Code (EFRC)	2161
Injector Part Number Original Equipment	1 816 187 C2/C3
Injection Timing	Not-Adjustable
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 824 703 C91 84
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 824 704 C91 84
High Idle Speed - RPM with manual transmission	2600 + 50
High Idle Speed - RPM with automatic transmission	2600 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2600 RPM
[49 State 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 18.0 psi ± 2.0 psi (124 kPa ± 14 kPa) @ 2600
7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2600 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and **ambient temperature** of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min. I Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2600 RPM
[California 1994 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A190C
Engine rating	190 BHP @ 2600 RPM
Engine Family Rating Code (EFRC)	2131
Injector Part Number Original Equipment	1816187C2/C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 824 703 C91 84
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 824 704 C91 84
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2600 + 50
High Idle Speed - RPM with automatic transmission	2600 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2600 RPM
[California 1994 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H ₂ O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H ₂ O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H ₂ O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	18.0 psi ± 2.0 psi (124 kPa ± 14 kPa) @ 2600 7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H ₂ O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2600 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A175F
Engine rating	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2151
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet] (Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
(Requires Stabilized Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2300 6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A175C
Engine rating	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2121
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 ... 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O•• (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2300
6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level **Max*** - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

..Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A190F
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2161
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 16.0 psi ± 2.0 psi (110 kPa ± 14 kPa) @ 2300
7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

--Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[California 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A190C
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2131
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[California 1994 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

Crankcase Pressure [Maximum]* (Requires Stabilized Operating Temperature) 6.0 in. H2O** (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 16.0 psi ± 2.0 psi (110 kPa ± 14 kPa) @ 2300
7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

--Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A175F
Engine rating	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2111
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi \pm 2.0 psi (103 kPa \pm 14 kPa) @ 2300
6.0 psi \pm 2.0 psi (42 kPa \pm 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) " 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A175C
Engine rating	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2112
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	".. 2500 + 200
Low Idle Speed - RPM	" 700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust .. " " "..... ".....	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2300
6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A190F
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2121
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O•• (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle **rated** engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 16.0 psi ± 2.0 psi (110 kPa ± 14 kPa) @ 2300
7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190HP @ 2300 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A190C
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2122
Injector Part Number Original Equipment	1 816187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 ... 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	... 700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	16.0 psi ± 2.0 psi (110 kPa ± 14 kPa) @ 2300
	7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (MiniMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model.	T 444E/A21 OF
Engine rating	210 BHP @ 2400 RPM
Engine Family Rating Code (EFRC)	2231
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 "
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	" 700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	" .. " " " " " "..... Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[49 State 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O •• (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2400
7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2400 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A210C
Engine rating	210 BHP @ 2400 RPM
Engine Family Rating Code (EFRC)	2232
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	700 ±50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	..... 2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[California 1995 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
(Requires Stabilized Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi \pm 2.0 psi (117 kPa \pm 14 kPa) @ 2400 7.0 psi \pm 2.0 psi (48 kPa \pm 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2400 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[49 State 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A21 OF
Engine rating	210 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2141
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	. 2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	... 700 ±50
Injection Control PressureVoltage @ Low Idle No Load.	590 ±50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[49 State 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2300 8.0 psi ± 2.0 psi (55 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[California 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A210C
Engine rating	210 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2142
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[California 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet] (Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
(Requires Stabilized	
Crankcase Pressure [Maximum]*	6.0 in. H2O ** (2.0 kPa)
Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi \pm 2.0 psi (117 kPa \pm 14 kPa) @ 2300 8.0 psi \pm 2.0 psi (55 kPa \pm 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[49 State 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A230F
Engine rating	230 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2151
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ±50
Injection Control PressureVoltage @ Low Idle No Load	590 ±50 psi (4.00 ±0.3 MPa) (0.94 ±0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ±0.7 MPa) (1.40 ±0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ±1.0 MPa) (3.15 ±0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[49 State 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O ** (2.0 kPa)
	Operating Temperature)

The following data to be taken at 'uliload, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ±2.0 psi (117 kPa ± 14 kPa) @ 2300
	11.0 psi ±2.0 psi (76 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[California 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	.....	T 444E/A230C
Engine rating		230 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)		2152
Injector Part Number Original Equipment		1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	.	1 823 560 C91 1.11
Injection Timing		Not-Adjustable
High Idle Speed - RPM with manual transmission		2500 + 50
High Idle Speed - RPM with automatic transmission	.....	2500 + 200
Low Idle Speed - RPM		700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	.....	590 ± 50 psi (4.00 ± 0.3 MPa) (0.94 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load		1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load		2470±150psi(17.0±1.0MPa) (3.15±0.,3Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)		
Intake		Not-Adjustable
Exhaust		Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[California 1995 1/2 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
(Requires Stabilized	
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi \pm 2.0 psi (117 kPa \pm 14 kPa) @ 2300 11.0 psi \pm 2.0 psi (76 kPa \pm 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A175F
Engine rating	" 175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2111
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi \pm 2.0 psi (103 kPa \pm 14 kPa) @ 2300
6.0 psi \pm 2.0 psi (42 kPa \pm 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model		T 444E1A175C
Engine rating	"	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)		2112
Injector Part Number Original Equipment		1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio		1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio		1 823 553 C91 1.0
Injection Timing	" "	Not-Adjustable
High Idle Speed - RPM with manual transmission		"..... 2500 + 50
High Idle Speed - RPM with automatic transmission		"..... 2500 + 200
Low Idle Speed - RPM	"	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	"	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load		1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load		2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)		
Intake		Not-Adjustable
Exhaust	.....	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1175 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H ₂ O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H ₂ O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]*	(Requires Stabilized Operating Temperature) 6.0 in. H ₂ O** (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	15.0 psi ± 2.0 psi (103 kPa ± 14 kPa) @ 2300 6.0 psi ± 2.0 psi (42 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H ₂ O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (11 DOC) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A190F
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2121
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	" Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 16.0 psi \pm 2.0 psi (110 kPa \pm 14 kPa) @ 2300
7.0 psi \pm 2.0 psi (48 kPa \pm 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches **stabilized** operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A190C
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2122
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet] (Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
(Requires Stabilized	
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	16.0 psi ± 2.0 psi (110 kPa ± 14 kPa) @ 2300 7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0–27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-1,2°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A21 OF
Engine rating	210 BHP @ 2400 RPM
Engine Family Rating Code (EFRC)	2231
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]*	20 psi (138 kPa)
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Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
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	(Requires Stabilized	
Crankcase Pressure [Maximum]*	Operating Temperature)	6.0 in. H2O** (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2400
	7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
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Smoke Level Max* - Bosch Number	1.3 @ 2400 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at tuilload and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
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Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A210C
Engine rating	..... 210 BHP @ 2400 RPM
Engine Family Rating Code (EFRC)	2232
Injector Part Number Original Equipment	1 816 187 C3
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450±50 psi (3.10±0.3 MPa) (0.78±0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ±0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	..... Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]*	20 psi (138 kPa)
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Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
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	(Requires Stabilized	
Crankcase Pressure [Maximum]*		6.0 in. H2O** (2.0 kPa)
	Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2400
Intake Manifold Pressure*	7.0 psi ± 2.0 psi (48 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
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Smoke Level Max* - Bosch Number	1.3 @ 2400 RPM
	1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
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Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A21 OF
Engine rating	210 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2141
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
(Requires Stabilized Operating Temperature)	

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2300 8.0 psi ± 2.0 psi (55 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (11 a0C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/A210C
Engine rating	210 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2142
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	700 ±50
Injection Control PressureVoltage @ Low Idle No Load	450 ±50 psi (3.10 ±0.3 MPa) (0.78 ±0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ±0.7 MPa) (1.40 ±0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ±0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet] (Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]* (Requires Stabilized Operating Temperature)	6.0 in. H2O** (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi \pm 2.0 psi (117 kPa \pm 14 kPa) @ 2300 8.0 psi \pm 2.0 psi (55 kPa \pm 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) ."	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1A230F
Engine rating	230 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2151
Injector Part Number Original Equipment	1 822 890 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C91 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	450 ± 50 psi (3.10 ± 0.3 MPa) (0.78 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.10 ± 0.7 MPa) (1.40 ± 0.2 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.3 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[49 State 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	" 6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]*	(Requires Stabilized Operating Temperature) 6.0 in. H2O•• (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2300 11.0 psi ± 2.0 psi (76 kPa ± 14 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max. - Bosch Number ... "	1.3 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
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The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	" " 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

--Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[California 1996 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O•• (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 17.0 psi ± 2.0 psi (117 kPa ± 14 kPa) @ 2300
11.0 psi ± 2.0 psi (76 kPa ± 14 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444EJ175 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E18175
Engine rating	175 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2111
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020±100psi(7.00±0.7MPa) (1.44±0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	..... 2180 ± 150 psi (15.0 ± 1.0 MPa) (2.81 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E11'75HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet] (Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
Crankcase Pressure [Maximum]* (Requires Stabilized Operating Temperature)	6.0 in. H2O** (2.0 kPa)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	15.1 psi \pm 1.5 psi (104 kPa \pm 10 kPa) @ 2300 4.7 psi \pm 1.5 psi (32 kPa \pm 10 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	0.4 @ 2300 RPM 0.6 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	,. 6-12°F (3.3-6.6°C)
--	-----------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E18190
Engine rating	190 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2121
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.00 ± 0.7 MPa) (1.44 ± 0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2320 ± 150 psi (16.0 ± 1.0 MPa) (2.98 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1190 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max.	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	15.5 psi ± 1.5 psi (107 kPa ± 10 kPa) @ 2300 7.0 psi ± 1.5 psi (48 kPa ± 10 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	0.6 @ 2300 RPM 1.3 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
--	--------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (110°C) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1821 0
Engine rating	210 BHP @ 2400 RPM
Engine Family Rating Code (EFRC)	2231
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number (With Exhaust Back Pressure Device) AIR Ratio	1 823 554 C91 1.0
Turbocharger Part Number (Without Exhaust Back Pressure Device) AIR Ratio	1 823 553 C91 1.0
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.00 ± 0.7 MPa) (1.44 ± 0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold) Intake	Not-Adjustable
Exhaust " " .	".. Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2400 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	"	17.25 psi ± 1.5 psi (119 kPa ± 10 kPa) @ 2400
		7.00 psi ± 1.5 psi (48 kPa ± 10 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*		0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number		0.6 @ 2400 RPM
		1.9 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
--	-------	--------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)		230°F (11 DOC) Max.
Lube Oil Pressure at Operating Temperature		
Low Idle (Min.)		10-30 psi (137-344 kPa)
Rated Speed (Min./Max.)		40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E/BH21 0
Engine rating	210 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2141
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number AIR Ratio	1 823 560 C92 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020±100psi(7.10±0.7MPa) (1.44±0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1210 HP @ 2300 RPM
[50 State "997 **Model Year**]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]	
(Check at High Idle [No Load]) - Max	12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max	25 in. H2O (6.25 kPa)
Fuel Pressure [Minimum]*	20 psi (138 kPa)
Fuel Inlet Restriction Maximum*	6 in. Hg. Vacuum (20.261 kPa)
	(Requires Stabilized
Crankcase Pressure [Maximum]*	6.0 in. H2O** (2.0 kPa)
	Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure*	14.5 psi ± 1.5 psi (100 kPa ± 10 kPa) @ 2300 8.0 psi ± 1.5 psi (55 kPa ± 10 kPa) @ 1500
Exhaust Back Pressure (After Turbocharger [Maximum])*	0-27 in.H2O (6.7 kPa)
Smoke Level Max* - Bosch Number	0.8 @ 2300 RPM 1.9 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
--	--------------------

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery)	230°F (11 DOC) Max.
Lube Oil Pressure at Operating Temperature	
Low Idle (Min.)	10-30 psi (137-344 kPa)
Rated Speed (Min.IMax.)	40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1B230
Engine rating	230 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2151
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C92 1.11
Injection Timing	Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	..... 2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.00 ± 0.7 MPa) (1.44 ± 0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2470 ± 150 psi (17.0 ± 1.0 MPa) (3.15 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	..... Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1230 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 14.8 psi ± 1.5 psi (102 kPa ± 10 kPa) @ 2300
10.0 psi ± 1.5 psi (69 kPa ± 10 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 0.8 @ 2300 RPM
3.6 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (11 DOC) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

PERFORMANCE SPECIFICATIONS

T 444E1250 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS

Engine/Model	T 444E1B250
Engine rating	250 BHP @ 2300 RPM
Engine Family Rating Code (EFRC)	2161
Injector Part Number Original Equipment	1 822 803 C1
Turbocharger Part Number (With Wastegate) AIR Ratio	1 823 560 C92 1.11
Injection Timing	" Not-Adjustable
High Idle Speed - RPM with manual transmission	2500 + 50
High Idle Speed - RPM with automatic transmission	2500 + 200
Low Idle Speed - RPM	700 ± 50
Injection Control PressureVoltage @ Low Idle No Load	440 ± 40 psi (3.00 ± 0.3 MPa) (0.76 ± 0.1 Volts)
Injection Control PressureVoltage @ High Idle No Load	1020 ± 100 psi (7.00 ± 0.7 MPa) (1.44 ± 0.1 Volts)
Injection Control PressureVoltage @ Rated Speed and Full Load	2480 ± 150 psi (17.1 ± 1.0 MPa) (3.16 ± 0.2 Volts)
Intake and Exhaust Valve Clearance (Engine Off - Hot or Cold)	
Intake	Not-Adjustable
Exhaust	Not-Adjustable

PERFORMANCE SPECIFICATIONS

T 444E1250 HP @ 2300 RPM
[50 State 1997 Model Year]

PERFORMANCE SPECIFICATIONS CONTINUED

The following data to be taken at high idle with [no load].

Air Cleaner Restriction* [Measured @ Air Cleaner Outlet]
(Check at High Idle [No Load]) - Max 12.5 in. H2O (3.13 kPa)
(Check at Full Load, Rated Speed) - Max. 25 in. H2O (6.25 kPa)

Fuel Pressure [Minimum]* 20 psi (138 kPa)

Fuel Inlet Restriction Maximum* 6 in. Hg. Vacuum (20.261 kPa)

(Requires Stabilized
Crankcase Pressure [Maximum]* 6.0 in. H2O** (2.0 kPa)
Operating Temperature)

The following data to be taken at full load, full throttle rated engine speed on chassis dynamometer or on highway.

Intake Manifold Pressure* 15.0 psi ± 1.5 psi (103 kPa ± 10 kPa) @ 2300
11.0 psi ± 1.5 psi (76 kPa ± 10 kPa) @ 1500

Exhaust Back Pressure (After Turbocharger [Maximum])* 0-27 in.H2O (6.7 kPa)

Smoke Level Max* - Bosch Number 1.3 @ 2300 RPM
4.6 @ 1500 RPM

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator 6-12°F (3.3-6.6°C)

The following data to be taken after engine reaches stabilized operating temperature.

Lube Oil Temperature (Oil Gallery) 230°F (110°C) Max.

Lube Oil Pressure at Operating Temperature
Low Idle (Min.) 10-30 psi (137-344 kPa)
Rated Speed (Min./Max.) 40-70 psi (276-483 kPa)

*Engine must be at normal operating temperature.

**Crankcase pressure [maximum] as measured with Orificed Restrictor Tool ZTSE4146.

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ELECTRONIC CONTROL SYSTEM

DIAGNOSTIC FORM

Section 3.1
Page 1

INTRODUCTION

GENERAL INSTRUCTIONS

This section contains the supporting information for the Electronic Control System Diagnostic form. It includes engine and vehicle recommended diagnostic procedures, a description of each control circuit's function and a detailed drawing with specifications for each circuit. The technician can be directed to the appropriate control circuit through the "Circuit Index" column on the Electronic Control System Diagnostic form EGED-135-1


Engine and Vehicle Electronic Diagnostics are indexed by circuit acronyms listed on the Electronic Control System Diagnostic form. The Section Index lists the acronyms with the corresponding page numbers to quickly locate the circuit (s) requiring diagnostics. The diagnostic information is structured as described below.

- The function page(s) for each circuit is intended to give a technician a brief description of what that circuit does and what faults the control system can detect.
- The diagnostic page(s) for each circuit is intended to give the technician information required to test that circuit and determine if it is functioning correctly.

ELECTRONIC CONTROL SYSTEM

DIAGNOSTIC FORM

ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM EGED-135-1 (FRONT SIDE)

 INTERNATIONAL® T 444E DIESEL ELECTRONIC CONTROL SYSTEM DIAGNOSTICS	Technician _____ Date _____ Customer Name _____ Dealer Name _____ Dealer Location _____ Unit# _____
--	---

Flash Codes	Circuit	Condition Description	Comments	P _r Causes
111	ECM	No fault detected-Flash Code Only	No errors detected by the ECM or IDM	
112	ECM PWR	Elect.Sys. Voltage B+ Out of Range High	Battery voltage to ECM more than 16 volts	Charging System Fault
113	ECM PWR	Elect.Sys. Voltage B+ Out of Range Low	Battery voltage to ECM less than ... volts	Low Battery or resistance in circuit
114	ECT	Engine coolant temp signal out of range low	Default 82°C-Glow plugs on 120 sec. HOEI	ECT signal circuit or sensor grounded
115	ECT	Eng. temp signal out of range high	Default 82°C-Glow plugs on 120 sec. No EBP operation	ECT circuit or
116	MAP	MAP frequency out of range	Default Inferred MAP-Low permeation acceleration	High frequency noise, airleak, sensor
117	MAP	MAP signal is inactive.	Default Inferred MAP-Low permeation acceleration	Short high, low or open
118	MAP	MAP above spec. level at idle	Default Inferred MAP-Low permeation acceleration	MAP plugged
119	ICP	ICP signal out of range low	Default open loop control-Limitation	Circuit short low, open, defective sensor
120	ICP	ICP signal out of range high	Default open loop control-Limitation at idle	Circuit short high, defective sensor
121	APSAVS	Acceler. Position signal out of range low	APS voltage lower than 1.52 volts-Eng. idle only	Unshielded, open circuit or
122	APSAVS	Acceler. Position signal out of range high	APS voltage higher than 4.55 volts-Eng. idle only	Short - Vref or 12 volt, defective sensor
123	APSAVS	Accelerator Position signal in	APSAVS Conflict-Limited to IFS, APS	Failed APS signal
124	APSAVS	Accelerator Position & idle limitation disagree	APSAVS Conflict-Limited to IFS, APS	Both APS & IVS signal failure
125	APSAVS	Idle Validation Switch Circuit Fault	APSAVS Conflict-Limited to 50% APS	Failed IVS signal
126	VBS	Vehicle Speed signal out of range low	VPM detects VBS out of range-Cruise/PTD	VBS circuit open or shorted to ground
142	VSS	Vehicle Speed signal out of range high	VPM detects VSS out of range-Cruise/PTD	VBS circuit shorted to Vref or 12 volts
143	CMP	Wrong id id CMP sig. transmission gear cam	CMP signal intermittent	Foot operation, defective sensor
144	CMP	CMP signal noise detected	ECM detects excessive outside inputs	Electrical
145	CMP	CMP ICP has increased	No CMP signal while ICP signal increased	Short high, low, open or defective sensor
151	BARO	Barometric Press. signal out of range high	BARO signal high	Short high or open circuit
152	BARO	Barometric Press. signal out of range low	BARO signal low	Short low
153	IAT	Air temp. signal out of range low	IAT signal low - EBP	IAT signal circuit or sensor grounded
154	IAT	Air temp. signal out of range high	IAT signal high - EBP	IAT circuit or sensor open
210	EOP	Engine Oil Pressure signal out of range low	EOP signal low	Short low
211	EOP	Engine Oil Pressure signal out of range high	EOP signal high	High or open
213	SCCS	SCCS signal out of range low	SCCS signal lower than 1.2 mV	Open circuit
214	SCCS	SCCS signal out of range high	Reverse APS signal higher than 4.55	
221	SCCS	SCCS switch	SCCS signal incorrect voltage	Short or resistance in 1400Ω circuit
222	BRAKE	Brake Pedal Position signal out of range low	Terms 23 (BNO) & 43 (Hc) disagree	Faulty switch or relay
223	DCL/ATA	VPM not communicating with ECM	Engine will not start	DCL circuits open or shorted
224	KAM PWR	KAM corrupt	KAM memory parity error	No battery voltage to ECM terminal 1
231	DCL/ATA	ATA common fault	ATA link open or shorted	ATA or
232	DCL/ATA	Unable to format ECM map. ATA DCL	Will not turn Warning Light ON	ATA data link circuits shorted high or low
233	TACH	Tachometer buffer	VPM not receiving Tach	Tach output open or shorted
234	DCL/ATA	Unable to format ATA messages to ECM	ECM will not turn Warning Light ON	EST relay OFF & VPM powered up
235	DCL/ATA	VPM/ECM DCL fault	No ECM diagnostic replies	DCL circuits open or shorted
241	IPR	Inj. Ckt. Pres Regulator OCC self test failed	IPR-Output Circuit Check-Engine Off Test	Shorted high or low or
242	ECM/IDM	IDM self test failed	IDC1 Output Circuit Check-Engine Off Test	High or low or open
243	IDM PWR	IDM Power relay OCC failed	IDM relay-Output Circuit Check-Engine 011 Too.	IDM enable relay shorted high/low
244	EDL	IDLOCC	IDL relay-Output Circuit Check-Eng. 011 Too	EDL circuit open or shorted
245	EPR	Exhaust Press Reg. self test failed	EPR-Output Circuit Check-Eng. 011 Too	Short high or low or open
251	GPC	Glow Plug self test failed	GP relay-Output Circuit Check-Engine Off Test	Short high or low or open
252	GPC	Glow Plug Lamp OCC self test failed	GP Lamp-Output Circuit Check-Engine Off Test	Glow Plug Lamp circuit open/shorted
253	ECM/IDM	Fuel Inj. sync circuit OCC self test failed	Cyl. position Output Ckt Check-Eng. Off Test	Open IDL circuit - No IDL power
254	ECM	Output Circuit Check Out of Range High		High voltage during OCC
255	ECM	Output Circuit Check Out of Range Low		Low voltage during OCC test
256	EDT	Engine Oil Temp. signal out of range low	EDT signal low	EDT signal circuit or sensor grounded
257	EDT	Engine Oil Temp. signal out of range high	EDT signal high	EDT sensor or circuit open
313	EOI	Engine Oil Pressure Below Warning Level	ECM detects low oil pressure, Oil Light ON	No or low oil, oil pres. pickup -
314	EOI	Engine Oil Pressure Below Critical Level	ECM detects low oil pressure, Warning Light ON	defective, worn bearing
315	EOI	Engine Speed (Tach RPM) limit exceeded	ECM recorded excessive engine speed	Improperly downshifted
316	ECT	Eng. coolant temp. unable to reach commanded set pt.	Enabled only when Cold Ambient Protection	Leading thermostat, cooling system problems
321	ECT	Eng. Coolant Temperature Warning level	Coolant Temperature Greater than 104.0°F (40°C)	Cooling system problem
322	ECT	Engine Coolant Temp above Critical	Coolant Temperature Greater than 233.6°F (112.5°C)	
323	Est.	Engine coolant level below Warning/Critical level	ECM detects low coolant	Check coolant level, if low check for leaks

** Faults only available if Engine Protection is enabled

ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM

ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM EGED-135-1 (FRONT SIDE)

Chassis Model	Complaint
VIN Number	Active Codes
Engine Serial Number	Inactive Codes
VPM serial Number	VPM version
ECM Serial Number	ECM version
	Standard Test Codes
	Event Log Codes

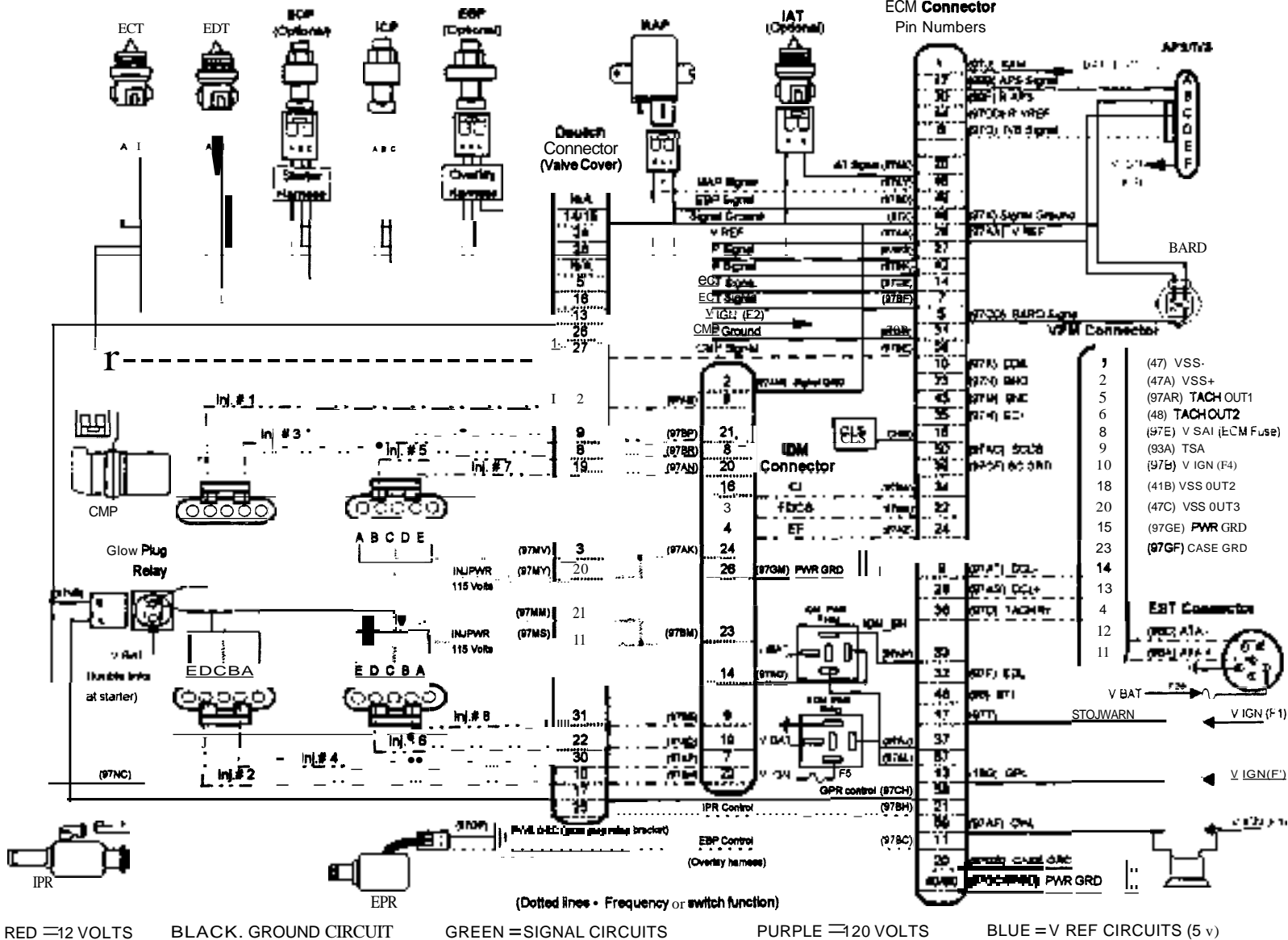
Flash Codes	Circuit Index	Condition Description	Comments	Probable Causes
324		Idle Shutdown Timer Enabled Engine shutdown.	Idle shutdown timer on and Idle time exceeded limit	Idle time exceeded limit
325	ECT	Per. regulated, matched to cooling sys performance	Engine power reduced due monitoring system	Low coolant level or coolant overtemp
326	IPR	Inj. Cntrl. Press above system working range	ICP - 3675 psi (25 Mpa)	Grounded IPR circuit, stuck IPR valve
327	ICP	Inj. Cntrl. Press above spec with engine off	ICP signal voltage higher than expected - Engine Off	Circuit shorted or defective sensor
328	IPR	Inj. Cntrl. Press - low desired	Desired pressure - match output	Check for proper servicing, test IPR
329	IPR	ICP unable to achieve point (gear performance)	ICP - not = ICP signal - period of time	Injector "O" rings, ICP sensor, High pressure pump
330	IPR	ICP unable to achieve pressure during cranking	Less than 725 psi ICP pressure after 10 - cranking	Air in oil, injection pressure problems (see manual)
341	EBP	Exhaust back pressure signal out of range low	EBP -	Short low
342	EBP	Exhaust back pressure signal out of range high	EBP device disabled	Sh on high
343	EPR	Excessive exhaust back pressure	EBP above working range	Check EBP valve position, exhaust restriction
344	EBP	Exhaust back pressure vs spec. w/Eng. off	EBP sig. volt. higher than expected w/Eng not running	Check for plugged EBP tube or biased sensor
351	EPR	EBP - expected level @ high Engine speed	EBP failure associated @ 3300 RPM	EBP - stuck, EPR stuck.
352	EPR	Exh. bk.	Pressure does not match output in KOER test	EBP - responding, restricted exhaust
421-428	INJ	Low side - high side opens (Cyl # indicated)	IDM detected an open injector circuit	Individual injector harness open.
431-438	INJ	Low side shorted - high side (Cyl # indicated)	IDM detected a shorted injector circuit	Injector or harness shorted to high side
441-448	INJ	Low - VBAT (Cyl # indicated)	IDM - 12 - injector drive low side	Inj. harness shorted - low (control) ckt - B-
451-458	INJ	Low - to grd (Cyl # indicated)	IDM detected inj. low side shorted to grd - 4 Cyl run	Inj. harness shorted on - ckt to grd
461-468	Part. Diag	Cyl. Contrib. test failed (Cyl # indicated)	ECM finds cylinder contribution insufficient	
469	INJ	Multiple -	Right side has more than	Right side short, open and ground
470	INJ	has multiple faults	Left side has more than 1 high side fault	Left side short, open and ground
471	INJ	High side in Bank 1 open	Right side high voltage at	Open ckt to right side injector feed
472	INJ	High -	Left side high voltage supply open	Open ckt to left - injector
473	INJ	Bank 1 high side short to ground or VBAT	Right side high - ckt shorted	to right side of engine shorted
474	INJ	Bank 2 high side short - ground or VBAT	Left - high - ckt s	Harness to left - engine
475	IDM PWR	IDM internal failure	Internal IDM fault	Defective IDM
523	IDM PWR	is low	Voltage is low @ IDM	Ckt 87CP/87AG - volts, IDM relay def.
524	INJ		Short ckt - left and right banks	
525	ECM/IDM	Cylinder identification signal	Distorted low volt. @ ICP signal - long, intermittent	ICP signal - low - in
526	ECM/IDM	Cyl - signal high	Detected high volt. @ a signal - long, intermittent	ICP sig. - high or open to IDM - intermittent
527	ECM/IDM	IDM - not detected by ECM	ICP - IDM wiring - Eng.	Ckt 87CP/87AG low - IDM relay def.
528	ECM/IDM	IDM faults not received	Repair codes 242, 243 or 263 - if set	Ckt 87CP/87AG low volts, IDM relay def.
544	INJ	in Bank 2	IDM detected more than 1 left side injector low volts	Injector harness shorted to ground
545	INJ	in	IDM detected more than 1 right side injector low volts	Injector harness shorted to ground
550	CMP	Incorrect ECM installed for CMP timing wheel	Mismatch between ECM and CMP sensor	Incorrect ECM
551	VPM	ECM not compatible w/ VPM software	VPM/ECM are not compatible	Components changed in the field are not compatible
552	VPM	Installed VPM not compatible w/ ECM software	VPM/ECM are not compatible	Components changed in the field are not compatible
553	ECM	Py - KAM corrupt fault	KAM memory defective	Interrupted KAM power supply or defective ECM
554	VPM	Eng. using Mfg. default ratings program engine	Engine operates @ 2 - Hp - 1 t	VPM not programmed, but installed on truck
555	VPM	Engine using field - lift rating	Eng. limited to 180 Hp Options not	VPM not programmed @ CM, etc
556	VPM	Invalid Eng. rating code - VPM programming	Eng. family ratings not received from VPM	VPM not programmed properly
525	ECM	Module software background process was inactive	ECM software is faulty	Replace ECM
53	ECM	RAM (read only memory) self test fault	ECM failure	Replace ECM
532	ECM	RAM memory-CPU	ECM failure	Replace ECM
533	DCU/ATA	VPM is communicating incorrectly - ECM	ECM/VPM incorrect communications	Ckts 87AT/87AS as open/shorted
534	VPM	Internal fuelmeter memory location in error	VPM memory for fuelmeter cannot read	Fuel totals may be incorrect; replace VPM
535	VPM	Internal hourmeter memory location in error	VPM memory for hourmeter cannot be read	Hour totals may be incorrect; replace VPM
541	VPM	Internal odometer memory location in error	VPM memory for odometer cannot	Mileage totals may be incorrect; replace VPM
542	VPM	Internal fuelmeter fault	EEPROM memory cannot write fuelmeter totals	Use - lost; Replace VPM to correct
543	VPM	Internal hourmeter fault	EEPROM memory cannot write hourmeter totals	Hour totals are lost; Replace VPM to correct
544	VPM	Internal odometer fault	EEPROM memory	Replace VPM to correct
545	VPM	Internal EEPROM memory location error	EEPROM memory not read by VPM	Check for
546	VPM	Feature memory data content corrupted	VPM detects error in feature -	VPM on, pull fuse F4 and reinstall
552	VPM	Eng.-fuel memory corrupted	VPM detects error in engine rating list	With VPM on, pull fuse F4 and reinstall
553	VPM	Engine rating memory data content corrupted	Attempt - reprogram/replace VPM if reoccurs	
554	VPM	EEPROM memory - self test	VPM software fault	VPM will reset

T444E Electronic Engine Controls • 1994 to 1997

Engine Mounted Components

Truck Mounted Components

Cab Mounted Components



ELECTRONIC CONTROL SYSTEM

DIAGNOSTIC FORM

ELECTRONIC CONTROL SYSTEM DIAGNOSTIC FORM EGED-135-1 (PREPARED SIDE)

60 Pin Signal V.lue. T 444-E											
Pin Number	Acronym	Circu" Name	Circu" Number	Key Off	Key On	Low Idle		High Idle		Operating Ranga	Comments
						Signal	Data Ust	Signal	Data UsI		
1	KAM PWR	Keep Alive Memory Power	91J	VaAT	V BAT	V BAT	V BAT	V BAT	V BAT	V BAT	B+ for ECM KAM memory
5	BARe	Barometric Pressure Sensor	97 CD	Ov	4.5 - 4.6 v	4.5 - 4.6v	15-14 PSI	4.5 - 4.6 v	15-14 PSI	4.9 - 2.0v	4.6v " Avg. BARO sea level
1	ECT	Engine Coolant Temperature	97BF	0-25v	Temperature Dependent					.6v" 195°F	4.53 v= -40°F / .35Bv= 230°F
8	IVS	Idle Validation Switch	91D	Ov/Ov	Ov/12v	Ov		12v	-	11l12v	APS Pedal Up/Down
9	DCL (-)	Data Communication link	97 AT	Ov	1 - 3v	1 - 3 v		1 - 3v		Variable Freq.	Digital data stream from VPM 1 + 3 v
10	DOS (clutch)	Oriveline Disengagement Switch	97 A	Ov/Ov	12v/Ov	12v/Ov	Off/On	12v/Ov	OWOn	12v/Ov	Clutch Pedal Up/Down (Cruise/PTO)
11	EPR	Exhaust Back Pressure Reaulator	91 BC	Ov	1.5v	1.85v		1.91v		300/1195 Hz	Exhaust Back Pressure
13	GPL	Glow Plug Lamp	IBG	Ov	OV/12v	12v		12v		Ov/12v	Ov=Light On 12v=light Off
14	EOT	Engine Oil Temperature	97CE	Ov	Temperature Dependent					.6v = 195°F	4.53 v= -40°F | .35Bv= 230°F
11	STO/WARN	Self Test Output/Warn Lamp	97T	Ov	B+	B+		B+		12v	Ov=LighlOn 12v=Light Off
18	CLS	Coolant Level Switch	34 B	Ov	B+	B+		B+		12v	Ov. Uaht On 12v- liaht Off
20	CASEGRO	Case Ground	97GB	Ov	Ov	Ov		Ov		Ov	
21	IPR(rea)	Injection Pressure Regulator	97BH	Ov	10-13v	10-13v		10-13v		10 - 13v	Duty Cycle Current Controlled
22	FDCS	Fuel Delivery Command Signal	97 BB	Ov	Ov	1-2v/46.5 Hz		2-3v/200 Hz		491200 Hz	700-3000 RPM
23	BOO	Brake Normally Open Switch	91 N	Ov/12v	Ov/12v	Ov/12v	Off/On	Ov/12v	Off/On	Ov/12v	Brake Pedal Up/Down
24	EF	IDM Feedback (Electronic feedback)	91 AZ	Ov	1 - 3v	.3-1 v		1.52.5 v		46.51200 Hz	100 Hz with key on enaine off
25	IAT	Intake Temperature Sensor	97 AX	Ov	Temperature Dependent					3.07v=68°F	4.53 v= -40°F | .35Bv= 230°F
26	V REF	Voltage Reference	97AA	Ov	5 ± .5v	5 ± .5v		5 ± .5v		5 ± .5v	
27	ICP - sensor	Injection Control Pressure Sensor	97BG	Ov	.2 - .3v	.8B - 1.0v	540- 640 PSI	1.4 - 1.5 v	990 - 1050	.9 - 3.25v	3.15 v = 2410 PSI(Full Load)
28	DCL 1+)	Data Communication link	91 AS	Ov	1 - 3v	1 - 3 v		1 - 3v		Variable Freq.	Digital data stream from VPM 1 - 3 v
30	RAPS	Remote Accelerator Pedal Sensor	99 F								
31	CMP GRO	CMP Sensor Ground	97GR	Ov	Ov	Ov		Ov		Ov	
32	EDL	Enaine Data line	97 F	Ov	Ov	0.1		B+		0/12	Auto Trans. only (WOT transition)
33	10M EN	IDM Enable Relay	97 AH	Ov	12v -> Ov	Ov		Ov		12v/Ov	12v=IOM Off Ov=IOM On
34	CI	Cylinder Identification	91BA	Ov	.5 v	6-7v 15-7 Hz		7.2v/24.9 Hz		5 Hz-600 Hz	WiFiFluke BB in Tach mode reads RPM
35	ECl	Enoine Crank Inhibit	97 H								
36	TACH (out)	Tachometer Output	97O	Ov	Ov	6.5v/1140Hz	100 RPM	6.5v/540 Hz	2100 RPM	140-600Hz	Varies with eng. RPM (RPM/5)
37	VPWR	Ignition Power	97 AJ	Ov	VIGN	VIGN	VIGN	VIGN	VIGN	VIGN	Ignition source power
39	SCGRO	Speed Control Grd.	97CF	Ov	Ov	Ov		Ov		Ov	
40	PWR GRD	Power Ground	97GC	Ov	Ov	Ov		Ov		ov	
42	EOP	Enoine Oil Pressure Sensor	97BK	Ov	.7 - .1 v	2 -4.7v	10 -38 PSI	4.6 -4.8 v	38 PSI	7 - 4.8v | 0-38 PSI	Sensor limited 10.3B PSI Maximum
43	BNC	Brake Normally Closed	97 M	Ov	12v/Ov	12v/Ov	Off/On	12v/Ov	Off/On	12v/Ov	Brake Pedal Up/Down (Cruise/PTO)
44	RVREF	Remote Voltage Reference	97 DO	Ov	5 ± .5v	5 ± .5v		5 ± .5v		5 ± .5v	
45	MAP	Manifold Absolute Pressure Sensor	97 AY	Ov	2.5v	2.5v	o PSI	2.5v	.5 - 2.5 PSI	10B-186 Hz	10B/114Hz;Almosp. Pres (sea level)
46	Sig. GRO	Signal Ground	91X	Ov	Ov	Ov		Ov		Ov	Ground for all sensor .ianals
47	APS	Accelerator Pedal Sensor	99B	Ov	.25v - .5 v	.25v - .5 v	0%	3.5-4.0 v	100%	25-4v / 0-100 %	
48	STI	Self Test Input	98	Ov	5v	5v		5v			Ov when rounded for enoine off tests
49	EBP- Sensor	Exhaust Back Pressure Sensor	97BO	Ov	B-1 v	.8-1 v		1.5 - 1.7 v		.8 - 1.1	3.3v excessive pressure code set
50	SECS	Cruise Control	97 AC	Ov	6.58v	6.58v		6.5Bv			Varies with switch position
56	CMP	Camshaft Position Sensor	97 BE	Ov	120r2.5v	6 - 7v		6 - 7v		140-600 Hz	700-3000 RPM
57	VPWR	Ignition Power	97 AL	Ov	VIGN	VIGN	VIGN	VIGN	VIGN	VIGN	Ignition source power
58	GPR	Glow Plug Relay	97CH	Ov	OV/12v	Ov/12v		12v			Ov=GPR On 12v=GPR Off
59	OWL	Oil/Water Lamp	97AF	Ov	12v	12v		12v			Ov=OWL On 12v=OWL Off
60	PWRGRO	Power Ground	97 GO	Ov	Ov	Ov		Ov		Ov	

ELECTRONIC CONTROL SYSTEM

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX	Sec.3.5 Page No.	FAULT DESCRIPTION
111 ECM	86 	No Fault Detected - Flash code only
112 ECM PWR	98	Electrical System Voltage B+ out of range HIGH
113 ECM PWR	98 	Electrical System Voltage B+ out of range LOW
114* ECT	104	Engine Coolant Temperature signal out of range LOW
115* ECT	104.	Engine Coolant Temperature signal out of range HIGH
121* MAP	182	Manifold Absolute Pressure Frequency Out of Range
122* MAP	182 	Manifold Absolute Pressure Signal is inactive
123 MAP	182 	Man Absolute Press (MAP) above spec. level at low idle
124* ICP	146 	Injection Control Pressure Signal out of range LOW
125 ICP	146 	Injection Control Pressure Signal out of range HIGH
131* APS/JVS	4	Accelerator Position Signal out of range LOW
132* APSIIVS	4	Accelerator Position Signal out of range HIGH
133* APS/IVS	5 	Accelerator Position Signal in-range fault
134* APS/IVS	5 	Accelerator Position and Idle Validation disagree
135* APS/IVS	5 	Idle Validation Switch circuit fault
141 VSS	238 	Vehicle Speed Signal out of range LOW
142 VSS	238	Vehicle Speed Signal out of range HIGH
143 CMP	32	Wrong number of CMP signal transitions per cam revolution
144 CMP	32 	CMP Signal noise detected
145 CMP	33	CMP Signal inactive while ICP has increased
151 BARO	12 	Barometric Pressure Signal out of range HIGH
152 BARO	12 	Barometric Pressure Signal out of range LOW
154 fAT	140 	Intake Air Temperature Signal out of range LOW
155 IAT	140 	Intake Air Temperature Signal out of range HIGH
211* . . . EOP	118 	Engine Oil Pressure Signal out of range LOW
212* EOP	118	Engine Oil Pressure Signal out of range HIGH
213 SCCS	190 	Remote Throttle Signal out of range LOW
214 " SCCS	190	Remote Throttle Signal out of range HIGH
221 SCCS	189	SCCS Switch or Circuit fault
222 BRAKE	19 	Brake Switch Circuit Fault
223 DCUATA	39 	VPM not communicating with ECM

* - Indicates WARN ENGINE LAMP on when fault is set.

ELECTRONIC CONTROL SYSTEM

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX (Continued)

FLASH CODE CIRCUIT INDEX	Sec.3.5 Page No.	FAULT DESCRIPTION
224 KAM PWR	176	KAM Corrupt
231 DCUATA	39	ATA Common Fault
232 DCUATA	40	Unable to forward ECM message to ATA DCI
233 TACH	212	Tachometer buffer is inactive
234 DCUATA	40	Unable to forward ATA message to ECM
235 DCUATA	40	VPM / ECM DCI fault
241 IPR	168	Injection Control Pres..Regulator aCC Self Test failed
242 ECM/IDM	91	FOGS circuit to IDM aCe Self Test failed
243 IDM PWR	152	10M Power Relay aCC Self Test failed
244 EDI	110	Engine to Transmission Data Line (EDL) OCC Fault
245 EPR	132	Exhaust Pressure Regulator aCC Self Test failed
251 GPC	136	Glow Plug Controller aCC Self Test failed
252 GPC	136	Glow Plug Lamp aCC Self Test failed
253 ECM/IDM	91	Fuellnj. Sync Circuit aCe Self Test failed
254 ECM	86	aCe Self Test ECM test circuit out of range HIGH
255 ECM	86	aCC Self Test ECM test circuit out of range IOW
311* EDT	. . . 126	Engine Oil Temperature Signal out of range IOW
312* EOT	126	Engine Oil Temperature Signal out of range HIGH
313 EOP**	118	Engine Oil Pressure below warning level
314 EOP**	".. 119	Engine Oil Pressure below critical level
315* . . . . . "	.....	Engine Speed (Tach RPM) limit exceeded
316 ECT	105	Engine Coolant Temperature Unableto Reach commanded set point
321 ECT**	105	Engine Coolant Temperature above warning level
322 ECT**	. . 105	Engine Coolant Temperature above critical level
323 ECI	79	Engine Coolant level below warning / critical level
324		Idle Shutdown Timer Enabled Engine Shutdown
325 ECT	105	Power reduced, matched to cooling system performance
331* IPR	168	Injection Control Pressure above system working range
332* ICP	146	Injection Control Pressure above spec with engine off
333* IPR	168	Injection Control Pressure above/ below desired level

* - Indicates WARN ENGINE LAMP on when fault is set.

** - Faults only available if Engine Protection is enabled.

ELECTRONIC CONTROL SYSTEM

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX (Continued)

FLASH CODE CIRCUIT INDEX	Sec.3.5 Page No.	FAULT DESCRIPTION
334* IPR	168	ICP unable to achieve setpoint (poor performance)
335* IPR	168	ICP unable to build pressure during cranking
341 ESP		Exhaust Back Pressure signal out of range LOW
342 ESP		Exhaust Back Pressure signal out of range HIGH
343 EPR	132	Excessive Exhaust Back Pressure
344 ESP	,	Exhaust Back Pressure above Spec. with Engine OFF
351 EPR	131	Exhaust Back Pressure below expected level at high engine speeds
352 EPR	131	Exhaust Back Pressure above or below desired level
421 INJ	160	LOW to HIGH Side Open - Cyl1
422 INJ	160	LOW to HIGH Side Open - Cyl2
423 INJ	160	LOW to HIGH Side Open - Cyl3
424 INJ	160	LOW to HIGH Side Open - Cyl 4
425 INJ	160	LOW to HIGH Side Open - Cyl5
426 INJ	160	LOW to HIGH Side Open - Cyl 6
427 INJ	160	LOW to HIGH Side Open - Cyl 7
428 INJ	160	LOW to HIGH Side Open - Cyl 8
431 INJ	160	LOW to HIGH Side Short - Cyl1
432 INJ	160	LOW to HIGH Side Short - Cyl2
433 INJ	160	LOW to HIGH Side Short - Cyl3
434 INJ	160	LOW to HIGH Side Short - Cyl4
435 INJ	160	LOW to HIGH Side Short - Cyl5
436 INJ	160	LOW to HIGH Side Short - Cyl6
437 INJ	160	LOW to HIGH Side Short - Cyl 7
438 INJ	160	LOW to HIGH Side Short - Cyl8
441 INJ	160	LOW side short to VBAT- Cyl 1
442 INJ	160	LOW side short to VBAT - Cyl2
443 INJ	160	LOW side short to VBAT - Cyl3
444 INJ	160	LOW side short to VBAT - Cyl4
445 INJ	160	LOW side short to VBAT - Cyl5
446 INJ	160	LOW side short to VBAT - Cyl6
447 INJ	160	LOW side short to VBAT - Cyl 7
448 INJ	160	LOW side short to VBAT - Cyl8

* - Indicates WARN ENGINE LAMP on when fault is set.

ELECTRONIC CONTROL SYSTEM

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX (Continued)

FLASH CODE CIRCUIT INDEX	Sec.3.5 Page No.	FAULT DESCRIPTION
451 INJ	161	LOW side short to ground – Cyl1
452 INJ	161	LOW side short to ground - Cyl2
453 INJ	161	LOW side short to ground - Cyl 3
454 INJ	161	LOW side short to ground - Cyl 4
455 INJ	161	LOW side short to ground – Cyl 5
456 INJ	161	LOW side short to ground - Cyl 6
457 INJ .. "	161	LOW side short to ground – Cyl 7
458 INJ	161 "	LOW side short to ground - Cyl 8
461 Perf. Diag.		Cyl Contribution Test Failure - Cyl1
462 Perf. Diag.		Cyl. Contribution Test Failure – Cyl2
463 Perf. Diag.		Cyl. Contribution Test Failure - Cyl 3
464 Perf. Diag.		Cyl. Contribution Test Failure - Cyl 4
465 Peri. Diag.		Cyl. Contribution Test Failure - Cyl5
466 " .. Perl. Diag	"	Cyl. Contribution Test Failure - Cyl 6
467 Perf. Diag.		Cyl. Contribution Test Failure - Cyl7
468 " Perl. Diag.		Cyl. Contribution Test Failure - Cyl 8
511* .. " INJ	161	Bank 1 has multiple faults
512* INJ	161	Bank 2 has multiple faults
513* INJ	161	High Side to Bank 1 Open
514* ----- INJ	161	High Side to Bank 2 Open
515* ----- INJ	161	Bank 1 High Side Short to Ground or VBAT
521* INJ	161	Bank 2 High Side Short to Ground or VBAT
522* IDM PWR .. "	153	IDM Internal Failure
523 IDM PWR	153	10M power voltage is LOW
524* INJ "	161	Both High Side Switches shorted together
531* .. " ECM/IDM	91	Cylinder identification (CI) Signal Low
532* ECM/IDM	91	Cylinder Identification (CI) Signal high
541 * ECM/IDM	92	IDM Feedback TOGGLE not detected by ECM
543* ECM/IDM	92	IDM faults not received
544 INJ	162	Injector Fault in Bank 2
545 INJ	162 "	Injector Fault in Bank 1
612* CMP	33	Incorrect ECM installed for CMP (timing) wheel

* - Indicates WARN ENGINE LAMP on when fault is set.

ELECTRONIC CONTROL SYSTEM

FLASH CODE CIRCUIT INDEX

FLASH CODE CIRCUIT INDEX (Continued)

FLASH CODE CIRCUIT INDEX	Sec.3.5 Page No.	FAULT DESCRIPTION
613* VPM	231	Installed ECM not compatible with VPM Software
614* VPM	231	Installed VPM not compatible with ECM software
615 ECM	86, 231 ..	Programmable Parameter KAM Corrupt fault
621* VPM	231	Engine using MFG. Default rating program engine
622* VPM	231	Engine using Field Default rating
623* VPM	232	Invalid Engine Rating Code; Check VPM programming
625 ECM	86	Module Software Background Process was inactive
631 ECM	86	ROM (Read Only Memory) Self Test fault
632 ECM	86	RAM Memory-CPU Self Test Fault
633 DCUATA	41	VPM is communicating incorrectly with ECM
634 VPM	232	Internal Fuel meter memory location in error
635 VPM	233	Internal Hourmeter memory location in error
641 VPM	233	Internal Odometer memory location in error
642 VPM	233	Internal Fuelmeter Fault
643 VPM	233	Internal Hourmeter Fault
644 VPM	233	Internal Odometer Fault
645 VPM	233	Internal EEPROM memory location error
651 ... VPM	233	Feature memory data content corrupted
652 VPM	234	Engine/Fuel memory data content corrupted
653 VPM	234	Engine/Rating memory data content corrupted
654 VPM	234	Watchdog Timeout

* - Indicates WARN ENGINE LAMP on when fault is set.

SENSOR AND ACTUATOR LOCATIONS (ENGINE)

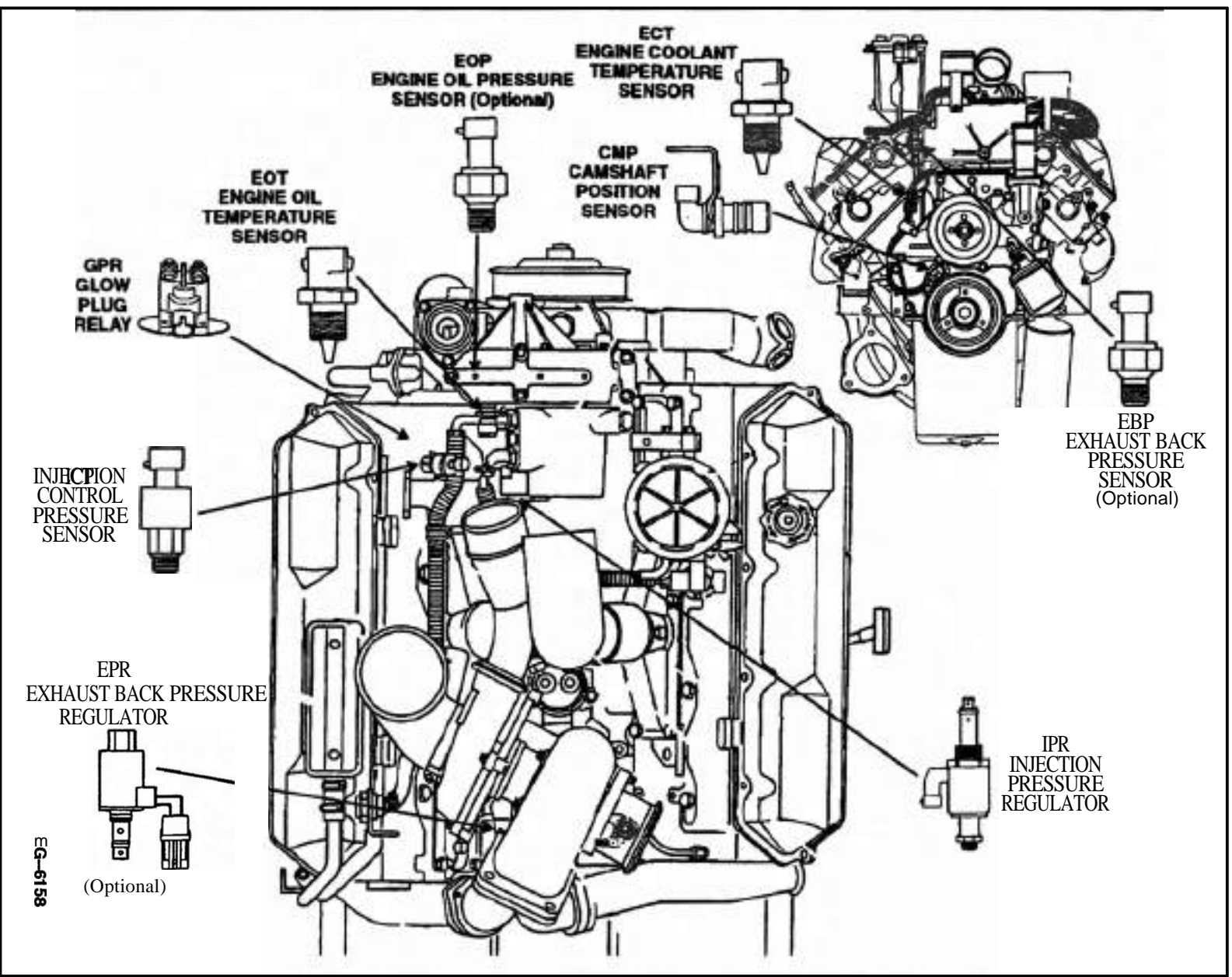


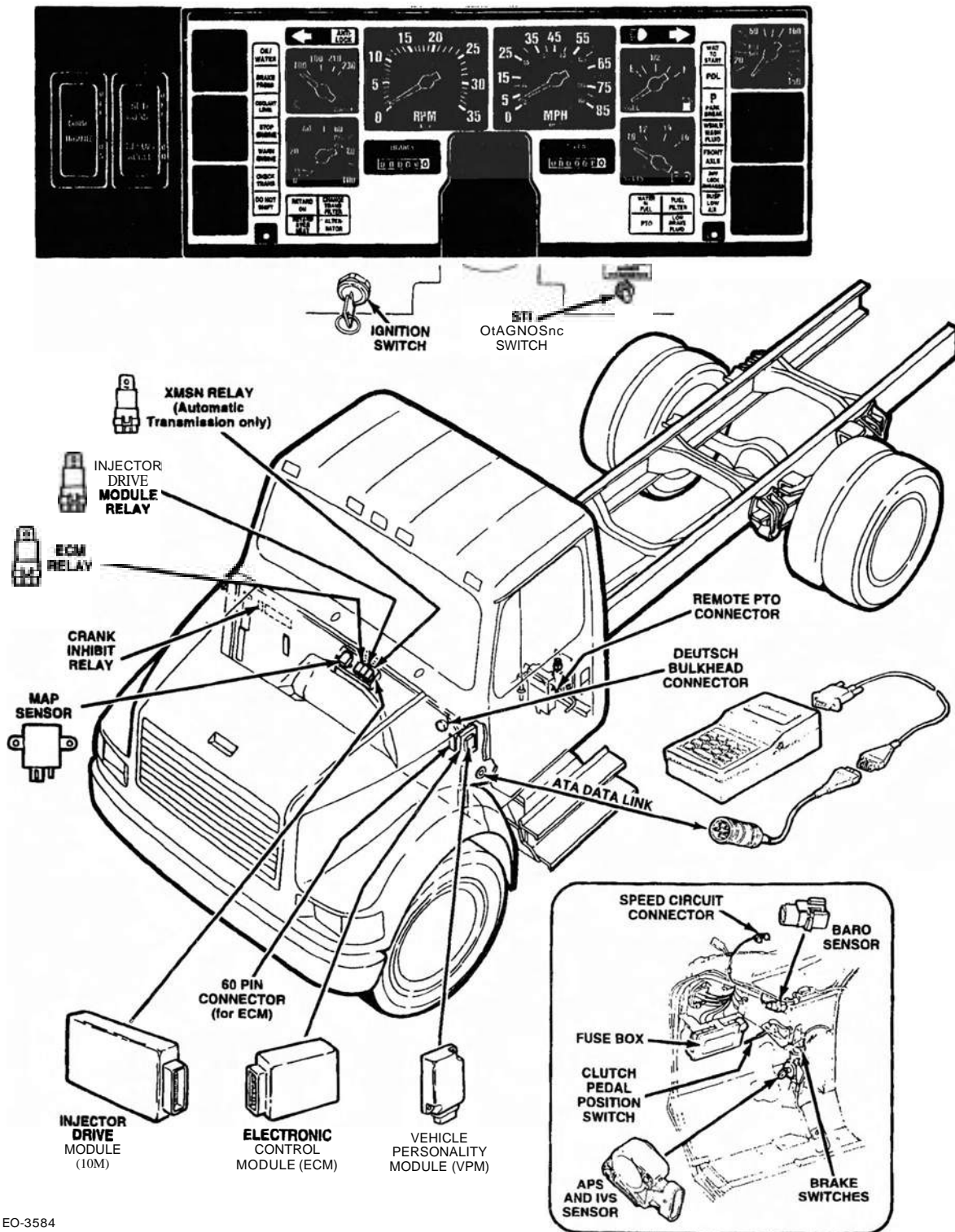
Figure 3.3-1 Sensor and Actuator Locations on Engine.

EGS-25-1

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ELECTRONIC CONTROL SYSTEM COMPONENT LOCATIONS (VEHICLE)

ELECTRONIC CONTROL SYSTEM VEHICLE/ENGINE INTERFACE



EO-3584

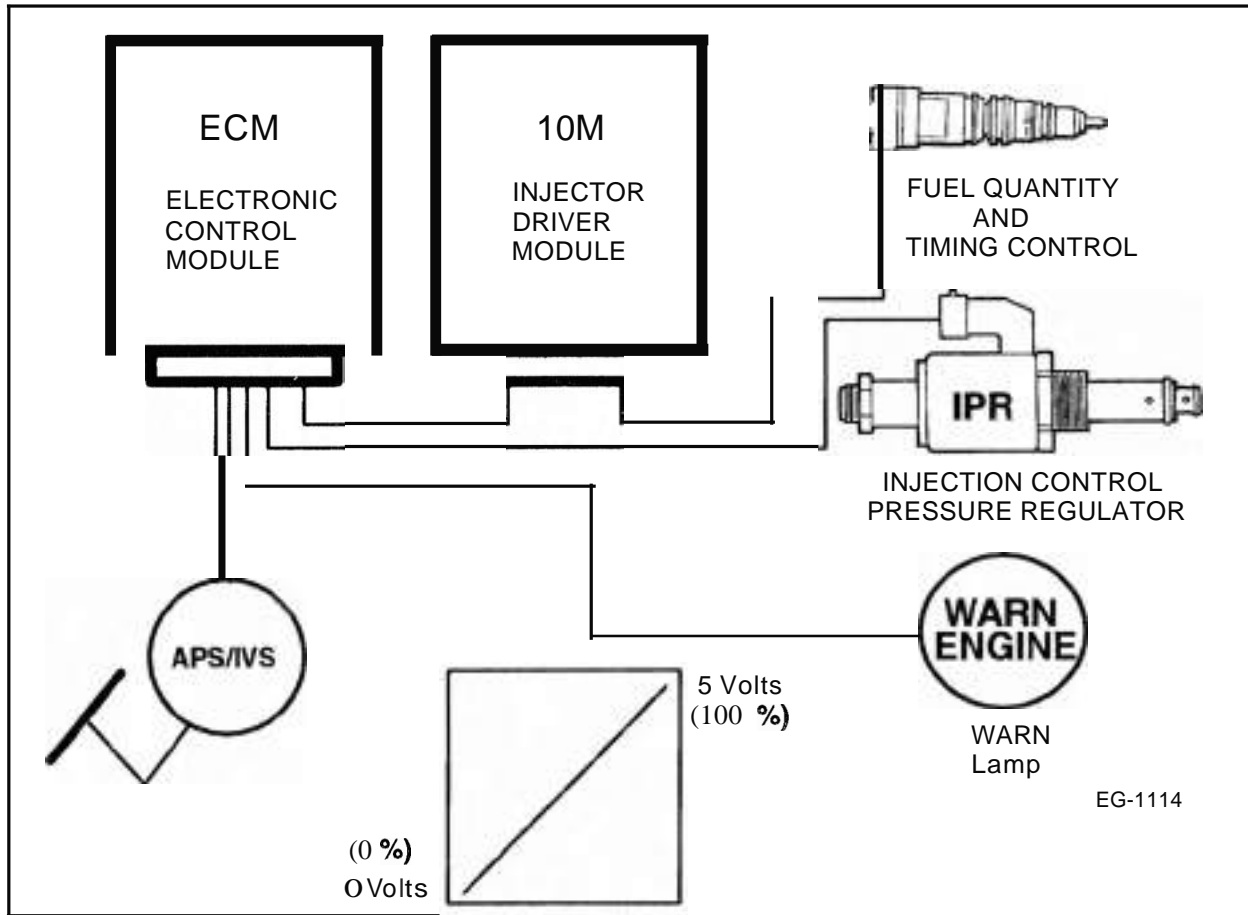
Figure 3.3-2. Electronic Control System Component Locations (Vehicle)

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5

Page2 ACCELERATOR PEDAL POSITION SENSOR/IVS SWITCH (APS/IVS)

APS/IVS PEDAL POSITION SENSOR /IDLE VALIDATION SWITCH



SIGNAL FUNCTIONS

The Accelerator Pedal Position Sensor (APS) is a potentiometer type sensor which, when supplied with a 5 volt reference signal from the Electronic Control Module (ECM), provides a linear analog voltage signal that indicates the driver's demand for power.

The Idle Validation Switch (IVS) is a 0/12 volt switch that provides the ECM with a redundant signal to verify when the pedal is in the idle position.

Fuel Quantity and Timing Control - The APS signal is used in calculating desired fuel quantity and injector timing.

Injection Control Pressure - Accelerator pedal position is one of the controlling variables in the calculation of desired injection control pressure.

FAULT DETECTION/MANAGEMENT

Any detected malfunction of the APS or IVS sensor circuit will illuminate the WARN ENGINE lamp.

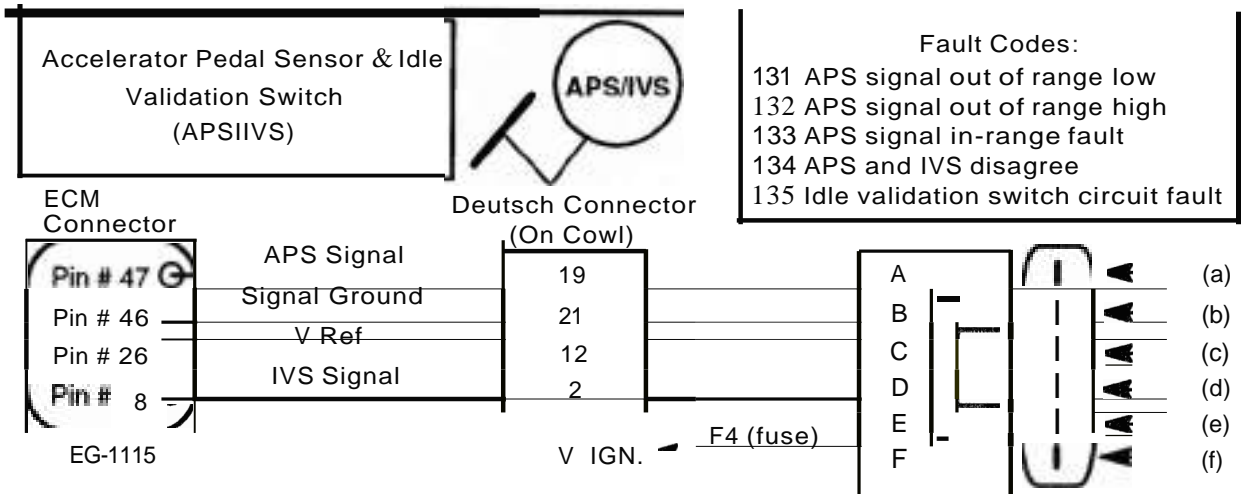
An APS signal that is detected out of range high or low by the ECM will cause the engine to ignore the APS signal and will only allow the engine to operate at low idle.

If a disagreement in the state of IVS and APS is detected by the ECM and the ECM determines that it is an IVS fault, the ECM will only allow a maximum of 50% APS to be commanded.

If a disagreement in the state of IVS and APS is detected by the ECM and the ECM can not discern if it is an APS or IVS fault or if it is an APS fault, the engine will be allowed to operate at low idle only.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ACCELERATOR PEDAL POSITION SENSOR/IVS SWITCH (APS/IVS) Page 3



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
B to Grd.	< 5 ohms	Resistance to chassis ground, check with key off, > than 5 ohms harness is open.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
O to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Signal Checks (Check with Sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
A to Grd.	0- .25 volts	If greater than .25 volts signal ground wire is shorted to V Ref or battery.
B to Grd.	0- .25 volts	Signal ground no voltage expected.
C to Grd.	5 ± .5 volts	VRef check key on, if VRef not present check open/short to grd #26 to C, see VRef circuit.
O to Grd.	0- .25 volts	If greater than .25 volts signal ground wire is shorted to V Ref or battery.
F to Grd.	12 ± 1.5 volts	< 10.5 v check for poor connection, 0 v check for open/short to grd circuit or blown fuse.

Harness Resistance Checks (Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#47 to A	< 5 ohms	Resistance from 60 pin connector to harness connector - APS Signal
#46 to B	< 5 ohms	Resistance from 60 pin connector to harness connector - Signal Ground
#26 to C	< 5 ohms	Resistance from 60 pin connector to harness connector - V Ref
#8 to O	< 5 ohms	Resistance from 60 pin connector to harness connector - IVS Signal
V IGN. to F	< 5 ohms	Resistance from V IGN. power to harness connector

Position	APS Test Points (+) #47 to H #46		IVS Test Points (+) #8 to (-) #46		Operational Voltage Checks (Check with breakout box and the EST tool installed key "ON")
	Voltage	%APS	Voltage	%APS	Comments
Low Idle	.25 to .8 V	0%	0 volts	0%	IVS voltage should toggle just off low idle position.
High Idle	3 to 4.5 V	98-100%	12 ± 1.5v	98-100%	If APS measures only 50% and volt signal in spec., IVS fault detected.

Fault Code Descriptions

- 131 APS signal was less than 0.146 volts for more than 0.5 seconds *
- 132 APS signal was greater than 4.56 volts for more than 0.5 second *
- 133 APS signal in-range fault *
- 134 APS and IVS agree *
- 135 Idle validation switch circuit fault - 50% APS only.

* -IF FAULT CODE IS SET. ENGINE OPERATION WILL DEFAULT TO RUN AT LOW IDLE SPEED ONLY.

APSI/IVS EXTENDED SYSTEM DESCRIPTION

Navistar electronic engines use an electronic accelerator pedal assembly that includes a Accelerator Position Sensor (APS) and Idle Validation Switch (IVS). These two functions are integrated into one component mounted on the pedal. The accelerator pedal assembly is serviceable to the extent that the APS/IVS switch can be replaced without replacing the complete assembly.

The engine Electronic Control Module (ECM) determines the position of the accelerator pedal by processing the input signals from the Accelerator Position Sensor (APS) and Idle Validation Switch (IVS).

ACCELERATOR POSITION SENSOR (APS)

Refer to circuit diagram on page 6 for the following discussion.

The ECM sends a regulated 5 volt signal through ECM connector (379) terminal 26 to APS connector (382) terminal C. The APS then returns a variable voltage signal (depending on pedal position) from APS connector (382) terminal A to the ECM at terminal 47. The APS is grounded from connector (382) terminal 8 to the ECM signal ground terminal 46.

APS AUTO-CALIBRATION

The ECM learns the lowest and highest pedal positions by reading and storing the minimum and maximum voltage levels from the APS. In this manner the ECM "auto-calibrates" the system to allow maximum pedal sensitivity. The ECM auto-calibrates as the key is ON, but when the key is turned OFF, these values are lost. When the key is turned on again, this process starts over. When the pedal is disconnected (or new one installed), the pedal does not need to be calibrated, as the calibration happens when the key is turned on.

IDLE VALIDATION SWITCH (IVS)

The ECM expects to receive one of two signals through ECM connector (379) terminal 8 from APS/IVS connector (382) terminal D:

- 0 volts when the pedal is at the idle position.
- 12 volts when the pedal is depressed.

The Idle Validation Switch receives 12 volt ignition voltage from 10A fuse F4 (H1 with FBC). When the

pedal is NOT in the idle position (throttle applied), the IVS sends a 12 volt signal to the ECM.

The ECM compares the inputs it receives at terminals 47 and 8 from the APS/IVS to verify when the pedal is in the idle position. If the APS signal at terminal 47 indicates throttle is being applied, then the ECM expects to see 12 volts at IVS terminal 8. If the APS signal at terminal 47 indicates throttle is not applied, then the ECM expects to see 0 volts at the IVS terminal 8. The timing process is critical between the APS and the IVS sensors. For this reason, it is very difficult to determine if the APS/IVS assembly is working properly using a volt-ohmmeter.

ECM DIAGNOSTICS

When the key is ON, the ECM continuously monitors the APS/IVS circuits for expected voltages. It also compares the APS and IVS signals for conflict. If the signals are not what the ECM expects to see, Fault codes will be set.

FLASH CODE 131

ATA CODE PID 91 FMI 4 -

ECM: *APS OUT OF RANGE LOW*

The ORL (out of range low) code 131 is set if the ECM detects a voltage lower than 0.146 volts at terminal 47. Possible causes include: a short to ground or an open in circuit 998. This code is displayed by either the ProLink EST or using the Engine Warn Light to flash codes.

When code 131 is active, the ECM restricts engine speed to idle and turns the Engine Warning Light ON. If the condition causing code 131 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume. If code 131 is active, perform Testing APS Circuits on page 8.

FLASH CODE 132

ATA CODE PID 91 FMI 3 -

ECM: *APS OUT OF RANGE HIGH*

The ORH (out of range high) code 132 is set if the ECM detects a voltage greater than 4.56 volts at terminal 47. Possible cause: short to VREF or 12 volts in circuit 99B. This code is displayed by either the ProLink EST or using the Engine Warn Light to flash codes.

APSIIVS EXTENDED SYSTEM DESCRIPTION (Continued)

FLASH CODE 132
ATA CODE PID 91 FMI 3 -
ECM: *APS OUT OF RANGE HIGH* (Continued)

When code 132 is active, the ECM restricts engine speed to idle and turns the Engine Warn Light ON. If the condition causing code 132 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume. If code 132 is active, perform Testing APS Circuits on page 8.

FLASH CODES 133, 134 AND 135
APS IN-RANGE FAULTS

The ECM checks the voltage output of the APS by comparing the APS signal with the IVS signal. APS and IVS signals can disagree in two cases:

- The APS signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position.
- The APS signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict. If code(s) 133, 134 and/or 135 are active, perform Testing IVS Circuits on page 7 and Testing APS Circuits on page 8.

FLASH CODE 133
ATA CODE PID 91 FMI 2 -
ECM: *APS IN RANGE FAULT*

If the IVS signal is changing and the APS signal is constant, the ECM assumes APS is the conflict source and sets code 133. Engine rpm is restricted to idle and the Engine Warn Light is turned ON.

FLASH CODE 134
ATA CODE PID 91 FMI 7 -
ECM: *APSRVS DISAGREE*

If neither the APS or IVS is changing, or both are changing or the ECM cannot determine the faulty code in specified time, then code 134 is set, engine rpm is restricted to idle and the Engine Warn Light is turned ON.

FLASH CODE 135
ATA CODE SID 230 FM111-
ECM: *IVS CIRCUIT FAULT*

If the APS is changing and IVS is constant, the ECM assumes IVS is the conflict source and sets flash code 135. In this case the ECM limits the APS signal to a lower value, which provides less than full rpm, but does not limit engine rpm to idle. The Engine Warn Light is not turned ON.

Note that codes 133, 134 and 135 are caused by an intermittent condition, the codes remain ACTIVE until the vehicle has been shutdown and restarted. They do not recover without cycling the key switch.

TROUBLESHOOTING

The APS and IVS circuits operate with low current levels. When troubleshooting, pay special attention to the connectors.

BEFORE P-E-R-F-O-R-M-I-N-G ANY TEST

Inspect connectors for pushed back, damaged, corroded or dirty terminals, as well as making sure that the terminals and wires are properly crimped. Make sure the connectors are properly joined together. Also check for any damage to the wiring and make sure system grounds are clean and tight.

TESTING APS/IVS CIRCUITS

- If flash codes 131 or 132 are present, perform Testing APS Circuits on page 8. If flash codes 133, 134 or 135 are present, perform Testing IVS Switch & Circuits on page 7.

These tests systematically check the APS and IVS circuits for:

- A. Short circuits to ground.
- B. Short circuits to unwanted voltage sources.
- C. Open circuits or excessive circuit resistance.
- D. Proper feeds and grounds.

Note: The tests performed on the accelerator pedal assembly check for shorts, opens and correct resistance values, but do not check for proper timing between the two functions. If all of the circuits between the ECM and the accelerator pedal assembly check good (Testing IVS Circuits on page 7) and APS Circuits on page 8, then the APS/IVS accelerator switch should be replaced.

CIRCUIT DIAGRAM

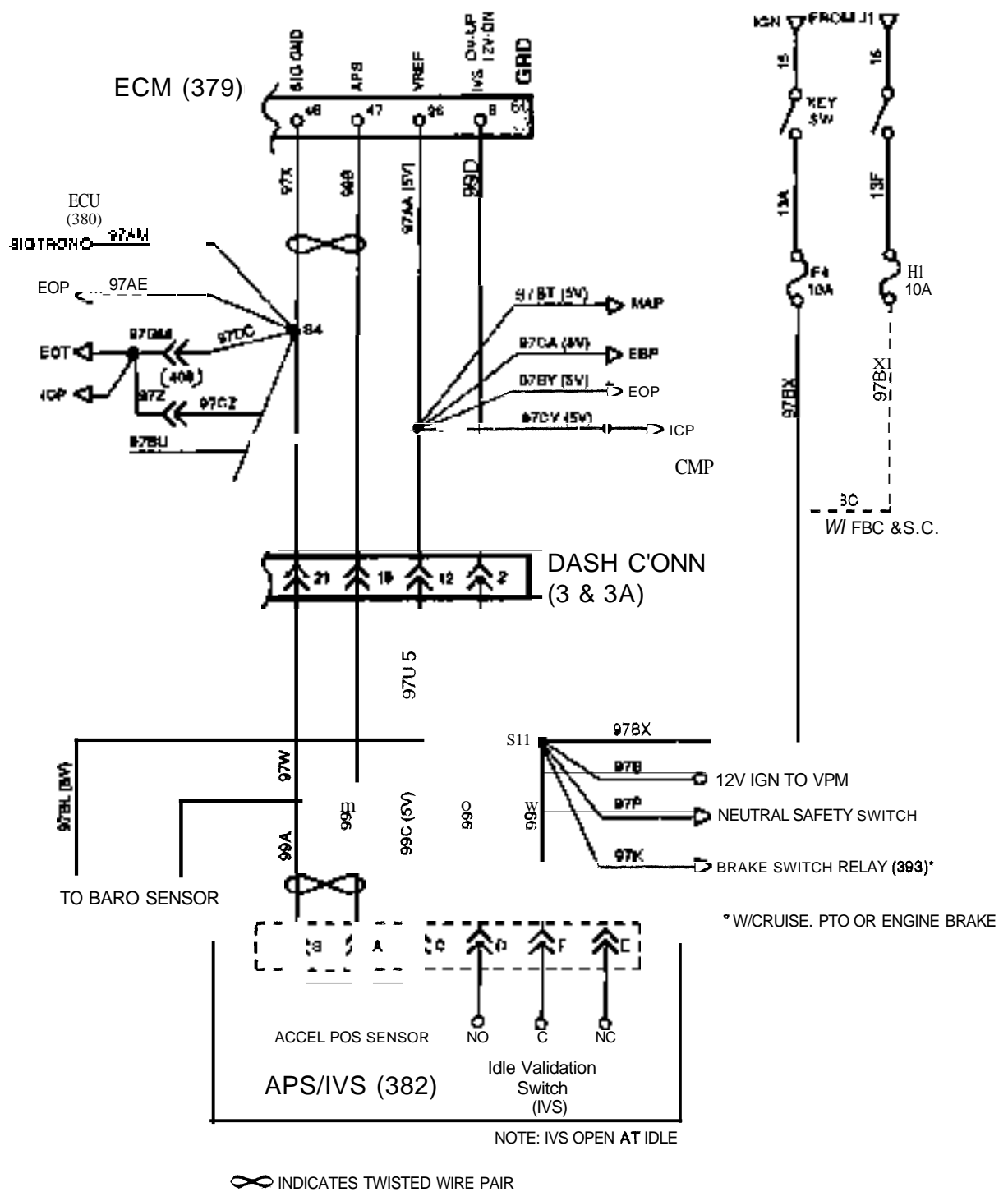
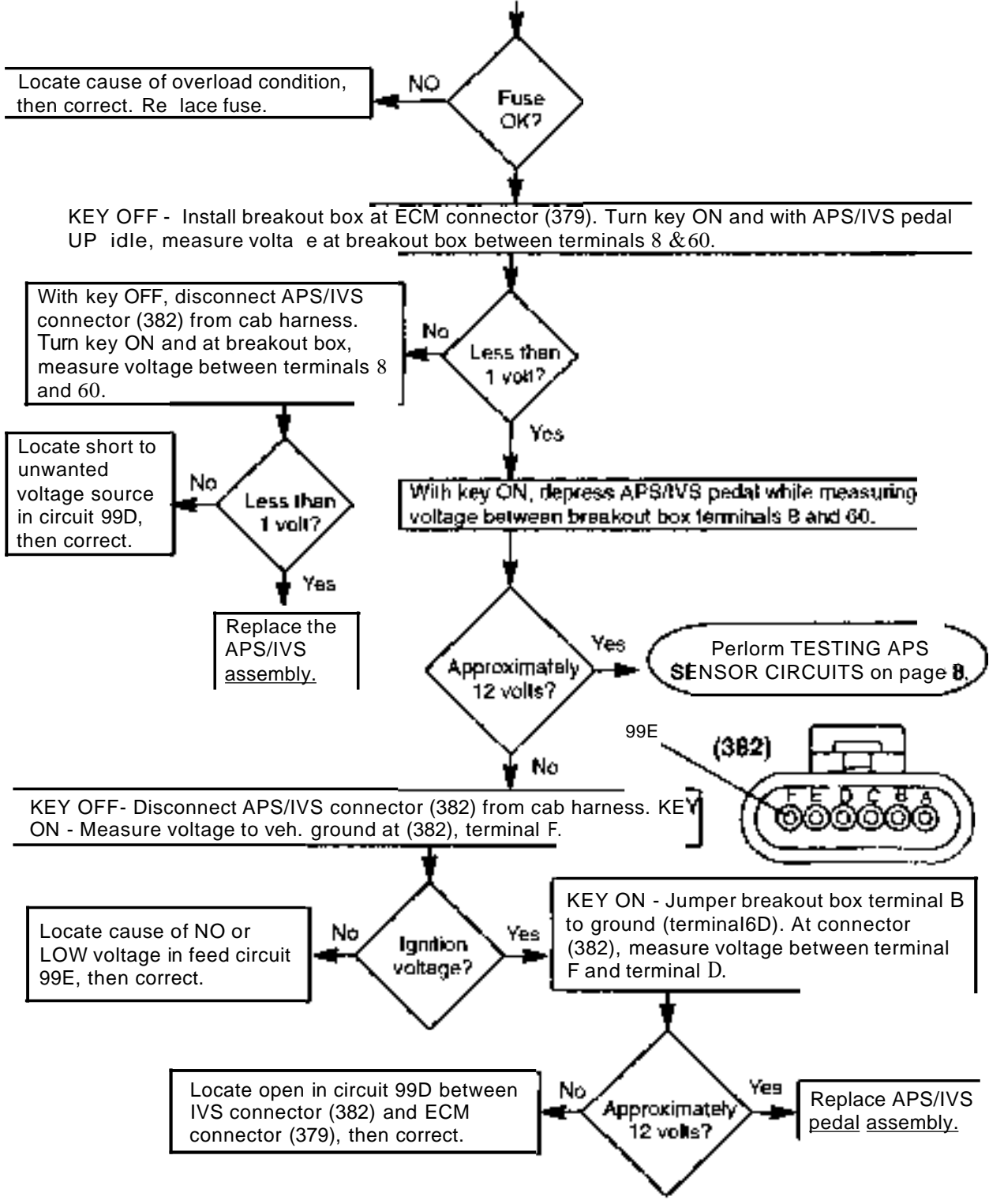


Figure 3.5-1 APS/IVS System

TESTING (IVS) IDLE VALIDATION SWITCH AND CIRCUITS

Refer to Figure 3.5-1, on page 6 while (Begin) performing this test.

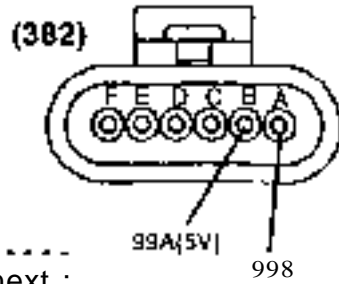
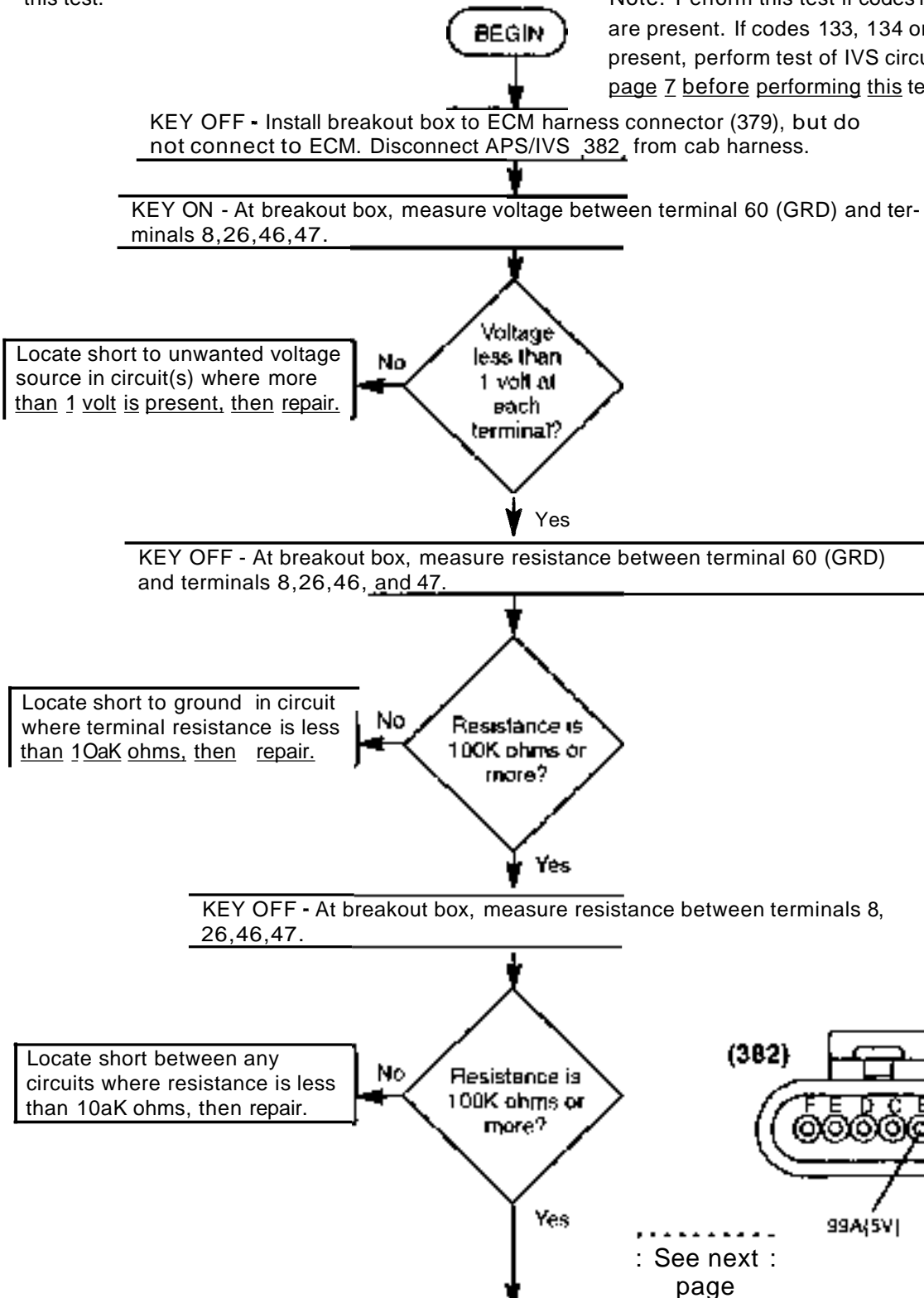
Check 10A fuse F4 (or H1 w/FBC) for open condition.



TESTING ACCELERATOR POSITION SENSOR (APS) CIRCUITS

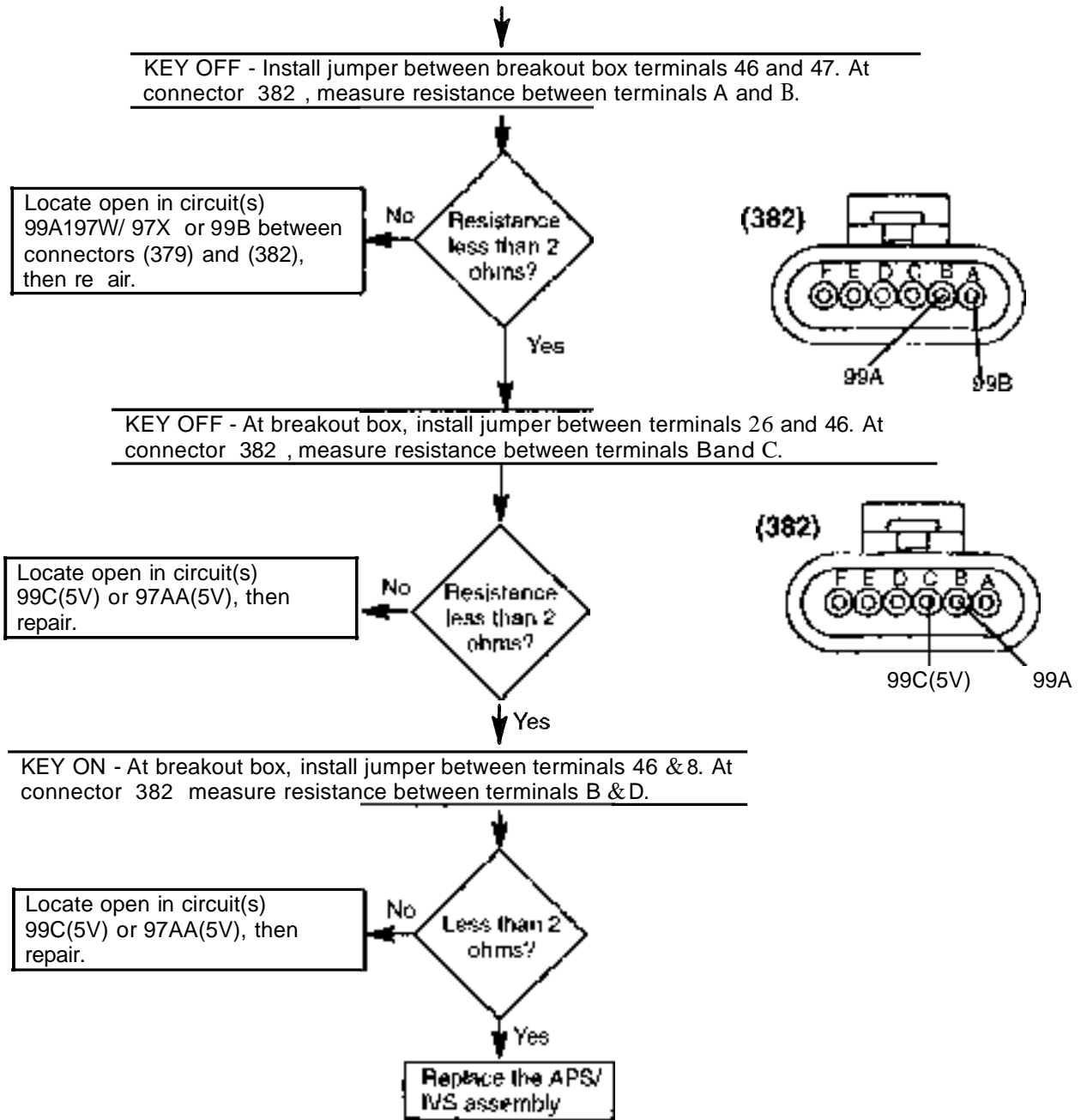
Refer to Figure 3,,5-1, on page 6 while performing this test.

Note: Perform this test if codes 131 or 132 are present. If codes 133, 134 or 135 are present, perform test of IVS circuits on page 7 before performing this test.



: See next :
page

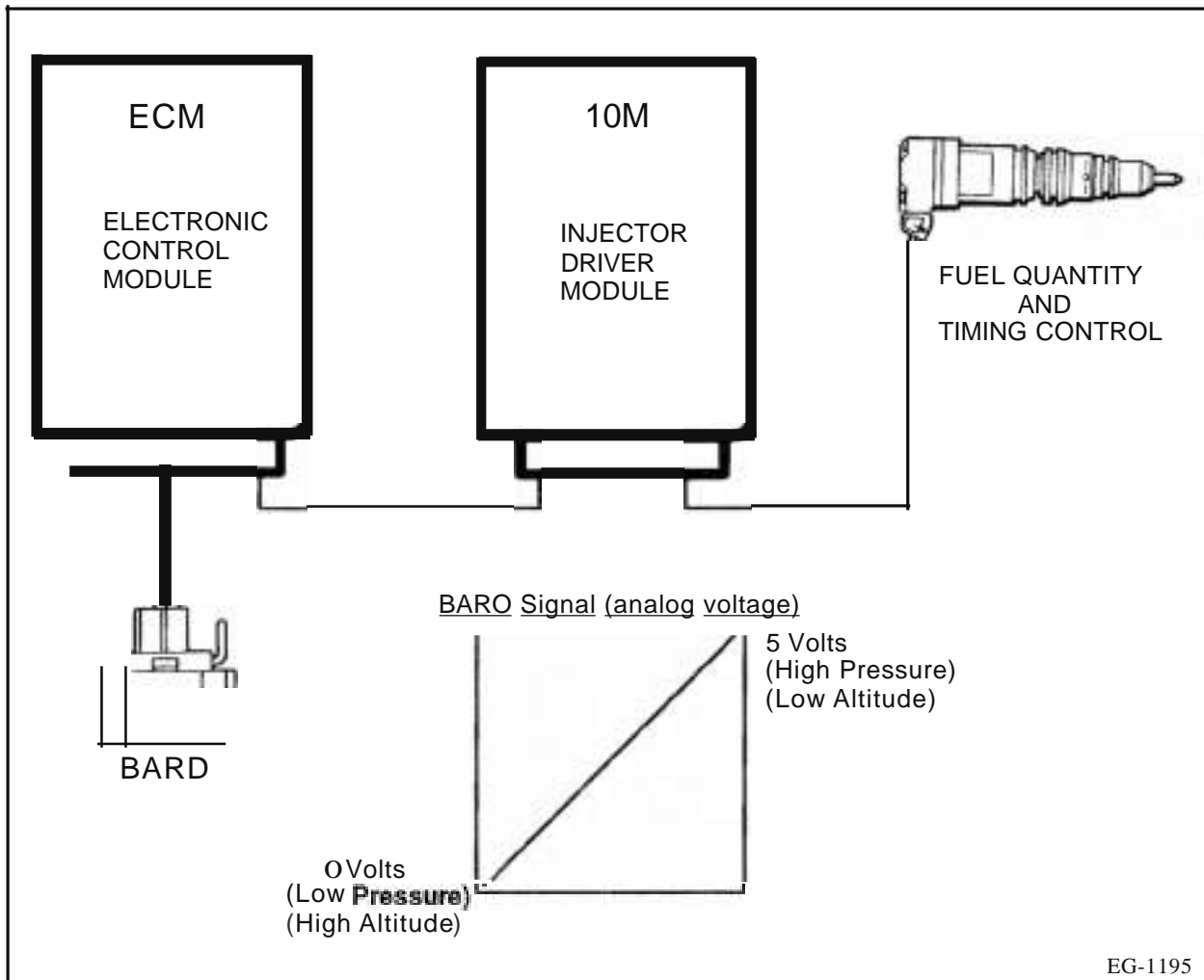
TESTING ACCELERATOR POSITION SENSOR (APS) CIRCUITS (Continued)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BAROMETRIC PRESSURE SENSOR (BARD)

BAROMETRIC PRESSURE (BARO) SENSOR



EG-1195

SIGNAL FUNCTIONS

The BARa (Barometric Pressure) sensor is a variable capacitance sensor that when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

Timing Control - The BARa signal is used to determine altitude to adjust timing and fuel quantity to optimize engine operation and control smoke throughout all altitude conditions.

FAULT DETECTION/MANAGEMENT

A BARa signal that is detected out of range high or low by the ECM will cause the ECM to ignore the BARa signal and use the Manifold Absolute Pressure (MAP) signal generated at low idle as an indication of barometric pressure. If a MAP fault is detected, the BARa will default to 29.6 in. Hg. of barometric pressure.

BAROMETRIC PRESSURE SENSOR (BARO)

Barometric
Pressure Sensor
(BARD)



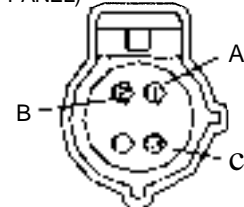
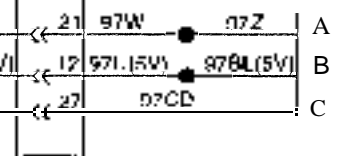
Fault Codes:
151 Out of Range High
152 Out of Range Low

ECM CONNECTOR
(379)

BARD SENSOR CONNECTOR (406)
(INSIDE RH INST. PANEL)



DASH (3)



(sensor mounted under dash)

After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground

(Check with Sensor Connector (406) Disconnected and Ignition key off all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis grd, check with key off, > than 5 ohms the harness is open.
B to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks

(Check with sensor Connector (406) Disconnected, Ignition Key On all accessories off)

Test Points	Spec.	Comments
B to Grd.	5 Volts + .5	V Ref, check with key ON, if voltage not is spec., see VRet circuit
C to Grd.	0 - .25 v	If voltage is greater than .25 v, signal wire is shorted to V ref or battery.

Harness Resistance Checks

(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector - Signal ground
#26 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector - VAef
#5 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector - BARD signal

Test Points (+) #5 to (-) #46		Operational Voltage Checks (Check with breakout box installed in line with the ECM)	
Voltage	In. Hg.	kPA	Comments
4.89	31.0905	105	High atmospheric pressure
4.6	29.61	100	Normal atmospheric pressure at sea level.
2.6	17.766	60	Normal atmospheric pressure at 10,000 feet.

Fault Code Descriptions

151 = Signal voltage was greater than 4.95 volts for more than 1.0 seconds.
152 = Signal voltage was less than 1.0 volts for more than 1.0 seconds.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BAROMETRIC PRESSURE SENSOR (BARO)

EXTENDED DESCRIPTION

BAROMETRIC PRESSURE SENSOR

Refer to circuit diagram on page 13 for the following discussion.

BAROMETRIC PRESSURE SENSOR (BARO) OPERATION

The ECM sends a regulated 5 volt signal from ECM connector (379) terminal 26 to BARO connector (406) terminal 2. The BARO sensor returns a variable voltage signal (represents atmospheric pressure) from BARO connector (406) terminal 3 to the ECM at terminal 5. The BARO sensor is grounded from connector (406) terminal 1 to the ECM signal ground terminal 46.

ECM DIAGNOSTICS

The ECM continuously monitors the signal from the BARO sensor to ECM terminal 5. If the signal is out of the expected range, a fault is logged (warning light does NOT turn on) and the ECM uses the Manifold Absolute Pressure (MAP) signal generated at low idle to determine barometric pressure.

Flash Code 151

ATA Code PID 108 FMI3

ECM: **BARO SIGNAL OUT OF RANGE HIGH**

BARO signal greater than 4.95 volts for more than 1 second.

Flash Code 152

ATA Code PID 108 FMI4

ECM: **BARO SIGNAL OUT OF RANGE LOW**

BARO signal less than 1.0 volt for more than 1 second.

TROUBLESHOOTING

The BARO circuits operate with low current levels. When troubleshooting, pay special attention to the connectors.

BEFORE PERFORMING ANY TEST

Inspect connectors for pushed back, damaged, corroded or dirty terminals, as well as making sure that the terminals and wires are properly crimped. Make sure the connectors are properly joined together. Also check for any damage to the wiring and make sure system grounds are clean and tight.

TESTING APSnVS CIRCUITS

NOTE: If fault codes indicate a problem is also present with the APS/IVS system, troubleshoot that system before performing the following test.

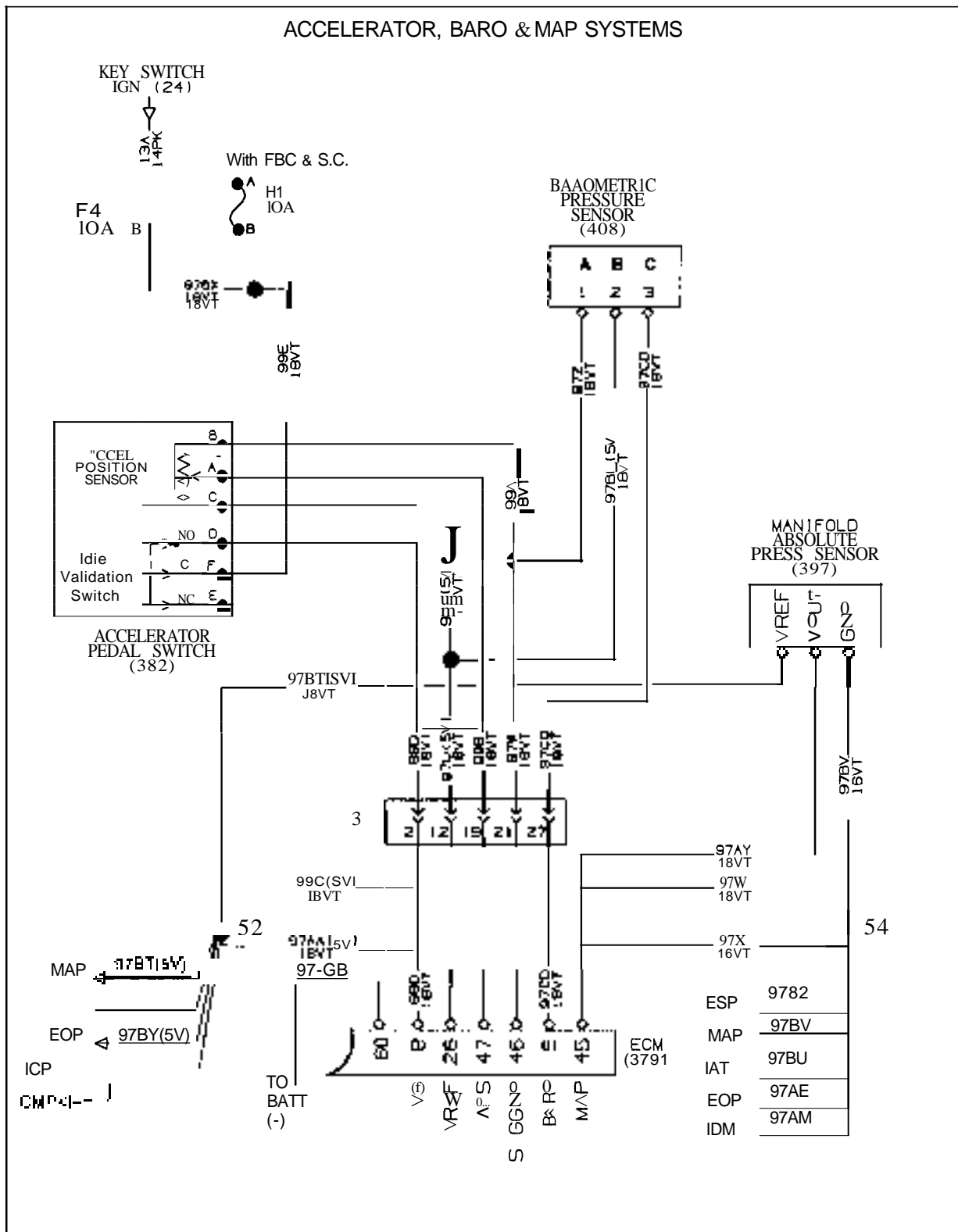
- If BARO flash code 151 or 152 is active, perform Testing Barometric Pressure Sensor Circuits on page 14.

This test systematically checks the BARO circuits for:

- A. Short circuits to ground.
- B. Short circuits to unwanted voltage sources.
- C. Open circuits or excessive circuit resistance.
- D. Proper feeds and grounds.

BAROMETRIC PRESSURE SENSOR (BARO)

CIRCUIT DIAGRAM

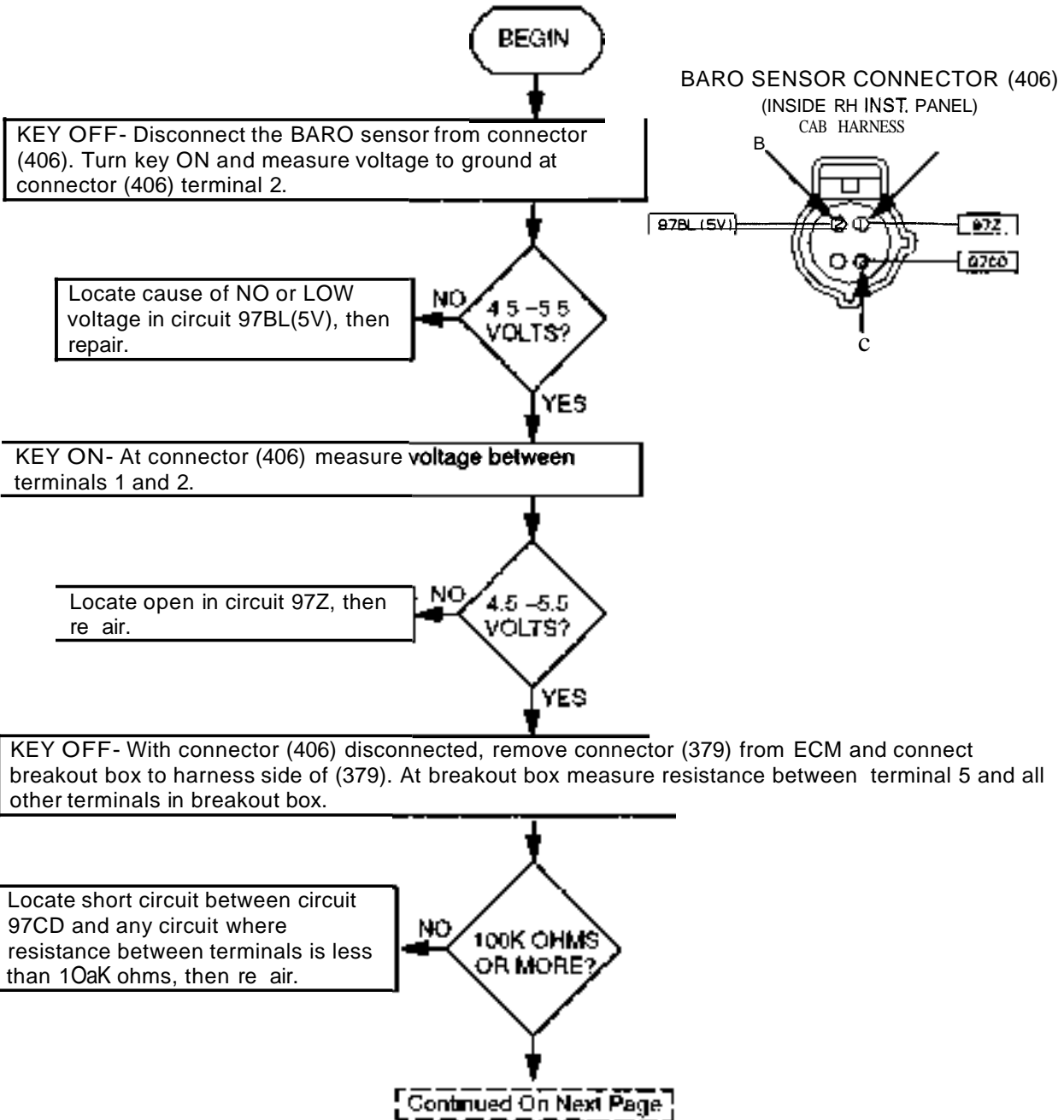


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BAROMETRIC PRESSURE SENSOR (BARO)

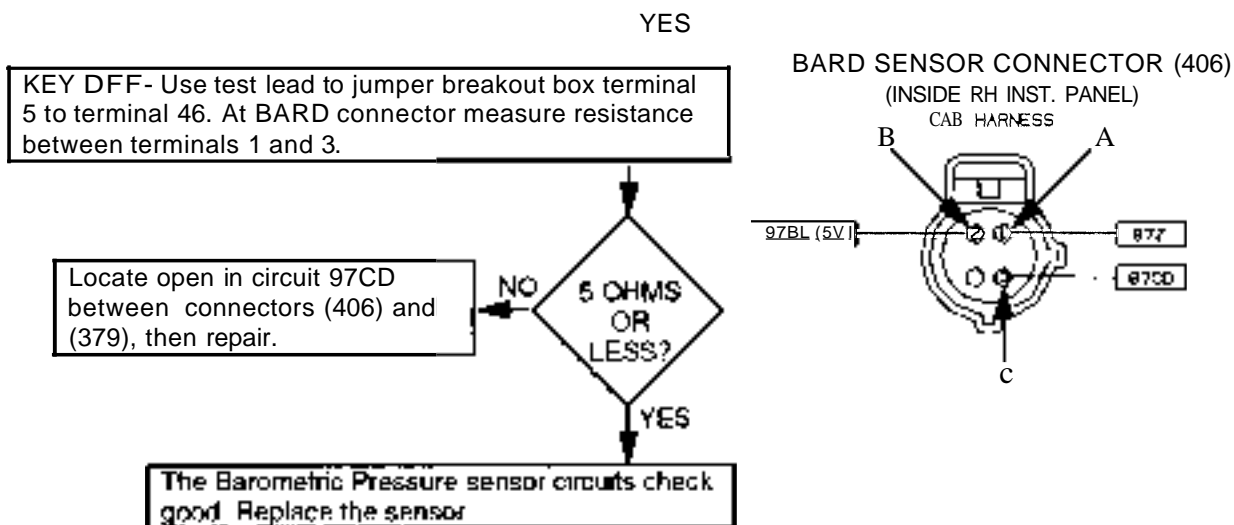
TESTING BAROMETRIC PRESSURE SENSOR CIRCUITS

Refer to circuit diagram on page 13, while performing this test.



BAROMETRIC PRESSURE SENSOR (BARO)

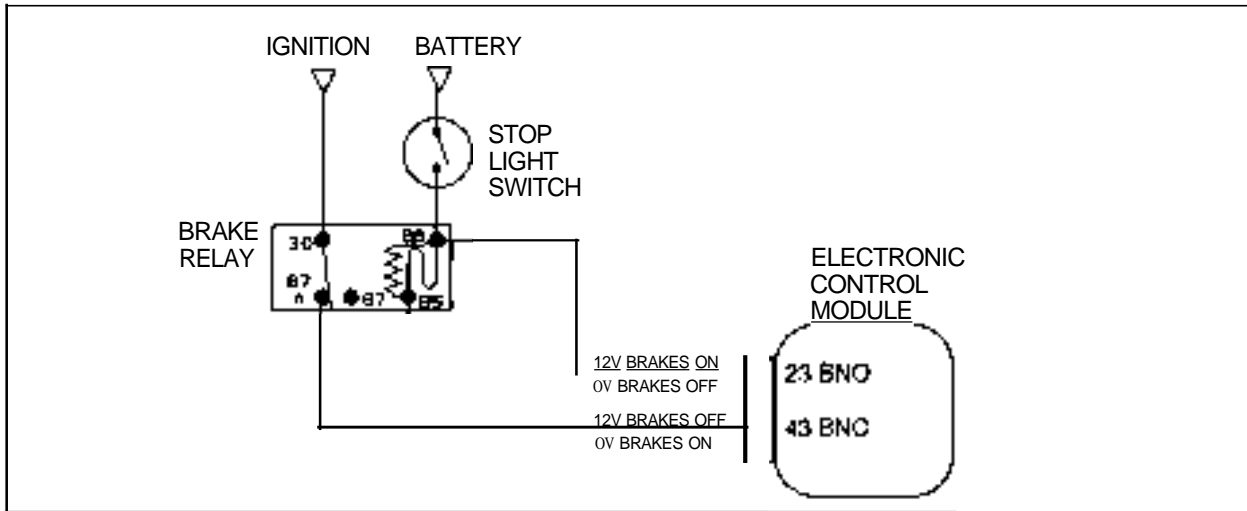
TESTING BAROMETRIC PRESSURE SENSOR CIRCUITS (Continued)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

BRAKE SWITCH/RELAY CIRCUITS



SIGNAL FUNCTION

The service brake switch circuit function is to communicate to the ECM when the service brakes are applied and when the brakes are not applied. This information is used with cruise control and PTA operation, which are controlled by the ECM.

SERVICE BRAKE SWITCH(ES)

There are three configurations of switches used.

1. With tractor air brakes (code 4092) a single normally open switch is used. Air pressure closes the switch with brakes applied.
2. With truck air brakes (4091) two normally open, air operated switches are in parallel circuits.
3. With hydraulic brakes (04040) two mechanical switches are used, but only one of the switches is linked to the ECM. The switches are actuated by the brake pedal arm.

With the key ON and service brakes released, ignition voltage is applied to ECM terminal 43 and no voltage is applied to terminal 23.

When service brakes are applied, voltage is applied to ECM terminal 23 and the voltage to ECM terminal 43 is turned OFF.

FAULT DETECTION MANAGEMENT

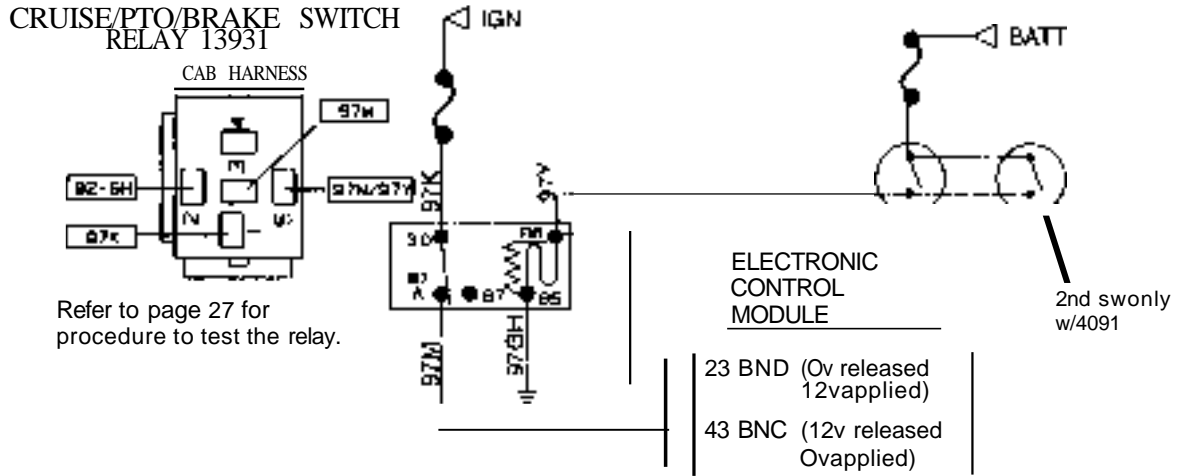
The ECM continuously monitors ECM terminals 23 (BNO) and 43 (BNC). The ECM expects to see 12V at one terminal and 0 volts at the other. If the Signals disagree (12 volts at both or 0 volts at both), then flash code 222 is set as an active fault.

When Flash code 222 is active, the Cruise and PTO systems are disabled. If the fault is intermittent, the system does not reset until the vehicle has been shut off and restarted.

This code does not turn ON the engine warning light.

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

Brake Switch / Relay (BRAKE)	Fault Codes: 222 Brake Switch Circuit Fault
---------------------------------	--



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Voltage Checks
(Connector (393) with relay removed, Ignition Key ON and Brakes Released)

Test Points	Spec.	Comments
Cir 97K to grd	12 ± 1.5 volts	< 10.5v check connections, if 0 volts, check for open/short to grd or blown fuse
Cir 97Y to grd	< 1.0 volt	> 1.0v check for short to VREF or 12v circuit or defective switch (switch adjustment with hydraulic brakes)
Cir 97K to 97GH	12 ± 1.5 volts	< 10.5v check connections, if 0 volts, check for open in ground circuit 97GH

(Connector (393) with relay removed, Ignition Key ON and Brakes Applied)

Test Points	Spec.	Comments
Cir 97Y to 97GH	12 ± 1.5 volts	< 10.5v check connections, if 0 volts check for open/short to grd or defective switch (switch adjustment with hydraulic brakes) or blown fuse.
Cir 97M to grd	< 1.0 volt	> 1.0 volt, check for short to VREF or 12 volt circuit

(Connector (379) with breakout box installed, brake relay installed, Ignition Key ON, and Brakes Applied)

Test Points	Spec.	Comments
#23 to grd	12 ± 1.5 volts	< 10.5v check connections, if 0 volts check for open circuit 97N
#43 to grd	< 1.0 volt	> 1.0 volt short to BATT or VREF or defective relay

(Connector (379) with breakout box installed, brake relay installed, Ignition Key ON and Brakes Released)

Test Points	Spec.	Comments
#23 to grd	< 1.0 volt	> 1.0 volt short to BATT or VREF or defective relay
#43 to grd	12 ± 1.5 volts	< 10.5v check connections, if 0 volts check for open circuit 97N or defective relay

Fault Code Descriptions

222 = Voltage at ECM pins #23 (BNO) and #43 (BNC) are the same

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

DESCRIPTION

All vehicles equipped with Cruise and PTO utilize the Brake Switch Relay (393) to notify the ECM of a brake ON or brake OFF condition.

WITH HYDRAULIC BRAKES

With hydraulic brakes the system includes (2) normally open brake switches (50) and (51) and the Brake Switch Relay (393).

Service Brakes NOT Applied

With the key ON and service brakes NOT APPLIED, ignition power from 10A fuse F4 (fuse H1 w/FBC) goes through the normally closed contacts (30 to 87A) of the Brake Switch Relay (393) to the ECM at terminal 43. When the brakes are not applied, the ECM sees 12 volts at terminal 43, the BNC (brake normally closed) terminal.

When the brakes are not applied, note that no voltage is present on circuit 97N to ECM terminal 23, the Brake Normally Open terminal.

When the ECM sees 12 volts at terminal 43 and 0 volts at terminal 23, it's programmed to interpret this condition as "service brakes are not applied."

Service Brakes Applied

Battery Power through 10A fuse F33 (fuse E3 w/FBC) is always present at the normally open (N.O.) brake switch (50). Applying the service brakes closes switch (50). With this switch closed, two things occur:

1. Power is applied to the Brake Switch Relay (393) causing it to energize, opening the N.C. contacts (30 to 87A). This turns OFF the power to ECM terminal 43 (BNC). ECM terminal 43 sees 0 volts.

2. Power is also applied (circuit 97N) to ECM terminal 23, which is the Brake Normally Open terminal. ECM terminal 23 sees 12 volts.

When the ECM sees 0 volts at terminal 43 and 12 volts at terminal 23, it's programmed to interpret this condition as "service brakes are applied."

WITH AIR BRAKES

With air brakes the system includes (2) normally open brake switches (70) and (71) and the Brake Switch Relay (393).

Service Brakes NOT Applied

With the key ON and service brakes NOT APPLIED, Ignition power through 10A fuse F4 (fuse H1 w/FBC) goes through the normally closed contacts (30 to 87A) of the Brake Switch Relay (393) to ECM terminal 43. When the brakes are not applied, the ECM sees 12 volts at terminal 43, the BNC (brake normally closed) terminal.

When the brakes are not applied, note that no voltage is present on circuit 97N to ECM terminal 23, the Brake Normally Open terminal.

When the ECM sees 12 volts at terminal 43 and 0 volts at terminal 23, it's programmed to interpret this condition as "service brakes are not applied."

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

SERVICE BRAKES APPLIED

Battery Power through 10A fuse F9 (30A fuse D3 w/FBC) is always present at the normally open (N.O.) brake switches (70) and (71). Applying the service brakes closes switches (70) and (71). With switches (70) and/or (71) closed, two things occur:

1. Power is applied to the Brake Switch Relay (393) causing it to energize, opening the N.C. contacts (30 to 87A). This turns OFF the power to ECM terminal 43 (BNC). ECM terminal 43 sees 0 volts.
2. Power is also applied (circuit 97N) to ECM terminal 23, which is the ECM Brake Normally Open terminal. ECM terminal 23 sees 12 volts.

When the ECM sees 0 volts at terminal 43 and 12 volts at terminal 23, it's programmed to interpret this condition as "service brakes are applied."

The air brake stop light circuits work the same as Navistar vehicles without the electronic VB engine. Refer to the Circuit Diagram book for complete circuit information.

DIAGNOSTICS**FLASH CODE 222**

SID 247 FMI2

ECM: *BRAKE SWITCH CIRCUIT FAULT*

The ECM continuously monitors ECM terminals 23 (BNO) and 43 (BNC). The ECM expects to see 12V at one terminal and 0 volts at the other. If the signals disagree (12 volts at both or 0 volts at both), then flash code 222 is set as an active fault.

When Flash code 222 is active, the Cruise and PTO systems are disabled. If the fault is intermittent, the system does not reset until the vehicle has been shut off and restarted.

This code does not turn ON the engine warning light.

WIRING CAUSES

A faulty brake switch, faulty brake switch relay, open fuses and/or open or short circuits (HIGH or LOW) can cause code 222 to set.

TROUBLESHOOTING

The ProLink EST can be used to monitor the brake switch operation. If the monitor indicates that the brake switch is not operating properly, or code 222 is active, perform the tests in this section.

BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery cables and grounds for clean, tight connections free of damage. Voltage tests will give misleading readings if the batteries are not fully charged.
- B. Before troubleshooting, inspect circuit connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect the suspect circuit grounds for clean, tight connections, free of any damage.

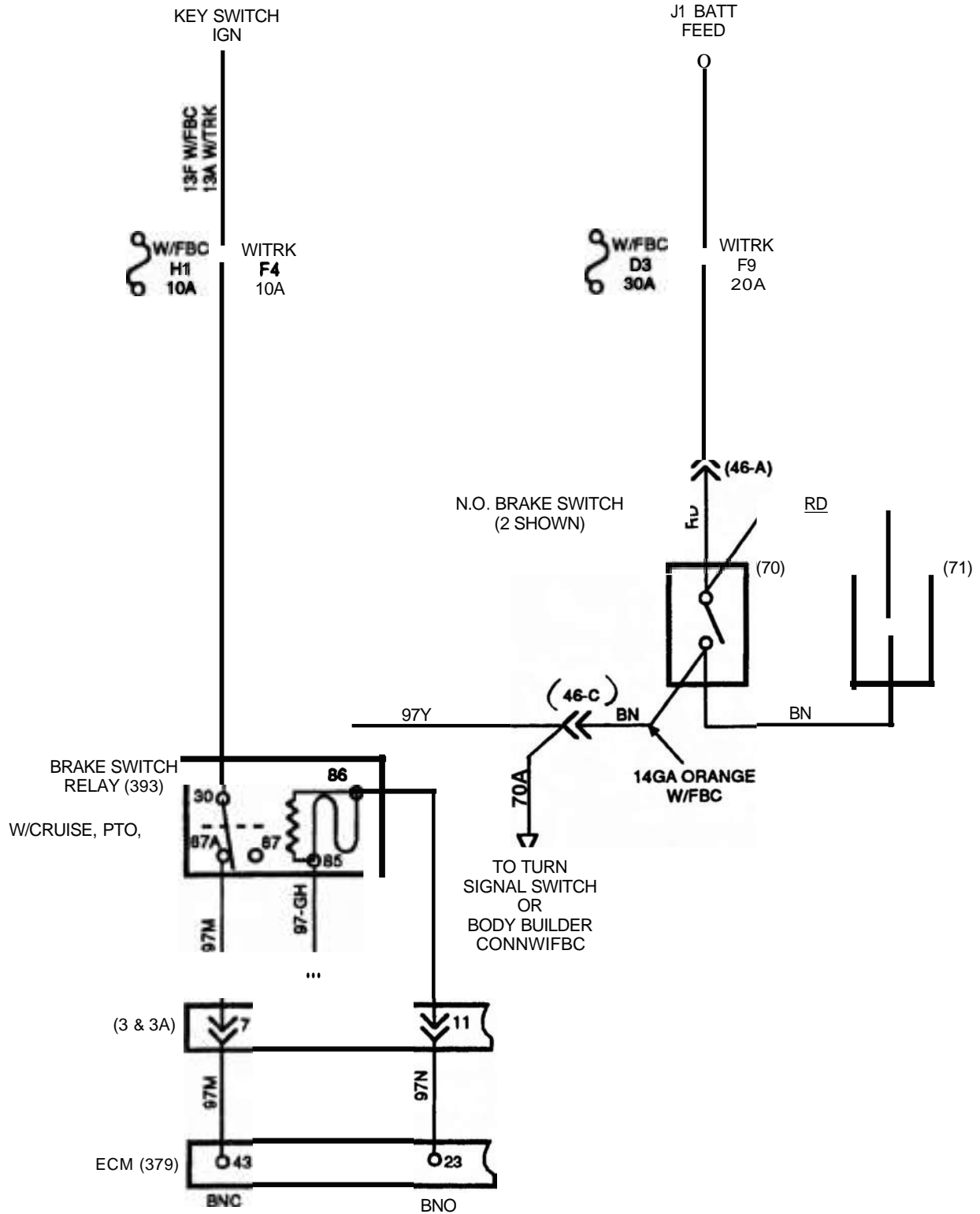
TESTING BNO/BNC BRAKE SWITCH SYSTEM

Air Brake Switch and Hydraulic Brake Switch circuit tests must be performed before Brake Switch Relay Circuit test.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

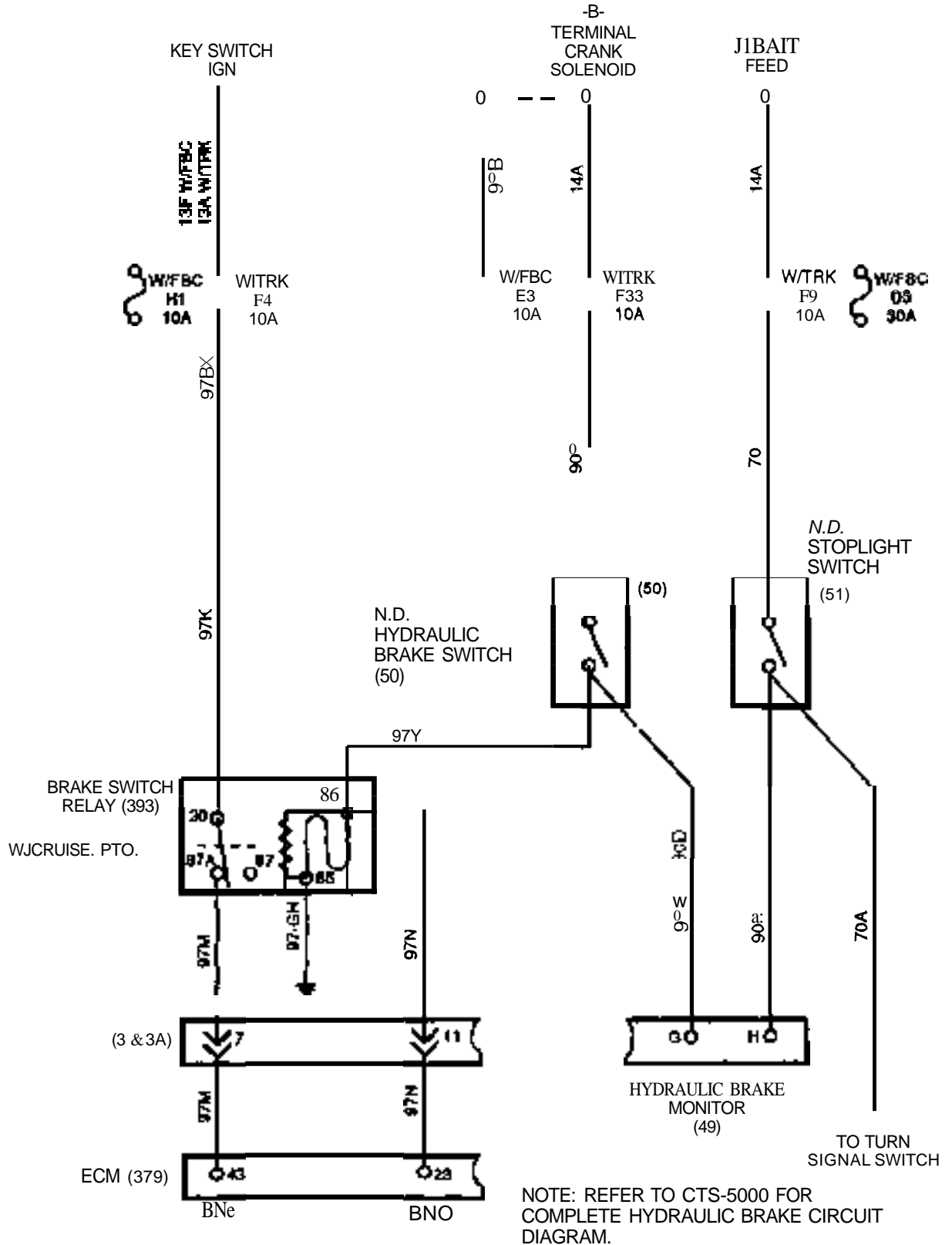
CIRCUIT DIAGRAM
AIR BRAKE BNOIBNC SWITCHIRELAY CIRCUITS



BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

CIRCUIT DIAGRAMS (Continued)

HYDRAULIC BRAKE BNO/BNC SWITCH/RELAY CIRCUITS



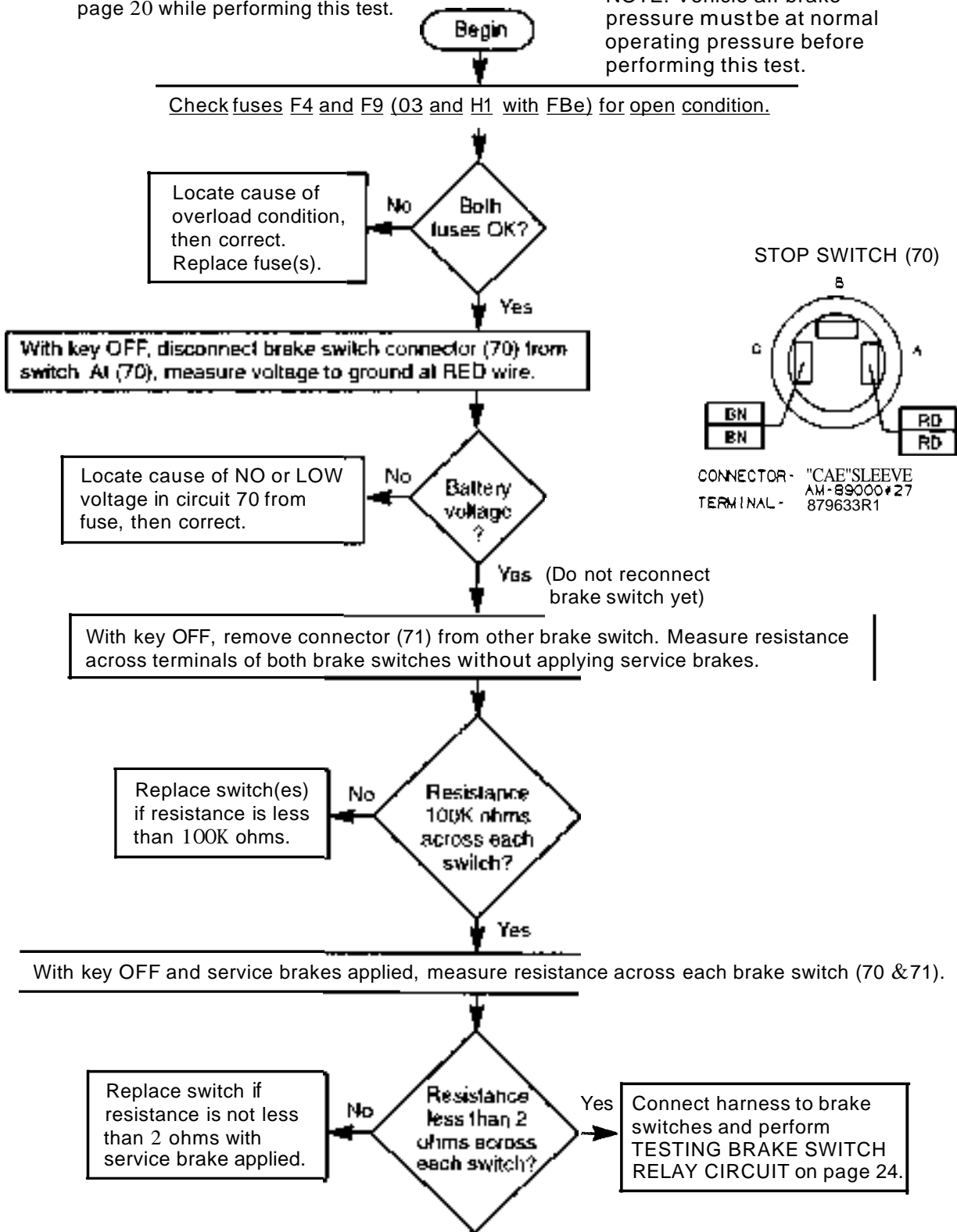
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

AIR BRAKE SWITCH CIRCUIT TEST

NOTE: Refer to circuit diagram on page 20 while performing this test.

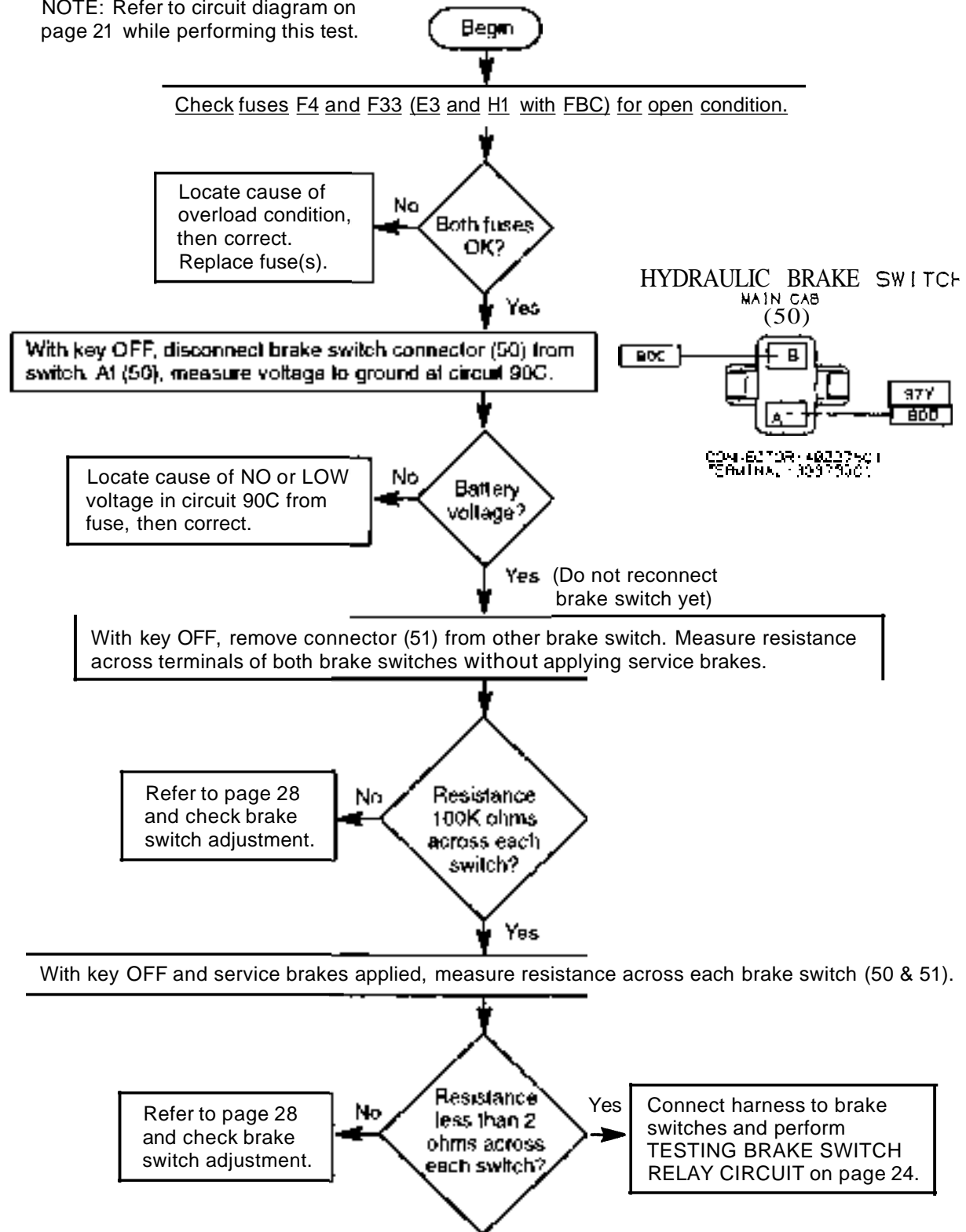
NOTE: Vehicle air brake pressure must be at normal operating pressure before performing this test.



BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

HYDRAULIC BRAKE SWITCH CIRCUIT TEST

NOTE: Refer to circuit diagram on page 21 while performing this test.



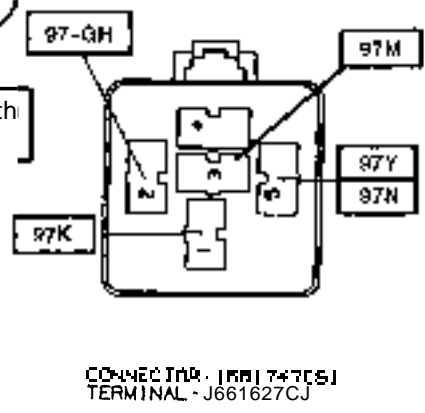
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

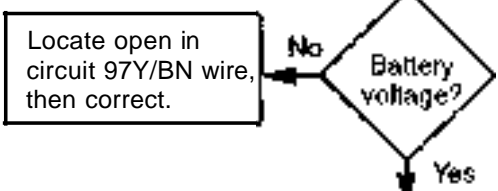
BRAKE SWITCH RELAY CIRCUIT TEST

Continued from Air or Hydraulic
BRAKE SWITCH Testing

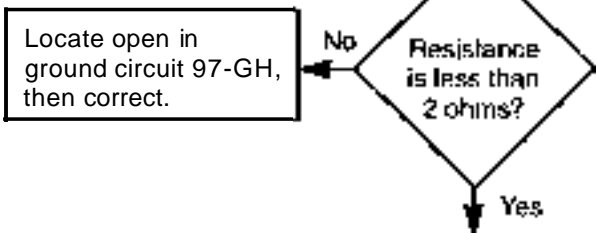
BRAKE SWITCH RELAY (393)



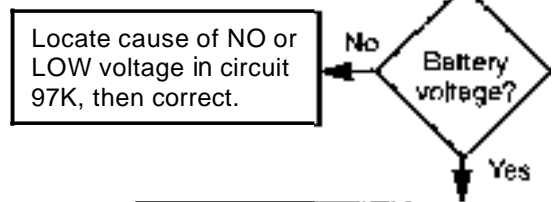
With key OFF, remove Brake Switch Relay from connector (393). With brakes applied, measure voltage at (393) terminal 5 (97Y) to gnd.



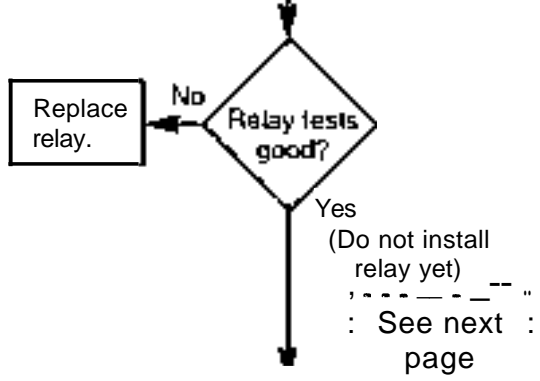
With key OFF, measure resistance to ground at connector (393) terminal 2 (97-GH).



With key ON, measure voltage at connector (393) between terminal 1 (97K) and terminal 2 (97-GH).



Perform TESTING HELLA RELAY on page 27.

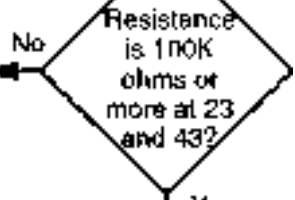


BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

BRAKE SWITCH RELAY CIRCUIT TEST (Continued)

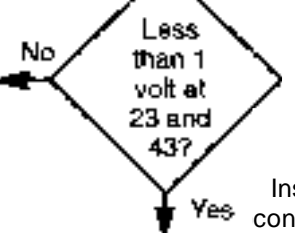
With key OFF, remove connector (379) from ECM, then connect breakout box to harness, but not to ECM. Measure resistance to ground terminals at breakout box terminals 23 and 43.

Locate short circuit to ground in circuit where terminal (23 OR 43) resistance is less than 100K ohms, then correct.



With key ON and SERVICE BRAKES RELEASED, measure voltage to ground at breakout box terminals 23 and 43.

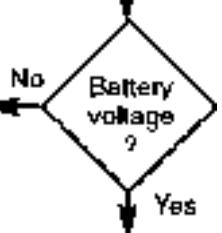
Locate short to "HOT" wire in circuit where terminal (23 OR 43) voltage was more than 1 volt, then correct.



Install relay in connector (393).

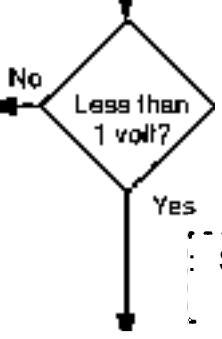
With key ON and BRAKES RELEASED, measure voltage at breakout box terminal 43.

Locate open in circuit 97M, then correct.



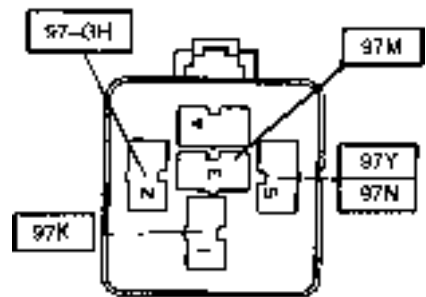
With key ON and BRAKES RELEASED, measure voltage at breakout box terminal 23.

Replace ECM.



See next page.

BRAKE SWITCH RELAY (393)

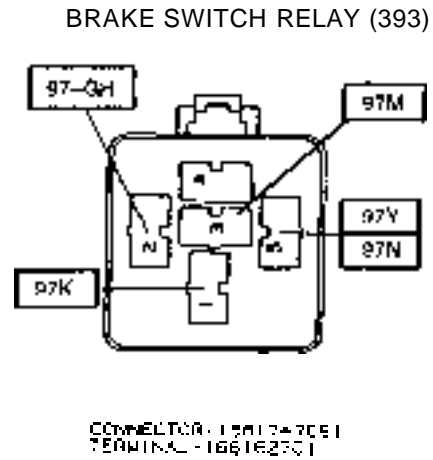
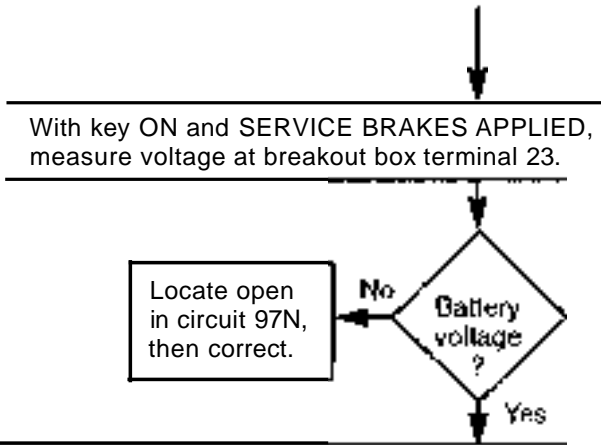


CONNECTOR: 971747591
SERIAL: 166192701

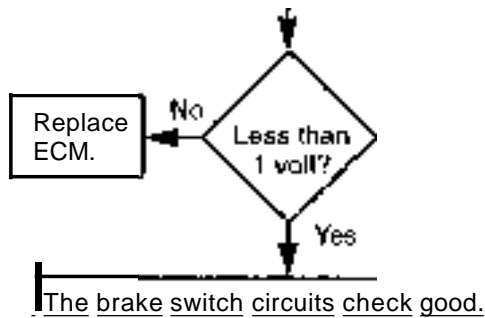
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

BRAKE SWITCH RELAY CIRCUIT TEST (Continued)



With key ON and BRAKES APPLIED, measure voltage at breakout box terminal 43.



BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

TESTING HELLA RELAYS

Refer to Figure 3.5-2 for this test.

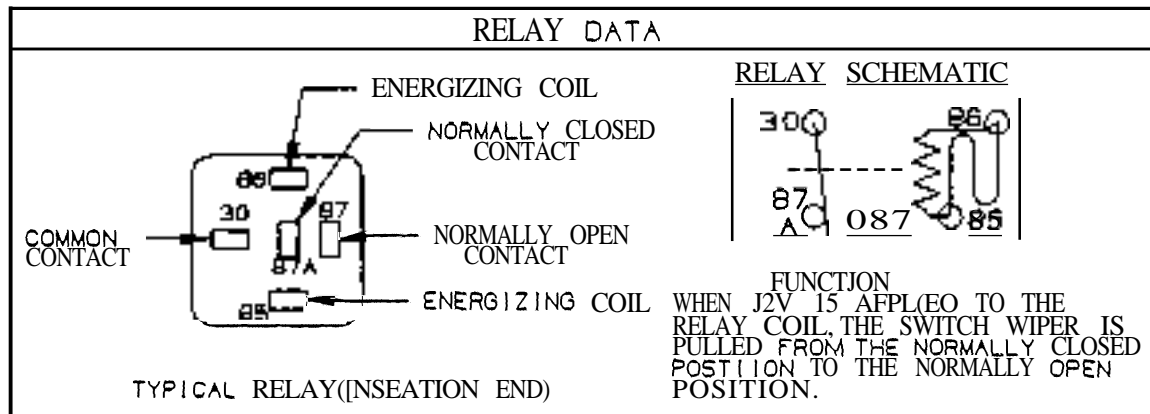


Figure 3.5-2 Hella Relay

With relay removed from connector:

1. Measure resistance between terminals 30 and 87A. If resistance is less than 2 ohms, go to step 2. If resistance is more than 2 ohms, replace the relay.
2. Measure resistance between terminals 30 and 87. If resistance is 100K ohms or more go to step 3. If resistance is less than 100K ohms replace the relay.
3. Connect (+) battery lead to terminal 85 and (-) lead to 86. The relay should energize with an audible click. If the relay energizes, go to step 4. If the relay does not energize, replace the relay.
4. With relay energized, measure resistance between terminals 30 and 87A. If the resistance is 100K ohms or more, go to step 5. If resistance is less than 100K ohms, replace the relay.
5. With relay energized, measure resistance between terminals 30 and 87. If resistance is less than 2 ohms the relay tests good. If resistance is greater than 2 ohms, replace the relay.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

BRAKE SWITCH/RELAY CIRCUITS (BRAKE)

PROCEDURE FOR ADJUSTING HYDRAULIC STOP LIGHT BRAKE

Disconnect cab harness from switches. See Figure 3.5-3

1. With PAL nut on upper switch finger tight, connect #1 test light leads to switch. Adjust switch until light just comes ON. Note position of *key* tab on connector body.
2. Hold PAL nut and rotate switch clockwise 1 full turn. Key/tab should be in the same position as in step 1.

NOTE: The #1 test light should be off and the switch set so that the brake pedal must be moved 0.50 inches at point of contact to make the light come on.

3. Tighten PAL nut on upper switch and watch key/tab so the switch is not turned when tightening the PAL nut.

4. With PAL nut on the lower switch finger tight, connect #2 test light leads to switch. Adjust the lower switch so that with the pedal depressed, both lights come on at the same time.

- A. NOTE: If test light #2 (lower switch) comes on first, move lower switch closer to the pedal.

If test light #1 (upper switch) comes on first, move lower switch away from the pedal.

5. Tighten PAL nut on both switches and test one more time.

6. Remove test lights and install connector with circuits 70/70A and 70B/70C on the upper switch and connector with circuits 90A and 90B on the lower switch.

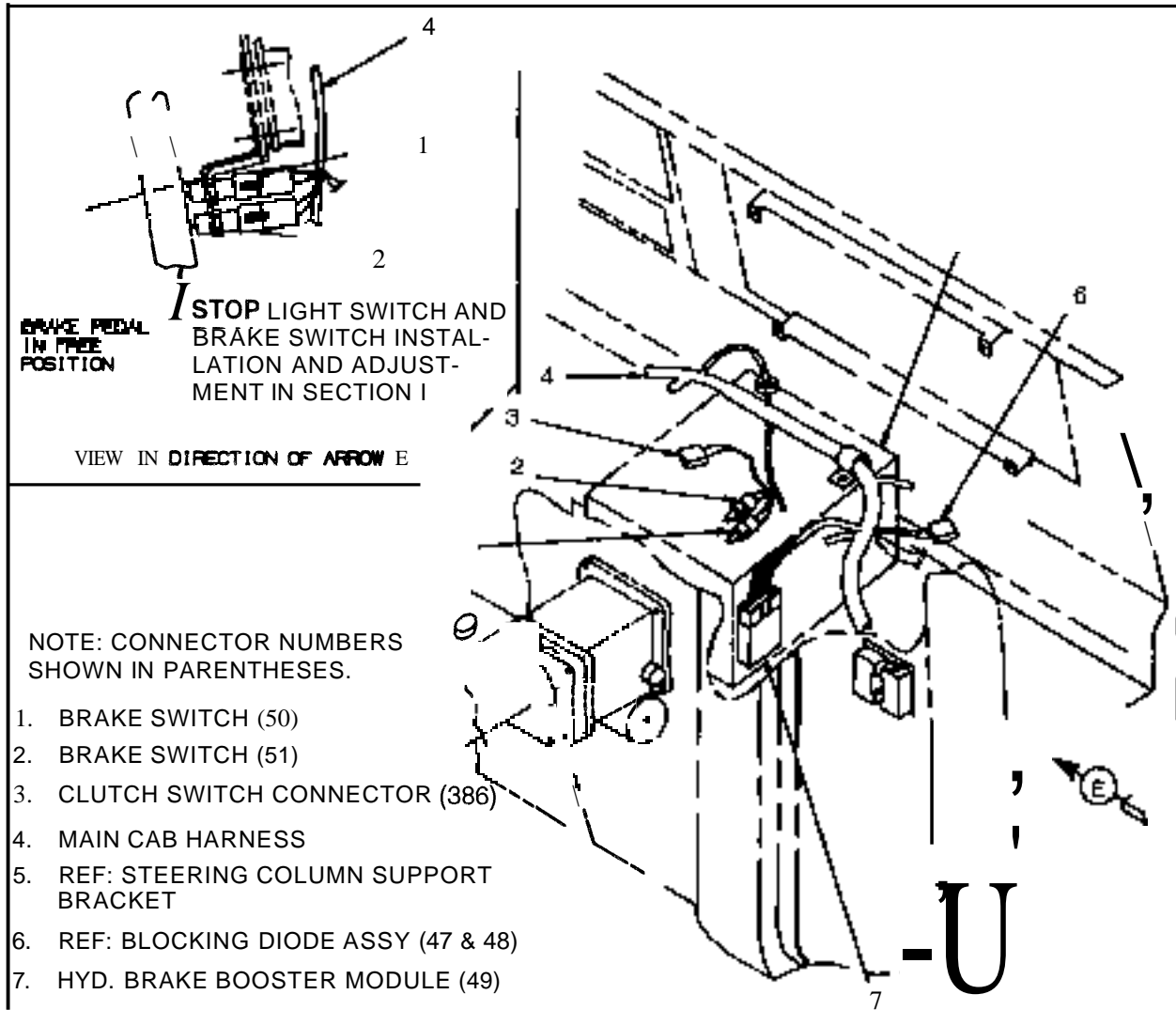
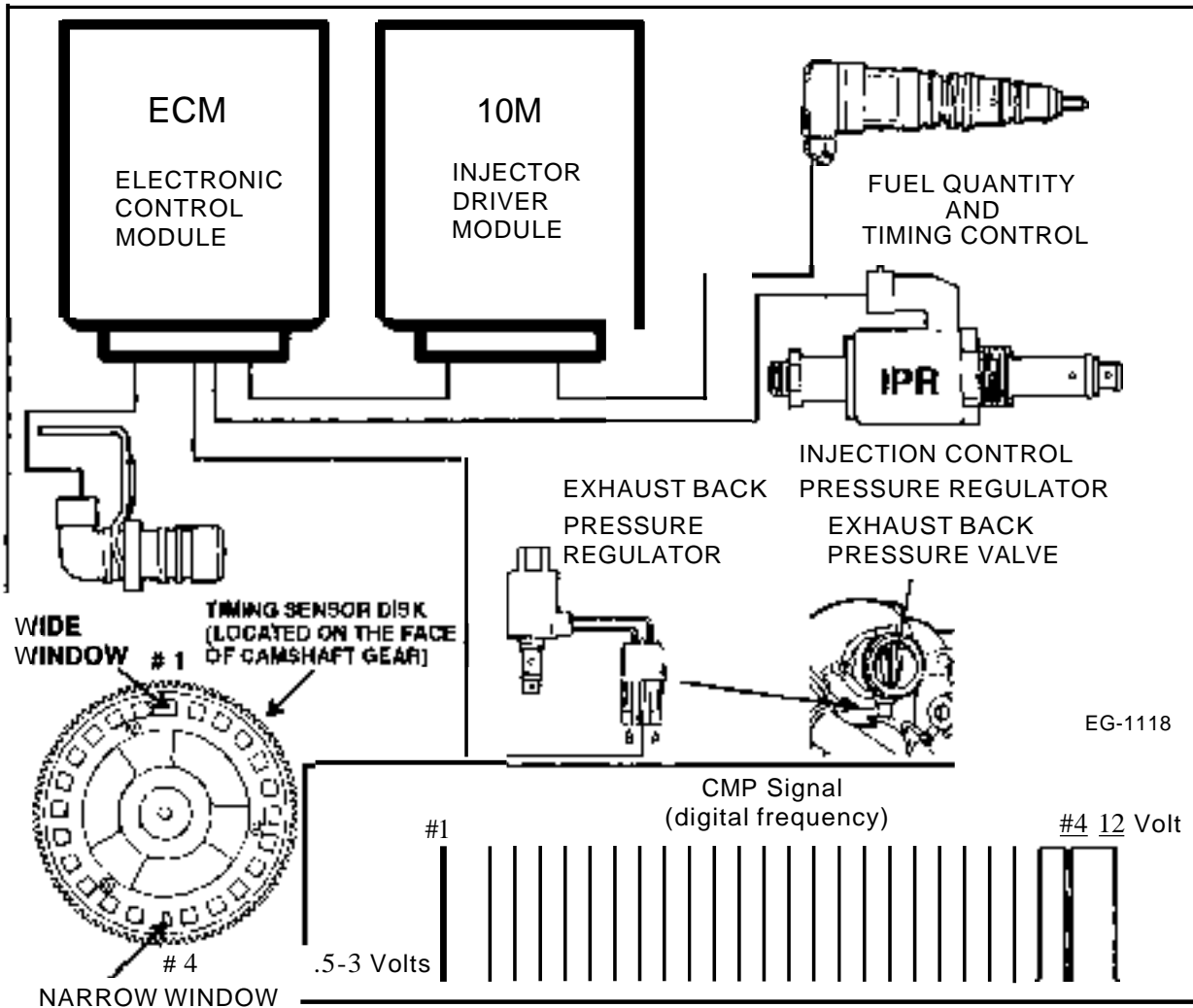


Figure 3.5-3 - Truck BNO/BNC Hydraulic Brake Switches

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

CAMSHAFT POSITION SENSOR (CMP)

CAMSHAFT POSITION (CMP) SENSOR



SIGNAL FUNCTIONS

The CMP (Camshaft Position) sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through its magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allows the ECM to detect engine speed and position.

Engine Speed - Is determined by counting 24 windows on the timing sensor disk each camshaft revolution.

Fuel Timing Control - The position of cylinder #1 and #4 is determined by distinguishing a narrow or wide window on the camshaft timing sensor disk.

Engine Mode Selection - Allows the ECM to discern when the engine is in the off, crank or run mode.

Injection Control Pressure - Engine speed is one of the controlling variables in the calculation of desired injection control pressure.

Exhaust Back Pressure - Exhaust back pressure control is a function of engine speed and load.

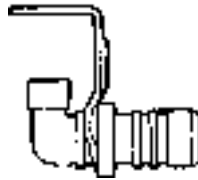
Fuel Quantity Control/Torque Limiting - Engine torque and fuel is controlled and is dependent on engine speed. Fuel quantity is determined by engine speed.

FAULT DETECTION/MP.NAGEMENT

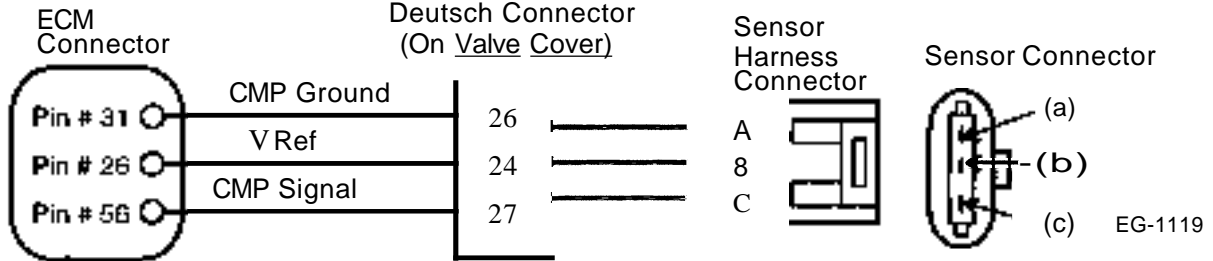
An inactive CMP signal during cranking is detectable by the ECM. An inactive CMP signal will cause a no start condition. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding fault code will be set. *The engine will not operate without a functioning CMP signal.*

CAMSHAFT POSITION SENSOR (CMP)

Camshaft Position
Sensor
(CMP)



Fault Codes:
143 CMP/SYNC Counts incorrect
144 Noise Rejection
145 Inactive CMP sensor
612 Incorrect ECM rriming Wheel



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground check with key off, if > than 5 ohms harness is open.
S to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with Sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	5 ± .5 volts	VAef check key on, VRef not present check open/short to grd #26 to B, see VAef circuit.
C to Grd.	12 ± 1.5 volts	If < than 10.5 v check for poor connection, if 0 v check for open/short to grd circuit.

Harness Resistance Checks
(Check with breakout box installed on engine harness only with ignition key Off)

Test Points	Spec.	Comments
#31 to A	< 5 ohms	Resistance from harness connector to 60 pin connector - Signal grd (CMP has dedicated grd circuit)
#26 to 8	< 5 ohms	Resistance from harness connector to 60 pin connector - V Ref.
#56 to C	< 5 ohms	Resistance from harness connector to 60 pin connector - CMP signal

Test Points		Operational Voltage Checks (Check with breakout box installed in line with the ECM and ignition key ON)
(+) #56 to (-) #31	Comments	
Voltage	Position	
12 ± 1.5 v	Vane	With the breakout box installed, the CMP sensor & ECM connected, bar engine by hand.
.5v to 3v	Window	The CMP signal voltage should change voltage state as timing wheel on cam is rotated.

Fault Code Descriptions

- 143 = Incorrect number of sync to transition counts detected, possible intermittent CMP sensor / circuit fault
- 144 = Electrical noise detected, check wire routing and grounds
- 145 = Inactive CMP signal detected during engine cranking when ICP pressure was sufficient for starting
- 612 = ECM/target disk mismatch detected (wrong ECM installed)

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5
Page 32

CAMSHAFT POSITION SENSOR (CMP)

CAMSHAFT POSITION SENSOR (CMP) EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes a Camshaft Position Sensor (CMP). This sensor provides the Electronic Control Module (ECM) with a signal that indicates camshaft position and engine speed.

The CMP sensor signal is used by the ECM to synchronize piston position to injector firing sequence. The injector firing order sequence begins when the ECM detects the narrow vane on the timing disk indicating #1 cylinder. Engine position for each cylinder is then continuously calculated as each vane on the timing disk passes by the CMP sensor. This information is processed by the ECM and used for injection timing and fuel delivery control. The ECM can then initiate the beginning of firing.

OPERATION

The Camshaft Position Sensor is a Hall Effect type sensor that generates a digital frequency as windows on the timing disk pass through the magnetic field. The frequency of the windows passing by the sensor as well as the width of selected windows allows the ECM to detect engine speed and position. When the narrow vane passes the CMP sensor the signal on time is less than when the other vanes pass the sensor. This produces a signal that the ECM uses to indicate engine position.

Engine speed is detected by the ECM by counting the frequency of the 24 signal pulses for each camshaft revolution.

ECM DIAGNOSTICS

Once the ECM has recognized the narrow vane (wide window) it will synchronize the engine firing order to the timing of the CMP signal. Every 2 crankshaft revolutions it will verify that synchronization. If the ECM receives too many or too few pulses for the number of engine revolutions, it will set a fault code.

The engine will not operate without a functioning CMP signal. However, the ECM will attempt to de-

termine the cause of an invalid signal and identify it with a fault code.

CMP codes that are set will become inactive codes if the key is turned off. These codes can be retrieved using the Self Test Input (STI) switch/(Engine Diagnostics switch) located on the vehicle dashboard or the Electronic Service Tool.

FLASH CODE 143
ATA CODE SID 21 FMI 2
WRONG # OF CMP SIGNAL TRANSITIONS
PER CAM REVOLUTION

Code 143 indicates the ECM has received CMP signals with the wrong number of transitions. This indicates that the ECM has counted the voltage transitions and found less than the specified number of pulses from the sensor. When this problem is continuous, the engine will stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not turn the warning light on.

Possible causes for code 143: Intermittent CMP signal caused by an intermittent circuit, defective Camshaft Position Sensor, or incorrect CMP sensor to timing disk clearance.

FLASH CODE 144
ATA CODE SID 21 FMI 2
CMP SIGNAL NOISE DETECTED

Code 144 indicates that the ECM has detected voltage spikes or transitions other than the CMP signal. If this problem is continuous the engine could stop running and the ECM will log an active code. If the key is shut off, the code will become an inactive code. This code will not cause the warning light to illuminate.

Code 144 may be due to: Poor ground connections for CMP or other electronic components. Wire harness shielding missing or incorrectly installed on the engine harness. Outside components that could induce voltage signals.

CAMSHAFT POSITION SENSOR (CMP)

CAMSHAFT POSITION SENSOR (CMP)
EXTENDED SYSTEM DESCRIPTION (Continued)

FLASH CODE 145
ATA CODE SID 21 FMI12
CMP SIGNAL INACTIVE WHILE ICP HAS INCREASED

Flash code 145 indicates that the ECM does not detect a CMP signal. This code would be set if the engine was rotating and the ECM detected a rise in ICP pressure, but did not detect a CMP signal. To set this code the engine must be rotated long enough for the ICP to increase. When this code is set the engine will not operate. This code will not cause the warning light to illuminate.

Possible causes for flash code 145: Defective CMP sensor, faulty sensor circuitry, or improper air gap between sensor and camshaft timing disk.

FLASH CODE 612
ATA CODE SID 21 FMI7
INCORRECT ECM INSTALLED FOR CMP TIMINGDISK

Flash code 612 indicates that the ECM has moni..

tared the CMP signal and the signal is incorrect for the programming in the ECM. This means that the ECM does not recognize the signal generated from the timing disk and CMP sensor.

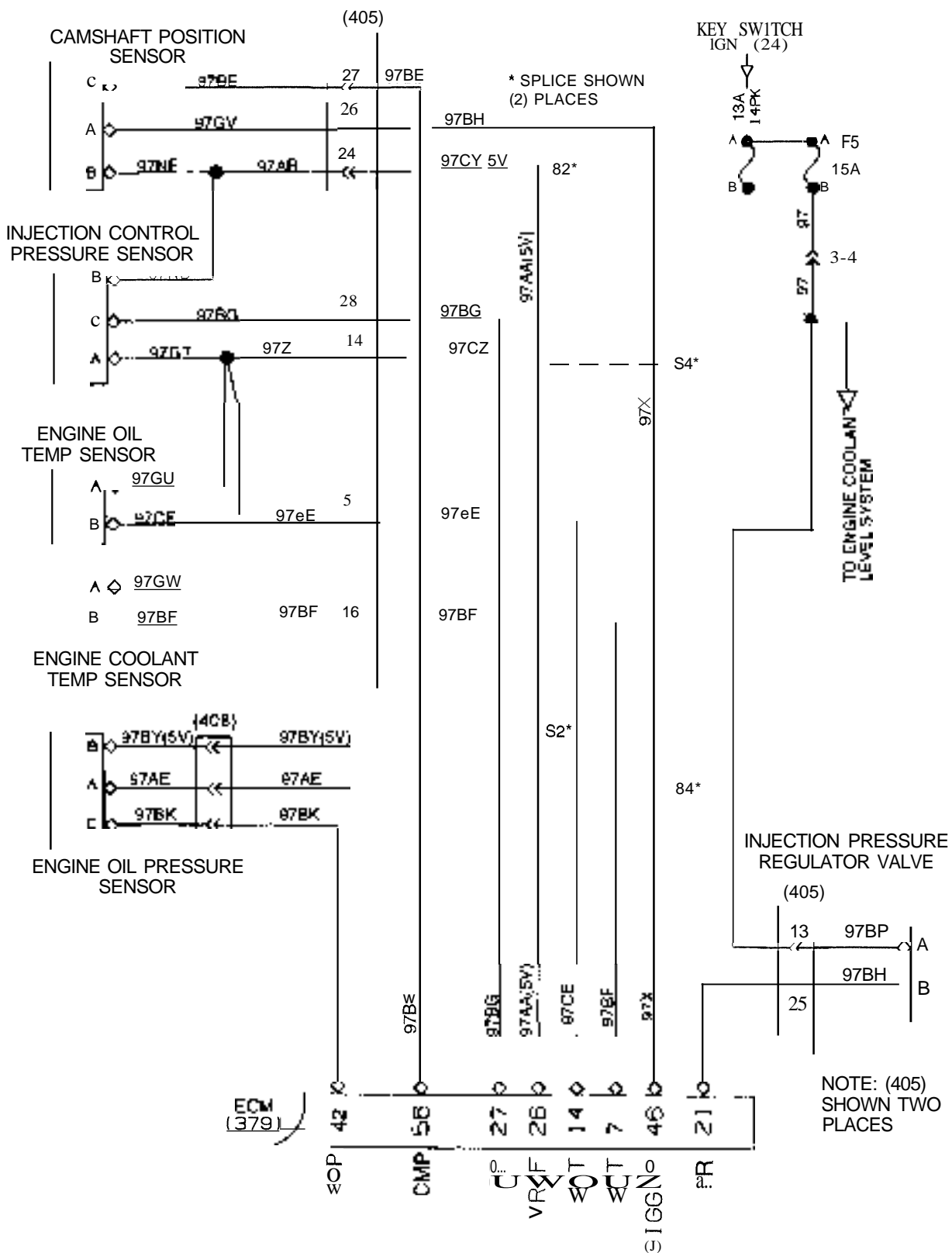
When this condition exists, the ECM does not send a Fuel Demand Command Signal (FCDS) to the Injector Drive Module (10M). The engine cannot operate without a FCDS signal from the ECM.

Possible causes: ECM has been accidentally replaced with an incorrect ECM for the particular engine application. (For example, the timing disk for the V-8 (T444E) and the 1-6 are different and generate a different signal. An ECM from an 1-6 engine will not run a V-8 (T444E) engine.) Incorrect signal due to a defective CMP sensor or incorrect air gap between the CMP sensor and the timing disk.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

CAMSHAFT POSITION SENSOR (CMP)

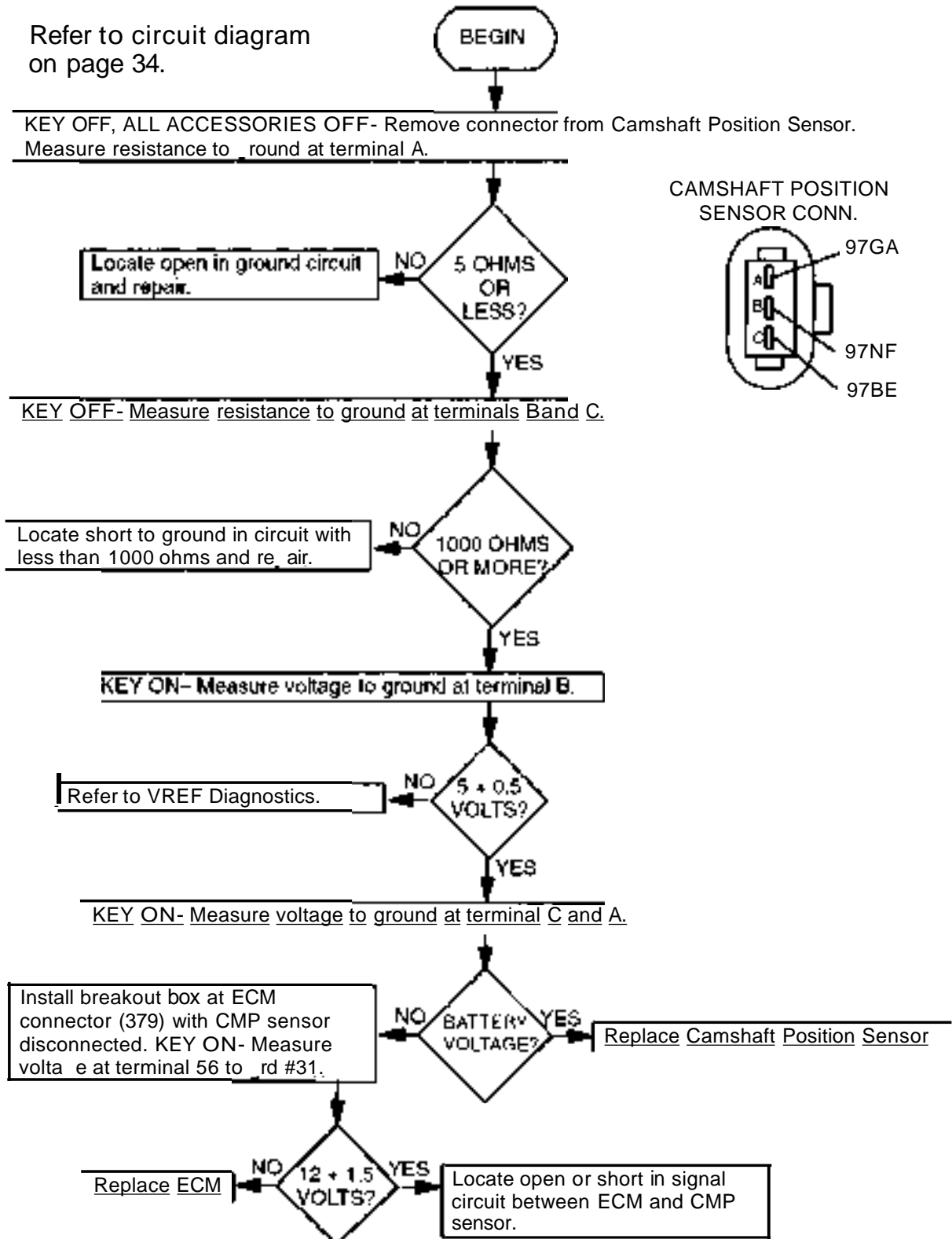
SENSOR CIRCUITS (DIAGRAM)



CAMSHAFT POSITION SENSOR (CMP)

CAMSHAFT POSITION SENSOR (CMP) CIRCUIT DIAGNOSTICS

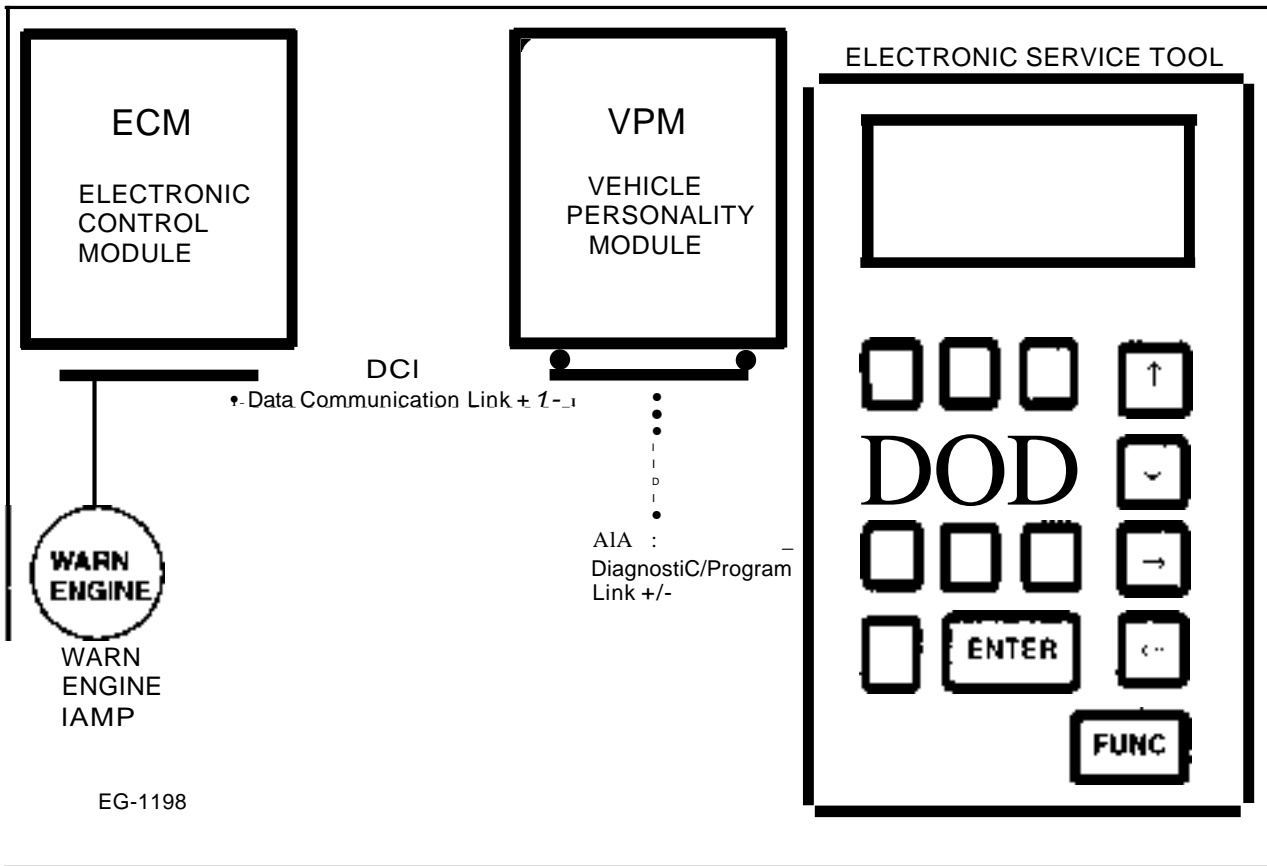
Refer to circuit diagram on page 34.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

DCUATA COMMUNICATION LINKS (DCUATA)

VPM COMMUNICATIONS
(Data Communications Link, ATA Link)



EG-1198

SIGNAL FUNCTIONS

Data Communication link - the Data Communication Link signal is a 0 to 5 volt variable width wave form signal that enables communication between the Vehicle Personality Module (VPM) and the ECM. It is used for communication of diagnostic and calibration data.

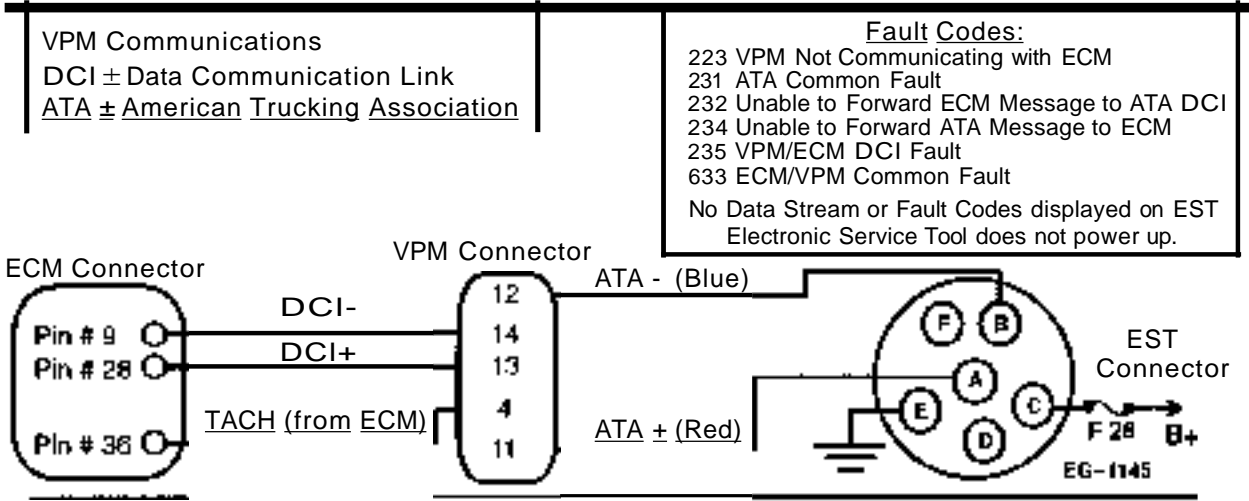
ATA Diagnostic/Programming link - The ATA signal is a 0 to 5 volt width wave form signal that enables communication between the VPM and the Electronic Service Tool (EST). It is used for communication of calibration, programming and diagnostic information.

Tachometer Signal - The ECM provides the VPM with a 0 to 12 volt tachometer signal. The frequency of the signal is one-fifth (1/5th) the RPM.

FAULT DETECTION/MANAGEMENT

The VPM and ECM can detect on a continuous basis an open, short or intermittent connection on the Del and ATA lines.

DCUATA COMMUNICATION LINKS {DCUATA}



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Key ON Engine OFF - Voltage Checks at EST Connector

+Test Points	Spec.	Signal	Comments
Cto E	B+	Power	Should be power at C at all times.

Connector Checks to Ground at ECM

(Check with breakout box installed, ignition key should be in the OFF position)

Test Points	Spec.	Signal	Comments
#9 to #46	> 1000 ohm	DCL-	< 1000 ohms indicates a short to grd. either thru the harness or internal in the ECM or VPM. Disconnect VPM and measure to grd again. If short still present, disconnect ECM and measure to grd. If short is still present, repair harness.
#28 to #46	> 1000 ohm	DCI+	

Harness Resistance Checks

(Check with breakout box installed, ignition key should be in the OFF position)

Test Points	Spec.	Signal	Comments
#9 to 14	< 5 ohm	DCI-	Resistance from 60 pin connector to harness connector - DCI Signal
#28 to 13	< 5 ohm	DCL+	Resistance from 60 pin connector to harness connector - DCI Signal
12 to B	< 5 ohm	ATA-	Resistance from VPM connector to EST connector - ATA Signal
11 to A	< 5 ohm	ATA+	Resistance from VPM connector to EST connector - ATA Signal
Cto B+	< 5 ohm	PWR	Resistance from EST connector to Fuse F28 - EST Power
E to Grd.	< 5 ohm	GAD	Resistance from EST connector to grd (ECM pin #46 if breakout box installed)

Fault Code Descriptions

223 VPM not communicating with ECM, DCI wiring faults, faulty VPM
 231 ATA Common Fault - ATA wiring faults, faulty VPM
 232 Unable to forward ECM message to ATA DCI - ATA wiring faults, faulty VPM
 234 Unable to forward ATA message to ECM-key is off w/EST installed, DCI wiring faults, faulty ECM
 235 VPM/ECM DCI Fault - DCI wiring faults, faulty ECM
 633 ECMNPM Common Fault - DeI wiring fault, SW mismatch, faulty VPM
 No Data Stream or Fault Codes displayed on Electronic Service Tool
 Electronic Service Tool does not power up.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

DCUATA COMMUNICATION LINKS (DCUATA)

EXTENDED DESCRIPTION

ECMNPM COMMUNICATION

The Navistar engine control system includes the Electronic Control Module (ECM), Vehicle Personality Module (VPM), and Injector Driver Module (10M). Refer to Figure 3.5-4. for the following discussion.

The engine control system "communicates" with the Electronic Service Tool through connector (384) as shown in Figure 3.5-4. The EST communicates with the VPM using the American Trucking Association (ATA) data link lines(1).

The ECM communicates with the VPM through a proprietary data link channel (DCI). The Data Communications link (DCI) channel connects the ECM and the VPM.

Both the ATA and DCI circuits use twisted wire pairs. All repairs to these pairs must maintain one complete twist per inch along the entire length of the circuits. These circuits are polarized (one positive and one negative) and reversing the polarity of these circuits will disrupt communications.

(1) - The ATA data link is defined by SAE recommended practices J1708 and J1587. This link and connector (384) were adopted by the Recommended Practices 1201 and 1202.

ATA COMMUNICATIONS

Refer to the circuit diagram on page 42 for the following discussion.

ATA DATA LINK CONNECTOR (384)

All communications between the EST (Prolink 9000™ using the Navistar cartridge) and the engine control system is done through the EST connector (384). This communications link supports:

- Displaying fault codes and operating conditions on the EST.
- Performing proprietary diagnostic tests programmed into the cartridge.
- Clearing fault codes.
- Programming performance parameter values.

EST connector (384) has six pins, labeled A through F, Figure 3.5-4. that provide the following:

- A. Fused BATTERY power is provided to Pin "C" to provide battery power for electronic service tools. Pin "E" provides a battery ground for the EST.
- B. Connector (384) terminal A is connected by circuit 98B(+) to the positive RED ATA bus and EST connector (384) terminal B is connected by circuit 980(-) to the negative BLUE (428) bus. These two connections allow communication with all components connected to the data link at these same two busses.

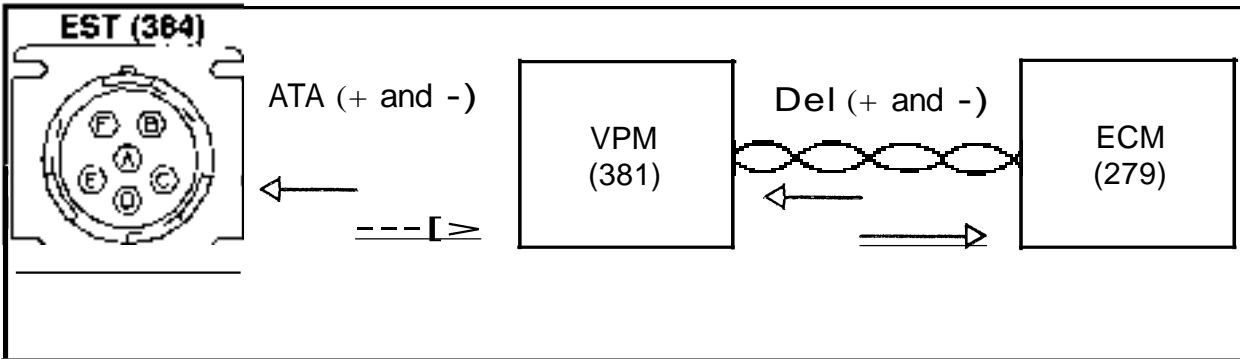


Figure 3.5-4. - ATA and DCI Communication

DCUATA COMMUNICATION LINKS (DCUATA)

EXTENDED DESCRIPTION (Continued)

POSITIVE AND NEGATIVE ATA DATA LINKS

The RED Positive and BLUE Negative Data link Busses connect the EST connector (384) and the VPM (381). They are also the connection point for other electronic components that require access to the engine control system through the ATA communications link.

The RED positive bus (427) is connected by circuit 98A(+) to the VPM at connector (381), terminal 11. The BLUE negative bus (428) is connected by circuit 98C(-) to the VPM at connector (381), terminal 12.

DCI COMMUNICATION LINKS

The VPM is connected to the ECM through the DCI. The DCI connection between the ECM and the VPM serves as a conduit for data sent on the ATA to be shared with the ECM. Communications between the ECM and the EST connector go through the VPM.

VPM - ECM COMMUNICATIONS

The positive (+) DCI link is circuit 97AS, which connects ECM connector (379) terminal 28, to the VPM through connector (381), terminal 13. The negative (-) DCI link is circuit 97AT, which connects ECM connector (379), terminal 9 to the VPM through connector (381), terminal 14. These two circuits (97AS and 97AT) are a twisted wire pair and pass through dash connector (3) at terminals 8 and 1.

Both the ATA and DCI circuits use twisted wire pairs. All repairs to these wire pairs must maintain one complete twist per inch along the entire length of the circuits. Both circuits are polarized (one positive and one negative) and reversing the polarity of the circuit will disrupt communications.

ECM DIAGNOSTICS

Flash codes that can be caused by defects occurring in the ATA or DCI circuits are discussed in this section. There are also Flash Codes related to or caused by faulty communication (corrupt or invalid data transmitted between the ECM and VPM), that are discussed in this section.

EST CONNECTOR (384)

The engine control system does not detect faults in the power or ground circuits to EST connector (384). If the service tool does not power up when

connected, try the service tool on another vehicle if one is available to determine if the service tool is working properly. If the service tool is OK, then perform Testing EST Connector (384) Power and Ground Circuits on page 43.

EST DISPLAYS

Should the EST display NO DATA, the ATA data link circuit from the EST connector to the VPM may be disrupted. Verify that the key is ON and then perform Testing The ATA Data link Circuits on page 44.

FAULT CODES

FLASH CODE 223

ATA CODE SID 252 FMI 7

VPM NOT COMMUNICATING WITH ECM

Symptom: Flash code 223 causes the engine to operate in Field Defaults, which turns the Engine Warning Light ON. When Field Defaults are being used by the ECM, Flash Code 622 also is set. If the condition causing code 223 is intermittent, and the condition is no longer present, the code will change to an inactive code, and the engine will resume normal operation.

Wiring Causes: DCI circuits 97AS and/or 97AT between the ECM and VPM: shorted low or High or Open.

If code 223 is active:

1. Perform TESTING DCI CIRCUITS on page 47.
 - A. If defect is found in DCI circuit, correct defect.
 - B. If the DCI circuits (97AT and 97AS) check good, replace the VPM.

FLASH CODE 231

ATA CODE SID 250 FMI 2

VPM: ATA COMMON FAULT

SYMPTOM: Code 231 does not turn Engine Warning light ON. This code can occur when the VPM can't access the ATA data link. If this occurs, there will not be any ATA data available at the electronic service tool (EST). The code can be "flashed" using the STI switch located on the instrument panel.

WIRING CAUSES: ATA positive or negative circuits between EST and VPM and any other electronic devices (transmissions, brakes etc.) using the ATA bus: Shorted (high or low), open, or busy (too many devices).

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

DCUATA COMMUNICATION LINKS (DCUATA)

DIAGNOSTICS (Continued)

FLASH CODE 231
ATA CODE SID 250 FMI 2
VPM: *ATA COMMON FAULT (Continued)*

If code 231 is active:

1. Perform Testing the ATA Data link Circuits on page 44.
 - A. If defect is found in ATA circuits, correct defect.
 - B. If defect is not found in ATA circuits, investigate SYSTEM CAUSES.

SYSTEM CAUSES: System causes can include:

- A. A defective ATA device (such as transmission controller or antilock brake controller) connected to the ATA bus is pulling the signal to ground.
- B. Too many ATA devices, although this would be rare.
- C. If no system causes are present, replace the VPM.

FLASH CODE 232
ATA CODE SID 250 FMI 9
VPM: *UNABLE TO FORWARD ECM MESSAGE TOATA DCL*

SYMPTOM: There are no ECM replies to requests from the EST or VPM. Flash Code 232 does not turn the Engine Warn light ON.

WIRING CAUSES: The positive and/or negative ATA data link circuits between the EST and VPM (or other devices installed using the ATA link): Shorted High or Low or Open.

If code 232 is active:

1. Perform Testing the ATA Data Link Circuits on page 44.
 - A. If wiring defect is found, correct defect.
 - B. If no wiring defects are found, investigate System Causes.

SYSTEM CAUSES: Code 232 can occur when the ECM is sending more messages than the VPM can transmit on the ATA bus. This can be caused by:

- A. A defective ATA device (such as transmission controller or antilock brake controller) connected to the ATA bus pulling the signal to ground.

B. Too many ATA devices or an incompatible ATA device has been connected to the ATA bus.

C. May be caused by code 231 occurring.

D. If none of the system causes are present, replace the VPM.

FLASH CODE 234
ATA CODE SID 248 FMI 9
VPM: *UNABLE TO FORWARD ATA MESSAGE TO ECM.*

SYMPTOM: There are no ECM replies to requests from the EST or VPM. There is NO Engine Warning light. Code 223 may also be present.

NOTE: Code 234 can be set by connecting the EST when the key is OFF. If the key was recently turned off, the VPM may still be powered. The VPM can stay on for up to 30 minutes after turning the key off. If the prolink is connected (key off), the VPM will unsuccessfully request data from the ECM, which is not powered with the key off. If this occurs, turn the key on and clear the codes.

WIRING CAUSES: DCI positive or negative circuits (97AT and/or 97AS): Shorted High or low or open between ECM and VPM.

If code 234 is active:

1. Verify that ignition key is ON.
2. Perform Testing DCI Data link Circuits on page 47.
 - A. If defect is found in DCI, correct defect.
 - B. If no defects are in DCI, replace the ECM.

FLASH CODE 235
ATA CODE SID 248 FMI 2
VPM: *VPMIECM DCL FAULT*

SYMPTOM: There are no ECM diagnostic replies to requests from the EST or VPM. Engine Warning light OFF. If the condition causing code 235 to set is intermittent and the condition is no longer present, the code will go to inactive status.

WIRING CAUSES: DCI circuits 97AT and/or 97AS are: shorted High or Low or Open between VPM and ECM.

If code 235 is active, Perform Testing DeI Data link Circuits on page 47.

- A. If wiring defect is found, correct defect.
- B. If wiring defect is not found, replace the ECM.

DIAGNOSTICS (Continued)

FLASH CODE 633
AIA CODE SID 252 FMI 2
ECM: *ECMNPM COMMON FAULT*

SYMPTOM: The engine operates on Field Defaults turning the Engine Warning light ON and setting code 622.

This code indicates that the ECM and VPM are communicating incorrectly. The message from the VPM contains bad data, or the VPM takes too long to respond to ECM requests for data. If this code is caused by an intermittent condition, and the condition is no longer present, the code will become inactive and normal engine operation will resume.

WIRING CAUSES: DCI circuits 97AT or 97AS between ECM and VPM are: shorted low, High or Open.

If code 633 is active:

1. Perform Testing DCI Data Link Circuits on page 47.
 - A. If defect is found in DCI, correct.
 - B. If there are no defects in the DCI, refer to codes 613 and 614 and verify that the ECM and VPM have the correct software versions. If the software versions are correct, replace the VPM.

CIRCUIT DIAGRAM

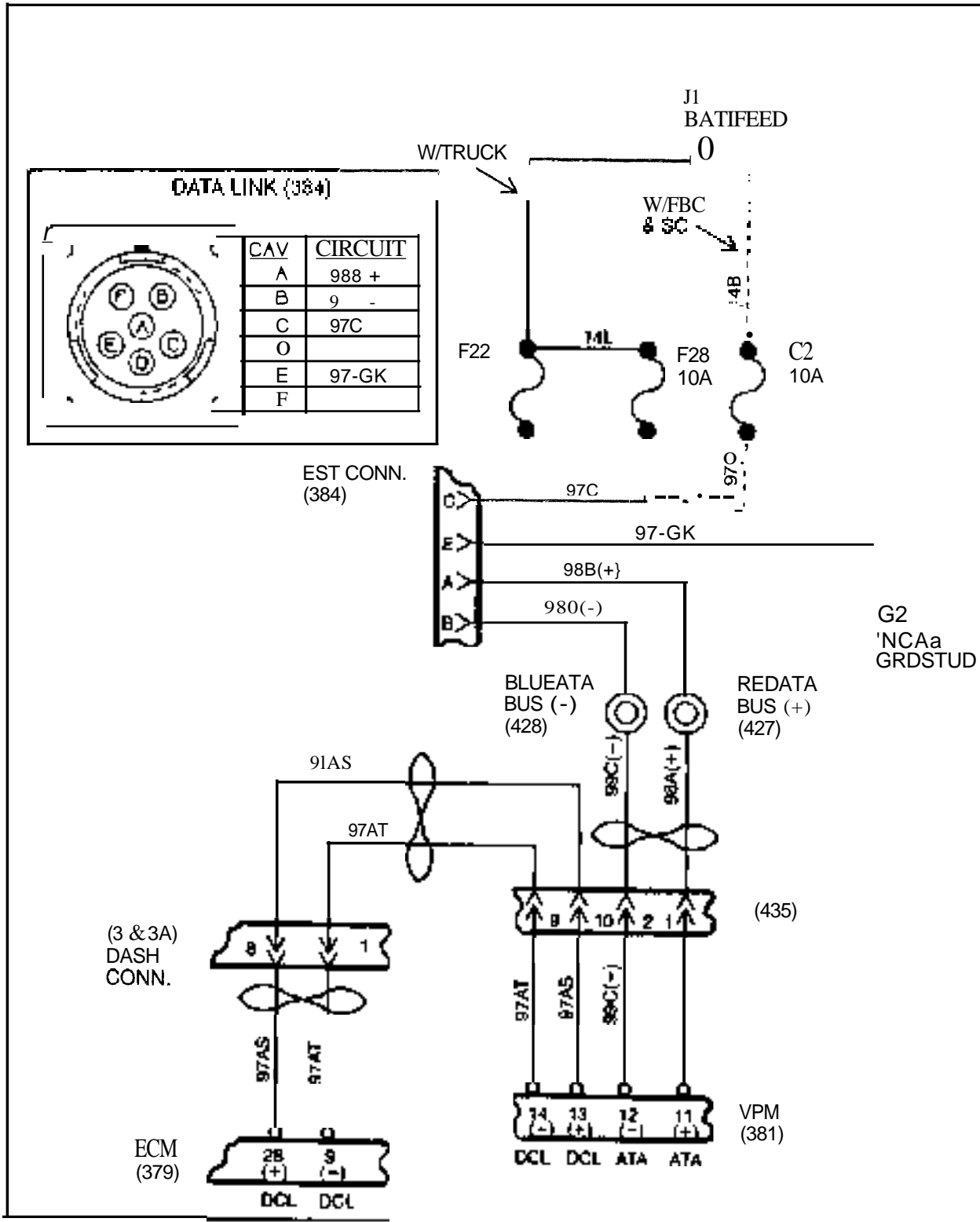


Figure 3.5-5. - ATA and DeI Communication links

TROUBLESHOOTING

The DCI and ATA circuits operate with very low current levels. When troubleshooting the DCI or ATA, pay special attention to the connectors.

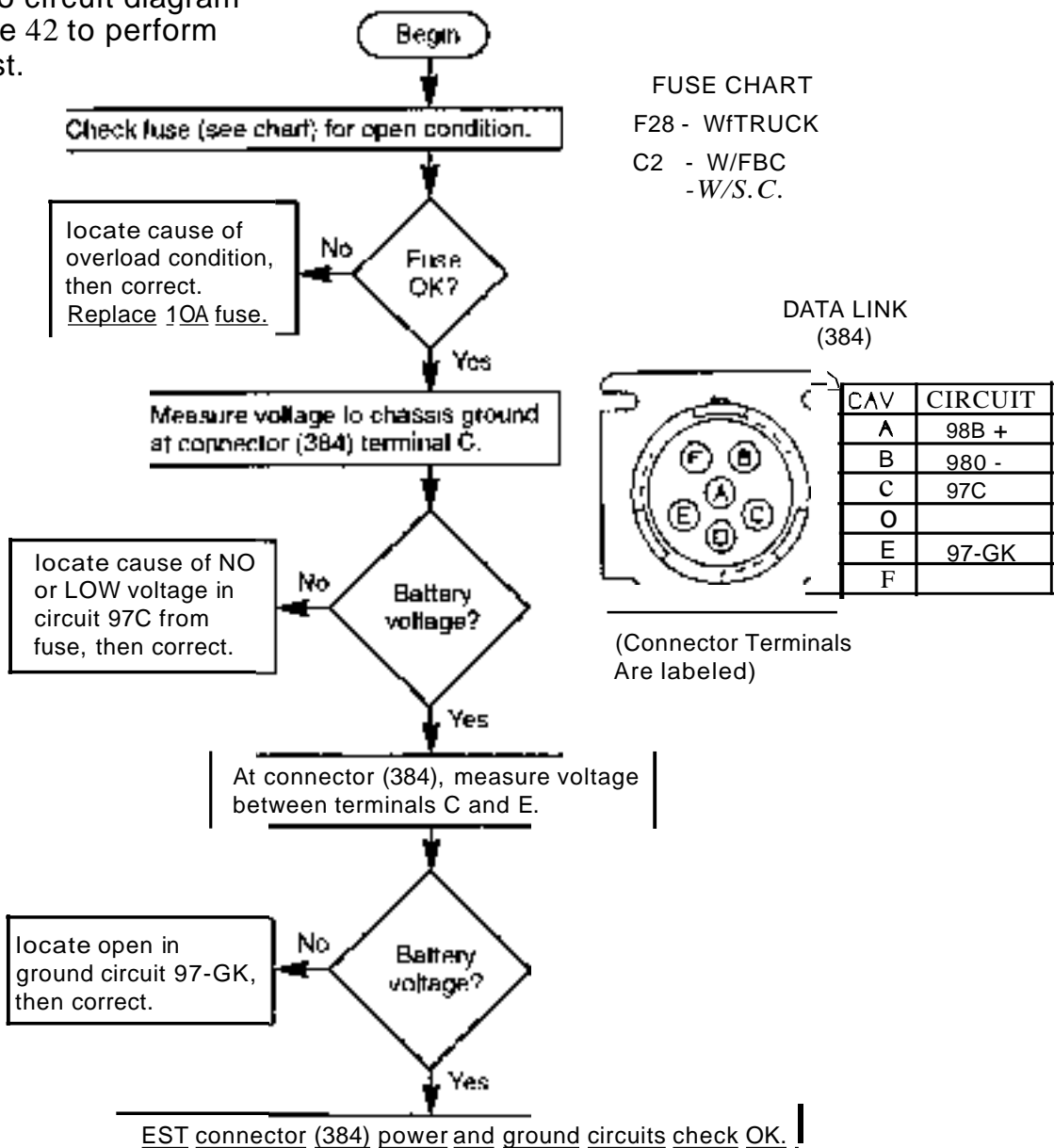
dirty terminals as well as making sure that the terminal and wire are properly crimped. Make sure the connectors are properly joined together. Also check for damage to wiring, and clean tight ground connections.

BEFORE PERFORMING ANY TEST

Inspect for pushed back, damaged, corroded or

TESTING EST CONNECTOR (384) POWER AND GROUND CIRCUITS

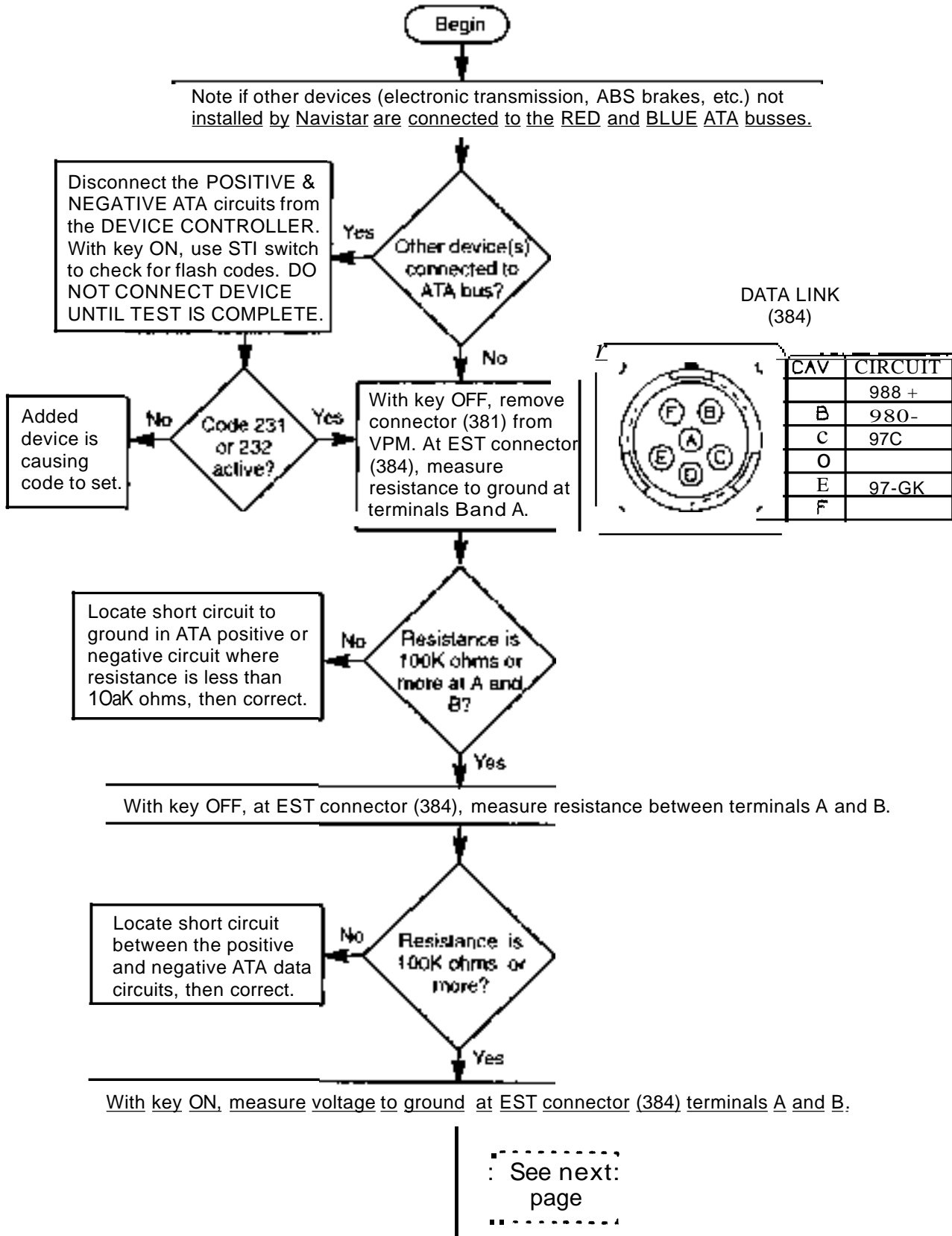
Refer to circuit diagram on page 42 to perform this test.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

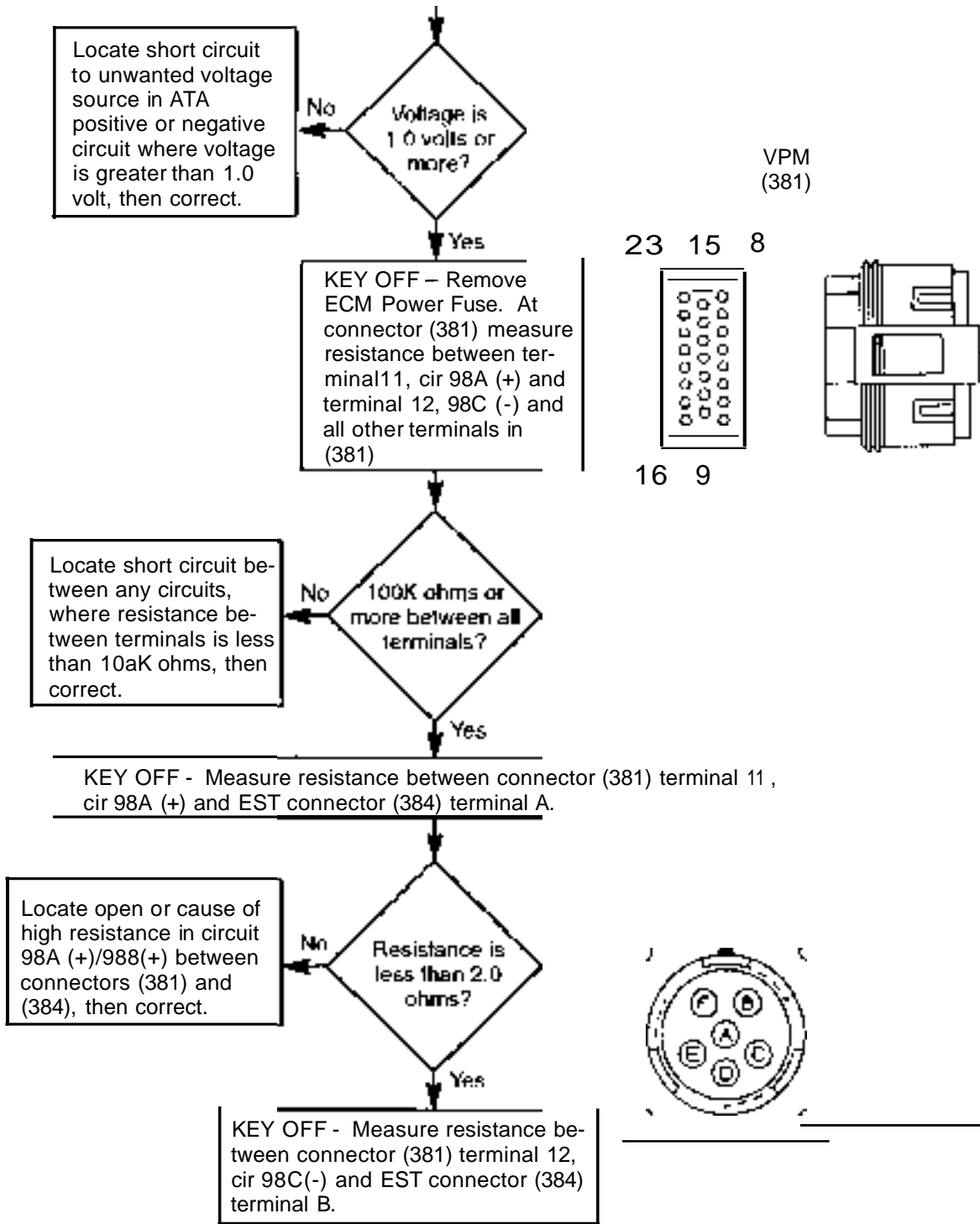
DCUATA COMMUNICATION LINKS (DCUATA)

TESTING THE ATA DATA LINK CIRCUITS



DCUATA COMMUNICATION LINKS (DCUATA)

TESTING THE ATA DATA LINK CIRCUITS (Continued)

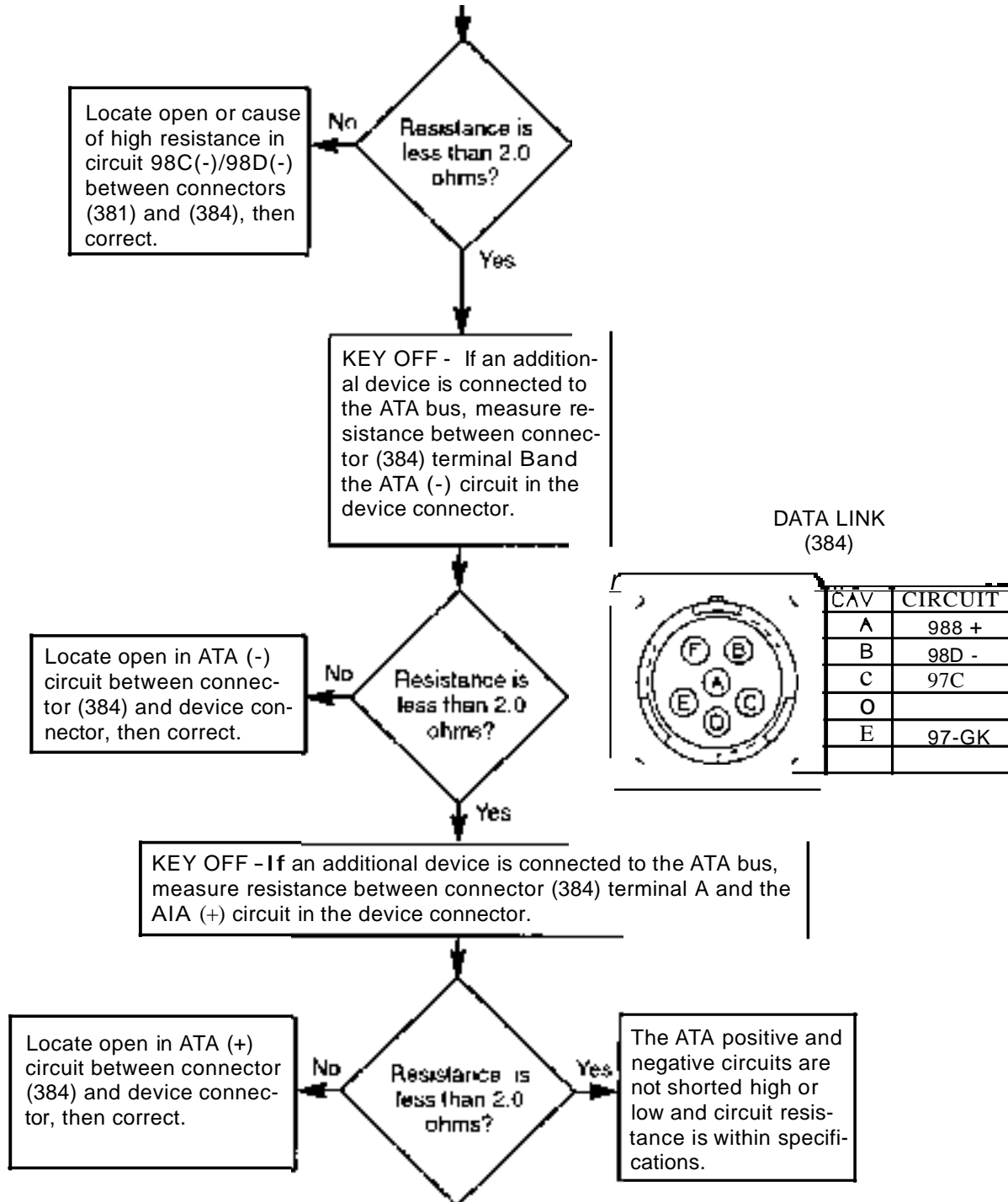


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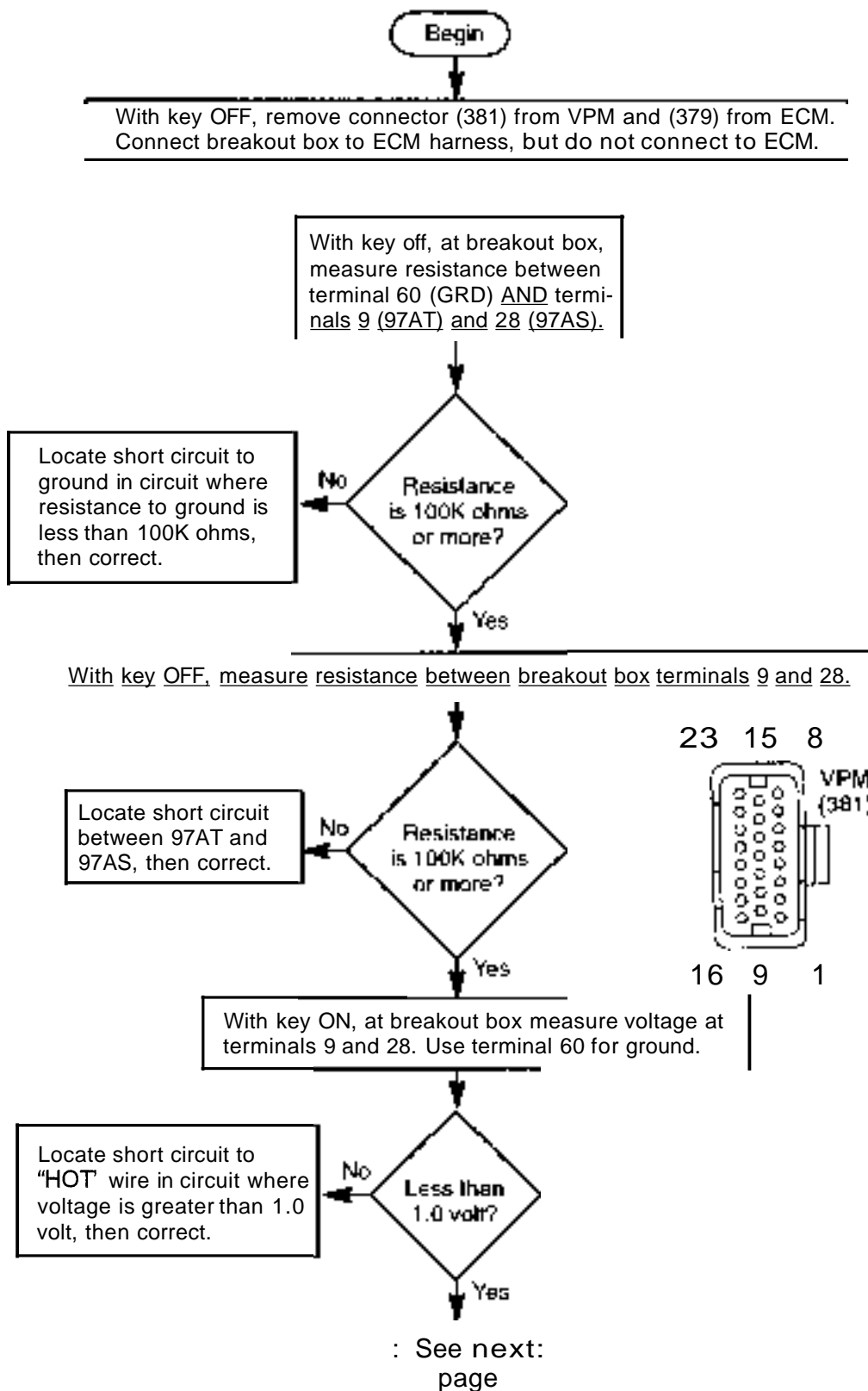
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

DCUATA COMMUNICATION LINKS (DCUATA)

TESTING THE ATA DATA LINK CIRCUITS (Continued)



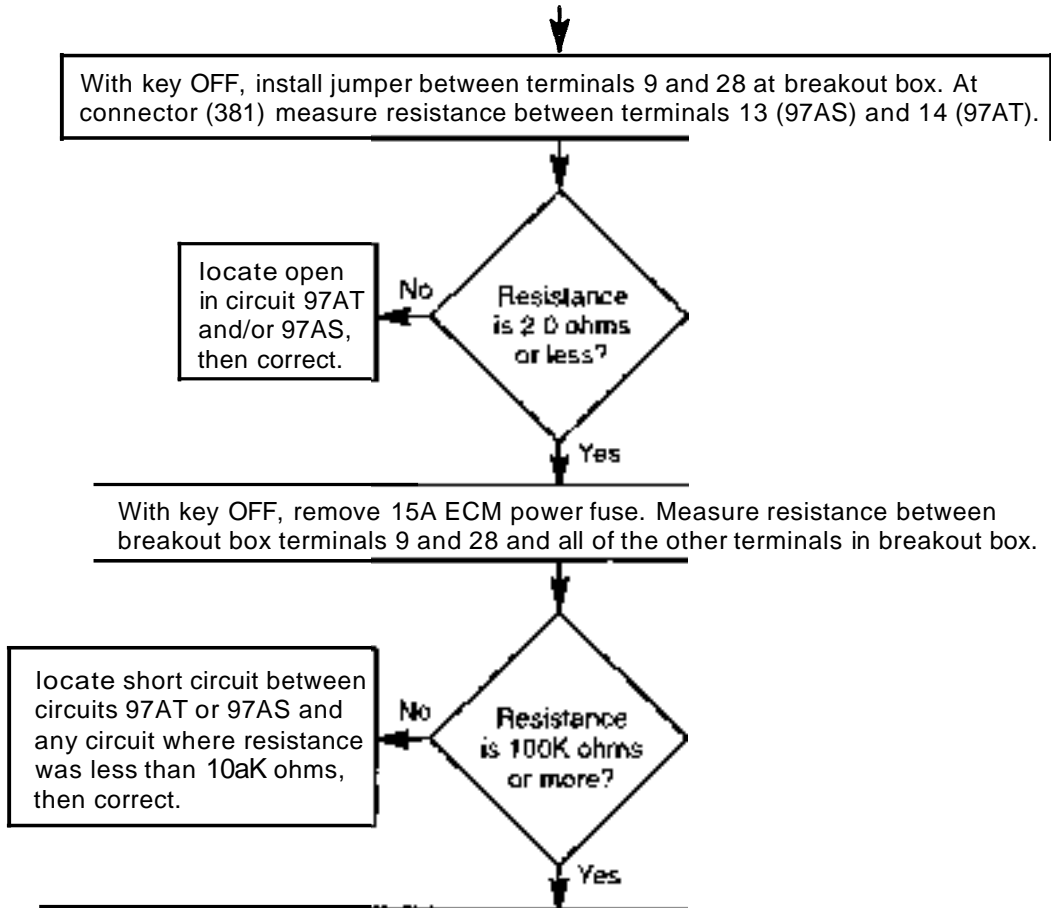
TESTING DCI DATA LINK CIRCUITS



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

DCUATA COMMUNICATION LINKS (DCUATA)

TESTING DCI DATA LINK CIRCUITS (Continued)

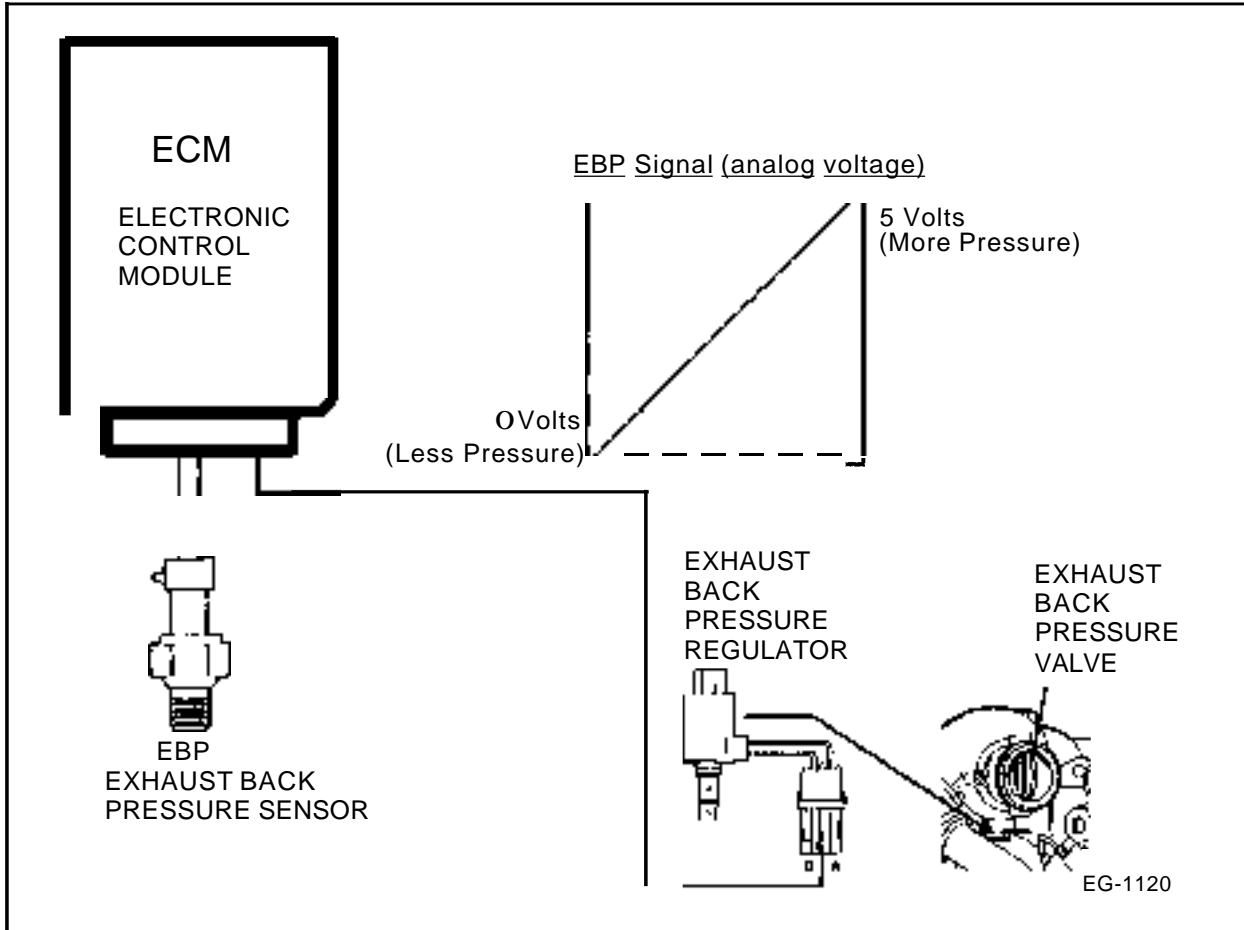


The Del circuits (97AT & 97AS) are not shorted HIGH or LOW and have continuity.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

EXHAUST BACK PRESSURE SENSOR (ESP)

EXHAUST BACK PRESSURE (EBP) SENSOR



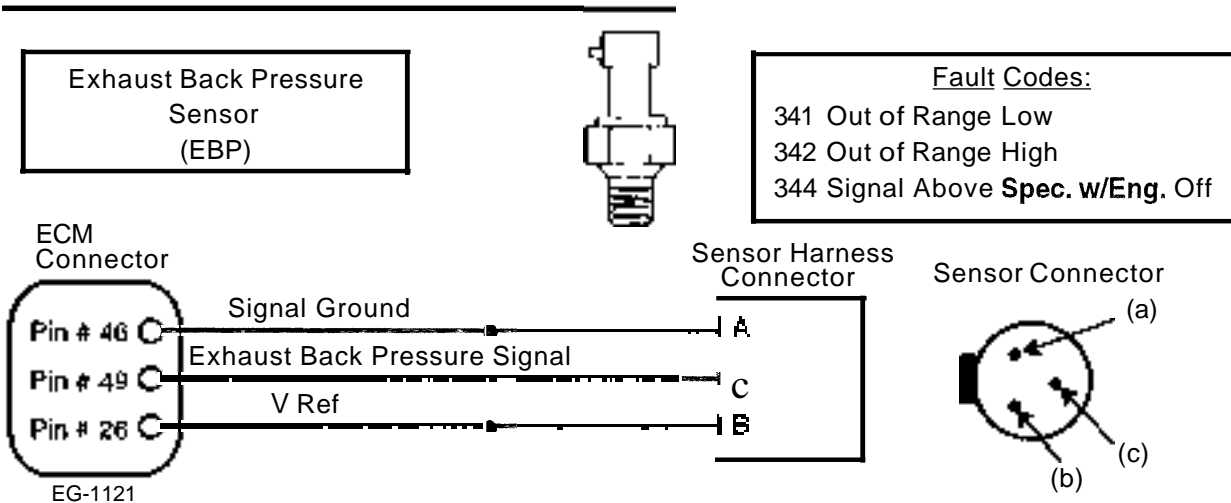
SIGNAL FUNCTIONS

The ESP (Exhaust Back Pressure) sensor is a variable capacitance sensor that when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

The ESP sensor's primary function is to measure exhaust back pressure so that the ECM can control the exhaust back pressure regulator when needed.

FAULT DETECTION/MANAGEMENT

An ESP signal that is detected out of range high or low by the ECM will cause the engine to ignore the ESP signal and disable exhaust back pressure operation.



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
 (Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground check with key off, if > than 5 ohms harness is open.
S to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
eta Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
 (Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	5 volts ± .5	V Ref. check with key ON, if voltage not in spec. , see V Ref circuit
C to Grd.	< .25 volts	If greater than 0.25 volts signal wire is shorted to V Ref of battery.

Harness Resistance Checks
 (Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector - Signal ground
#26 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector - V Ref
#49 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector - ESP signal

Test Points		Operational Signal Checks		Comments
(+) #49 to (-) #46		PSIG	KPAG	
.8 - 1.0 v	0	0	0	Signal with key "ON" and engine OFF (Value dependent upon atmospheric pressure and altitude.)
.8 - 1.0 v	0	0	0	Normal warm idle signal.
1.19 v	14.8	10.0	10.0	Minimum back pressure signal expected at 2300 RPM (See EPR diagnostics)

Fault Code Descriptions

- 341 = Signal voltage was less than .039 volts for more than 0.1 seconds.
- 342 = Signal voltage was greater than 4.90 volts for more than 0.1 seconds.
- 344 = Signal above 1.34 volts with engine off. 19 psi (130 kPa)

EXHAUST BACK PRESSURE SENSOR (EBP)

EXHAUST BACK PRESSURE SENSOR (EBP)

EXHAUST BACK PRESSURE SENSOR (ESP) EXTENDED SYSTEM DESCRIPTION

FUNCTION

The exhaust back pressure (EPB) sensor is included in the Navistar engine control system only when a vehicle is equipped with an exhaust back pressure valve.

The ECM monitors the ESP signal during engine operation. The ESP's primary function is to measure exhaust back pressure so that the ECM can control the exhaust back pressure regulator when needed to aid in maintaining and achieving normal engine operating temperature.

OPERATION

The exhaust back pressure sensor is a variable capacitance sensor. When pressure is applied to the sensor, the capacitance changes in relation to the pressure.

The ECM supplies a regulated 5 volt signal to terminal B of the E8P sensor from terminal 26 of the ECM. The ESP sensor is supplied a signal return (ground) at terminal A to terminal 46 of the ECM.

During engine operation, exhaust back pressure acting on the sensor causes the sensor's capacitance to vary which changes the incoming 5 volt reference signal in relation to pressure. The sensor's pressure signal at terminal C is sent to terminal 49 of the ECM. This signal increases equally in proportion to an increase in pressure up to a maximum of 38 PSI (262 kPa).

ECM DIAGNOSTICS

The ECM continuously monitors the signal from the E8P sensor to ensure the signal is within the correct operating range. If the signal is lower or higher than required, the ECM will set a fault code. This fault code is retrieved using the Electronic Service Tool (EST) or by reading the flash code using the STI diagnostic switch. If the ignition key is shut off, the code will be stored as an inactive code.

FLASH CODE 341
ATA CODE SID 34 FMI 20
EXHAUST BACKPRESSURE SIGNAL OUT OF RANGE LOW

Code 341 indicates the ECM has detected a ESP signal voltage less than .039 volts for more than 0.1 seconds. If this fault code is set, the ECM will ignore the E8P signal and continue to operate normally, however, if the fault is active the ECM will disable exhaust back pressure valve operation

Possible causes for code 341: Open Vref signal circuit or a defective ESP sensor.

FLASH CODE 342
ATA CODE SID 34 FMI19
EXHAUST BACKPRESSURE SIGNAL OUT OF RANGE HIGH

An out of range high code will be set if the ECM detects a voltage more than 4.9 volts for more than 0.1 seconds. If this fault code is set, the ECM will ignore the ESP signal and continue to operate normally. If this fault is active, the ECM will disable exhaust back pressure operation.

Code 342 may be caused by an open signal return circuit, a short to a voltage source or a defective ESP sensor.

FLASH CODE 344
ATA CODE SID 34 FMI29
EXHAUST SACK PRESSURE BELOW WARNING LEVEL

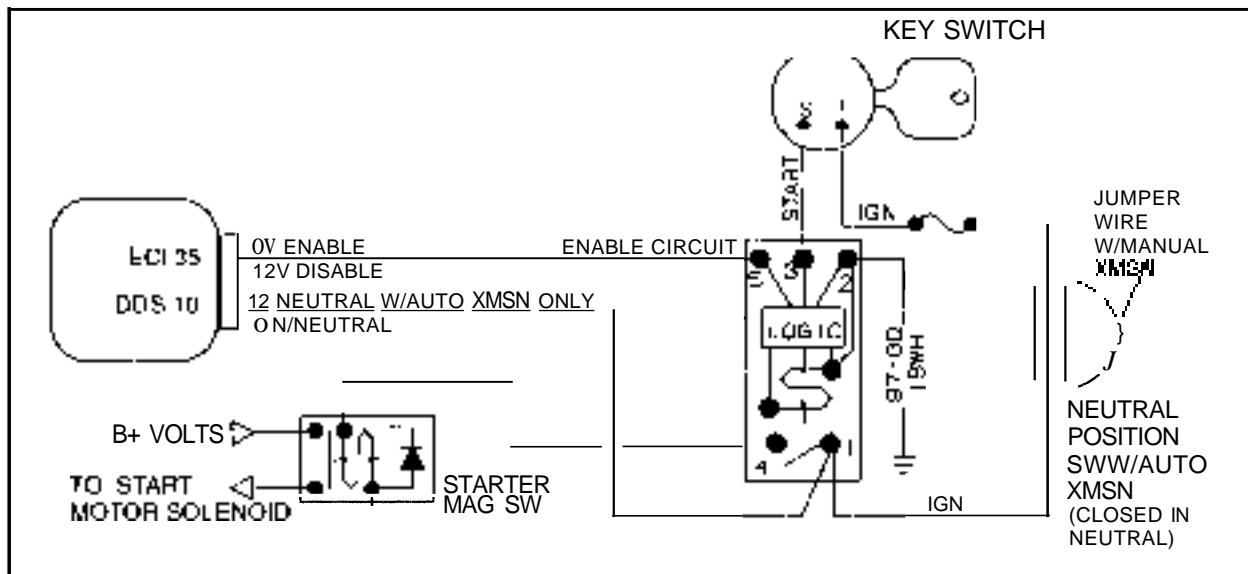
Code 344 indicates the exhaust back pressure was greater than 19 psi (130 Kpa) with the key "ON" and engine "OFF"

Code 344 may be caused by a defective or plugged ESP sensor or a restriction in the tube leading to the sensor. To confirm this, remove sensor and/or tube and inspect for carbon deposits.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (ECI)

ENGINE CRANK INHIBIT SYSTEM (ECI)



SIGNAL FUNCTION

The ECM uses the enable circuit to control engine cranking. The ECM prevents cranking motor operation: whenever the engine is running or whenever a vehicle with an automatic transmission is not in neutral.

ELECTRONIC CONTROL MODULE (ECM)

AUTOMATIC TRANSMISSION

With the key ON, the ECM enables the crank relay if the engine is not running and if 12 volts is present at terminal 10 with an automatic transmission.

MANUAL TRANSMISSION

With a manual transmission, the ECM programming doesn't look at terminal 10 in enabling the crank inhibit relay.

To enable the crank inhibit relay, the ECM sets terminal 35 LOW (ground state). To disable the crank relay, terminal 35 is HIGH (12 volts).

CRANK INHIBIT RELAY

Turning the key to the start position applies power to the crank inhibit relay at pin 2. If the relay is enabled by the ECM, the relay is energized and applies ignition voltage to the cranking motor magnetic switch control coil.

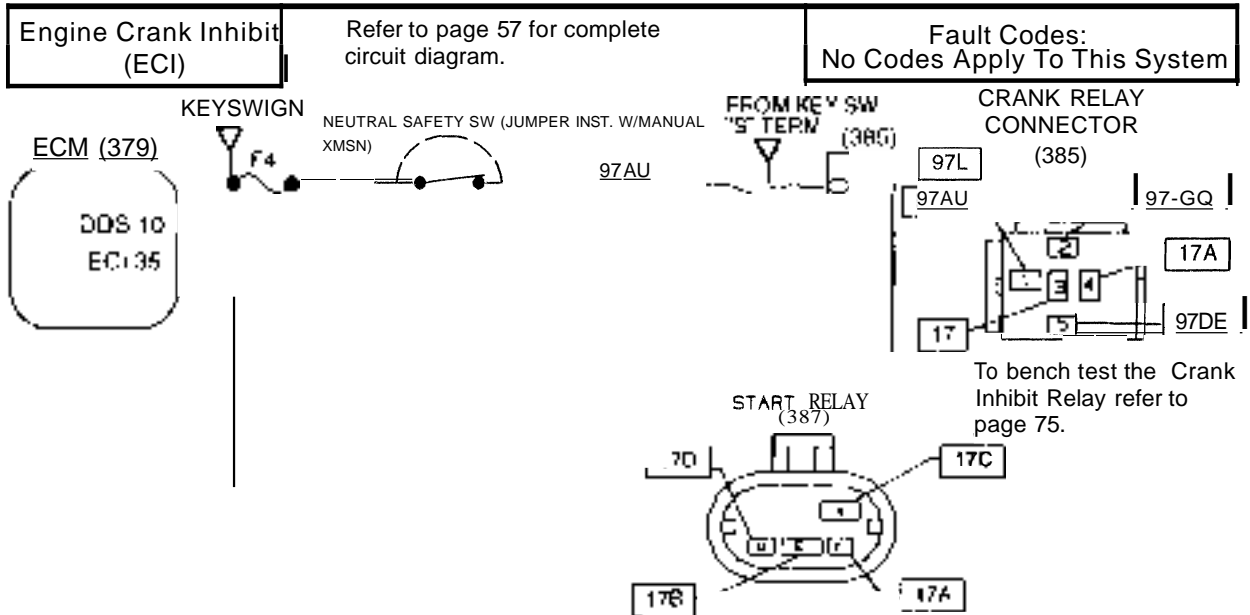
CRANKING MOTOR MAGNETIC SWITCH

The crank motor magnetic switch is used to switch battery power to the crank motor solenoid when the crank inhibit relay is energized. With thermo overcrank protection installed the magnetic switch is grounded through the overcrank thermo couple.

FAULT DETECTION MANAGEMENT

The ECM does not monitor the cranking system circuits. There are no fault codes for this system.

ENGINE CRANK INHIBIT (ECI)



ECI Relay Connector Checks (Connector 385) Relay removed, ignition Key ON, Transmission in Neutral		
Test Points	Spec.	Possible Causes
1+ to Grd.	12v + 1.5v	Open F4 fuse or open 97AU circuit, defective neutral position switch, or not plugged together with manual transmission.
1+ to 2-	12v + 1.5v	Open Grd. 97GQ
1+ to 4-	12v + 1.5v	Open 17A or 170. Defective start relay proceed to testing starter relay.
(Depress Clutch Pedal if equipped with Manual Xmsn or Place Auto Xmsn in Neutral)		
1+ to 5-	12v + 1.5v	Open 970E circuit or ECM control open. Proceed to testing at ECM.
(Turn ignition key to start or push start button with ignition key ON)		
3+ to 2-	12v + 1.5v	Open circuit 17, defective key or start switch.
<i>With transmission in Neutral and Clutch Depressed.</i>		
To jump ECI relay, connect a jumper wire between terminal 3 and 4. Turn ign. key to start or push starter button.		
ECM (Connector 379) Checks w/Brkout. Box installed, key ON, Xmsn in Neutral, Clutch Pedal not depressed		
Test Points	Spec.	Possible Causes
57+ to 60-	12v + 1.5v	Open power or ground to ECM, refer to "ECM PWR".
10+ to 60-	12v + 1.5v	Open F4 fuse, 97AU or 97L. Defective neutral position switch, clutch switch or jumpers missing.
(Depress clutch pedal if equipped with Manual Xmsn or Place Auto Xmsn in Neutral)		
57+ to 35-	12v + 1.5v	Incorrect signal at terminal 10. Incorrect VPM programming, or defective ECM.
(The following step should only be performed on vehicles with Manual Transmission) Depress clutch pedal		
10+ to 60-	< 1 volt	Improperly mounted or defective clutch switch.
<i>With transmission in Neutral and Clutch Depressed.</i>		
To jump ECM relay, connect a jumper wire between term. 60&35 of b.o.b. Turn ign. key to start or push starter button.		
Starter Relay Connector Checks (Connector 387) Key ON, Transmission in Neutral and Clutch Depressed		
Test Points	Spec.	Possible Causes
E+ to Grd.	12v + 1.5v	Open fusible link 17L or circuit 178.
E+ to D-	12v + 1.5v	Thermo fuse open or open Grd. circuit 170 or 17G or 11 GJ.
E+ to A-	12v + 1.5v	Open 17C or defective starter solenoid.
(Turn ignition key to start or push start button with ignition key ON)		
F+ to D-	12v+ 1.5v	Open 17Acircuit
<i>With transmission in Neutral and Clutch Depressed.</i>		
To jump starter relay, connect a jumper wire between terminal A and terminal E.		
NOTE: ENGINE SHOULD CRANK AS SOON AS JUMPER WIRE IS INSTALLED. TRANSMISSION MUST BE IN NEUTRAL OR CLUTCH DEPRESSED.		

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (ECI)

DESCRIPTION

The engine starting system is controlled by the Electronic Control Module (ECM). While cranking the engine, vehicle battery voltage may momentarily drop below 6 volts, causing the ECM to shut down. When voltage comes back up, the ECM will resume operation. The Crank Inhibit Relay (385) has a 2-second delay feature that allows the engine to continue to crank (for up to 2 seconds) while the ECM is OFF, so the engine starts properly.

The cranking system is disabled by the ECM when:

- A. The engine is running.
- B. The automatic transmission is not in neutral.
- C. The clutch is not depressed (only with optional customer feature requiring clutch pedal to be depressed to crank engine).

Components include:

- Start Switch (key or push button)
- Crank Inhibit Relay (385)
- Start Relay (387)
- Crank Motor and Solenoid
- Electronic Control Module (379)
- Neutral Position Switch with automatic transmission
- Clutch Switch (386) with optional "clutch depressed starting feature" previously discussed.

OPERATION

Refer to the circuit diagram on page 57 for the following discussion.

Energizing the engine starting system requires a series of events by the cranking system components.

The Engine Crank Inhibit Relay (385) receives inputs from several sources and if all conditions are present, the Start Relay (387) is energized.

CRANK INHIBIT RELAY (385)

The Crank Inhibit Relay has two major functions.

1. The ECM signal must "enable" the Crank Inhibit Relay for the cranking system to operate.
2. The relay must keep the engine cranking if vehicle battery voltage drops below 6 volts during cranking, causing the ECM to go off line momentarily.

The Crank Inhibit Relay has 5 terminals. To energize the Start Relay, the Engine Crank Inhibit relay interacts with the other cranking system components.

1. Crank Inhibit Relay Terminal #5 is connected by circuit 970E/97AH to ECM terminal #35. For the relay to enable the cranking system, voltage at ECM terminal #35 must be 0.1 - 0.6 volts. Note that the ECM switches terminal #35 between 0.1 - 0.6 volts and battery voltage, to either "enable" or "disable" the Crank Inhibit Relay. The chart in the circuit diagram shows terminal voltages for various conditions and vehicle configurations.

Example 1: With the engine running, ECM terminal #35 will be at battery voltage, preventing the crank system from engaging.

Example 2: With the customer selected "Clutch Must Be Depressed To Start" feature, if the clutch pedal is not depressed when preparing to start the engine, 12V would be present at ECM terminal #35, and the crank system would not engage. Depressing the clutch would cause ECM terminal #35 to switch to 0.1 - 0.6 volts.

ENGINE CRANK INHIBIT (ECI)

OPERATION (Continued)

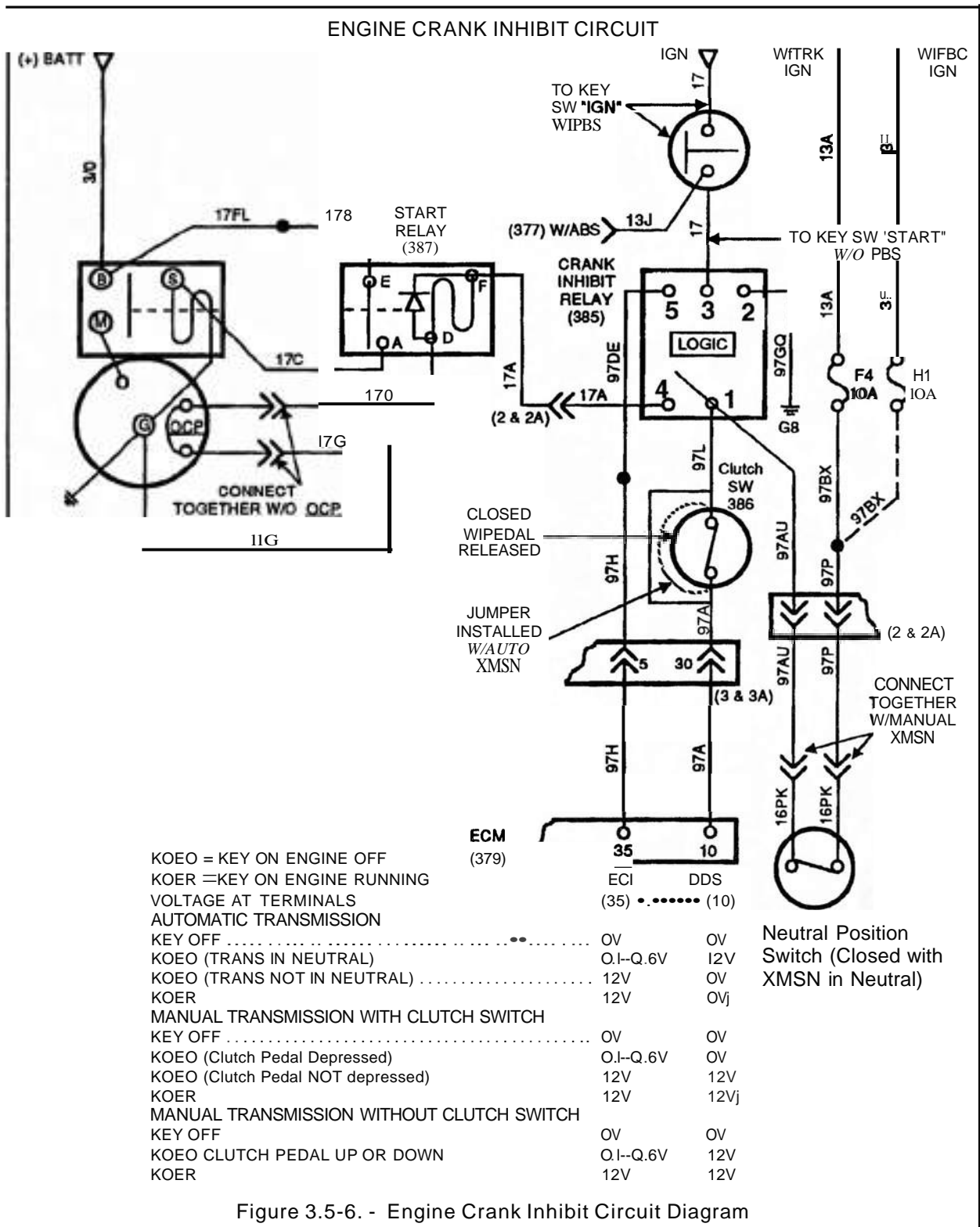


Figure 3.5-6. - Engine Crank Inhibit Circuit Diagram

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (EeI)

OPERATION (Continued)

2. Crank Inhibit Relay Terminal #1 receives power from the F4 fuse (H1 fuse w/FBC) when the key is ON. With an automatic transmission, the power must first pass through the Neutral Safety Switch (closed when in neutral). With a manual transmission, the power from F4 (or H1 w/FBC) is present whenever the key is ON.
3. Crank Inhibit Relay Terminal #2 is grounded by circuit 97-GQ to G8 ground point.
4. Crank Inhibit Relay Terminal #3 receives ignition voltage when the start switch is engaged (push button or key switch). This energizes the Crank Inhibit Relay (if steps 1, 2 and 3 occurred) causing voltage from terminal 4 to energize the Start Relay (387).
5. Crank Inhibit Relay Terminal #4 delivers output voltage on circuit 17A to the Start Relay when the Crank Inhibit Relay is energized.

START RELAY (387)

The Start Relay control coil is energized by voltage from the energized Crank Inhibit Relay on circuit 17A. When energized, battery voltage from "B" terminal of cranking motor solenoid is applied through the Start Relay contacts (E to A) to the "S" terminal of crank motor to energize the cranking motor. The Start Relay is a suppressed relay. The Start Relay has an internal diode to prevent voltage spikes from damaging electronic components in the vehicle system.

THERMO OVERCRANK PROTECTION (OCP)

On vehicles equipped with Thermo Overcrank Protection cranking motors, the ground circuit for the Start Relay is through the Thermo Overcrank thermocouple. If the cranking motor temperature reaches a certain level, the thermocouple opens, preventing further engine cranking until the cranking motor cools.

NEUTRAL POSITION SWITCH

With an Allison AT/MT automatic transmission a normally open (NO) Neutral Position Switch is used to turn power ON or OFF in circuit 97AU.

With the transmission in neutral, the switch is closed applying power to Crank Inhibit Relay terminal #1 and to ECM terminal 10. On the circuit diagrams,

ECM terminal 10 is labeled DDS (Driveline Disengagement Switch). The 12 volts at ECM terminal 10 tells the ECM that the Neutral Position switch is closed and that the transmission is in neutral.

With an Allison WT (electronic transmission controls), the neutral position switch is not used as the Allison WT Electronic Control Module determines shifter position. With the transmission in neutral, ignition power from the transmission Vehicle Interface Module (VIM) Neutral Start Relay is delivered on circuit 97AU to the Crank Inhibit Relay at terminal #1. From terminal 1, circuit 97U97A applies the ignition voltage to ECM DDS terminal 10.

When the vehicle has an automatic transmission (AT or WT), the clutch switch connector has a jumper connecting circuits 97L and 97A, completing the circuit between Crank Inhibit Relay (385) terminal 1 and ECM terminal 10.

With an automatic transmission, ECM terminal 10 is programmed to expect 12 volts on circuit 97A when the shifter is in neutral and 0 volts when the shifter is not in neutral. The circuit diagram table shows terminal voltages for various conditions and vehicle configurations.

The Prolink 9000 can be used to monitor the Neutral Position Switch. When the switch is closed (transmission in neutral), the Prolink (using PTa/Clutch Switch Status) indicates clutch ON, meaning the driveline is disengaged.

CLUTCH PEDAL SWITCH (386)

The clutch pedal switch determines driveline disengagement status for manual transmissions. The clutch pedal switch is an active component in the "cranking" process ONLY if the customer selected the "clutch pedal must be depressed to start the engine" feature. If this feature has been selected, the circuit operates as follows:

1. **With** the key switch ON, voltage from Crank Inhibit Relay (385) terminal 1 is applied on circuit 97L to the normally open (N.O.) clutch switch. The clutch switch is adjusted to be **CLOSED** while the clutch pedal is **RELEASED**, and **OPEN** when the clutch pedal is **DEPRESSED**. **With** the clutch switch closed, 12 volts from Crank Inhibit Relay terminal #1 is applied to ECM terminal 10.

ENGINE CRANK INHIBIT (ECI)

OPERATION (Continued)

CLUTCH PEDAL SWITCH (386) (Continued)

If the ECM sees 12 volts at DDS terminal 10, it determines that the pedal is not depressed, then the ECM applies 12 volts to ECM ECI terminal 35, disabling the Crank Inhibit Relay (engine will not crank condition). If the clutch pedal is depressed (opening the clutch switch), then 0 volts is present at ECM terminal 10, and the ECM switches ECM terminal 35 voltage to 0.1 - 0.6 volts, enabling the Crank Inhibit Relay (if all other conditions are OK). The table in the circuit diagram shows terminal voltages for various conditions and vehicle configurations.

The ProLink 9000 EST can be used to monitor the Clutch Switch position. When the clutch switch is open (clutch depressed), the ProLink indicates clutch ON, meaning the driveline is disengaged.

ELECTRONIC CONTROL MODULE

Electronic Control Module terminals 10 and 35 are directly involved with enabling the Crank Inhibit Relay. The ECM and VPM (VPM stores information for the ECM) are programmed differently for automatic or manual transmissions.

ECM TERMINAL 10 (DDS)

ECM terminal 10 receives input (12 volts or 0 volts) from either the clutch switch with a manual transmission or neutral position indication with an automatic transmission. The ECM uses the input to determine the voltage signal on ECM terminal 35. The various expected inputs are shown in the circuit diagram.

ECM TERMINAL 35 (ECI)

ECM terminal 35 is connected by circuit 97H to Crank Inhibit Relay terminal 5. Based on inputs to ECM terminal 10 and engine operating conditions, the ECM either applies 0.1 - 0.6 volts or 12 volts to terminal 35. If the ECM applies 0.1 - 0.6 volts to terminal 35, the Crank Inhibit Relay is "enabled." If the ECM applies 12 volts to terminal #35, then the Crank Inhibit Relay is NOT "enabled."

ECM PROGRAMMING

The ECM "enables" the Crank Inhibit Relay if:

1. The engine is not running.
2. The transmission is in neutral (with automatic transmission).
3. The clutch pedal is depressed (with optional safety feature requiring clutch pedal to be depressed to crank engine).

If these conditions do not exist, the Crank Inhibit Relay is not enabled and the engine will not crank. The table in the circuit diagram shows terminal voltages for various conditions and vehicle configurations.

TROUBLESHOOTING

The ECM "enables" or "disables" the engine cranking system with the Engine Crank Inhibit (ECI) relay. There are no ECM diagnostics available for this system. Perform the following tests to find the cause of a No Crank condition.

BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery cables and grounds for clean, tight connections free of damage. Voltage tests will give misleading readings if the batteries are not fully charged.
- B. Before troubleshooting a particular circuit, inspect connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands etc. The wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (ECI)

TROUBLESHOOTING (Continued) ENGINE DOES NOT CRANK

The tests for Engine Does Not Crank are divided into two parts: Part 1, Engine Does Not Crank. Part 2, Engine Does Not Crank with Manual XMSM and Clutch Switch. Refer to the Figure 3.5-7 while performing Part 1.

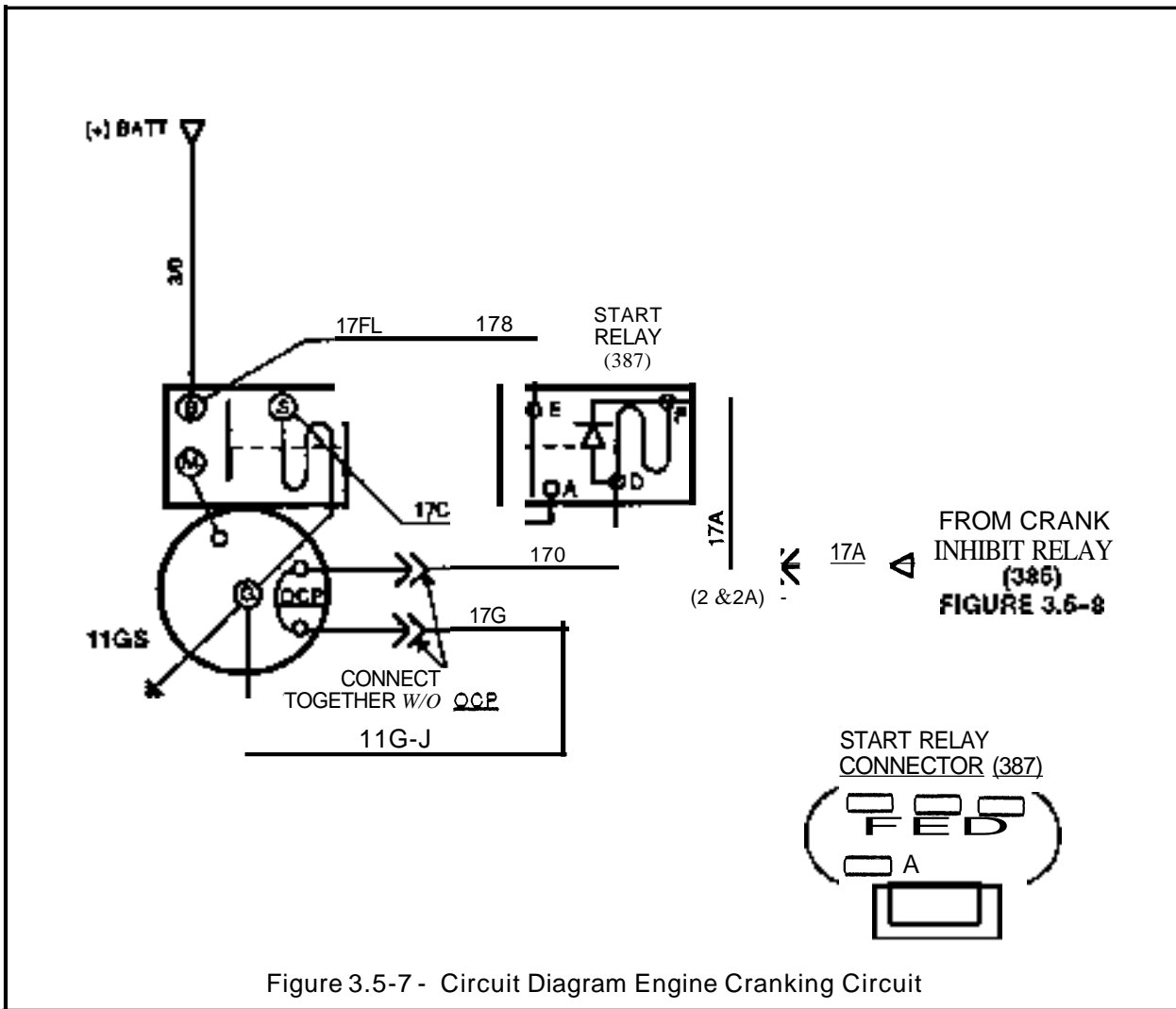


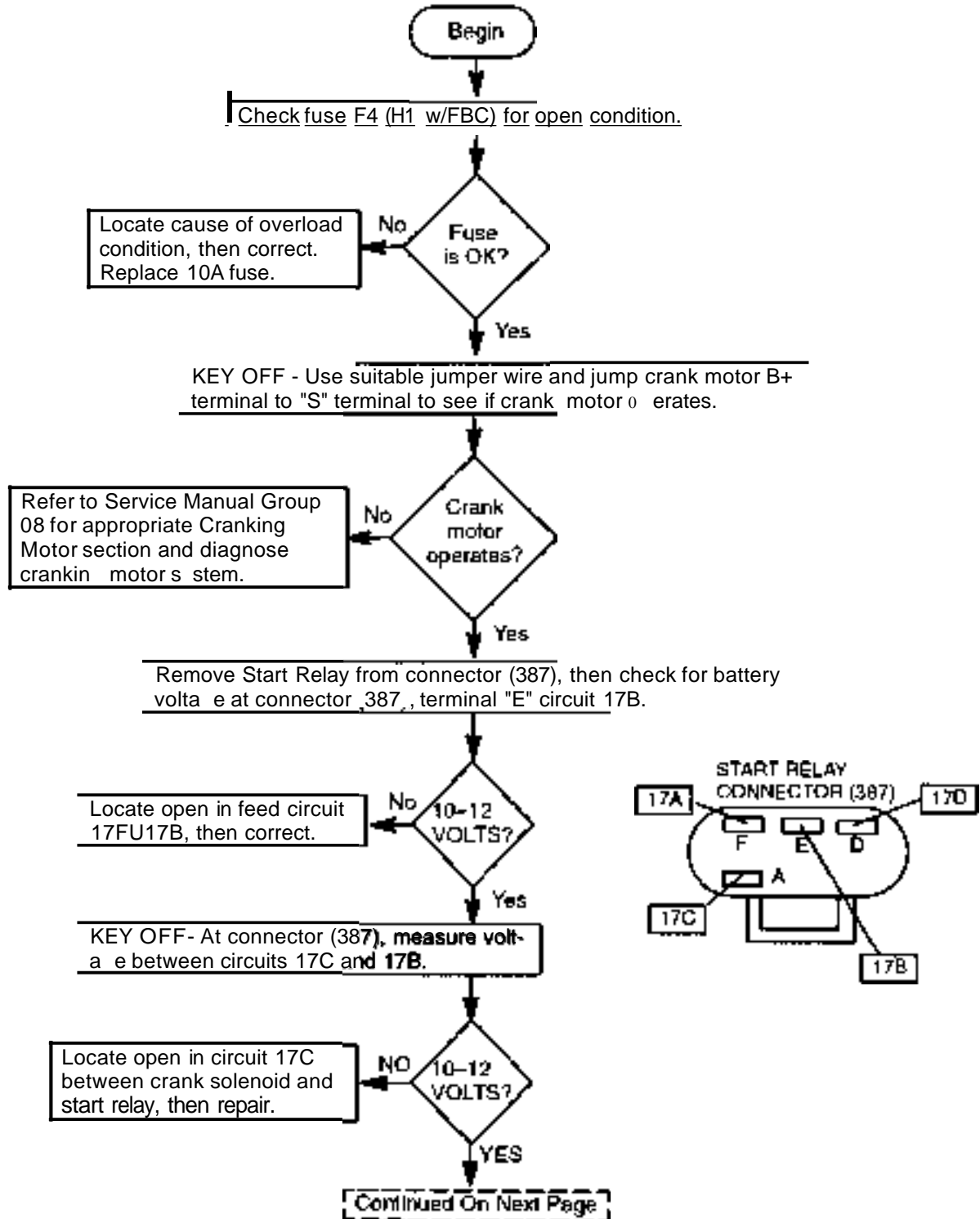
Figure 3.5-7 - Circuit Diagram Engine Cranking Circuit

ENGINE CRANK INHIBIT (ECI)

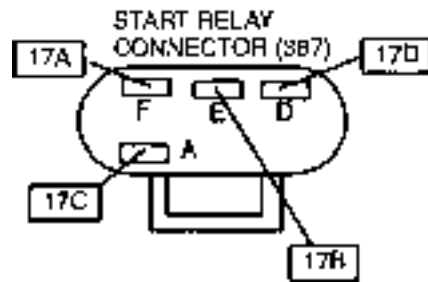
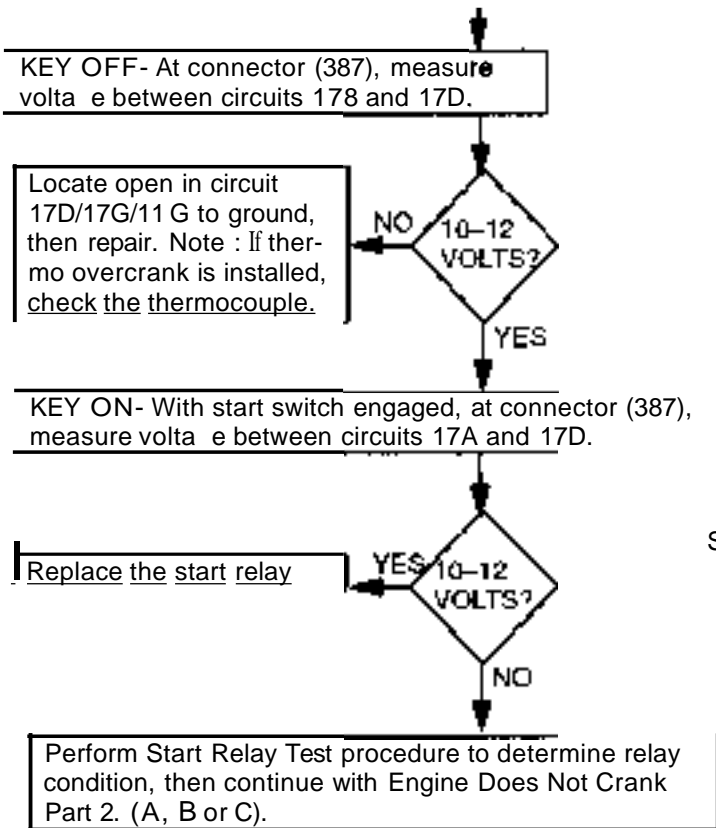
ENGINE DOES NOT CRANK TEST (PART 1)

The Part 1 troubleshooting chart is to be used with either a manual transmission (with and without clutch switch) or an Allison automatic transmission (AT, MT or WT).

For Part 2, select the appropriate troubleshooting chart for vehicle being tested: Manual Transmission With A Clutch Switch, or Manual Transmission Without Clutch Switch or Automatic Transmission.

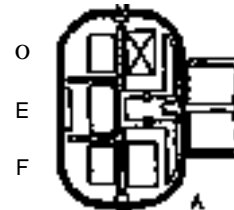


ENGINE DOES NOT CRANK TEST (PART 1) (Continued)



START RELAY TEST PROCEDURE

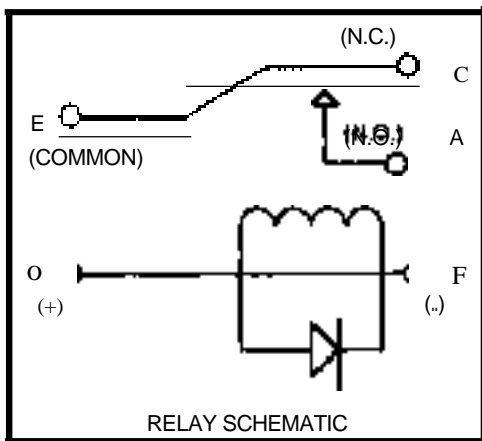
End View Of Start Relay



TEST STEPS

1. Measure resistance between D and F. A If resistance is 60 to 70 ohms go to step 2, otherwise replace the relay.
2. Measure resistance between C and E, then C and A.
 - A. If continuity is present between C and E but not between C and A, go to step 3.
 - B. If continuity is not present between C and E OR continuity is present between C and A, replace the relay.
3. Using test leads, connect (+) battery lead to D and (-) lead to F. Measure resistance between E and A.
 - A. If relay makes audible click and there is continuity between E and A, the relay checks OK.
 - B. If resistance between A and E is greater than 5 ohms, replace the relay.

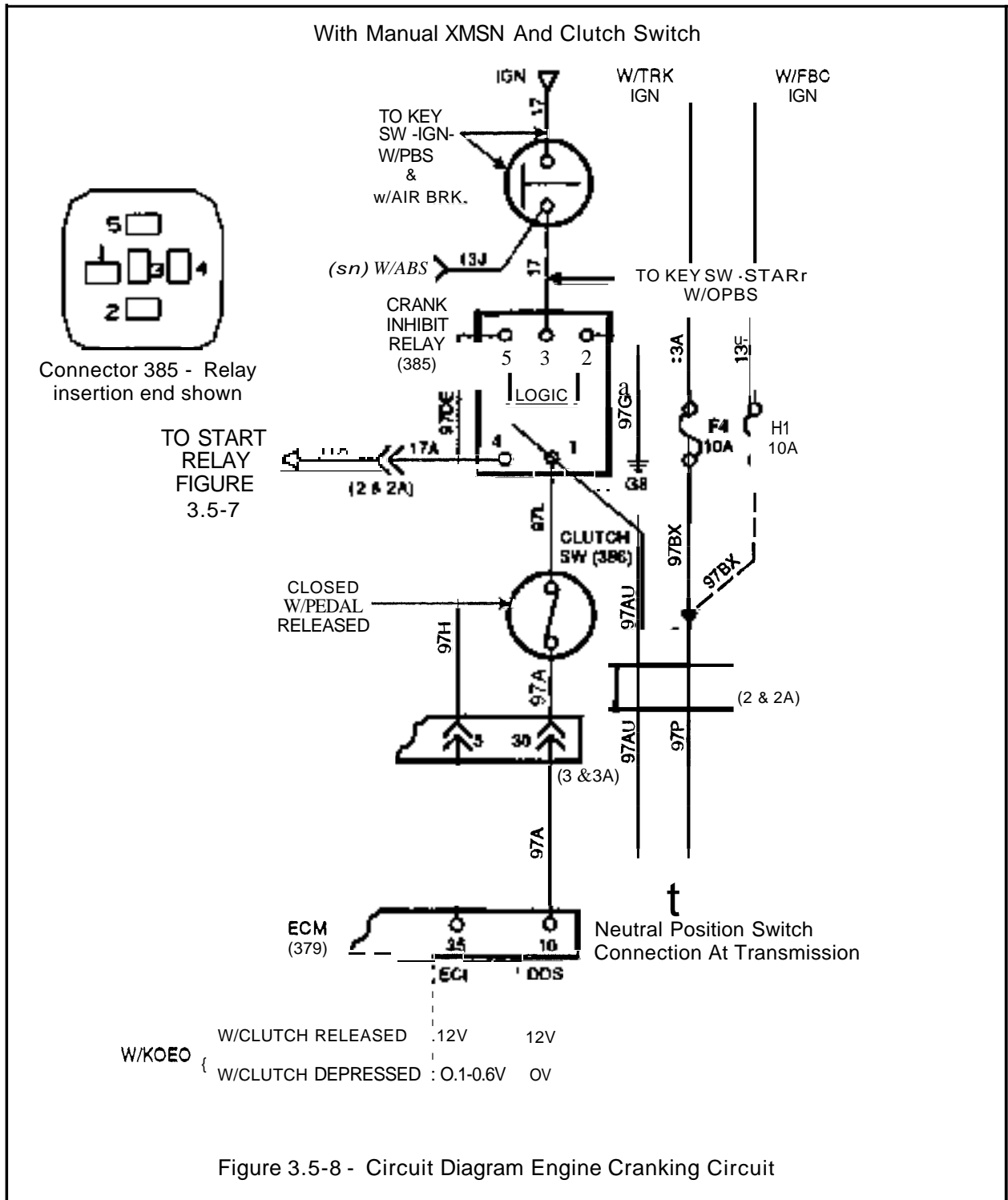
With Manual XMSN with Clutch Switch perform Engine Does Not Crank Part 2A p.63
 With Automatic XMSN perform Part 28 p.66
 With Manual XMSN without Clutch Switch, perform Part 2C p. 69



ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2A) WITH MANUAL XMSN AND CLUTCH SWITCH

Refer to Figure 3.5-8 while using (PART 2A) test procedure.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2A) (Continued)

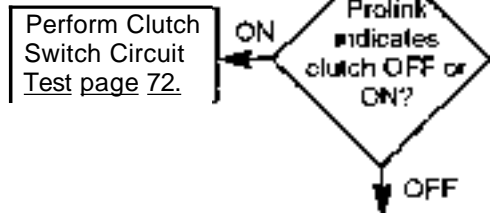
Use this test with manual transmission equipped with a clutch switch. While performing this test, you may be directed to perform the Clutch Switch Circuit Test on page 72.

Continued from ENGINE DOES NOT CRANK (Part 1)

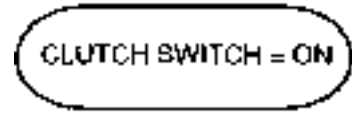
KEY ON - Use Prolink EST to check CLUTCH SWITCH position with pedal released UP. Prolink should indicate CLUTCH SWITCH OFF.



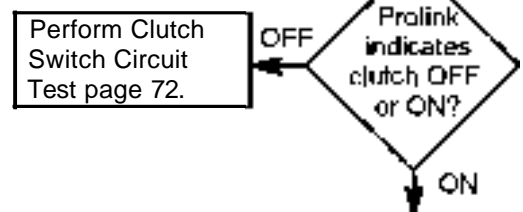
Indicates driveline is ENGAGED.



KEY ON - Use Prolink EST to check CLUTCH SWITCH position with pedal depressed. Prolink should indicate CLUTCH SWITCH ON.

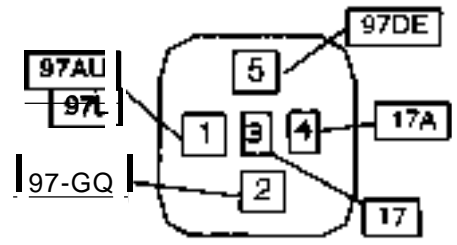
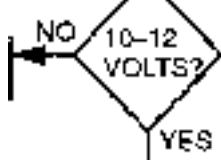


Indicates driveline is DISENGAGED.



KEY ON- Remove Crank Inhibit Relay from connector (385). At (385), measure voltage between terminals 1 and 2.

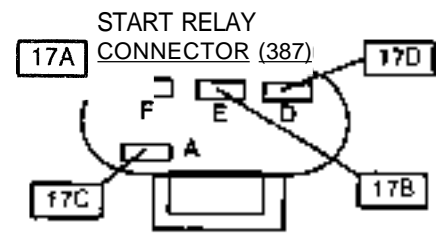
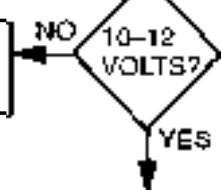
Locate open in 97-GQ, then repair



Connector (385) - Relay insertion end shown

KEY ON- At (385), measure voltage between terminals 1 and 4.

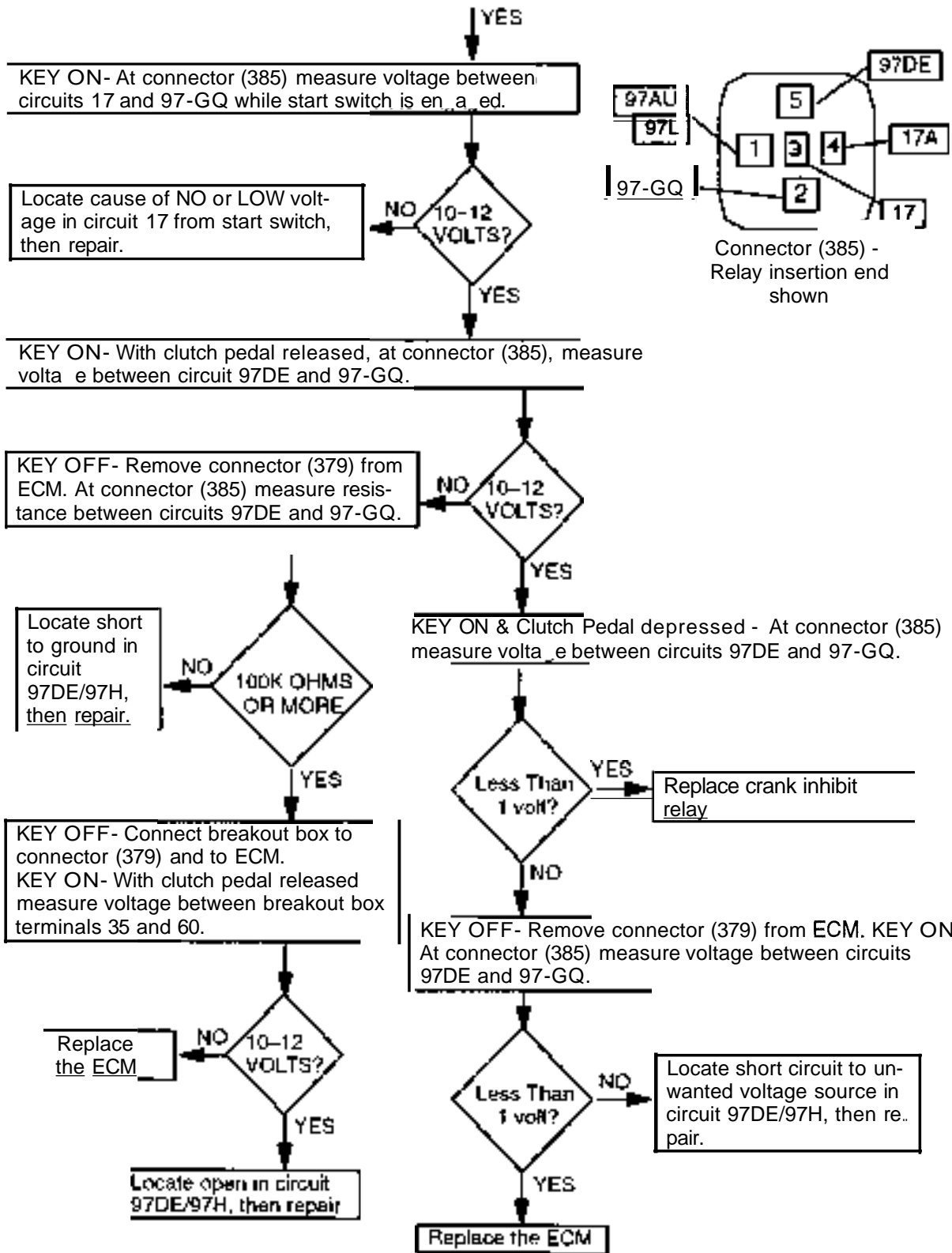
Locate open in circuit 17A between connectors (385) and (387), then repair.



Continued On Next Page.

ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2A) (Continued)

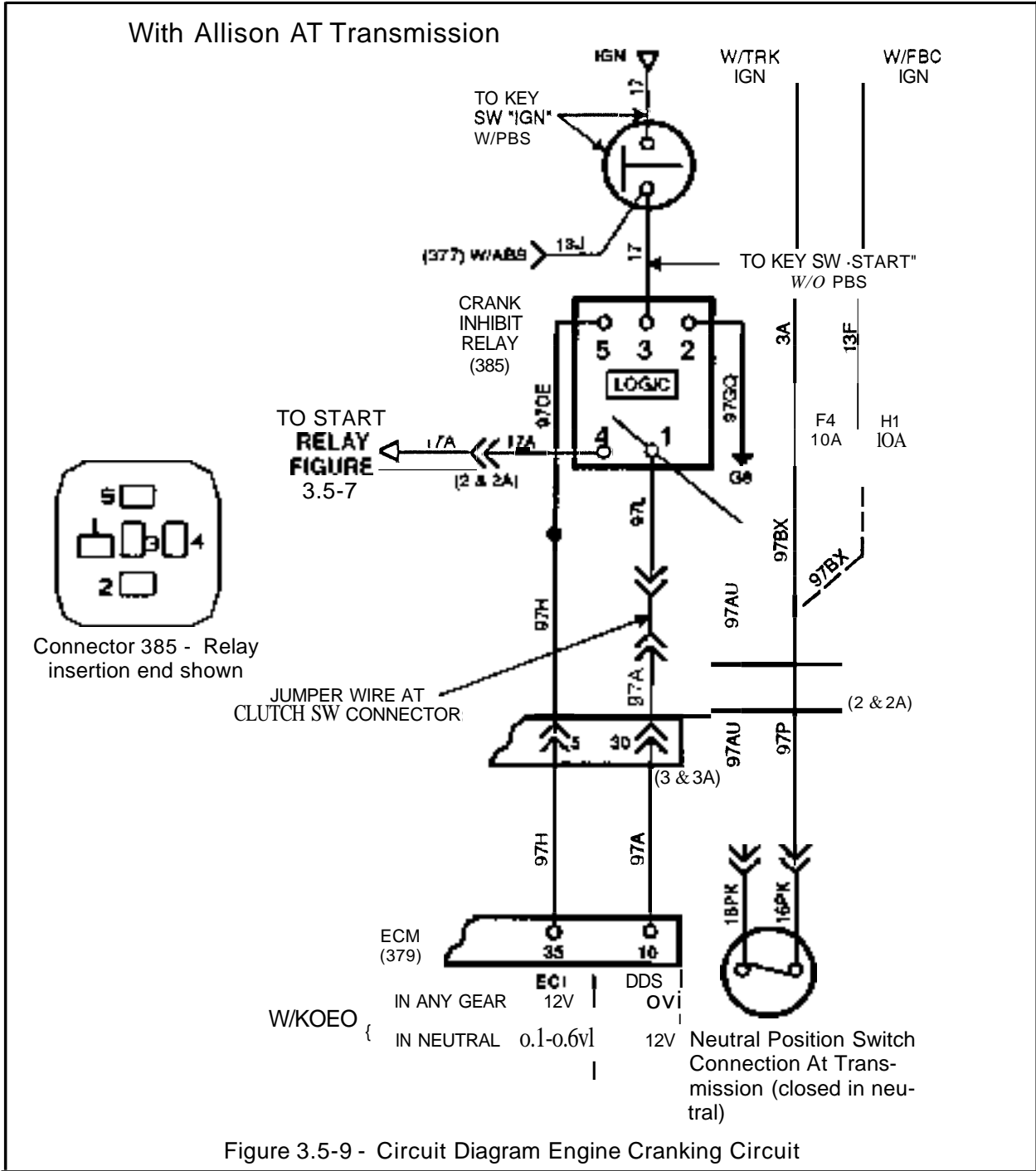


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (EeI)

ENGINE DOES NOT CRANK (PART 28) WITH ALLISON AT/MT TRANSMISSION

Refer to Figure 3.5-9 while performing test.



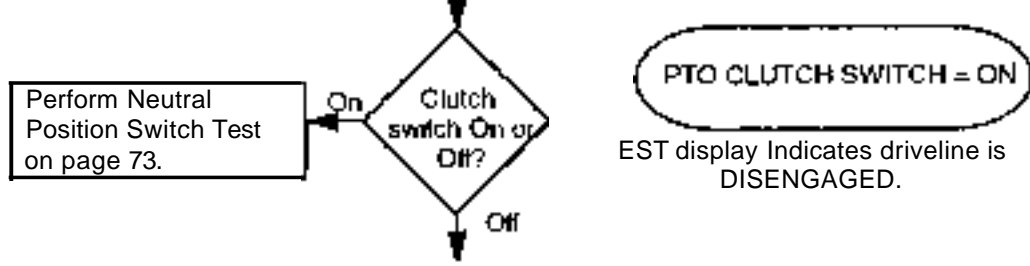
ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 28) (Continued)

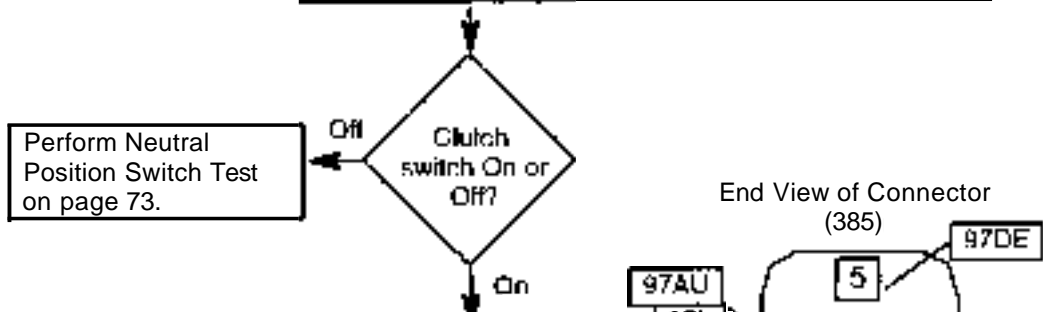
Use this test with automatic transmission. While performing this test, you may be directed to perform the Neutral Position Switch Circuit Test on page 73.

Continued from ENGINE DOES NOT CRANK (Part 1)

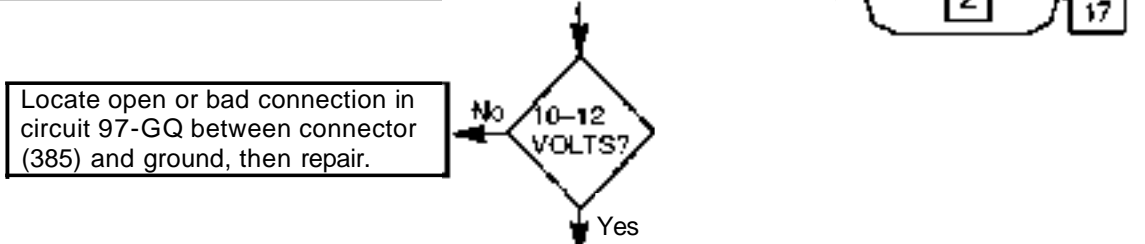
KEY OFF .. Use Prolink EST to check Neutral Position Switch with shifter in FOI Ward ear. EST should indicate clutch switch OFF.



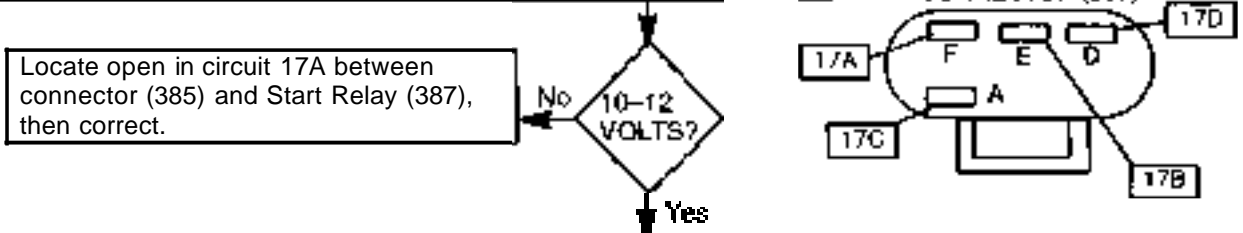
KEY ON - Use Prolink EST to check Neutral Switch position with shifter in neutral. The EST should indicate Clutch Switch ON.



KEY OFF- Remove Crank Inhibit relay from connector (385), KEY ON- At connector (385) measure voltage between circuit 97U97AU and 97-GQ.



KEY ON- At connector (385), measure voltage between circuit 97U97AU and circuit 17A.

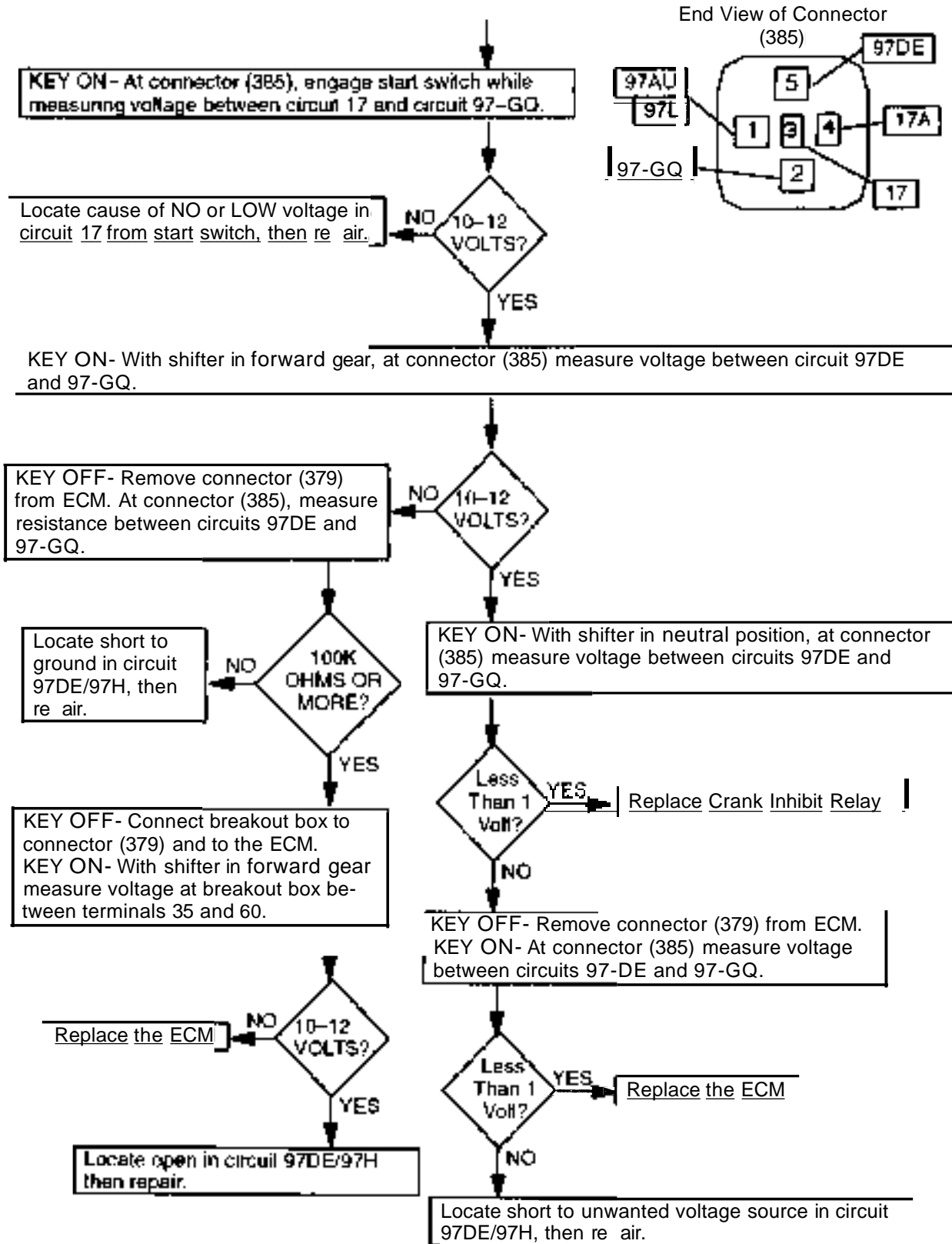


Continued On Next Page.

ENGINE CRANK INHIBIT (ECI)

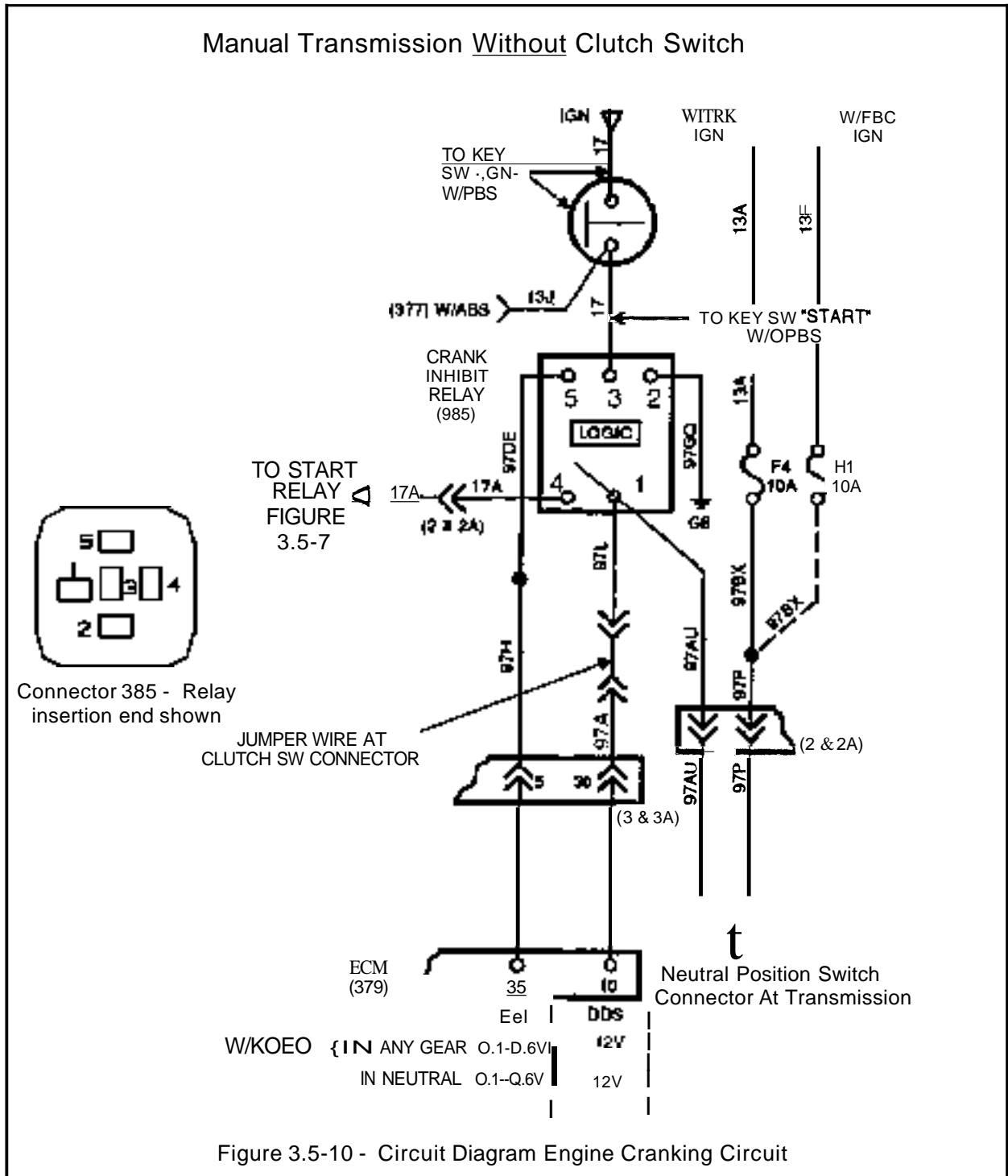
ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 28) (Continued)



ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2C) WITH MANUAL TRANSMISSION WITHOUT CLUTCH SWITCH
Refer to Figure 3.5-10 while performing test.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2C) (Continued)

Use this test with manual transmission without a clutch switch.

Continued from ENGINE DOES NOT CRANK (Part 1)

KEY ON- Use Prolink EST to check clutch switch position with clutch pedal released and depressed. Prolink should indicate Clutch Switch = ON, clutch pedal up or down.

NO
Locate open in circuit(s) 97A, 97L, 97AU, 97P or 97BX, then repair. Note that a jumper wire should be present at the Clutch and Neutral Position switch connectors.

Clutch Switch ON?

YES

KEY OFF- Remove Crank Inhibit Relay from connector (385). KEY ON- At (385) measure voltage between circuit 97U97AU and circuit 97GQ.

NO
10-12 VOLTS?

Locate open in circuit 97-GQ, then repair.

YES

KEY ON- At connector (385) measure voltage between circuit 97U97AU and circuit 17A.

NO
10-12 VOLTS?

Locate open in circuit 17A between connectors (385) and (387), then repair.

YES

KEY ON- With start switch engaged, at connector (385) measure voltage between circuit 17 and circuit 97-GQ.

NO
10-12 VOLTS?

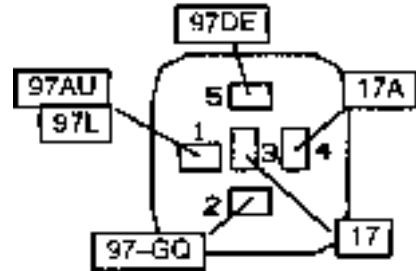
Locate cause of NO or LOW voltage in circuit 17 from start switch, then repair.

YES

Continued On Next Page

(Clutch Switch = ON)

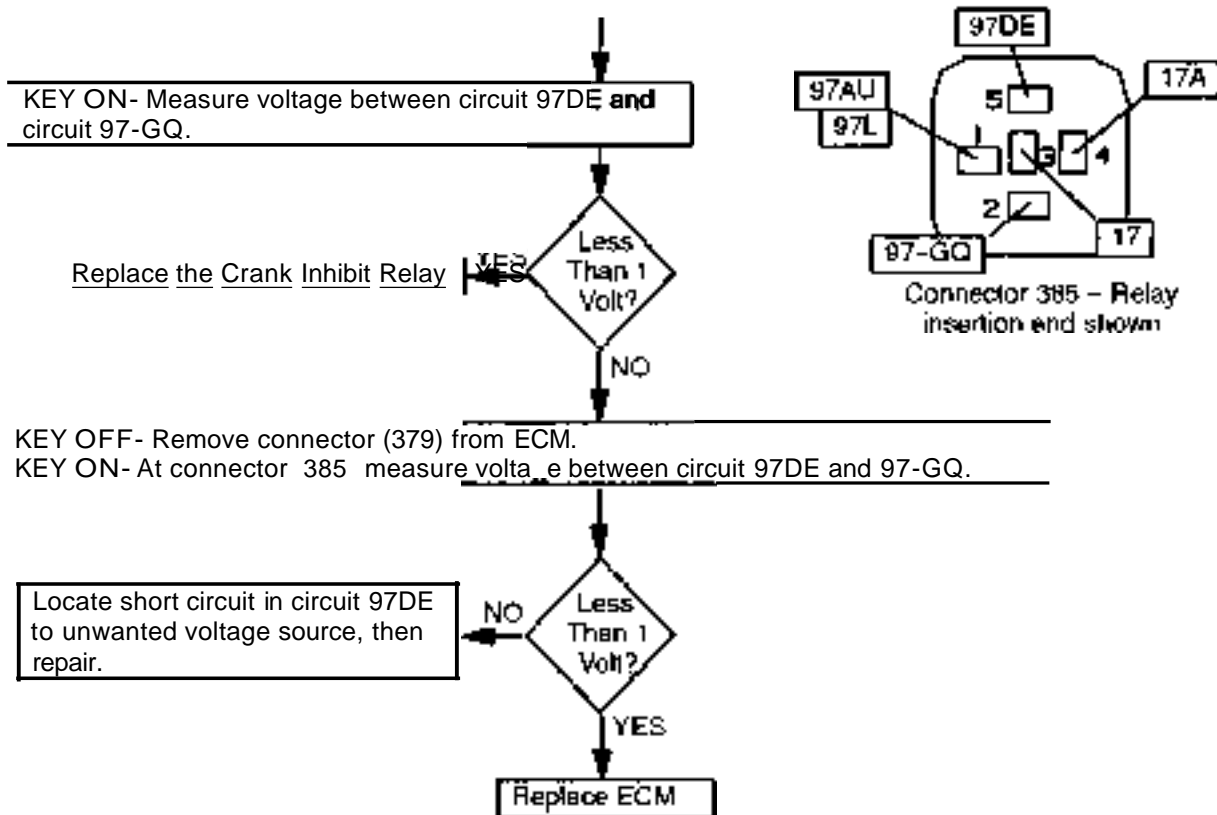
EST Indicates 12V is present at ECM terminal 10



Connector (385)
Relay insertion end shown

ENGINE CRANK INHIBIT (ECI)

ENGINE DOES NOT CRANK (PART 2C) (Continued)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

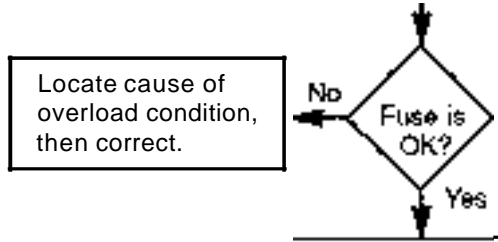
ENGINE CRANK INHIBIT (ECI)

CLUTCH SWITCH CIRCUIT TEST WITH CLUTCH SWITCH

Perform this test if directed by other test or if Prolink EST indicates the clutch switch is not functioning properly.

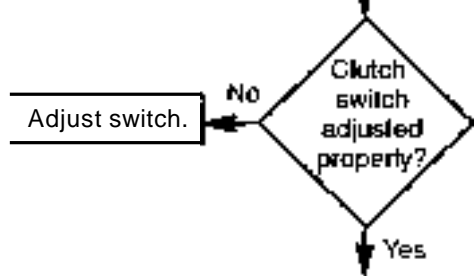
Continued from ENGINE DOES NOT CRANK (Part 2A)

Check 10A fuse F4 (H1 w/FBC) for open condition. (If electronic throttle pedal is working, the fuse is OK.)

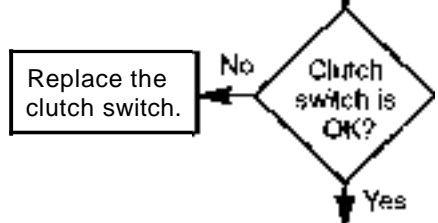


Check clutch switch adjustment. With pedal released, clutch switch should be closed and open with audible click when pedal is depressed.

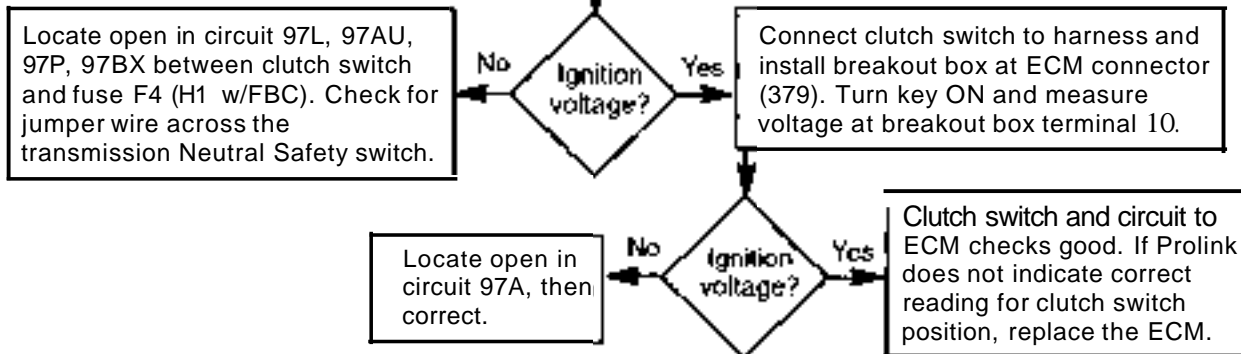
NOTE: The clutch switch is a Normally Open switch that is adjusted to be closed when the clutch pedal is released (up). Depressing the clutch pedal causes the switch to open.



KEY OFF - Disconnect circuits 97L and 97A from clutch switch. Use ohmmeter to check switch operation in open and closed position.



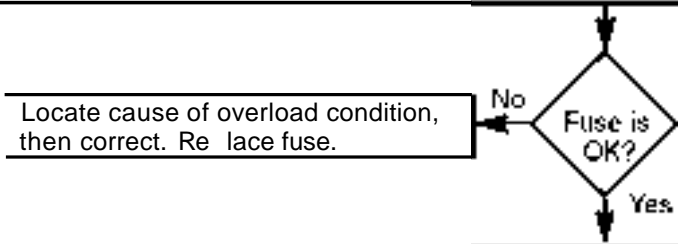
KEY ON - Measure voltage to ground at circuit 97L clutch switch connector.



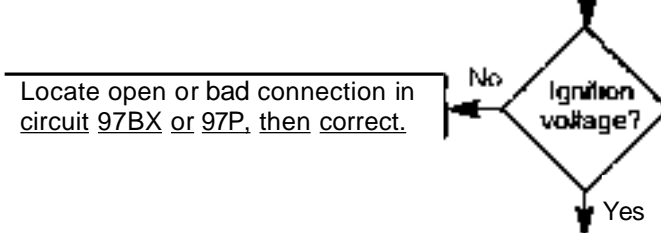
NEUTRAL POSITION SWITCH TEST WITH ALLISON ATIMT AUTOMATIC TRANSMISSION

Continued from ENGINE DOES NOT CRANK (Part 2B)

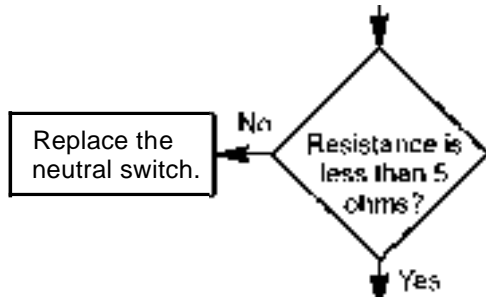
Check 10A fuse F4 (H1 w/FBC) for open condition. (If electronic throttle pedal is working, the fuse is OK.



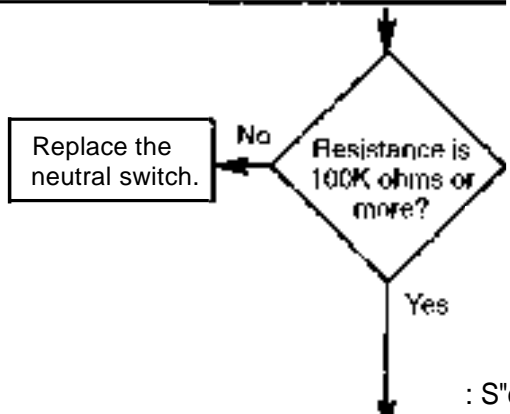
Disconnect harness from neutral position switch. Turn key ON and measure voltage to ground at circuit 97P of neutral safety switch harness connector.



KEY OFF - With transmission in neutral, measure resistance across neutral position switch terminals.



KEY OFF - With transmission shifter in forward gear, measure resistance across neutral switch terminals

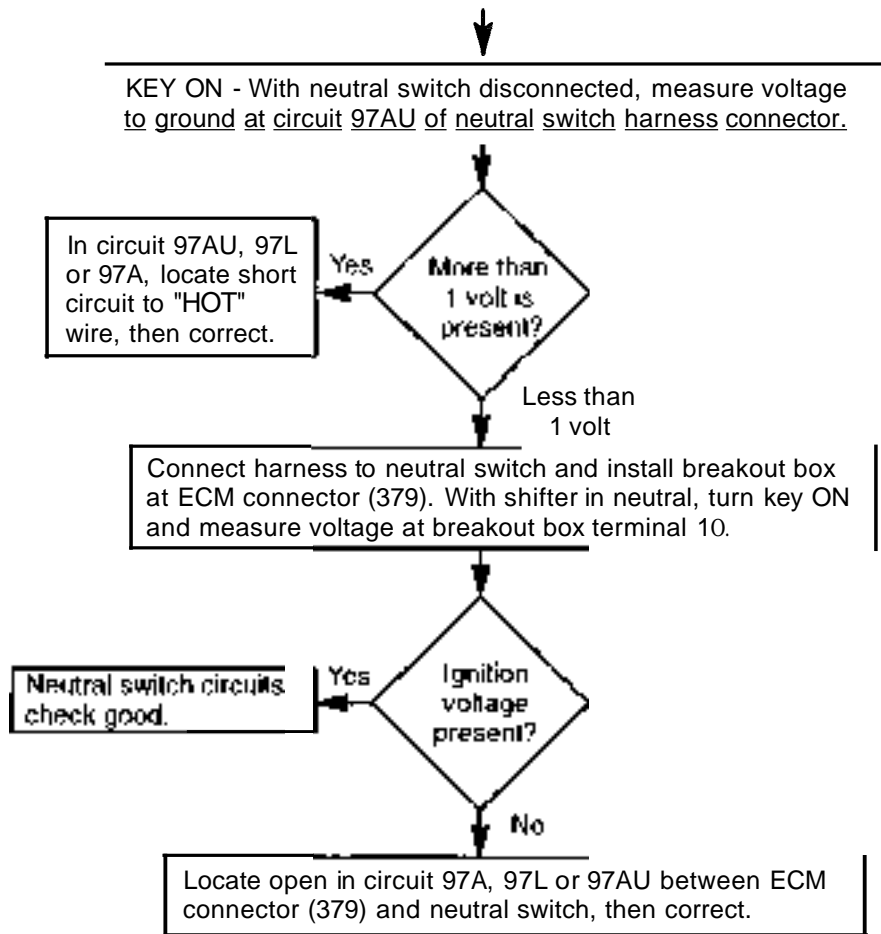


: See next page :

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE CRANK INHIBIT (EeI)

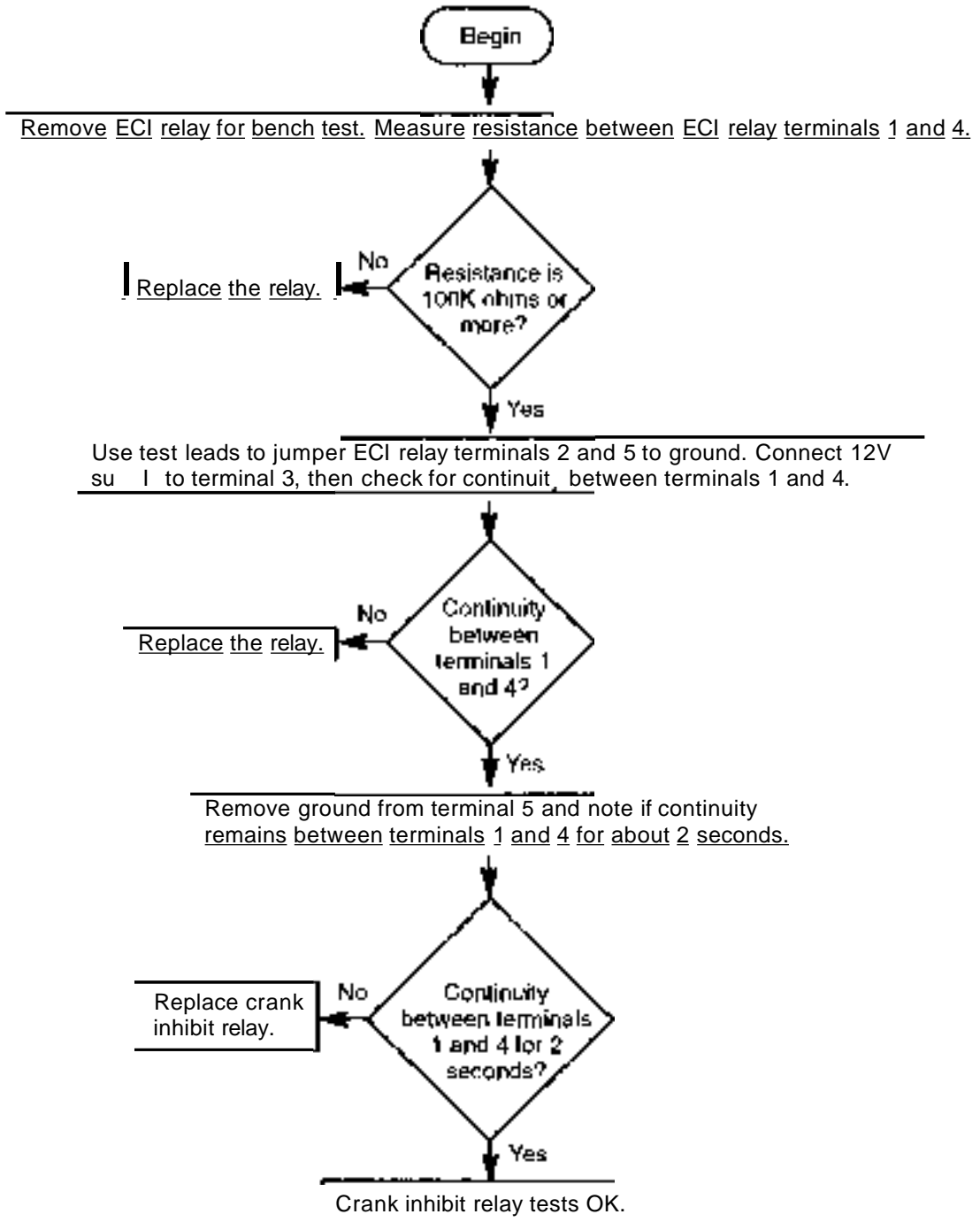
NEUTRAL POSITION SWITCH TEST WITH ALLISON ATIMT AUTOMATIC TRANSMISSION (Continued)



ENGINE CRANK INHIBIT (ECI)

ENGINE CRANK INHIBIT (ECI) RELAY TEST

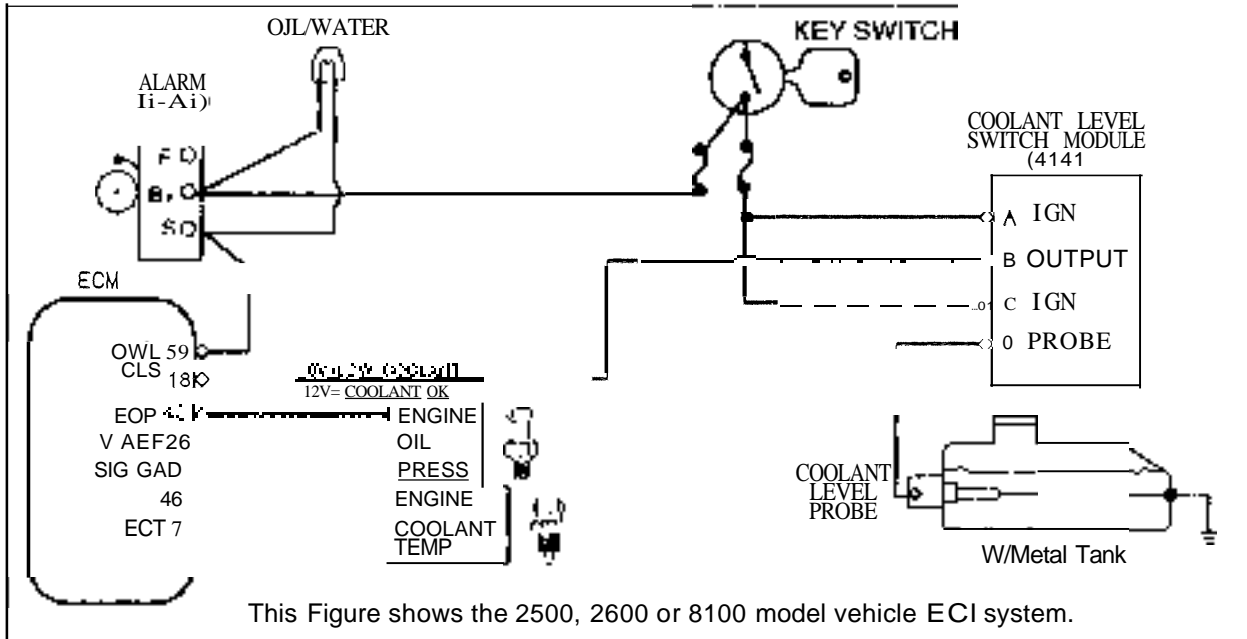
This procedure provides a method to bench test the Eci relay. The terminal numbers are marked on the relay.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT LEVEL SYSTEM (ECI)

ENGINE COOLANT LEVEL SYSTEM (ENGINE PROTECTION)



SIGNAL FUNCTION

With the optional engine protection system, the ECM monitors inputs from the Engine Oil Pressure sensor, Engine Coolant Temperature sensor and Low Coolant switch (or module). If any of these sensors detect out of range conditions beyond the warning level, ECM OWL terminal 59 goes LOW (grd) causing the alarm to sound and the oil/water warning light to turn ON. If the engine shutdown feature has been selected, and the out of range conditions go beyond the critical level, the ECM will initiate the shutdown process.

LOW COOLANT LEVEL SYSTEM

The 2500, 2600, 8100 models have a metal surge tank and use low coolant module and low coolant probe. All other models with a plastic composite surge tank utilize a magnetic low coolant switch in the surge tank instead of the module and probe.

2500,2600,8100 Models- The low coolant module outputs a 12V signal to ECM terminal when coolant levels are at specified levels and 0V when coolant is below the probe.

Models With Plastic Surge Tank- The low coolant switch is open when coolant is OK and closed when coolant is LOW. When this switch is OPEN, 12V is present at ECM terminal 18. When the switch is closed, voltage is pulled to zero at ECM terminal 18.

ENGINE OIL PRESSURE SENSOR

The Engine Oil Pressure (EOP) sensor sends a linear analog signal to ECM terminal 42. If the ECM detects oil pressure below the warning level the OWL is turned on. If oil pressure goes below the critical level, engine shutdown is initiated. Refer to Engine Oil Pressure (EOP) Sensor diagnostics for additional information and sensor circuit troubleshooting.

ENGINE COOLANT TEMPERATURE SENSOR

The Engine Coolant Temperature (ECT) sensor sends a 0-5 volt analog signal to ECM terminal 7. If the ECM detects coolant temperature above the warning level the OWL is turned on. If coolant temperature goes above the critical level, engine shutdown is initiated. Refer to Engine Coolant Temperature (ECT) Sensor diagnostics for additional information and sensor circuit troubleshooting.

FAULT DETECTION MANAGEMENT

There are no ECM diagnostics for the Engine Coolant Level system. Flash Code 323 will be active when a low coolant situation is present and the ProLink will indicate COOLANT LOW. After the coolant has been restored to proper levels, Flash code 323 will remain as an inactive code and the ECM will log the engine hours of the occurrence.

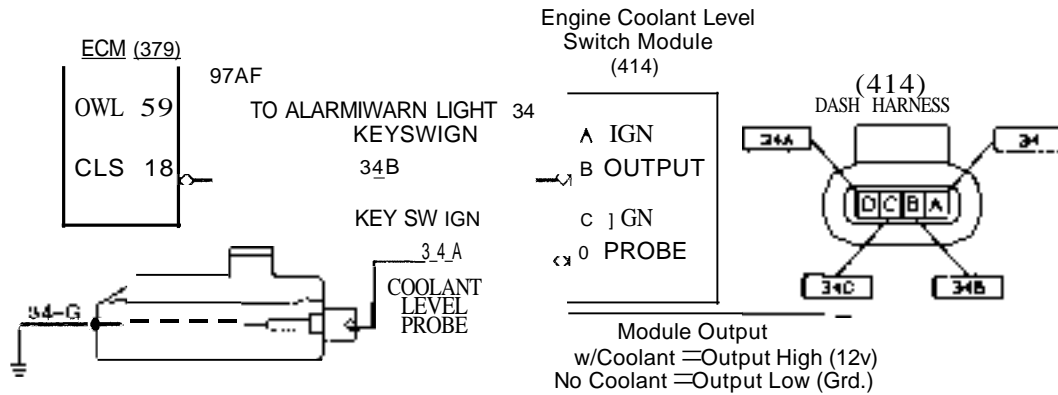
ENGINE COOLANT LEVEL SYSTEM (ECI)

MODELS WITH METAL SURGE TANK

Engine Coolant level
(ECI)

Fault Codes:
323 Engine Coolant Below Warning Critical Level

ENGINE COOLANT LEVEL MODULE



Connector Voltage Checks

Connector (414) with key ON, probe submerged in coolant and coolant module disconnected

Test Points	Spec.	Comments
A to grd	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to ground.
C to grd	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to ground.
eto D	5 to 10 volts min.	Dvolts check for open in probe circuit < less than 5V check connections and check probe for clean condition.
Cto 8	12 ± 1.5 volts	< than 10.5 volts check connections. 0 volts check for open circuit 348.

Operational Check

ECM Connector (379) with breakout box installed, probe submerged in coolant and key ON

Test Points	Spec.	Comments
#18 to grd	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to grd in circuit 348.

Fault Code Descriptions

323 = Indicates low coolant level. If coolant level full with code present, troubleshoot circuit.

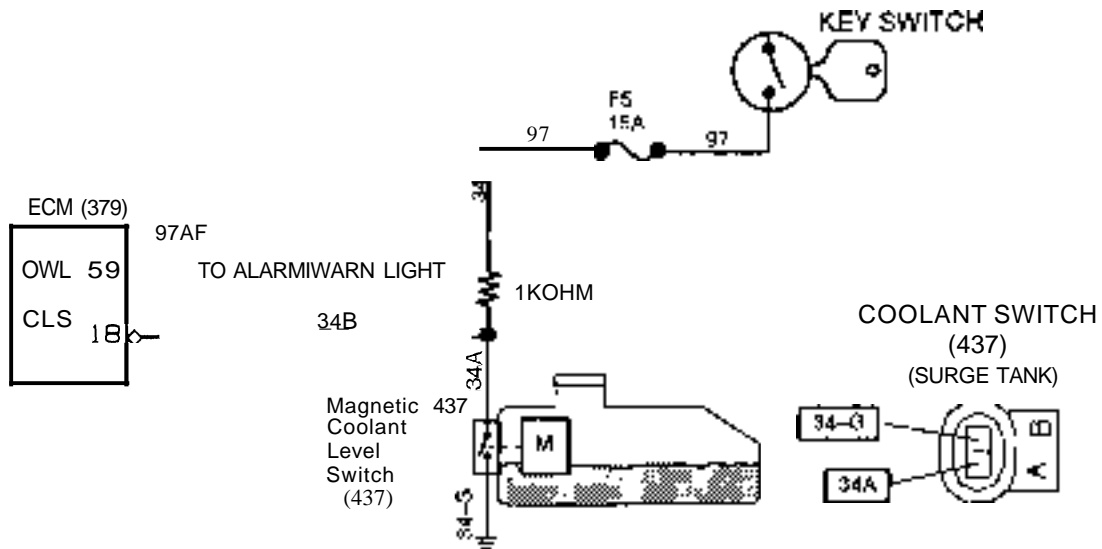
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT LEVEL SYSTEM (ECI)

MODELS WITH PLASTIC SURGE TANK

Engine Coolant level
(ECI)

Fault Codes:
323 Engine Coolant Below Warning Critical Level



Harness side of connector (437) - disconnected with key ON

Test Points	Spec.	Comments
A to grd.	6 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to ground or blown fuse
A to B	6 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open in ground path.

Switch side of connector (437) - disconnected with key OFF and coolant at proper level

Test Points	Spec.	Comments
A to B	>1000 ohms	< than 1000 ohms replace the switch (s/b less than 5 ohms with low coolant level)

Connector (379) with breakout box installed and key ON and coolant at proper level with (437) connected to ECI switch.

Test Points	Spec.	Comments
#18 to grd.	6 ± 1.5 volts	< than 10.5v check connections, if 0 volts check for open/short to ground or blown fuse or defective resistor.

Fault Code Descriptions
323 = Indicates low coolant level. If coolant level full with code present, troubleshoot circuit.

ENGINE COOLANT LEVEL SYSTEM (ECI)

DESCRIPTION

The Engine Coolant level (ECI) System is part of the optional Engine Protection Package.

The purpose of the ECI system is to monitor the engine coolant level and alert the driver when a low coolant condition is present by turning on the Oil/Water Warning light and the alarm buzzer. If the vehicle is programmed for Engine Shutdown as part of the Engine Protection Package, a low coolant signal will shut down the engine.

ENGINE COOLANT LEVEL (ECI)
MODULE AND PROBE

Refer to the circuit diagram on page 80 for the following discussion.

The ECI module (414) receives 12V ignition power from 15A fuse F4 (G1 fuse w/FBC) at terminals A and C. ECI Module, Terminal B is connected (circuit 34B) through connector (379) to ECM terminal 18 (ECI).

ECI module (414) terminal D is connected to the Coolant Level Probe located in the surge tank. A very low current signal from ECI module terminal D goes through the probe, then through the coolant (using coolant as a conductor) to ground (circuit 34-G). When the coolant level is above the probe, ECI module terminal B will be HIGH (12V), and Oil/Water Warning light is OFF.

With coolant level below the probe for more than 7 consecutive seconds (7 second delay prevents intermittent splashing signals), the ground path through the probe from ECI Module terminal D will be open. This causes the ECI module terminal B to go LOW (0 volts). With ECI terminal B at 0 volts, ECM terminal 18 is at 0 volts causing the ECM to turn on the Engine Warning Light and Alarm.

DIAGNOSTIC CODES

The ECM does not check the ECI circuits. Flash Code 323 is set indicating that a "low coolant" condition was detected.

FLASH CODE 323

PID 111 FM11

ECM: *ENGINE COOLANT BELOW WARNING/
CRITICAL LEVEL*

Flash Code 323 will be active when a low coolant situation is present and the Prolink will indicate COOLANT IOW. After the coolant has been restored to proper levels, Flash code 323 will remain as an inactive code and the ECM will log the engine hours of the occurrence.

TROUBLESHOOTING

Use the Prolink 9000 to monitor the ECI system operation. Prolink will indicate that the coolant level is FULL or LOW.

BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading readings if batteries are not fully charged.
- B. Before troubleshooting a particular circuit, inspect connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. The wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

ENGINE COOLANT LEVEL MODULE
AND PROBE TEST

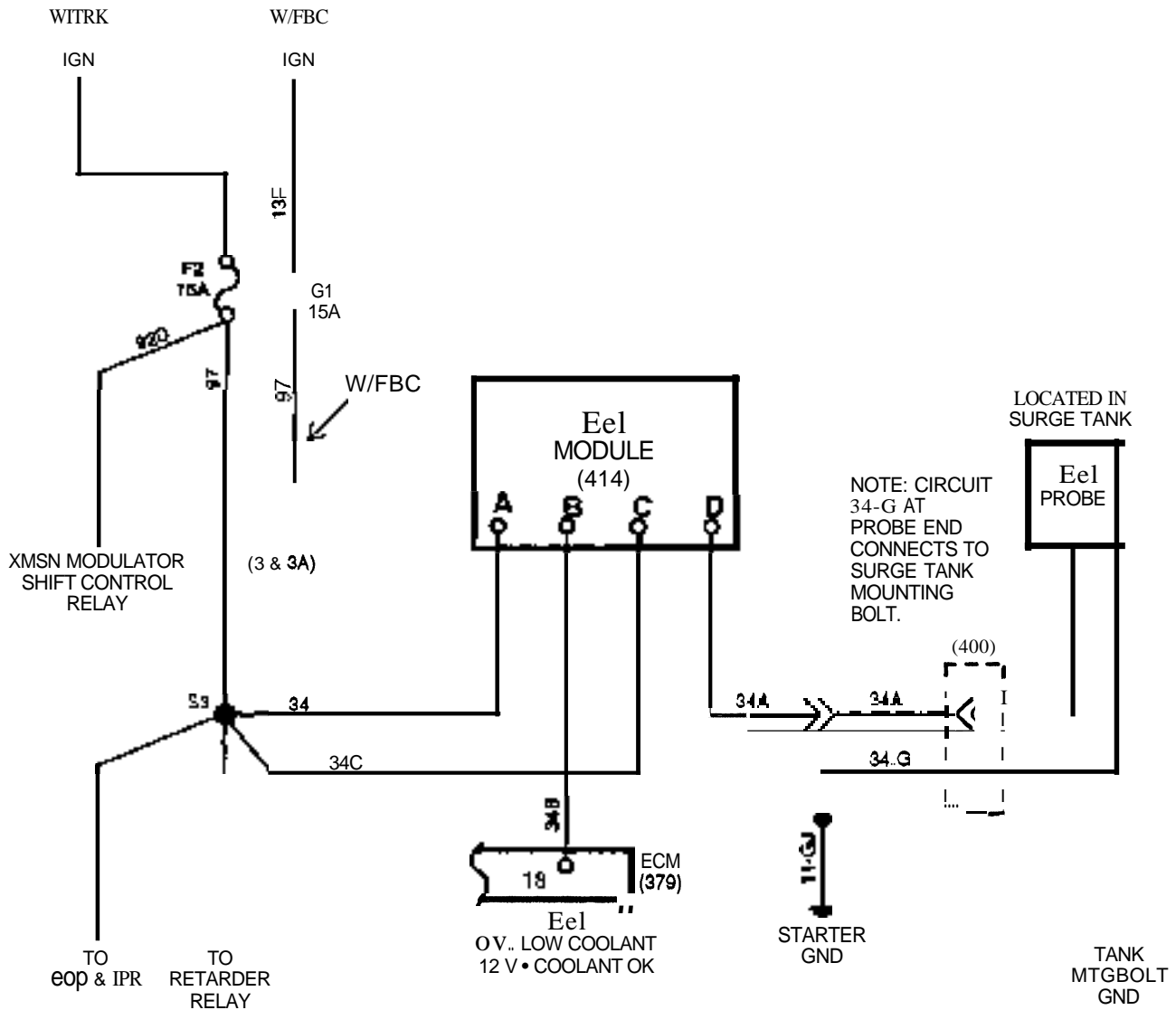
Perform Testing For False Low Coolant Signal on page 81, if Prolink indicates COOLANT IOW when coolant level is above the probe.

Perform Testing For False Full Coolant Signal on page 83, if Prolink indicates COOLANT FULL when coolant level is below the probe.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT LEVEL SYSTEM (Eel)

ENGINE COOLANT LEVEL SYSTEM CIRCUIT DIAGRAM

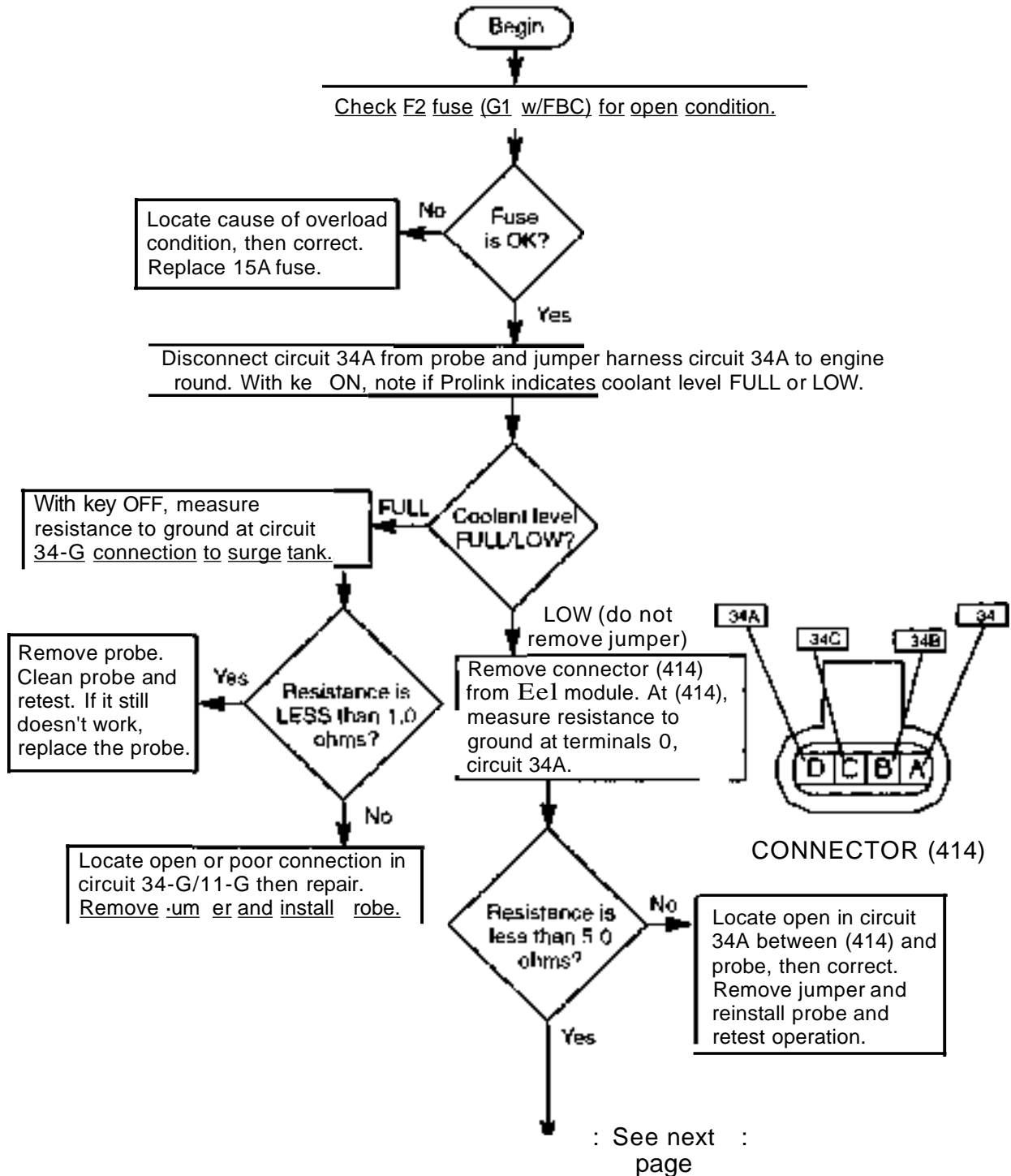


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT LEVEL SYSTEM (EeI)

TESTING FOR FALSE LOW COOLANT SIGNAL

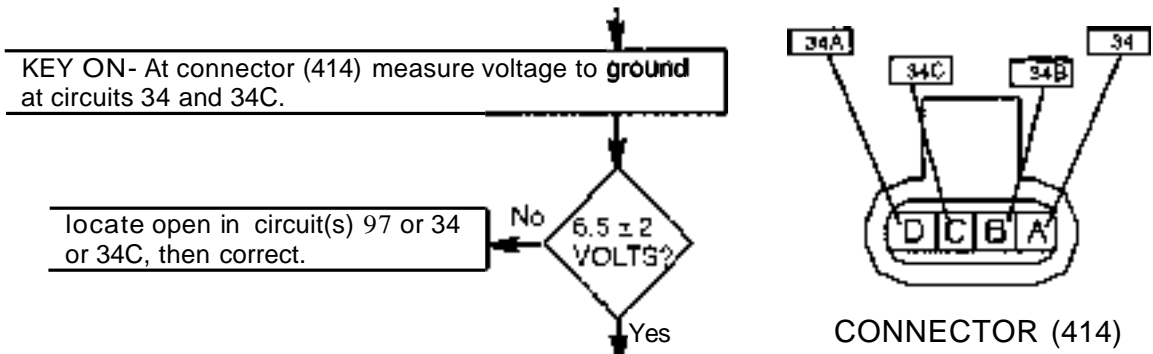
Perform this test if Prolink indicates LOW COOLANT when coolant level is above the probe.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

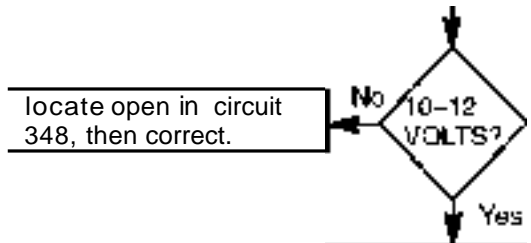
ENGINE COOLANT LEVEL SYSTEM (ECI)

TESTING FOR FALSE LOW COOLANT SIGNAL (Continued)

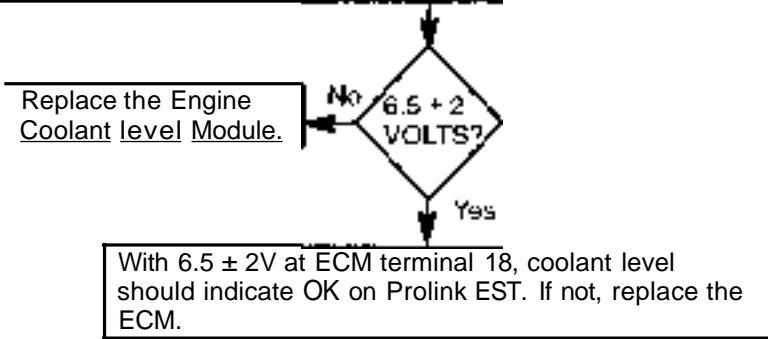


With connector (414) disconnected from ECI module, install breakout box at ECM harness connector 379, but do not connect to ECM. Jumper breakout box terminal 18 to 60 GRD.

KEY ON .. Measure voltage at connector (414) between terminals A (circuit 34) and B (circuit 34B).



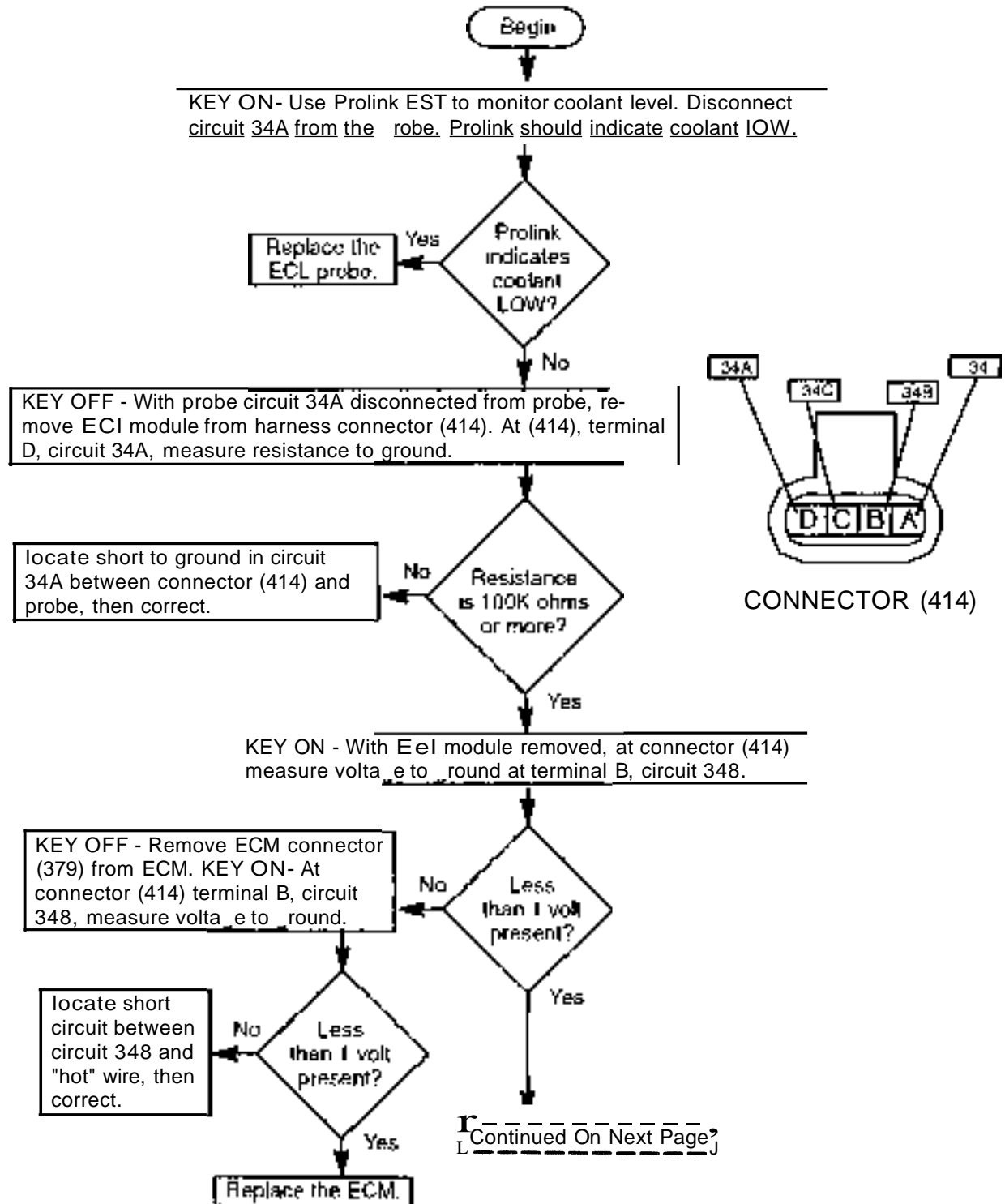
KEY OFF .. With circuit 34A still jumpered to ground at surge tank, connect breakout box to ECM and connect (414) to ECI module. Turn key ON and measure voltage between breakout box terminals 18 and 60.



ENGINE COOLANT LEVEL SYSTEM (ECI)

TESTING FOR FALSE FULL COOLANT SIGNAL

Perform this test if Prolink indicates COOLANT FULL when the coolant level is below the probe.



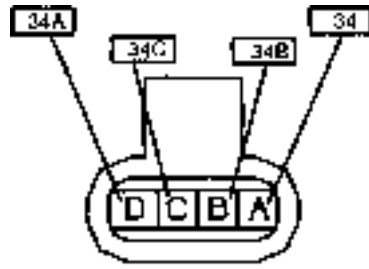
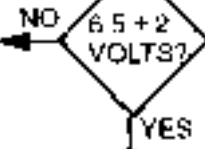
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT LEVEL SYSTEM (ECI)

TESTING FOR FALSE FULL COOLANT SIGNAL (Continued)

KEY ON- At connector (414), measure voltage to ground at terminals A (cir 34) and C (cir 34C).

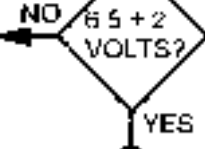
Locate cause of NO or LOW voltage, then repair.



CONNECTOR (414)

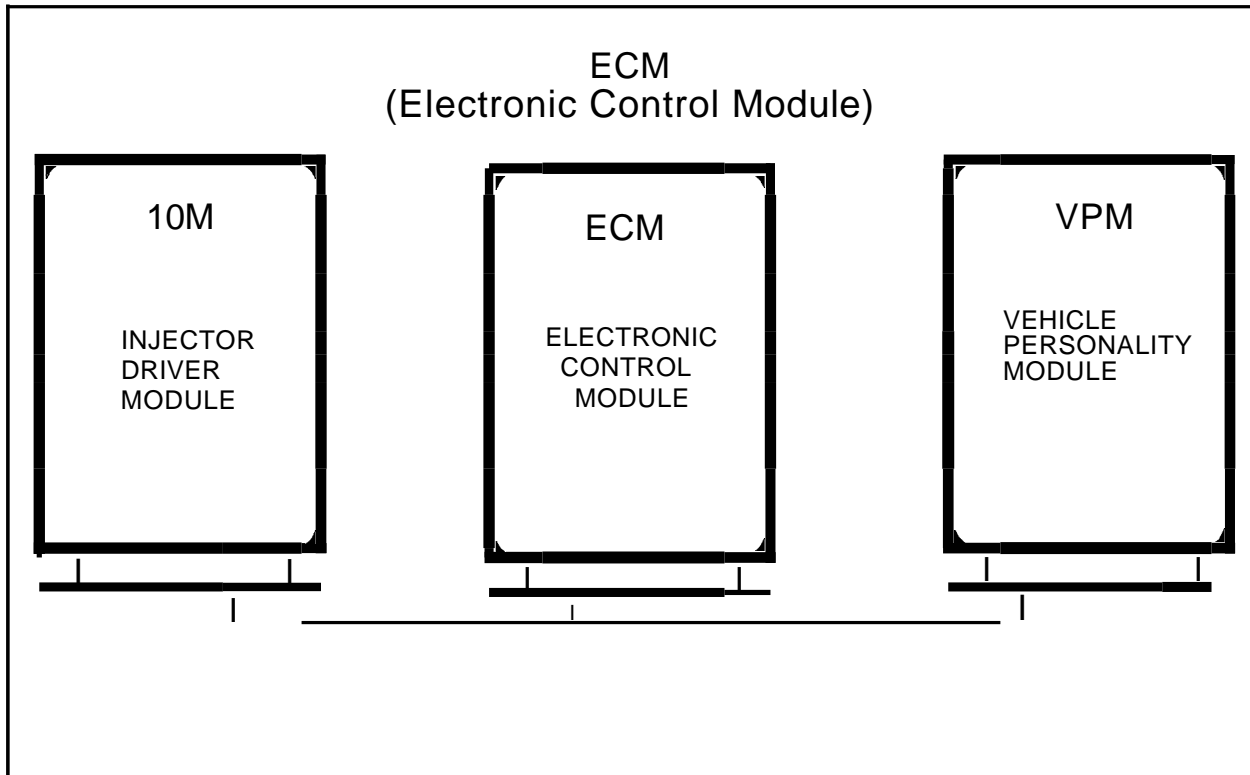
KEY OFF-Install ECI module in (414). Remove connector (379) from ECM and connect to breakout box. Do not connect breakout box to ECM. KEY ON- At breakout box measure voltage between terminals 18 (cir 348) and 60 (ground terminal).

Replace ECI module



Replace ECM

ECM SELF DIAGNOSTICS



SIGNAL FUNCTIONS

The Electronic Control Module (ECM) monitors and controls engine operation and performance, vehicle features such as PTa and cruise control, communicates information to the Vehicle Personality Module (VPM) and Injector Drive Module (10M).

FAULT DETECTION/IMANAGEMENT

The ECM is capable of internal fault detection and

dependent upon the severity of the problem, can provide fault management strategies to allow limited engine/vehicle operation.

FAULT DETECTION/MANAGEMENT

The ECM is capable of internal fault detection and dependent upon the severity of the problem, can provide fault management strategies to allow limited engine/vehicle operation.

ECM SELF DIAGNOSTICS

NORMAL OPERATION DIAGNOSTICS

During normal engine operation, the ECM automatically performs several tests to detect faults. During Normal Operation, the ECM performs the Start-up KAM Test and Continuous Diagnostics.

START-UP KAM TEST

The Start-up KAM Test is used to validate the ECM's Keep-Alive-Memory once each time the ECM resets (turns ON). If an error is detected, Flash codes 224 or 615 can be set.

FLASH CODE 615
ATA CODE SID 254 FMI13
ECM: *PROGRAMMABLE PARAMETER KAM CORRUPTFAULT*

Flash Code 615 can be set when Flash code 224 is set. If 224 is present, refer to Keep Alive Memory Power (KAM PWR) page 174 in this section to diagnose.

If code 224 IS NOT SET, code 615 indicates that the ECM's RAM is defective. Replace the ECM.

CONTINUOUS DIAGNOSTICS

Continuous diagnostic checks are made by the ECM during vehicle operation to detect out-of-range, rationality and system faults. Flash codes 112 and 113 can be set during this diagnostic process. Refer to (ECM PWR) in this section.

ON DEMAND DIAGNOSTICS (SERVICE DIAGNOSTICS)

The ECM will perform On-Demand Diagnostics (Service diagnostics) when requested by the service technician. The KOEO Standard Test Procedure includes:

- ECM Internal Self-Tests
- Output Circuit Checks (OCC).

ECM INTERNAL SELF-TESTS

Use the ProLink EST to perform the self-tests. The test procedure checks the ECM's CPU, RAM, and ROM. The test may set the following flash codes.

FLASH CODE 111
ATA CODE PID 194 FMI 0
ECM: *NO ERRORS DETECTED*

Flash Code 111 indicates that the ECM has not detected any errors.

FLASH CODE 625
ATA CODE SID 254 FMI 9
ECM: *ECM INACTIVE BACKGROUND*

Code 625 indicates that the ECM Software is Faulty. Replace the ECM.

FLASH CODE 631
ATA CODE SID 240 FMI 2
ECM: *ROM TEST FAULT*

If code 631 is present, replace the ECM.

FLASH CODE 632
ATA CODE SID 254 FMI12
ECM: *RAM/CPU TEST FAULT*

If code 632 is present, replace the ECM.

ECM OUTPUT CIRCUIT CHECKS (OCC)

During the OCC checks, the following ECM related codes can occur:

FLASH CODE 254
ATA CODE SID 254 FMI 3
ECM: *OCCORH*

If code 254 is present, replace the ECM.

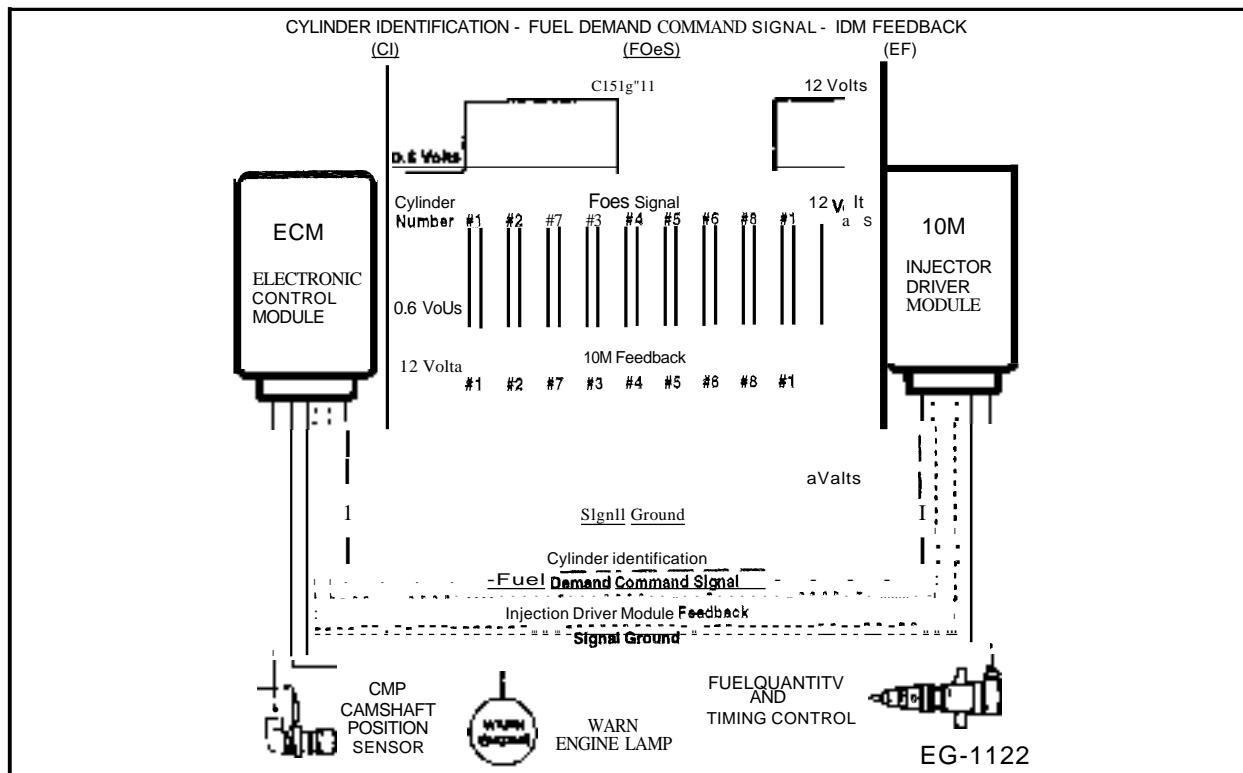
FLASH CODE 255
ATA CODE SID 254 FMI 4
ECM: *OCCORL*

If code 255 is present, replace the ECM.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ECM/IDM COMMUNICATIONS (ECM/IDM)

ECM - 10M COMMUNICATIONS



SIGNAL FUNCTIONS

Cylinder Identification - Cylinder Identification (CI) signal is a 0 to 12 volt wave form signal that communicates from the ECM to the IDM the position of cylinder 1. This signal is used by the IDM to synchronize the injector firing sequence. This signal is calculated from the signal generated from the Camshaft Position Sensor (CMP). The CI signal is generated by the ECM by "pulling down" (switching to grd.) a 12 volt communication circuit in the 10M.

Fuel Demand Command Signal - Fuel Demand Command Signal is a 0 to 12 volt wave form signal that communicates from the ECM to the IDM the required engine timing and duration of injector firing. The timing and duration of the signal is determined by ECM calibration and the signals of various sensor inputs. The FDCS signal is generated by the ECM by "pulling down" (switching to ground) a 12 volt communication circuit in the IDM.

Injector Driver Module Feedback - Injector Driver Module Feedback signal is a 0 to 12 volt wave form signal that communicates from the IDM to the ECM a mirror image of the FDCS signal. Extensions of the EF (Electronic Feedback) signal can indicate to the ECM possible problems with the injectors by the 10M as the engine is running. An EF toggle (100 hz. signal) generated when the key is first turned "ON" and before the engine starts, communicates to the ECM that the IDM is powered up. In an engine off

or engine running diagnostic mode, the EF signal is also used to communicate diagnostic information from the IDM to the ECM. The EF signal is generated by the IDM by "pulling down" (switching to grd.) a 12 volt communications circuit in the ECM.

FAULT DETECTION/MANAGEMENT

Cylinder Identification - Intermittent open or short to ground conditions can be detected by the 10M through 10M stuck high or low codes (532 & 531). Active faults can be detected by an on demand output circuit check performed during Engine Off Tests.

NOTE: THE ENGINE WILL NOT OPERATE WITHOUT A FUNCTIONING CI CIRCUIT

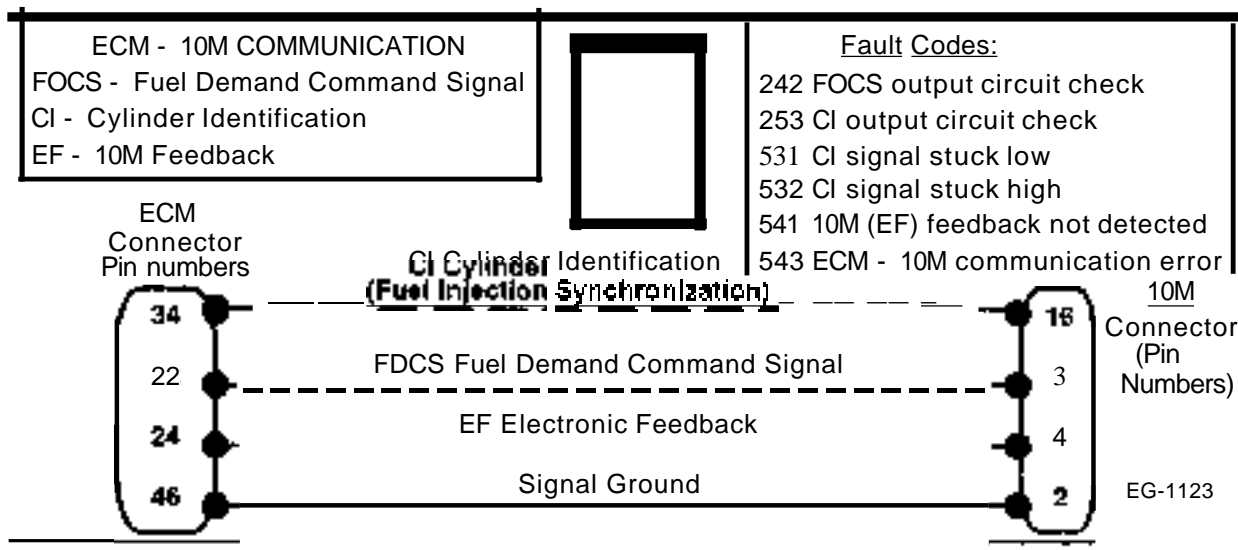
Fuel Demand Command Signal - Active faults can be detected by an on demand output circuit check performed during Engine Off Tests.

NOTE: THE ENGINE WILL NOT OPERATE WITHOUT A FUNCTIONING FDCS CIRCUIT

Injector Driver Module Feedback - Active faults can be detected by a toggle sequence that the ECM looks for on start up. The WARN lamp will be illuminated if this is detected.

NOTE: 10M DIAGNOSTIC FAULT CODES WILL NOT BE TRANSMITTED IF THE EF LINE IS NOT FUNCTIONING, HOWEVER, THE ENGINE WILL OPERATE NORMALLY.

ECM/IDM COMMUNICATIONS (ECM/IDM)



Key On Engine Off - Voltage Checks
(Check with breakout box installed with ignition key "ON" engine off)"

Test Points	Spec.	Signal	Comments
#34 to #46	0.6±0.1 v	CI signal	Less than .5v indicates an open between the ECM and IDM. 12 volts indicates an open in the ECM or breakout box.
#22 to #46	0.6 ± 0.1 v	FOCS signal	
#24 to #46	1 to 4 volts	EF feedback	With the key on, EF has a 100 hz. digital signal that will measure 1-4 volts w/ DVOM.

Connector Checks to Ground
(Check with breakout box installed, ignition key should be in the OFF position.)

Test Points	Spec.	Signal	Comments
#34 to #46	> 1000 ohms	CI signal	Less than 1000 ohms indicates a short to ground either thru the harness or internal in the ECM or 10M. Disconnect the 10M and measure to ground. If short still present, disconnect the ECM and measure to ground. If short still present, repair harness.
#22 to #46	> 1000 ohms	FOCS signal	
#24 to #46	> 1000 ohms	EF feedback	

Harness Resistance Checks
(Check with breakout box installed, ignition key should be in the OFF position.)

Test Points	Spec.	Signal	Comments
#34 to #16	< 5 ohms	CI signal	Resistance from ECM connector to 10M connector.
#22 to #3	< 5 ohms	FOCS signal	Resistance from ECM connector to IDM connector.
#24 to #4	< 5 ohms	EF feedback	Resistance from ECM connector to IDM connector.
#46 to #2	< 5 ohms	SIG Grd	Resistance from ECM connector to IDM connector.

Key On Engine Running (at low idle) - Voltage Checks - Intermittent Faults
(Check with breakout box installed and engine at low idle.)

(Monitor suspect lines with voltmeter and wiggle appropriate wires and connectors while engine is idling)

Test Points	Spec.	Comments
#34 to #46	5 - 8 volts	CI signal (0 to 12 volt digital signal). Monitor engine RPM w/Fluke 98 in TACH mode.
#22 to #46	1 - 1.5 volts	FDCS signal, 40 - 50hz. - 0 to 12 volt signal.
#24 to #46	.5 - 1.5 volts	EF signal, 40hz. - 0 to 12 volt signal

Fault Code Descriptions

- 242 =FOCS high or low resistance in the circuit detected during engine off test, OCC- test (REPAIR THIS FAULT FIRST).
- 253 =CI high or low resistance in the circuit detected during engine off test. OCC- test (REPAIR THIS FAULT FIRST).
- 531 =CI signal stuck low, harness or internal circuits of IDM shorted to ground (intermittent problem, historical fault only)
- 532 = CI signal stuck high, harness or internal circuits of IDM shorted to voltage source (intermittent problem, historical fault only)
- 541 =10M feedback (EF) (100 hz frequency transmitted during key ON, engine OFF) not detected.
- 543 =ECM-IDM communication error, no communication, detected on EF or wrong part number IDM.

*. OCC =Output Circuit Check

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ECM/IDM COMMUNICATIONS (ECM/IDM)

ECM 110M COMMUNICATIONS EXTENDED EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Electronic Control Module (ECM) and an Injector Drive Module (10M). The IDM's primary functions are to supply high current and voltage to power the injectors and to electrically "turn on" individual injectors upon command by the ECM. The ECM communicates and controls injector timing and fuel quantity and communicates engine position to the 10M to insure correct fueling timing, quantity and firing sequence. The 10M is also capable of feeding back or handshaking information received from the ECM and of communicating diagnostic information pertinent to injector or 10M operation to the ECM. Information is transmitted between the 10M and ECM on three circuits; (CI) Cylinder Identification, (FDCS) Fuel Oemand Command Signal and (EF) Electronic Feedback.

Cylinder Identification (CI) is the signal from the ECM to the 10M to indicate the beginning of the firing order. This signal is generated by the ECM to indicate to the 10M the position of #1 cylinder and synchronize injector firing order to engine position. Engine position is detected by the Camshaft Position (CMP) sensor by identifying the sync window in the timing disk. (Refer to CMP sensor for complete function)

Fuel Demand Command Signal (FOCS) is the signal sent by the ECM to the 10M to indicate the beginning and ending of each injection cycle. This precise "On/Off" signal controls the fuel timing and rate by varying the beginning and ending of injection.

Electronic Feedback (EF) signal is sent from the IDM to the ECM to verify 10M operation and communicate diagnostic information.

- On initial power up, the IDM will signal the ECM with a constant 100 Hz signal that it has successfully initialized.
- During engine operation, the EF signal mirrors the FDCS signal to the ECM to verify FDCS reception by the IDM and will modify the EF signal if certain injector faults are detected during engine operation.

- After an "Engine Off Standard Test" is performed, the EF signal will communicate diagnostic information stored in the 10M pertaining to IDM function or injector operation to the ECM.

OPERATION

CYLINDER IDENTIFICATION (CI)

When the 10M is powered up, 12 volts is supplied from pin 16 of the 10M to pin 34 of the ECM. The ECM will "pull down" this 12 volts low to approximately .6 volts (the voltage drop across an internal transistor in the ECM). After the ECM has received a sync signal from the CMP sensor and can identify the position of cylinder #1, it will toggle CI and allow it to go high (12 volts), 180° of camshaft rotation later or 360° of crankshaft rotation the ECM will again pull the CI signal low (.6 volts). This indicates to the 10M to initiate the firing sequence 1-2-7-3 when it receives the high signal and 4-5-6-8 when it receives the low signal. This signal will be repeated every camshaft revolution.

FUEL DEMAND COMMAND SIGNAL (FOeS)

When the 10M is powered up, 12 volts is also supplied from pin 12 of the IDM to pin 22 of the ECM, the ECM will "pull down" this 12 volts low to approximately .6 volts (the voltage drop across an internal transistor in the ECM). After the 10M has received the CI signal, the ECM will toggle the FDCS signal high and low to indicate to the 10M the beginning and ending of injector operation for each cylinder.

NOTE: THE ENGINE REQUIRES A FUNCTIONING CI AND FDeS SIGNAL TO OPERATE.

ELECTRONIC FEEDBACK (EF)

After the ignition key is turned "ON" and the ECM and 10M relays are enabled, the 10M is powered up and performs its internal self checks. To signal that the 10M is initialized, a 100 Hz signal is transmitted on the EF circuit to the ECM.

During engine operation, the EF signal mirrors the FDCS signal to the ECM to verify FOCS reception by the IDM and will modify the EF signal if certain injector faults are detected during engine operation.

After an "Engine Off Standard Test" is performed, the EF signal will communicate diagnostic information stored in the 10M pertaining to IDM function or injector operation to the ECM.

ECM/IDM COMMUNICATIONS (ECM/IDM)

ECMnDM COMMUNICATIONS EXTENDED
SYSTEM DESCRIPTION (Continued)

IDM DIAGNOSTICS

The 10M monitors operation of output circuits during engine operation. Output circuits that are shorted or open are detected by the 10M and are subsequently disabled if necessary to prevent damage to the output drivers. This will set a fault code. When a fault is detected during operation an EF "extension", transfers fault information to the ECM. Not all faults can be transferred during engine operation. However, faults are stored in the 10M when they are detected. These faults are transmitted during the "Engine Off Tests", as inactive faults.

At start up, the 10M performs a Self Test of internal components to determine if they are operating satisfactorily. The 10M compares the signal inputs to determine if the signal voltages are within specification, if not a fault code will be set. These faults are also transferred to the ECM on command as inactive faults.

ECM DIAGNOSTICS

The ECM monitors the timing of the EF signal while the engine is running. When it detects a fault sent from the 10M, it will log the transfer. However, it will be necessary to perform an Engine Off Standard Test to determine most fault codes stored in the 10M. The Engine Off Test may be initiated by the Electronic Service Tool or the STI Self Test Input switch located on the vehicle dash.

The ECM continually measures the communication signal voltage levels. If the voltage levels are lower or higher than expected, a fault code will be set to identify the circuit or component. The fault will be automatically recorded as an active code. If the ignition key is turned off, the fault will be stored as an inactive code.

FLASH CODE 242
ATA CODE SID 154 FMI11
*FUELS CIRCUIT TO IDM OCC SELF TEST
FAILED*

During the Engine Off Standard Output Circuit Check test, Code 242 will be set by the ECM, if the ECM did not detect a voltage transition on the FDCS circuit. This code will not cause the Engine Warning light to be illuminated.

Code 242 may be caused by a shorted high or low or open FOCs circuit. If accompanied by other communication codes could indicate the IDM is not powered up. This fault must be repaired for the engine to operate.

FLASH CODE 253
ATA CODE SID 153 FMI11
*FUEL INJ SYNC CIRCUIT OCC SELF TEST
FAILED*

Flash code 253 will be set during the Engine Off Standard Output Circuit Check test. This code is set by the ECM and indicates no voltage transition detected on the Cylinder Identification circuit. This fault will not cause the Engine Warning light to be illuminated.

Possible causes are a shorted (high or low) or open CI circuit. If accompanied by other communication codes could indicate the 10M is not powered up. This fault must be repaired for the engine to run.

FLASH CODE 531
ATA CODE SID 153 FMI4
FUEL INJ. SYNC SIGNAL LOW

Flash code 531 is set by the 10M and is transmitted to the ECM on command from the ECM during the Engine Off Standard Test. This code indicates that the 10M has detected that the FOCs signal and the CI signal have remained at 0 volts. This code will cause the Engine Warning light to be illuminated.

Possible cause may be a short to ground in the CI circuit. This fault must be repaired for the engine to run.

FLASH CODE 532
ATA CODE SID 153 FMI3
FUEL INJ. SYNC SIGNAL HIGH

Flash code 532 is set by the 10M and is transmitted to the ECM on command from the ECM during the Engine Off Standard Test. This code indicates the 10M has detected that the FDCS signal and CI signal have remained at 12 volts. This code will cause the Engine Warning light to be illuminated.

Possible causes are a short to a voltage source or an open CI circuit. This fault must be repaired for the engine to run.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ECM/IDM COMMUNICATIONS (ECM/IDM)

ECM/IDM COMMUNICATIONS EXTENDED SYSTEM DESCRIPTION (Continued)

FLASH CODE 541
AIA CODE SID 155 FMI11
*IDM FEEDBACK TOGGLE NOT DETECTED BY
ECM*

Flash code 541 is set by the ECM. The ECM monitors the CI, FOCS and EF signals for voltage levels. If the ECM detects that the CI or FOCS is open or if the EF signal is not sending a 100 Hz signal, this code will be set. This code will cause the Engine Warning light to be illuminated.

Possible causes are a short or open on the EF circuit if this code is the only code present. If accompanied by other 10M circuit faults the 10M may not be powered or operational. If displayed during an Engine Off Standard Test it will be accompanied by code 543. This code may be set due to other faults in the ECM due to a reset condition. If other codes are present repair them first in the order of importance for engine operation. This code should not prevent engine operation by itself.

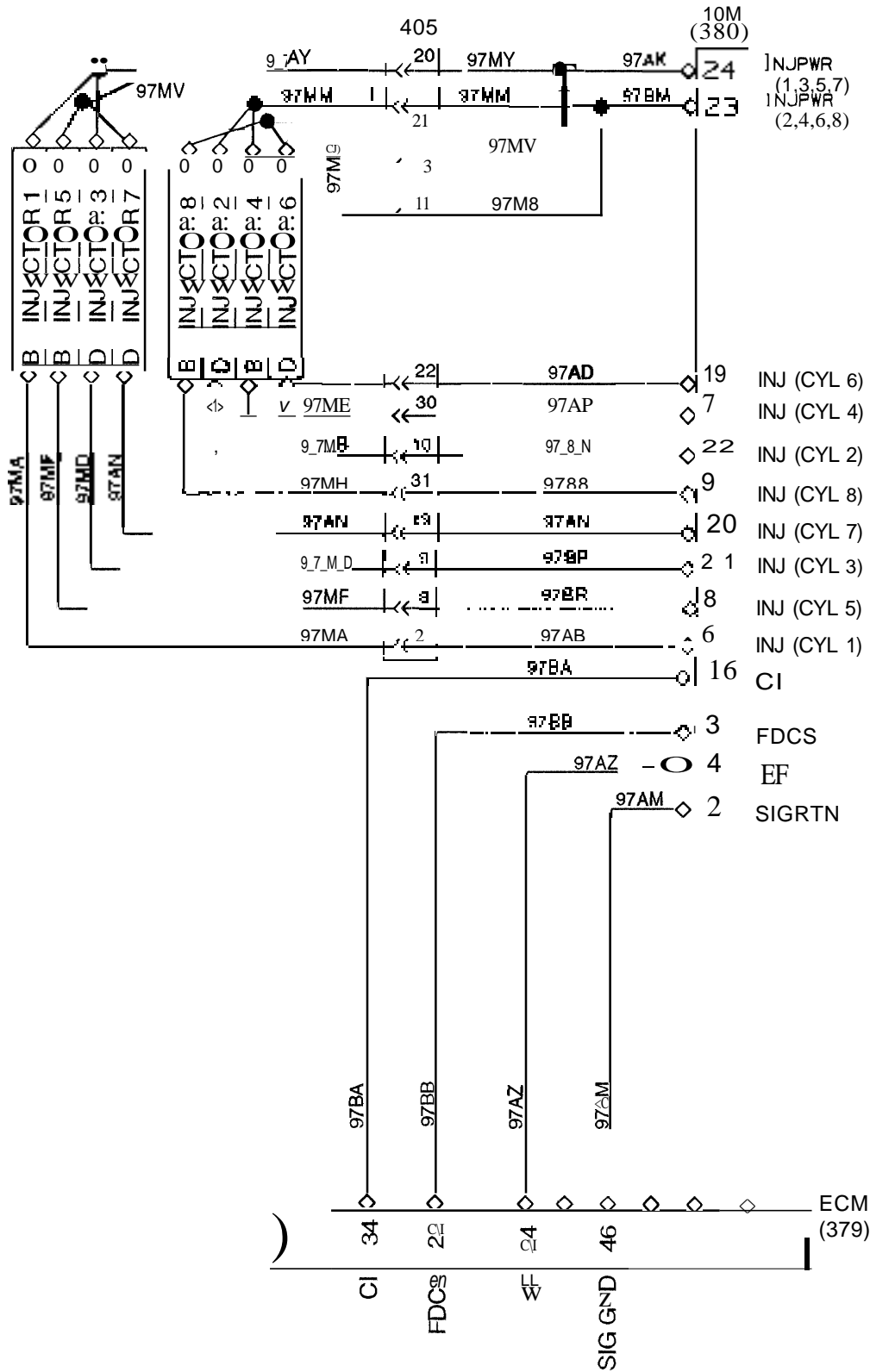
FLASH CODE 543
ATA CODE SID 155 FMI 7
10M FAULTS NOT RECEIVED

Flash code 543 is set by the ECM during an Engine Off Standard Output Circuit Check test. This indicates that the ECM has commanded the transmission of fault codes from the 10M and has not received the codes. If this code occurs, first record any active or inactive codes. Then clear the codes and rerun the Engine Off Standard Test. This code will cause the Engine Warning light to be illuminated.

Possible causes for this code would be opens or shorts in the 10M / ECM communications circuits or an 10M not powered. If accompanied by other faults repair the other faults first in the order of importance for engine operation. This code should not prevent engine operation by itself.

ECMIIDM COMMUNICATIONS (ECM/IDM)

INJECTOR DRIVE CIRCUIT

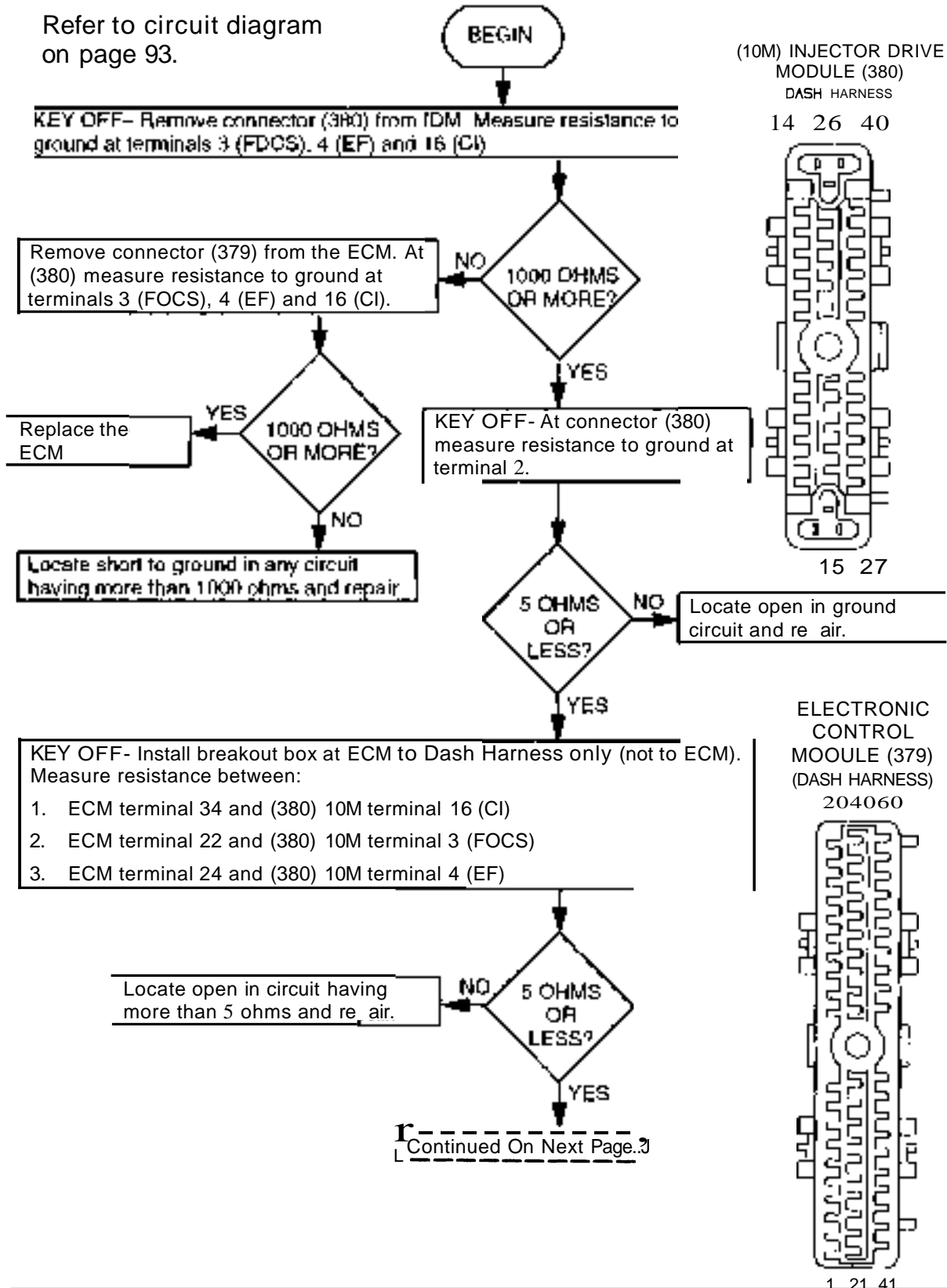


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ECM/IDM COMMUNICATIONS (ECM/IDM)

ECM ↔ 10M COMMUNICATIONS

Refer to circuit diagram on page 93.

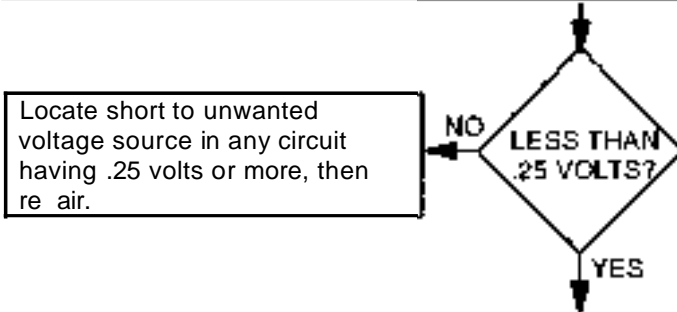


ECM/IDM COMMUNICATIONS (ECM/IDM)

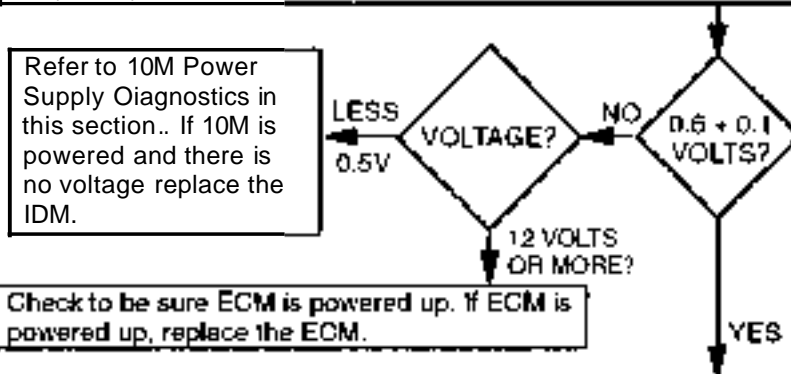
ECM ↔ 10M COMMUNICATIONS (Continued)

YES

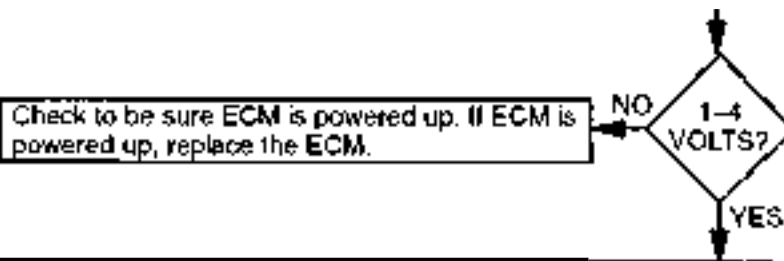
KEY ON- With breakout box connected to dash harness only and 10M disconnected at 380, measure voltage to ground at breakout box terminals 22, 24 and 34.



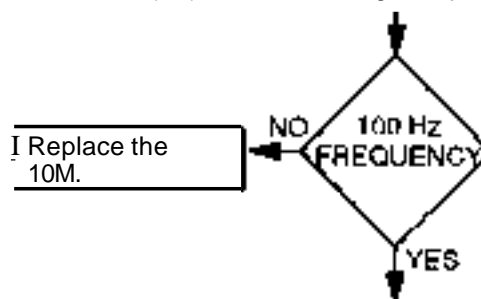
KEY OFF- Connect breakout box to ECM and install connector (380) to 10M. KEY ON- Measure voltage at breakout box terminals 34 (GI) and 22 (FOGS).



KEY ON- Measure voltage at breakout box terminal 24 (EF).

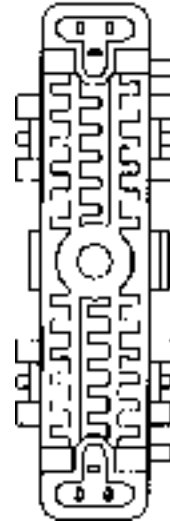


KEY ON- At breakout box terminal 24 (EF) measure voltage frequency.



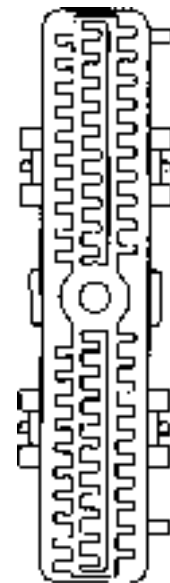
Circuits are complete. Further malfunctions indicate component failure.

(10M) INJECTOR DRIVE MODULE (380)
(Chassis Harness)
14 26 40



15 27

ELECTRONIC CONTROL MODULE (379)
(Chassis Harness)
204060



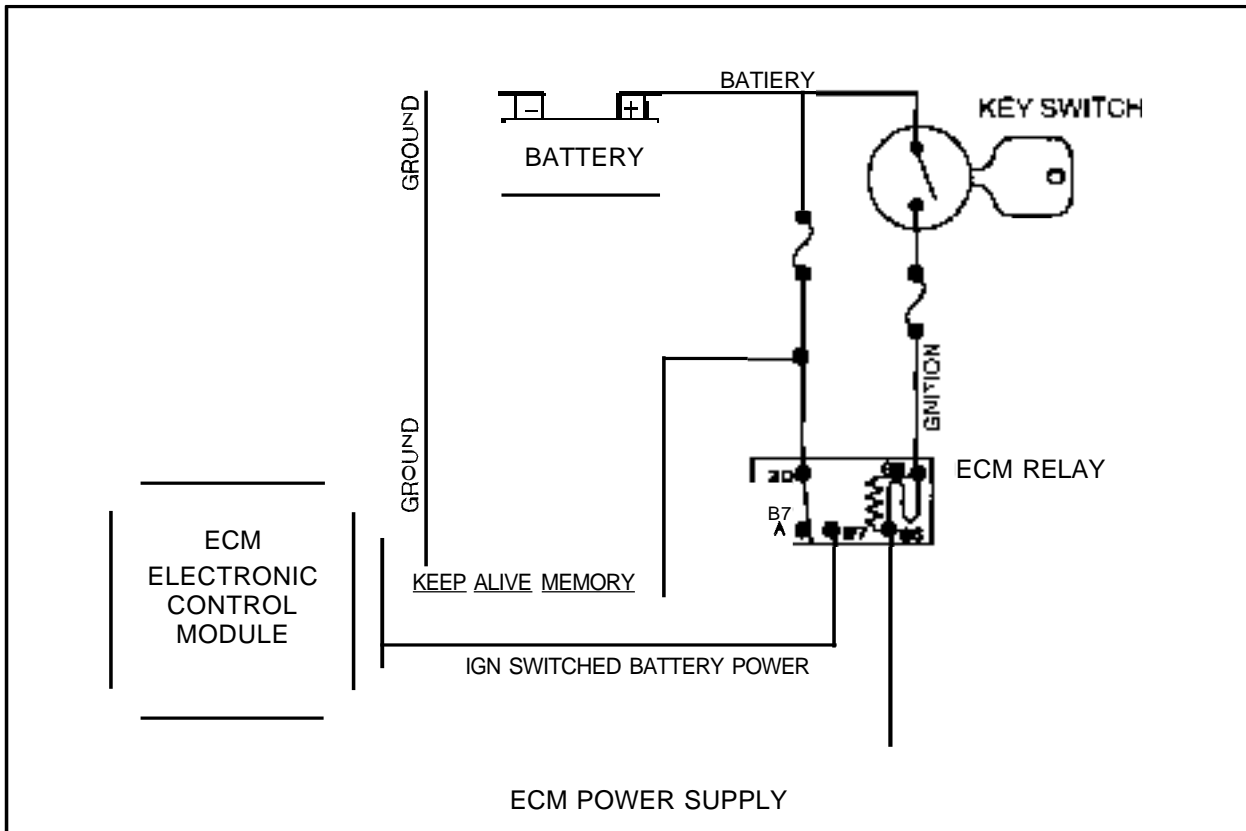
1 21 41

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5

Page 96 ELECTRONIC CONTROL MODULE POWER SUPPLY (ECM PWR)

ELECTRONIC CONTROL MODULE (ECM) POWER SUPPLY



CIRCUIT FUNCTIONS

The ECM receives 12 volt operating power with the key ON from the ECM power relay. The ECM also receives 12 volt battery power at all times for the Keep Alive Memory function.

ECM SWITCHED POWER

Turning the key ON energizes the ECM power relay causing 12 volt battery power to be applied to ECM terminals 37 and 57.

ECM KEEP ALIVE MEMORY POWER

Battery power is applied at all times to support the ECMs keep alive memory. Refer to KEEP ALIVE

MEMORY POWER CIRCUITS in this section for additional information.

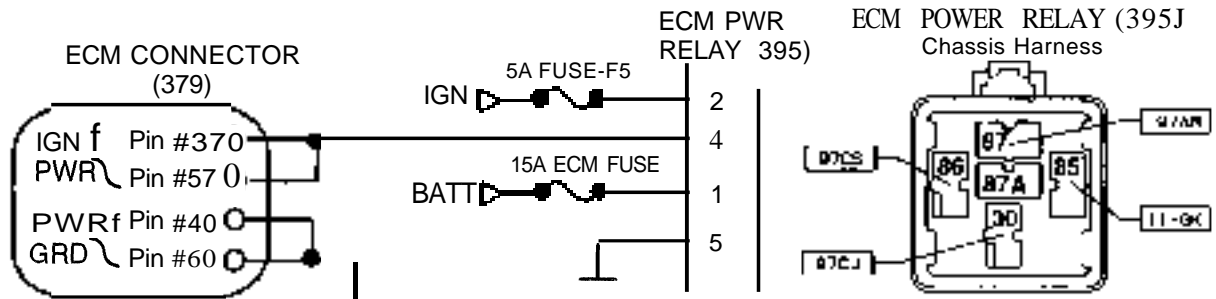
ECM POWER GROUND

ECM terminals 40 and 60 are grounded through the chassis harness to the negative battery terminal.

FAULT DETECTION MANAGEMENT

The ECM monitors voltage at terminals 37 and 57. If the ECM continuously receives less than 6.5 volts or more than 18 volts a fault code will be set. The fault codes do not cause the Warning light to be turned ON. If the condition is intermittent, the code will be logged as an inactive code.

Electronic Control Module Power Supply (ECM-PWR)	Fault Codes: 112 Internal power out of range high 113 Internal power out of range low 224 KAM Corrupt
--	---



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector (395) - Check connector (395) with relay removed, ECM connector (379) disconnected and key ON.

Test Points	Spec.	Comments
#30 to Grd.	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open/short to ground or blown fuse
#86 to Grd.	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open/short to ground or blown fuse
#86 to #85	12 ± 1.5 volts	< than 10.5 v check grd circuit connections, 0 v check for open ground circuit
#30 to #87	0volts	Any voltage indicates a short to ground in ECM feed circuit

Connector (379) - Check with breakout box installed on engine harness only and connector (395) with relay removed and key OFF.

Test Points	Spec.	Comments
#40 to Grd. #60 to Grd.	< 5 ohms	> 5 ohms indicates open or poor connection in ground circuits.
#37 to Grd. #57 to Grd.	>1000 ohms	< 1000 ohms indicates a short to ground

Connector (379) to (395) - Check with breakout box installed on engine harness only and connector (395) with relay removed and key OFF

Test Points	Spec.	Comments
#87 to 37 #87 to 57	<5 ohms	> 5 ohms indicates an open or poor connection. If <5 ohms the ECM power relay is suspect.

Fault Code Descriptions
112 =Internal power was more than 18 volts.
113 =Internal power was less than 6.5 volts.
224 =Keep Alive Memory in ECM lost.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5

Page 98 ELECTRONIC CONTROL MODULE POWER SUPPLY (ECM PWR)

EXTENDED DESCRIPTION

Refer to the Electronic Control Module power supply circuit diagram on page 99 for the following discussion.

The Electronic Control Module (ECM) Power Relay (395) has battery power supplied directly from the batteries to terminal 30. This circuit is protected by the 15A ECM #1 PWR fuse that is part of the battery cable assembly.

When the key switch is turned ON, the ECM Power Relay (395) is energized by ignition power from 5A fuse F5 (5A fuse C1 with FBC) at the relay control coil terminal 86. With the ECM Power Relay (395) energized, power flows through the normally open (N.D.) relay contacts (30 to 87) then on circuit 97AR to ECM connector (379), terminals 37 and 57.

The ground side of the ECM Power Relay control coil (terminal 85) is grounded by circuit 11-GK at the Electronic Ground Stud located at the cab. The Diode Assy (415) prevents the electronic components from voltage spikes created by the relay opening and closing.

The ECM power ground terminals 40 and 60 are grounded through ECM connector (379) at the negative battery terminal.

ECM DIAGNOSTICS

If the ECM continuously receives less than 6.5 volts or more than 18 volts at terminals 37 and 57, it will cause Flash Code 112 or 113 to be set.

FLASH CODE 112
ATA CODE PID 168 FMI3
ECM: *INTERNAL VOLTAGE POWER OUT OF RANGE HIGH*

Code 112 can be caused by either of two conditions:

1. Vehicle voltage supply to the ECM is continuously more than 18 volts. Excessive voltage can be caused by a defective alternator.
2. The ECM has an internal fault.

If the condition causing code 112 is intermittent, the code will change from active to inactive status.

Code 112 does not cause the Engine Warning light to turn ON.

FLASH CODE 113
ATA CODE PID 168 FMI4
ECM: *INTERNAL VOLTAGE POWER OUT OF RANGE LOW*

Code 113 can be caused by consistently less than 6.5 volts being applied to ECM terminals 37 and 57. This can be caused by a defective alternator, low batteries, and/or increased resistance in the battery feed circuits. Code 113 does not turn the Engine Warning Light ON. If the condition causing Code 113 to set is an intermittent condition, when the condition is no longer present, the code status will change from active to inactive.

FLASH CODE 224
ATA CODE SID 254 FMI 2
ECM: *KAM CORRUPT*

Flash code 224 can be caused by high or low battery power supply to ECM terminal 1 OR an internal ECM error.

TROUBLESHOOTING

If Flash Code 112 is active, refer to CTS- 5000 Master Service Manual, GROUP 08 ALTERNATORS and troubleshoot the charging system.

If Flash Code 113 is active or NO voltage is present to the ECM, perform TESTING ECM POWER SUPPLY CIRCUITS on page 100. If the power supply to the ECM checks good, replace the ECM.

If a vehicle no-start condition is present and there is no power to the ECM, perform TESTING ECM POWER SUPPLY CIRCUITS on page 100.

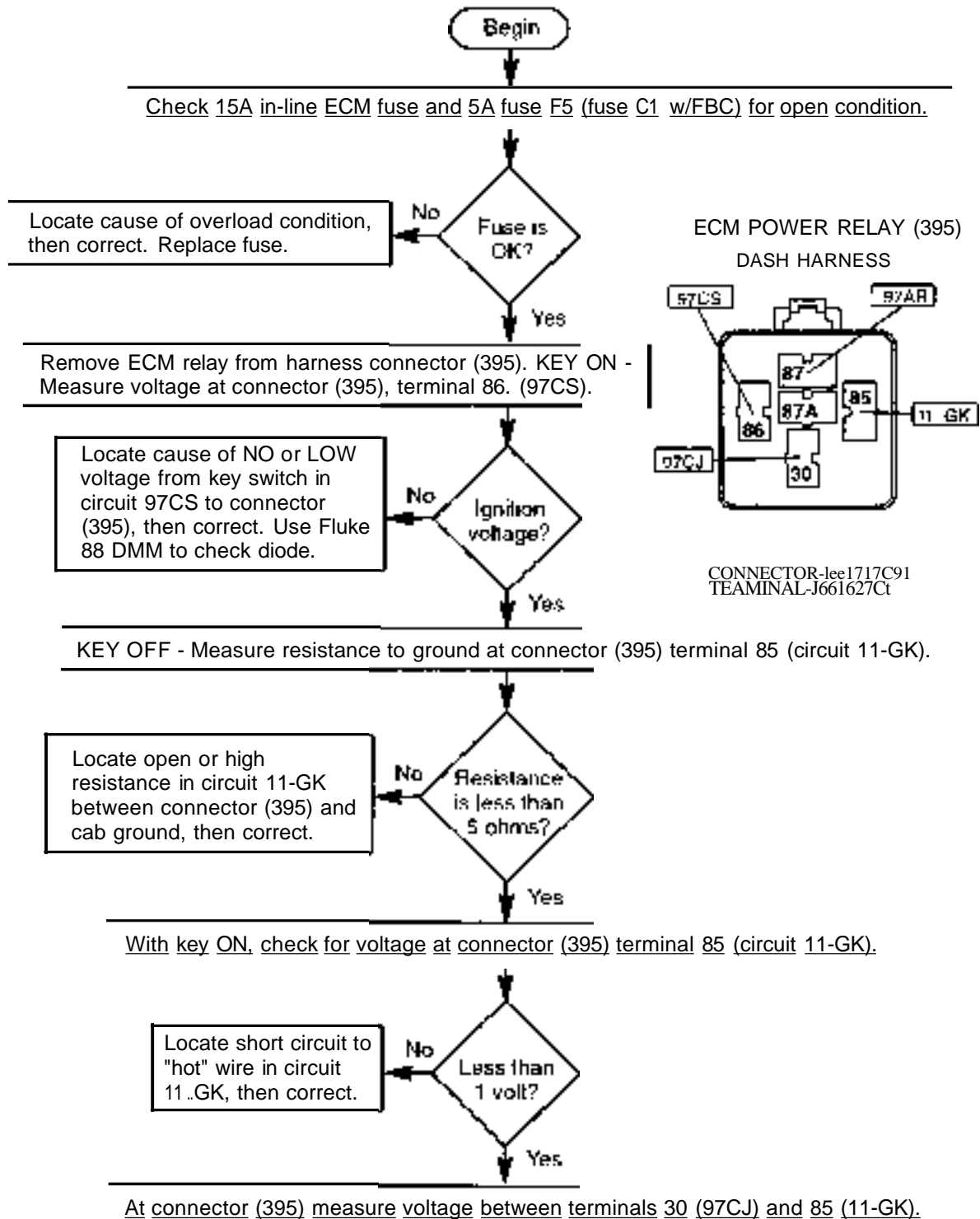
BEFORE PERFORMING ANY TESTS

Inspect ECM power relay circuit connectors for pushed back, damaged, corroded or dirty terminals as well as making sure the terminals and wires are properly crimped. Make sure connectors are properly joined together. Also check for damaged wiring, and clean, tight battery and ground connections.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

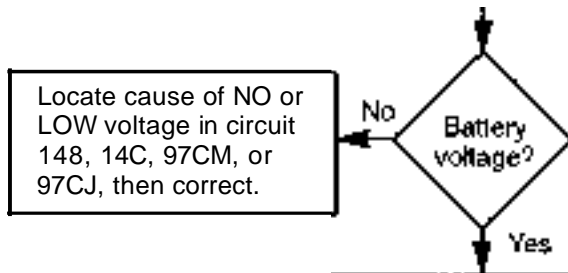
ELECTRONIC CONTROL MODULE POWER SUPPLY (ECM PWR)

TESTING ECM POWER SUPPLY CIRCUITS

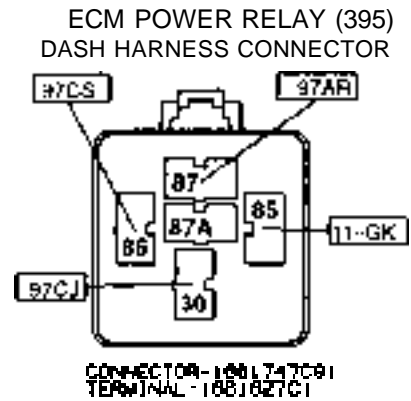


: See next:
page

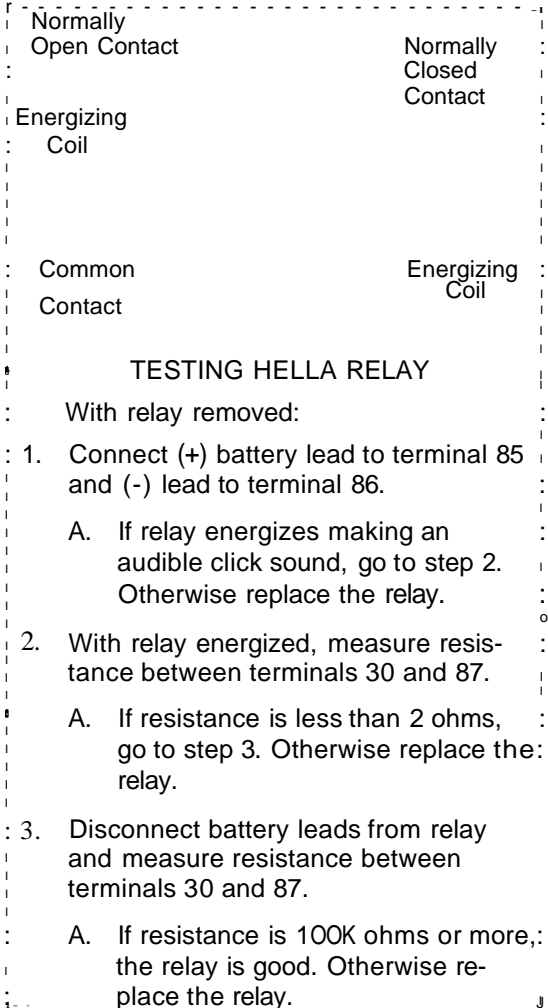
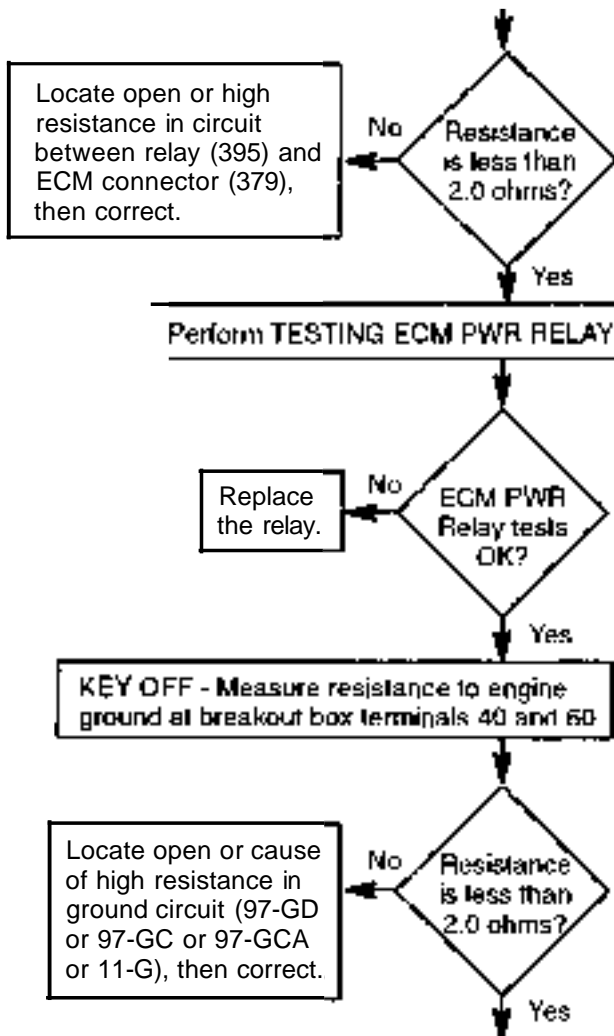
TESTING ECM POWER SUPPLY CIRCUITS (Continued)



With key OFF, install breakout box to ECM harness connector (379), but do not connect breakout box to ECM.



KEY OFF - Measure resistance between connector (395), terminal 87 (97AR) and breakout box terminals 37 and 57.

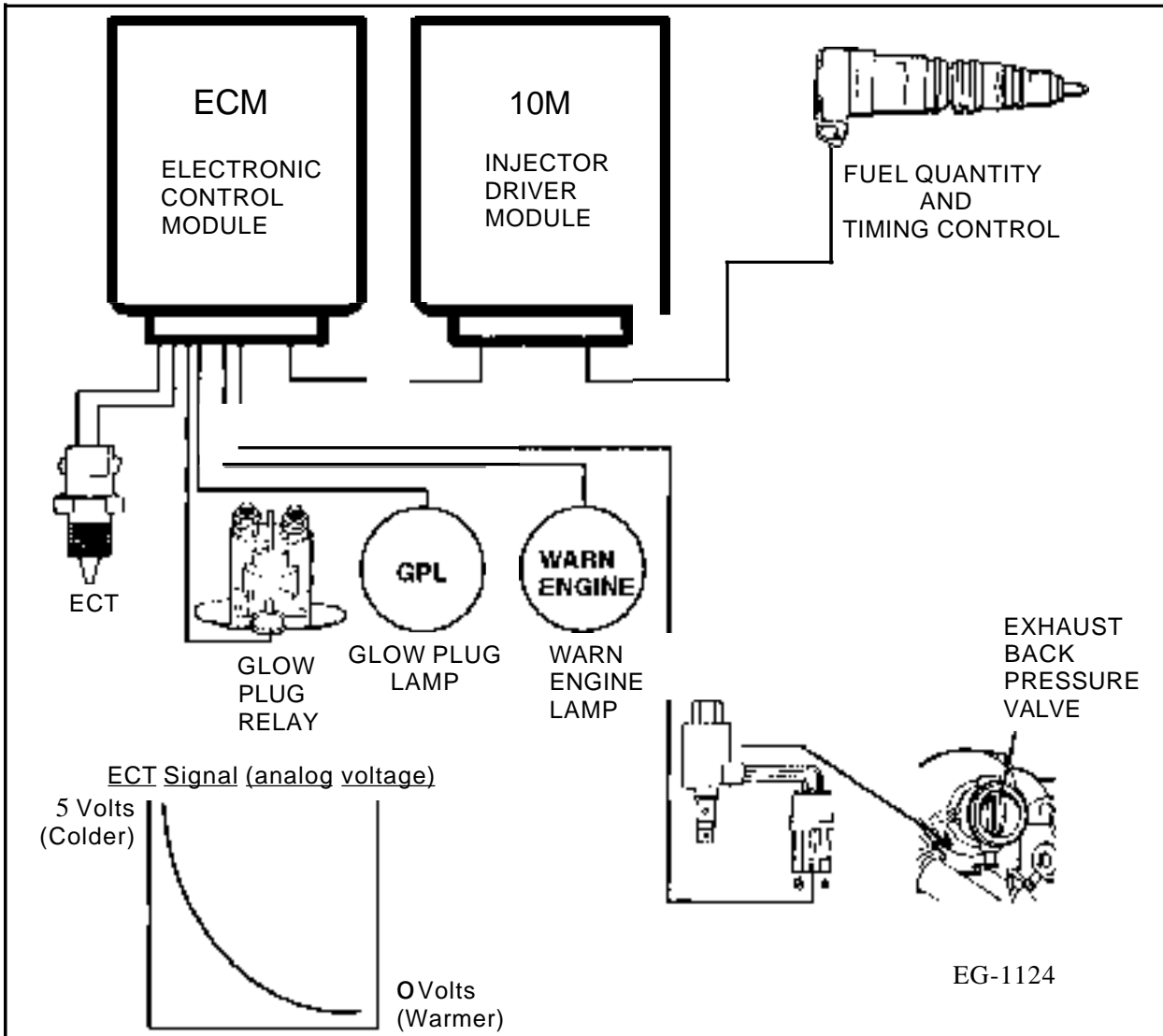


ECM PWR Supply circuits and relay check good. If the ECM still does not power up, replace the ECM.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

ENGINE COOLANT TEMPERATURE (ECT) SENSOR



SIGNAL FUNCTIONS

The Engine Coolant Temperature (ECT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM it produces a 0 to 5 volt analog signal that will measure temperature.

Coolant Temperature Compensation - At coolant temperatures greater than 214°F (101° C) fuel quantity is reduced by 6% for each degree of temperature (OC), until engine temperature reaches 218° F (103°C). Above 218° F (103°C) fuel is reduced by 3% for each °C increase in temperature.

Idle Speed - At temperatures below 158° F, (70° C) low idle is incrementally increased to a maximum of 875 RPM.

Glow Plug Control - Glow plug relay and lamp on

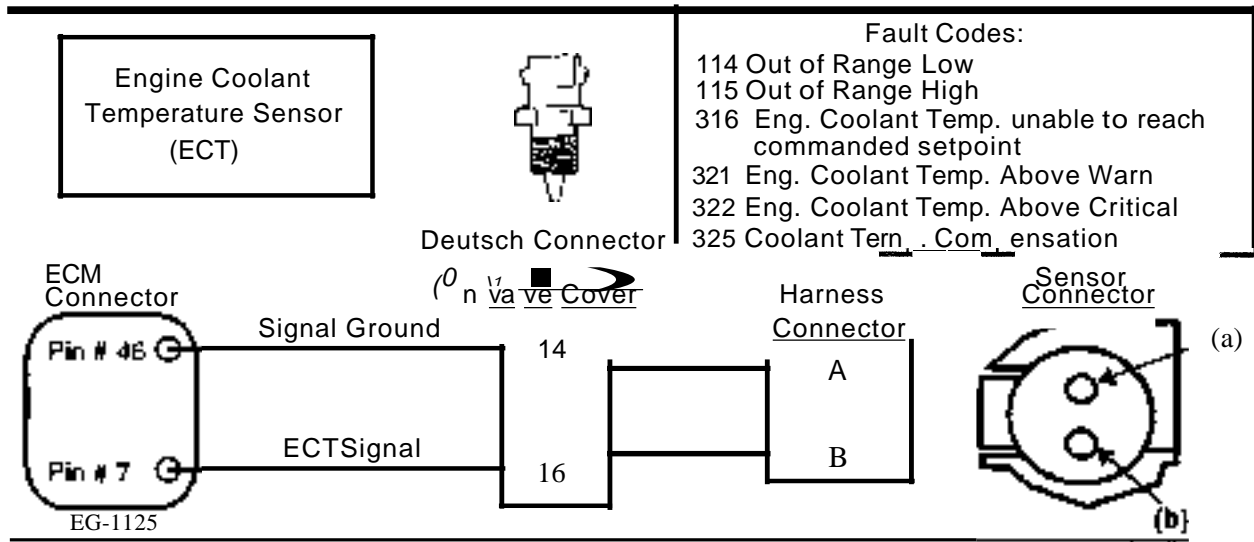
times are directly affected by engine coolant temperature.

Engine Warning and Protection - Optional feature when enabled will warn driver of overheat condition and can be programmed to shut the engine down.

FAULT DETECTION/MANAGEMENT

An ECT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the ECT signal and assume an engine coolant temperature of -29° F (-20° C) for starting and a temperature of 180° F (82° C) for engine running conditions. The WARN lamp will also be illuminated as long as the fault condition exists.

ENGINE COOLANT TEMPERATURE SENSOR (ECT)



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key OFF, if > 5 ohms the harness is open.
8 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	4.6 - 5.0 v	Pull up voltage, if no or low voltage, circuit has open or high resistance or short to Grd.
A to Grd.	0 - .25 v	If greater than .25 volts, wire is shorted to V Ref. or battery

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from harness connector to 60 pin connector - Signal ground
#7 to B	< 5 ohms	Resistance from harness connector to 60 pin connector - ECT Signal

Test Points (+) #7 to (-) #46		Operational Signal Checks (Check with breakout box installed in line with the ECM)		
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
0.53 v	248	120	1.19 K ohms	
0.96 v	212	100	2 K ohms	
1.37v	176	80	3.84 K ohms	
4.37 v	32	0	69.2 K ohms	
4.60 v	-5	-20	131.0 K ohms	

Fault Code Descriptions

Circuit Faults:

- 114 = Signal was less than .127 volts for more than 0.1 seconds. (Probable short to ground.)
- 115 = Signal voltage was greater than 4.8 volts for more than 0.1 seconds. (Probable open circuit.)

Cooling System Faults:

- 316 = Coolant temp. has not reached 41 ° F
- 321 = Engine Coolant Temperature above WARN level 225° F (107° C)
- 322 = Engine Coolant Temperature above Critical level 234° F (112.5°C)
- 325 = Coolant Temperature Compensation enabled,
(Reduces fuel quantity 6% for each degree °C above 214° F (101°C))

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

ENGINE COOLANT TEMPERATURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Engine Coolant Temperature sensor. The ECM measures the Engine Coolant Temperature signal and uses this information for Coolant Temperature Compensation and optional high temperature warning and shut down systems.

Coolant temperature Compensation is used to protect the engine if the coolant temperature is too high. The ECM monitors the ECT signal to determine the coolant temperature. If the coolant reaches 214°F (101°C), the ECM will reduce the fuel delivery by 6% for each Celsius degree of temperature increase. If the coolant temperature increases to 218°F (104°C), fuel quantity will be reduced 3% for each Celsius degree of temperature increase. Coolant Temperature Compensation can be programmed to be inoperative in certain applications where full engine performance is required over the protection of the engine.

On engines equipped with an engine warning system, the ECM will activate the audible warning alarm and illuminate the red Oil/Water warning light when the engine coolant temperature reaches 225°F (107°C).

On engines equipped with an engine shut down system, the ECM will shut the engine off when the coolant temperature reaches 235°F (112.5°C). The vehicle operator may restart the engine by turning the ignition key "OFF" and then restarting it. Upon restart, the ECM will allow the engine to run for an additional 30 seconds, before shutting off the engine again.

OPERATION

The Engine Coolant temperature sensor is a thermistor type sensor which changes resistance when exposed to different temperatures.

When the temperature of the coolant is decreased, the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the coolant is increased the resistance of the thermistor decreases, which causes the signal voltage to decrease.

The ECT sensor is supplied a regulated 5 volt reference voltage from ECM terminal 7. The sensor is

grounded at terminal A through the signal return, terminal 46, at the ECM. As the coolant temperature increases or decreases, the sensor changes resistance and provides the ECM with the coolant temperature signal voltage at terminal 7 of the ECM. This signal voltage is then read by the ECM to determine the temperature of the coolant.

ECM DIAGNOSTICS

With the ignition key "ON", the ECM continuously monitors the ECT circuit for expected voltages. If the signal voltage is less than or more than expected the ECM will set a fault code.

If the ECM detects a fault in the ECT signal, the ECM will disregard the signal and default to a temperature of 180°F (82°C) for engine running operation and -4°F (-20°C) for starting the engine. If the fault is no longer present, the ECM will once again return to normal operation using the ECT signal for processing.

Faults in the ECT signal can be retrieved using the Self Test Input Switch (STI) or the Electronic Service Tool. If the fault is no longer present, it will be stored as an Inactive Code.

FLASH CODE 114
AIA CODE PID 110 FMI4
Eel: *OUT OF RANGE LOW*

An out of range low code will be set if the ECM detects a voltage less than .127 volts for more than 0.1 seconds. If this fault is Active, the ECM will use the default value of 180°F (82°C).

Code 114 may be caused by a short to ground or a shorted or biased sensor.

FLASH CODE 115
ATA CODE PIO 110 FMI3
ECI: *OUT OF RANGE HIGH*

An out of range high code will be set if the ECM detects a voltage greater than 4.6 volts for more than 0.1 seconds. If this fault is Active, the ECM will use the a default value of 180°F (82°C).

Code 115 may be caused by an open circuit, an open sensor, or a short to another voltage source.

**ENGINE COOLANT TEMPERATURE SENSOR
EXTENDED SYSTEM DESCRIPTION (Continued)**

FLASH CODE 316
ATA CODE PID 110 FMI1
*ENGINE COOLANT TEMPERATURE UNABLE
TO REACH COMMANDED SETPOINT*

Code 316 will only be set with engines that have the Cold Ambient Protection (CAP) System enabled. This code will be set after the engine has run for greater than 120 minutes and has not exceeded 147°F (75°C) for vehicles with manual transmissions and 140°F (60°C) for vehicles with automatic transmissions.

NOTE: THIS CODE ONLY INDICATES THAT THE ENGINE HAS NOT BEEN ABLE TO REACH OPERATING TEMPERATURE. IT DOES NOT INDICATE AN ELECTRONIC FAULT.

Possible causes of code 316: Extended idle time, cold ambient temperatures, (may require use of winter front), thermostat stuck open, mis-plumbed cooling system (thermostat bypass bypassed), auxiliary heater cores cooling off engine (school bus applications or fan clutch locked on).

FLASH CODE 321
ATA CODE PID 110 FMI 0
*ENGINE COOLANT TEMPERATURE
ABOVE WARNING LEVEL*

Code 321 will be set if the ECM detects engine coolant temperature above 225°F (107°C). When this occurs, the ECM illuminates the OIUWATER warning light and sounds the audible alarm (if equipped), alerting the operator that a potential for engine damage exists.

If the temperature drops below 225°F(107°C), the code will become inactive and the ECM will return to normal operation.

FLASH CODE 322
ATA CODE PIO 110 FMI 7
*ENGINE COOLANT TEMPERATURE ABOVE
CRITICAL LEVEL*

Code 322 will be set if the ECM detects engine coolant temperature above 235°F (112.5°C). When this occurs, the OIUWATER warning light illuminates and the audible alarm sounds (if equipped) will alert the operator that the temperature is increasing (having set code 321) indicating a potential for engine damage. With code 322 active, the engine will shut down. At the same time the code and current engine hours will be recorded in the VPM as an Engine Event.

If the temperature drops below 235°F (112.5°C), the code will become inactive and the ECM will return to normal operation. Should the engine shut down, it can be restarted to move the vehicle to a safe place.

FLASH CODE 325
ATA CODE PID 110 FMI14
*POWER REDUCED, MATCHED TO COOLING
SYSTEM PERFORMANCE*

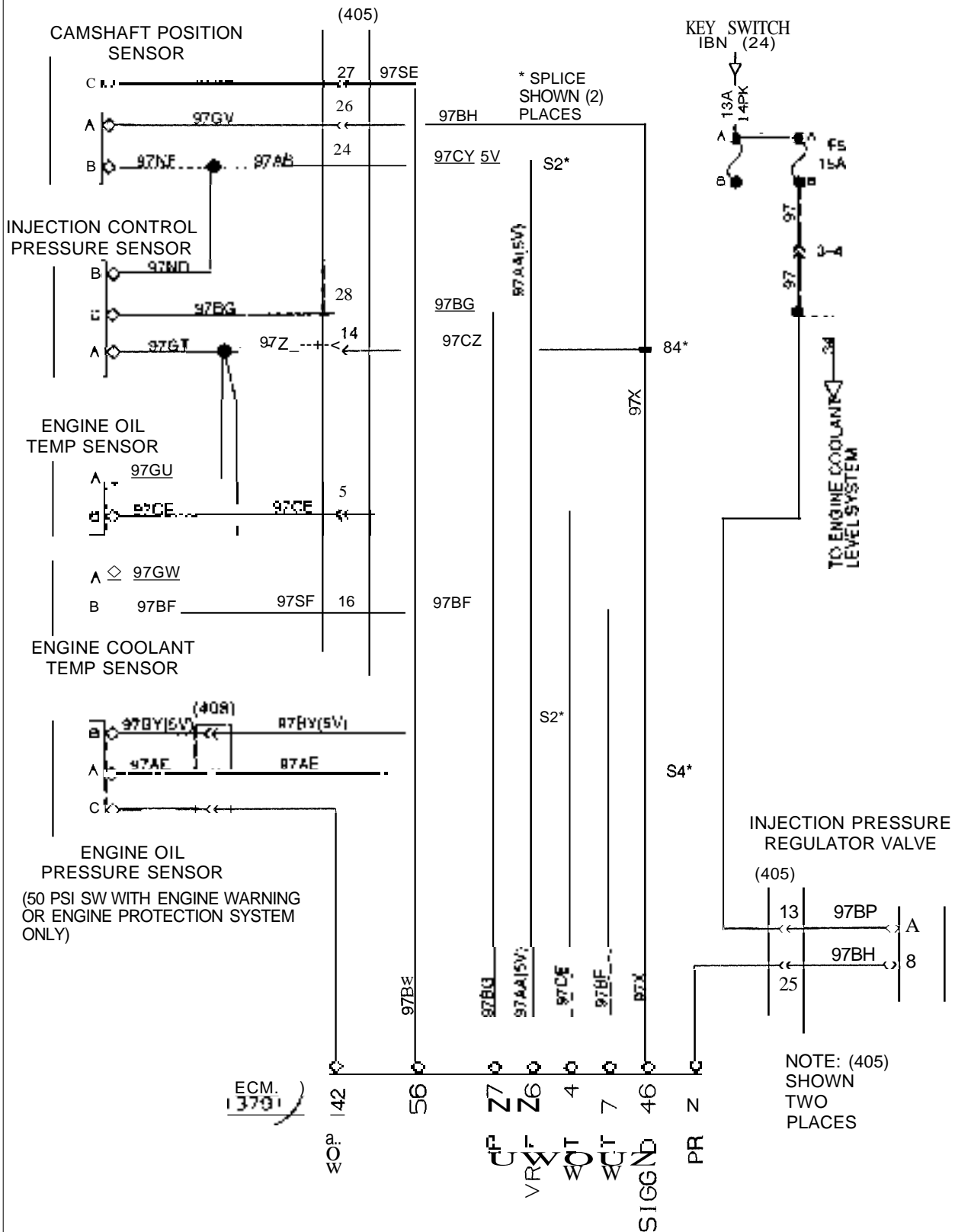
Code 325 will be set if the cooling system temperature exceeds 214°F (101°C). At this temperature the ECM will reduce the fuel delivered to the engine at or near the maximum demand level. For each one Celsius degree of temperature the fuel will be reduced 6%. This reduces the heat produced by the engine thereby reducing the burden on the engine cooling system. It will also slow the vehicle speed encouraging the operator to downshift, thus increasing the efficiency of the cooling system.

As the temperature is reduced the compensation level is reduced until the temperature drops below 214°F (101°C) at which normal operation is resumed.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

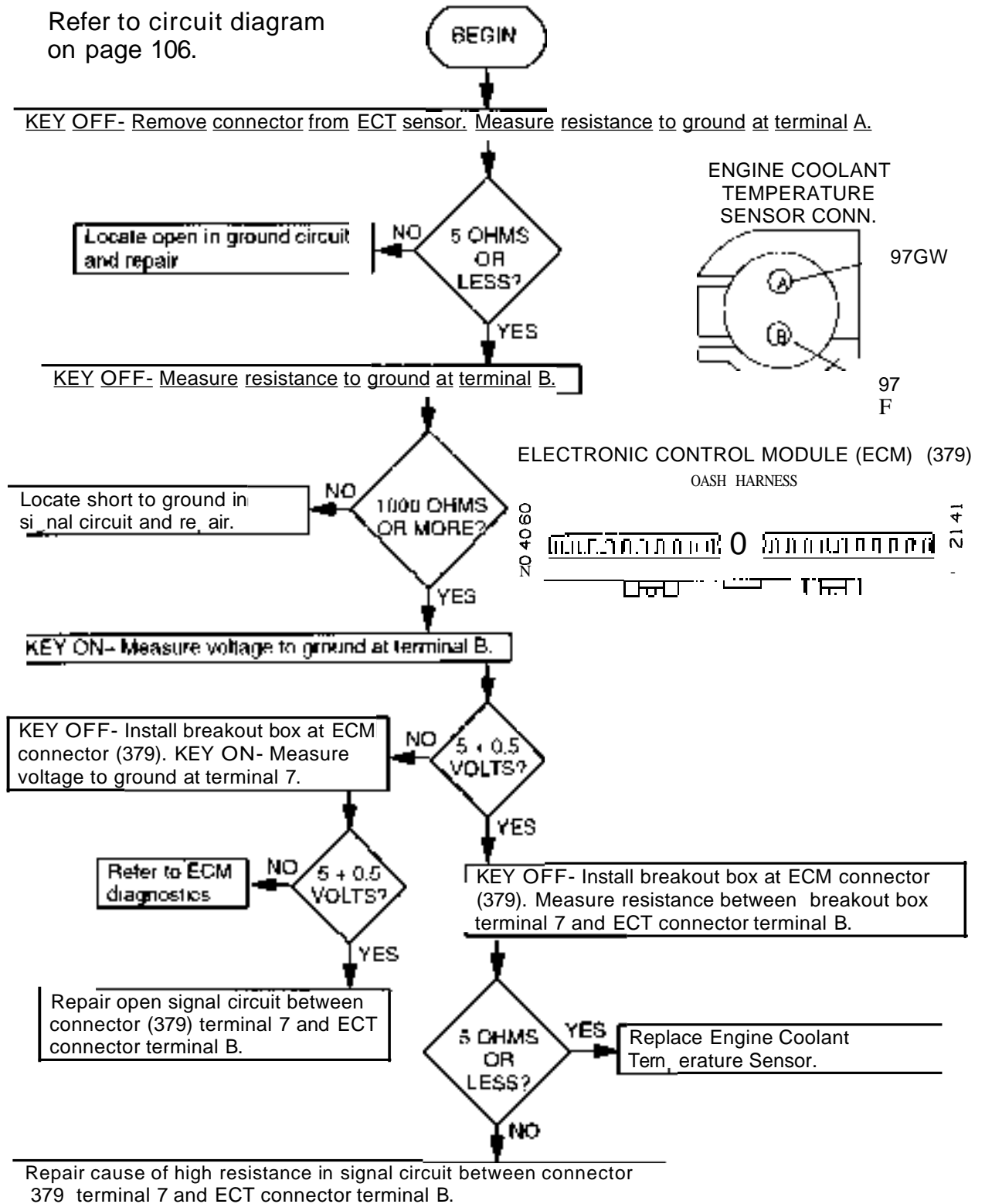
SENSOR CIRCUIT DIAGRAM



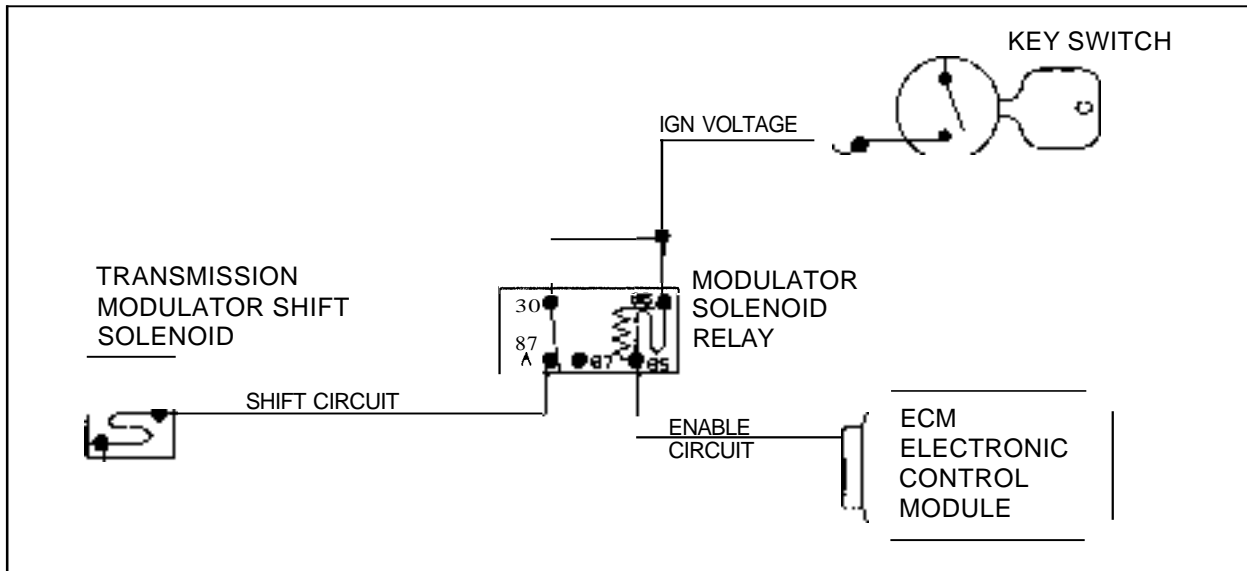
ENGINE COOLANT TEMPERATURE SENSOR (ECT)

ENGINE COOLANT TEMPERATURE (ECT) SENSOR DIAGNOSTICS

Refer to circuit diagram on page 106.



(EDL) ENGINE DATA LINE WITH ALLISON AT/MT TRANSMISSION



CIRCUIT FUNCTIONS

The Electronic Control Module is programmed with two shift schedules: The Closed Throttle Mode and the Wide Open Throttle Mode.

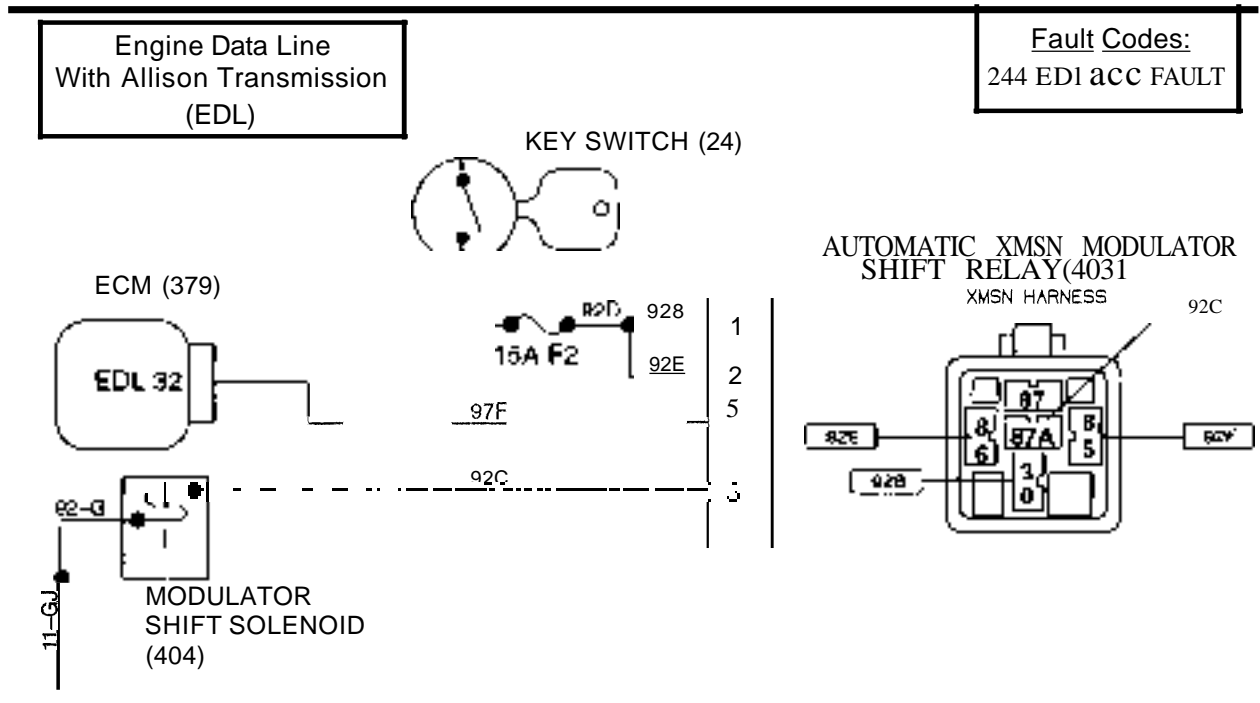
1. The Closed Throttle Mode is for situations with moderate engine load. ECM terminal 32 will be Low (0 volts). This energizes the relay, turning off power to the solenoid, causing the transmission to shift at approximately 65% of engine load.
2. The Wide Open Throttle Mode is for heavy load situations. ECM terminal 32 will be High (12 volts). This de-energizes the relay causing 12 volts to be applied to the solenoid. In this mode, the ECM has shift schedules that occur at 80% of engine load.

When the engine is operating at less than the load shift point, ignition voltage is not applied to the shift solenoid. When the ECM commands a shift, the relay coil ground is opened by the ECM, which de-energizes the relay, turning ON the power to the shift solenoid, causing it to shift.

FAULT DETECTION

The ProLink EST is used to initiate the KOEO Output Circuit Tests. This will test the enabling circuit between the key switch, through the relay coil and circuit to ECM terminal 32. If an open or short (high or low) is found in this circuit, Flash Code 244 will be set.

Note that the test does not check relay function or the circuit to the shift solenoid.



NOTE: Check fuse F2 and either test relay (refer to Bench Testing Relay on page 113) or substitute known good relay and check vehicle shift operation before testing circuits.

(BATTERY MUST BE IN A FULL CHARGE CONDITION)

Connector Checks To Chassis Ground

Connector (403) - Check connector with relay removed and key ON

Test Points	Spec.	Comments
#30 to Grd.	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open/short to ground or blown fuse
#86 to Grd.	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open/short to ground or blown fuse
#86 to #87A	>10.0 volts	< than 10.0 v check circuit connections, 0 v check for open in circuit 92C or 92-G or defective solenoid.
#30 to #85	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open in circuit 97F.

Connector (403) - Check with breakout box installed and relay removed from (403) and key ON. Use ProLink EST to initiate Output State Test and set outputs HIGH (refer to SECTION 5.2 for performing Output State Test).

Test Points	Spec.	Comments
Breakout box #32 to Grd.	12 ± 1.5 volts	< 12 ± 1.5 volts the ECM is defective
At (403) terminal 85 to Grd.	12 ± 1.5 volts	< than 10.5 v check connections, 0 v check for open/short to ground in circuit 97F.

Fault Code Descriptions

244 = Output circuit check performed during Engine Off test detected high or low resistance in EDL relay coil circuit.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5

Page 110 ENGINE DATA LINE WITH ALLISON AT/MT TRANSMISSIONS (EDL)

EXTENDED DESCRIPTION

Engine Data Line (EDL) output from the ECM controls the Transmission Modulator Shift Solenoid Control Relay (403), which in turn controls the Transmission Modulator Shift Solenoid (404).

The ECM is programmed with two shift schedules: Closed Throttle Mode and Wide Open Throttle Mode. The Closed Throttle Mode schedule for a transmission is for situations with a moderate engine load. The transmission will shift at approximately 65 percent of engine load. The Wide Open Throttle Mode shift schedule has shift points that occur at 80 percent of engine load. This provides increased power in heavy load situations for passing or faster acceleration.

The ECM analyzes engine operating data and determines which mode is most appropriate for current operation. The physical Allison transmission uses EDL output from ECM connector (379) terminal 32 to select the most appropriate shift schedule depending upon engine loads.

Refer to the circuit diagram on page 111 for the following discussion.

When ECM terminal 32 is LOW (0 volts), the transmission operates in the Closed Throttle Mode (normal shift schedule). When ECM terminal 32 is HIGH (12 volts), the transmission operates in the Wide Open Throttle Mode.

WIDE OPEN THROTTLE MODE OPERATION

In the Wide Open Throttle Mode, ECM terminal 32 is HIGH (12 volts) and the XMSN Shift Modulator (404) is energized. The Transmission Modulator Shift Solenoid Control Relay (403) receives ignition power at common terminal 30 and control coil terminal 186. When ECM terminal 32 is HIGH (12 volts), circuits 97F and 92E have 12V so the relay (403) does not energize. The ignition power on circuit 928 goes through the normally closed (N.C.) contacts

(30 to 87A) to the Transmission Modulator Shift Solenoid (404), causing the shift solenoid to energize.

CLOSED THROTTLE MODE OPERATION

In the Closed Throttle Mode, ECM terminal 32 is LOW (0 volts) and Transmission Shift Modulator (404) is not energized. When ECM terminal 32 is LOW (0 volts), circuit 97F grounds the Modulator Shift Control Relay control coil causing the relay to energize, opening the normally closed (N.C.) contacts (30 to 87A) in relay (403), TURNING OFF the power to the Transmission Modulator Shift Solenoid (404), which is de-energized.

ECM DIAGNOSTICS

The ECM does not continuously monitor the EDL circuits. To check these circuits use the Prolink EST to perform the KOEO - Output Circuit Checks (OCC).

FLASH CODE 244
ATA CODE SID 248 FMI11
ECM: *EDL DCC FAULT*

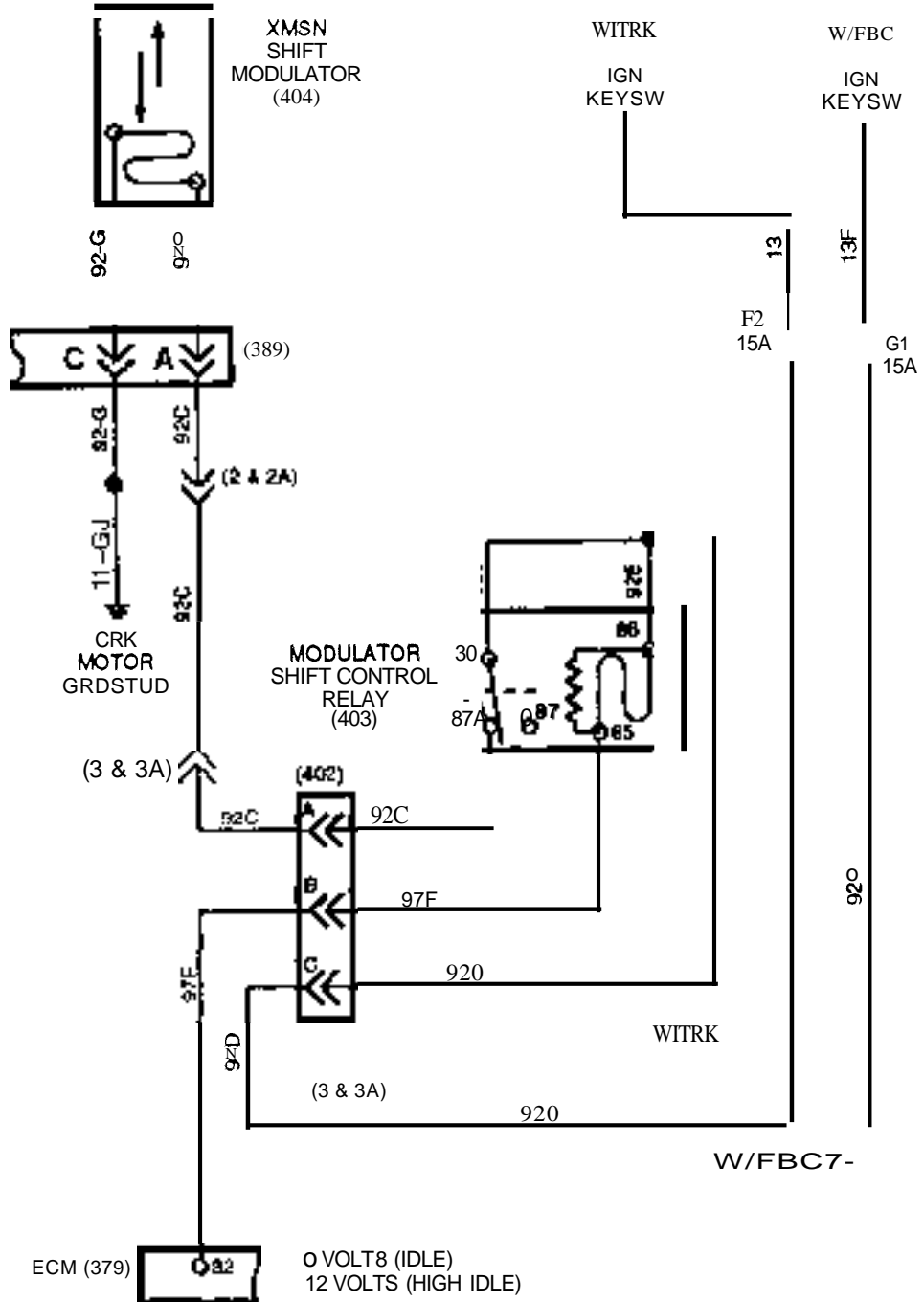
The OCC Test checks the Relay Control Coil circuits 97F, 920, 92E and the relay control coil for opens or shorts (high or low). If a defect is noted, Flash Code 244 will be set. The Engine Warning light does not turn ON.

Note that the ECM diagnostics DO NOT check the actual operation of the Modulator Shift Solenoid Control relay (403) or the Modulator Shift Solenoid (404). The ECM diagnostics also do not check circuits 928, 92C, 92-G or 11-GJ. For these reasons, it is possible for the Allison AT/MT transmission Modulator Shift Solenoid not to function, without a fault code. Testing Modulator Shift Control Circuits located in TROUBLESHOOTING on page 112 include tests for these circuits.

If Flash code 244 is active or the transmission shift modulator does not operate properly perform Testing Modulator Shift Solenoid (404) Circuits on page 112.

CIRCUIT DIAGRAM

MODULATOR SHIFT SOLENOID W/ALLISON AT XMSN



TROUBLESHOOTING

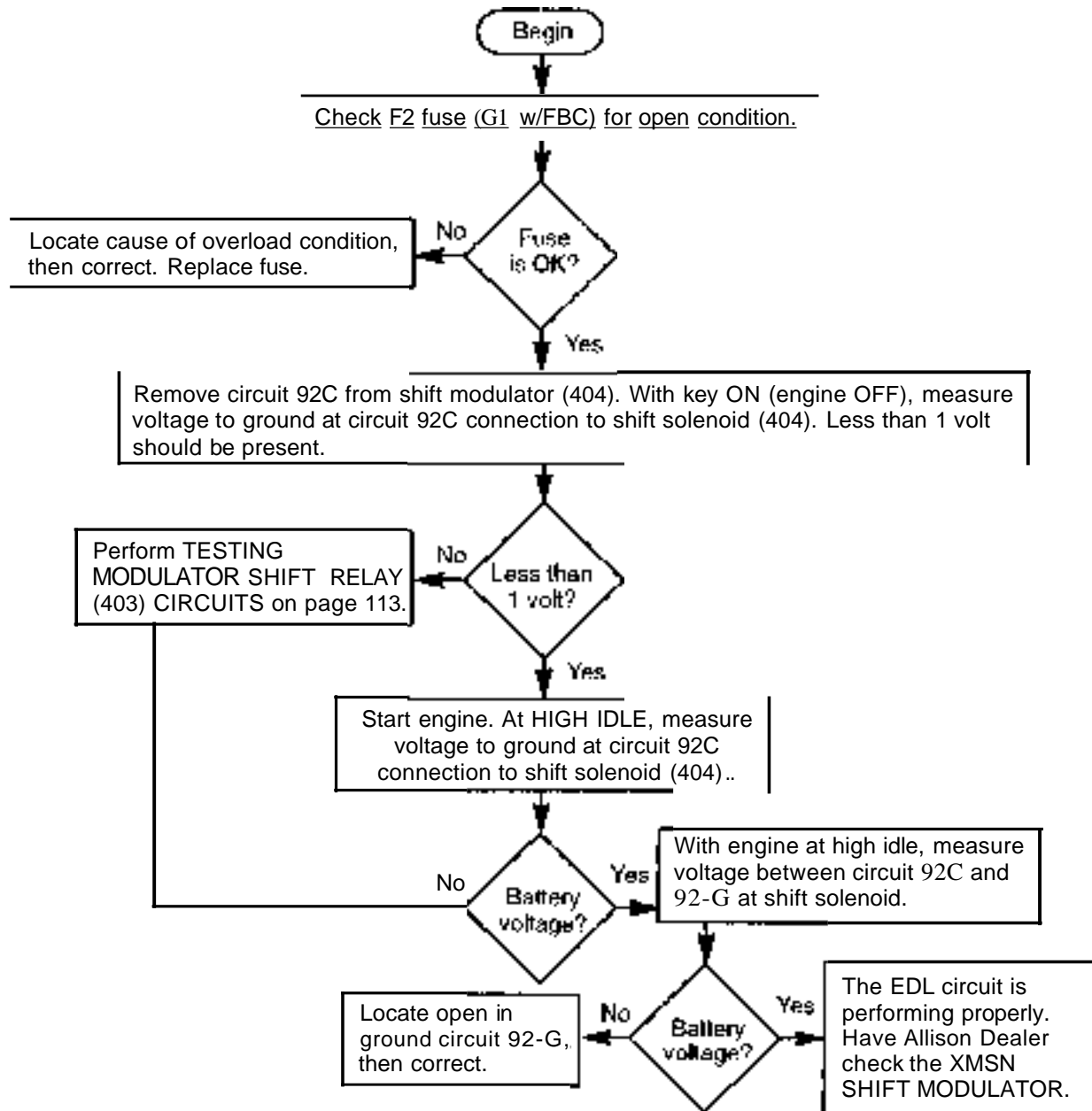
BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery cables and grounds for clean, tight connections free from damage. The voltage tests will give misleading readings if the batteries are not fully charged.
- B. Before troubleshooting, inspect connectors for pushed back, loose or damaged (spread or

dent) terminals, or wires with cut strands etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.

- C. Before troubleshooting, inspect the suspect circuit grounds for clean, tight connections free of any damage.

TESTING MODULATOR SHIFT SOLENOID (404) CIRCUITS

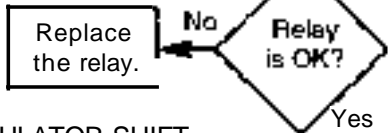


TESTING MODULATOR SHIFT CONTROL RELAY (403) CIRCUITS

Continued from
TESTING POWER TO
MODULATOR SHIFT
SOLENOID (404).

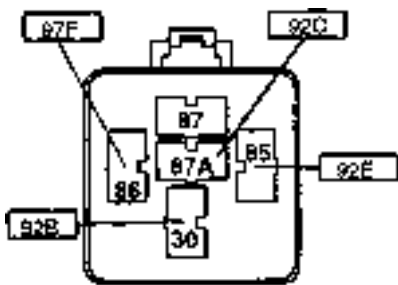
With key OFF, remove relay from connector (403).
Remove connector (379) from ECM and install
breakout box to harness connector only (not to ECM).

With relay removed, bench test the relay.



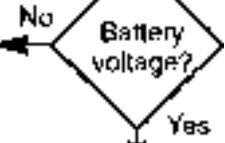
MODULATOR SHIFT
CONTROL RELAY (403)

HARNESS



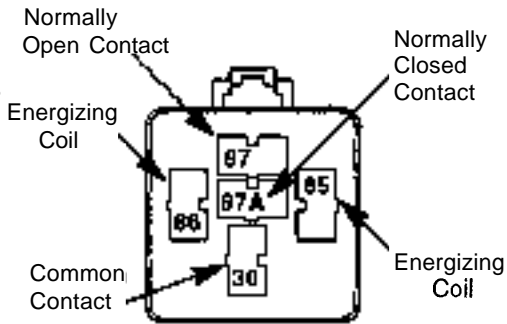
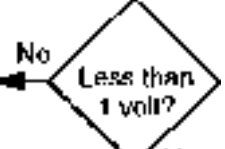
CONNECTOR - 1001747001
TERMINAL - 10010270

Locate cause of NO or
LOW voltage in circuit(s)
928, 92E or 92D from
fuse, then correct.



With key ON, measure voltage to ground at (403) terminals 2 (97F) and 3 (92C).

Locate short circuit to
"HOT" wire in circuit where
terminal voltage is more
than 1 volt, then correct.



Typical Relay Insertion End

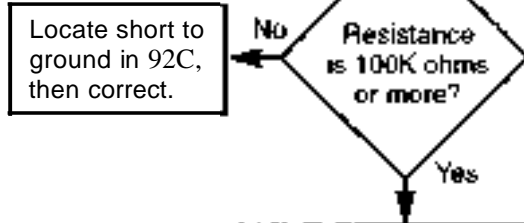
BENCH TESTING RELAY

1. Connect (+) battery lead to terminal 86 and (-) lead to terminal 85.
 - A. If relay energizes making an audible "click" sound, go to step 2.
2. With relay energized, measure resistance between terminals 30 and 87A.
 - A. If resistance is 100k ohms or more, go to step 3, otherwise replace the relay.
3. Remove battery leads and measure resistance between terminals 30 and 87A.
 - A. If resistance is less than 2 ohms, the relay is good. Otherwise replace the relay.

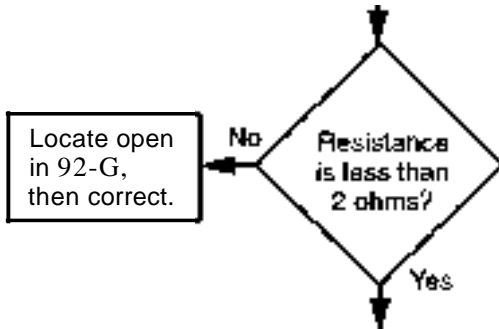
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TESTING MODULATOR SHIFT CONTROL RELAY (403) CIRCUITS (Continued)

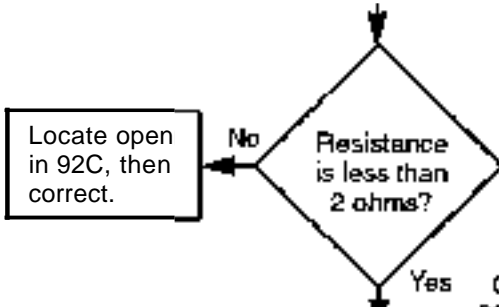
With key OFF, disconnect circuit 92C from solenoid (404). Measure resistance to ground at 92C.



With key OFF, measure resistance to ground at 92-G.



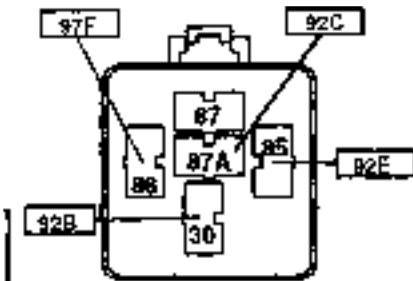
With key OFF, connect circuits 92-G and 92C together, then at connector (403) measure resistance to ground at terminal 3 (92C).



Connect 92C & 92-G to solenoid.

With key OFF, measure resistance between breakout box terminal 32 and connector (403) terminal 2 (97F).

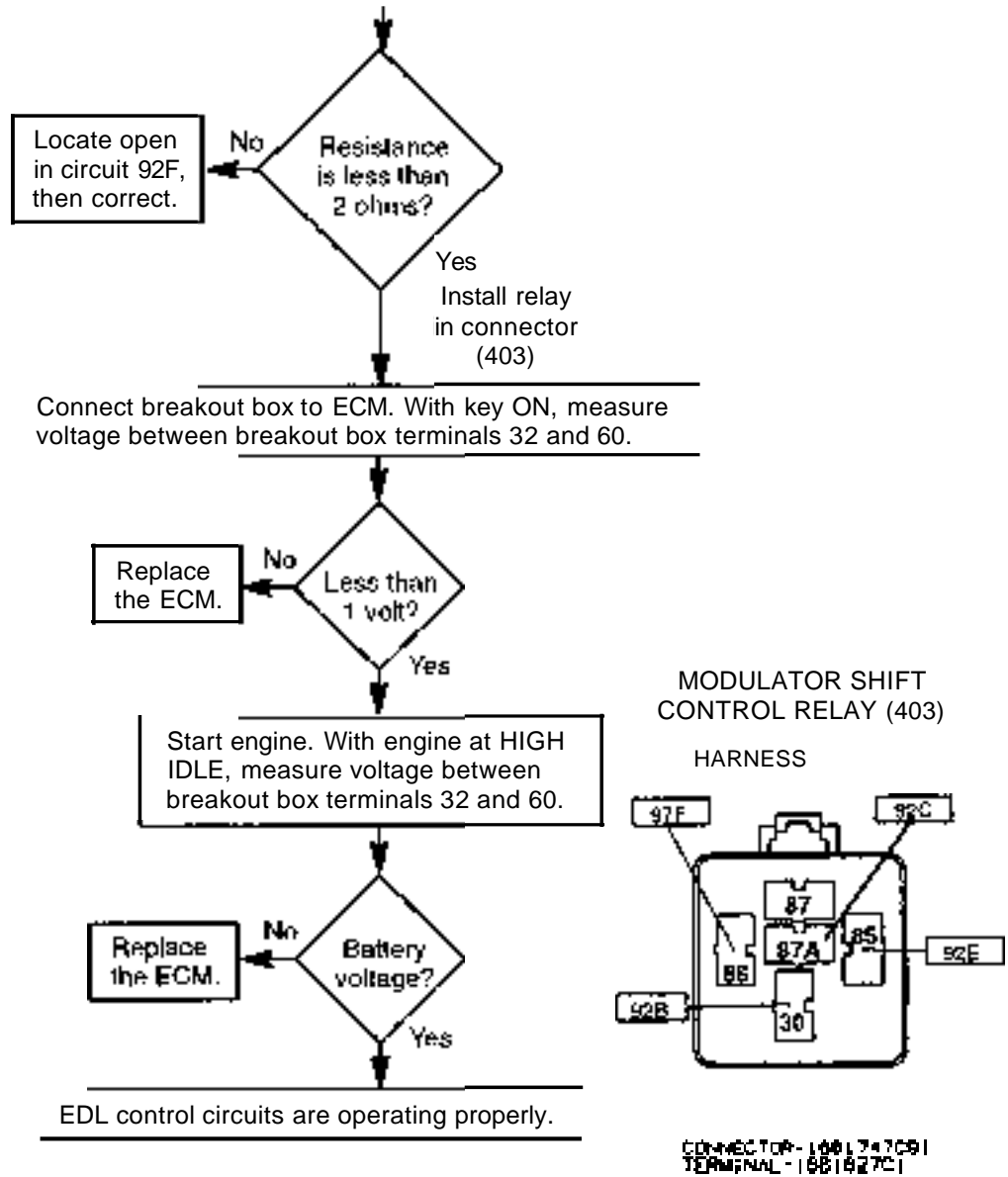
MODULATOR SHIFT CONTROL RELAY (403) HARNESS



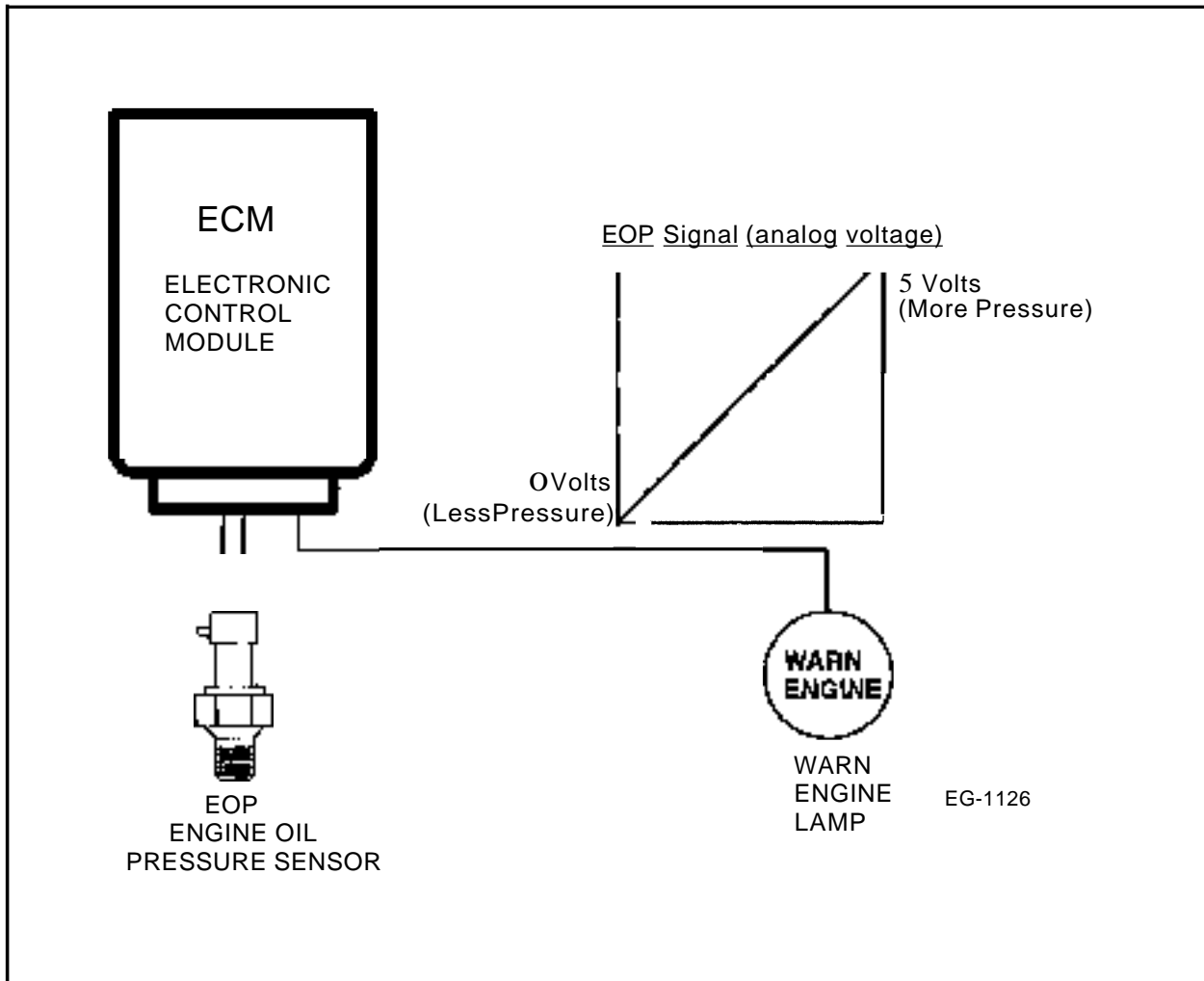
CONNECTOR, 60, 743091
TERMINAL - 10614270

: See next :
page :
..... :

TESTING MODULATOR SHIFT CONTROL RELAY (403) CIRCUITS (Continued)



ENGINE OIL PRESSURE (EOP) SENSOR



SIGNAL FUNCTIONS

The Engine Oil Pressure (EOP) sensor is a variable capacitance sensor, that, when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates engine oil pressure.

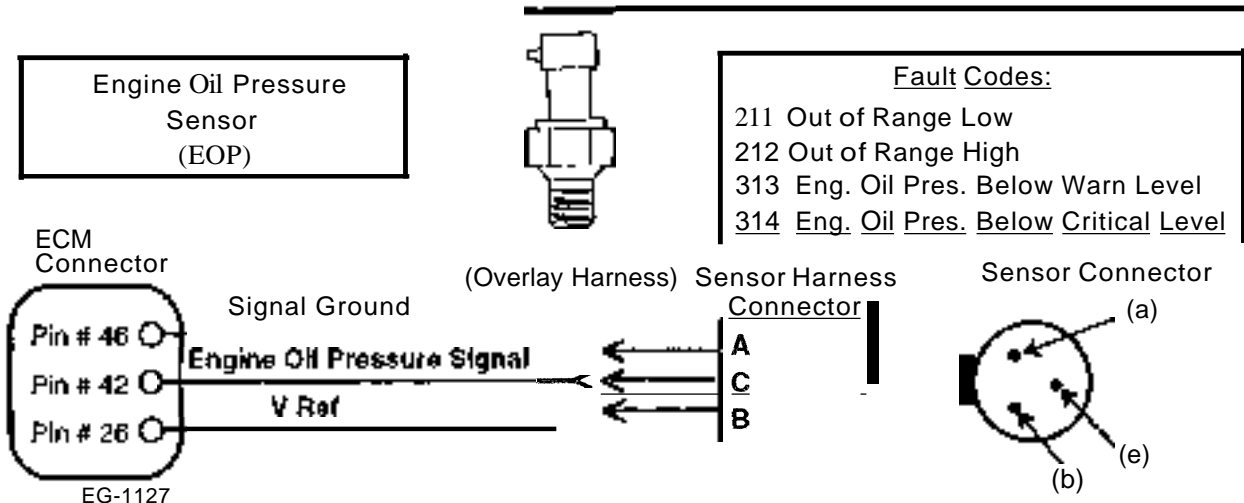
Engine Warning and Protection - An optional feature which, when enabled, will warn driver of low engine oil pressure condition and can be programmed to shut the engine down.

FAULT DETECTION/MANAGEMENT

An EOP signal that is detected out of range high or low by the ECM will cause the engine to ignore the EOP signal and disable Engine Warning and Protection.

NOTE: The EOP sensor only reads **0-38** psi.

ENGINE OIL PRESSURE SENSOR (EOP)



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground check with key off, if > than 5 ohms harness is open.
8 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	5 volts ±.5	V Ref. check with key ON, if voltage not in spec. , see V Ref circuit
C to Grd.	0-.25 volts	If greater than 0.25 volts signal ground wire is shorted to V Ref of battery.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector - Signal ground
#26 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector - V Ref
#42 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector - EOP signal

Test Points (+) #42 to (-) #46		Operational Signal Checks (Check with breakout box installed in line with the ECM)	
Voltage	PSJ	kPA	Comments
1.39 v	5	34	
1.89 v	10	69	
2.9 v	20	138	
3.81 v	38	262	Maximum pressure sensor is capable of measuring

Circuit Faults:

Fault Code Descriptions

211 = Signal was less than .039 volts for more than 0.1 seconds.
212 = Signal voltage was greater than 4.9 volts for more than 0.1 seconds.

Oil Pressure Faults:

313 = Engine oil pressure < 5 psi (34 kPa) @ 700 RPM or 10 psi (69 kPa) @ 1400 RPM or 20 psi (138 kPa) @ 2000 RPM
314 = Engine oil pressure < 2 psi (14 kPa) @ 700 RPM or 5 psi (34 kPa) @ 1400 RPM or 12 psi (152 kPa) @ 2000 RPM

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE OIL PRESSURE SENSOR (EOP)

ENGINE OIL PRESSURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Engine Oil Pressure sensor (EOP) is included in Navistar engine control system only when a vehicle is equipped with either the Engine Warning or optional Engine Shutdown engine monitoring system.

The ECM measures the EOP signal to monitor the oil pressure during engine operation. If the oil pressure drops below 5.0 PSI (34kPa) @ 700 RPM or 10.0 PSI (69 kPa) @ 1400 RPM or 20.0 PSI (138 kPa) @ 2000 RPM, the ECM will illuminate the OIU WATER WARN light and sound the audible warning alarm. If the vehicle is equipped with the Engine Shut down system and the oil pressure drops to 2.0 PSI (14kPa) @ 700 RPM or 5.0 PSI (34 kPa) @ 1400 RPM or 12.0 PSI (152 kPa) @ 2000 RPM, the ECM will shut the engine off.

OPERATION

The Engine Oil Pressure sensor is a variable capacitance sensor. When pressure is applied to the sensor, the capacitance changes in relation to the pressure.

The ECM supplies a regulated 5 volt signal to terminal B of the EOP sensor from terminal 26 of the ECM. The EOP sensor is supplied a signal return (ground) at terminal A to terminal 46 of the ECM.

During engine operation, oil pressure acting on the sensor causes the sensor's capacitance to vary which changes the incoming 5 volt reference signal in relation to pressure. The sensor's oil pressure signal at terminal C is sent to terminal 42 of the ECM. This signal increases equally in proportion to an increase in pressure up to a maximum of 38 PSI (262 kPa).

ECM DIAGNOSTICS

The ECM continuously monitors the signal from the EOP sensor to ensure the signal is within the correct operating range. If the signal is lower or higher than required, the ECM will set a fault code. This fault code is retrieved using the Electronic Service Tool (EST) or by reading the flash code using the STI diagnostic switch. If the ignition key is shut off, the code will be stored as an inactive code.

During engine operation, the ECM also monitors the engine speed signal. It compares the expected oil pressure specification versus engine speed. If the ECM detects that the oil pressure is lower for a given engine speed, the ECM will set a fault code. If the pressure is lower than the "critical" level, the ECM

will record a fault code. The VPM will automatically record this as a low oil pressure "Event" which is stored in the VPM memory and cannot be erased using the EST. This becomes a record of operation of the engine.

FLASH CODE 211

ATA CODE PID 100 FMI 4

*ENGINE OIL PRESS SIGNAL OUTOF RANGE
LOW*

An out of range low code will be set if the ECM detects a voltage less than .039 volts for more than 0.1 seconds. If this fault code is set the ECM will ignore the EOP signal and continue to operate normally. However, if the fault is Active, the ECM will turn on the Engine Warning light.

Code 211 may be caused by an open Vref feed, open signal circuit or a defective sensor.

FLASH CODE 212

ATA CODE PID 100 FMI3

*ENGINE OIL PRESSURE SIGNAL OUTOF
RANGE HIGH*

An out of range high code will be set if the ECM detects a voltage more than 4.9 volts for more than 0.1 seconds. If this fault code is set, the ECM will ignore the EOP signal and continue to operate normally. If this fault is active, the ECM will illuminate the Engine Warning light.

Code 212 may be caused by an open signal return circuit, a short to a voltage source or a defective sensor.

FLASH CODE 313

ATA CODE PID 100 FMI1

*ENGINE OIL PRESSURE BELOW WARNING
LEVEL*

Code 313 indicates that the oil pressure has dropped below the warning level. The specification for the warning level is 5.0 PSI (34kPa) @ 700 RPM or 10.0 PSI (69 kPa) @ 1400 RPM or 20.0 PSI (138 kPa) @ 2000 RPM.

Code 313 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.

NOTE: IT MAY BE POSSIBLE TO SET THIS CODE AT START-UP, ESPECIALLY IF THE OIL WAS JUST CHANGED, OR AFTER A REBUILD UNTIL THE OIL SYSTEM IS PRIMED.

ENGINE OIL PRESSURE SENSOR (EOP)

ENGINE OIL PRESSURE SENSOR
EXTENDED SYSTEM DESCRIPTION
(Continued)

FLASH CODE 314
ATA CODE 100 FMI7
*ENGINE OIL PRESSURE BELOW CRITICAL
LEVEL*

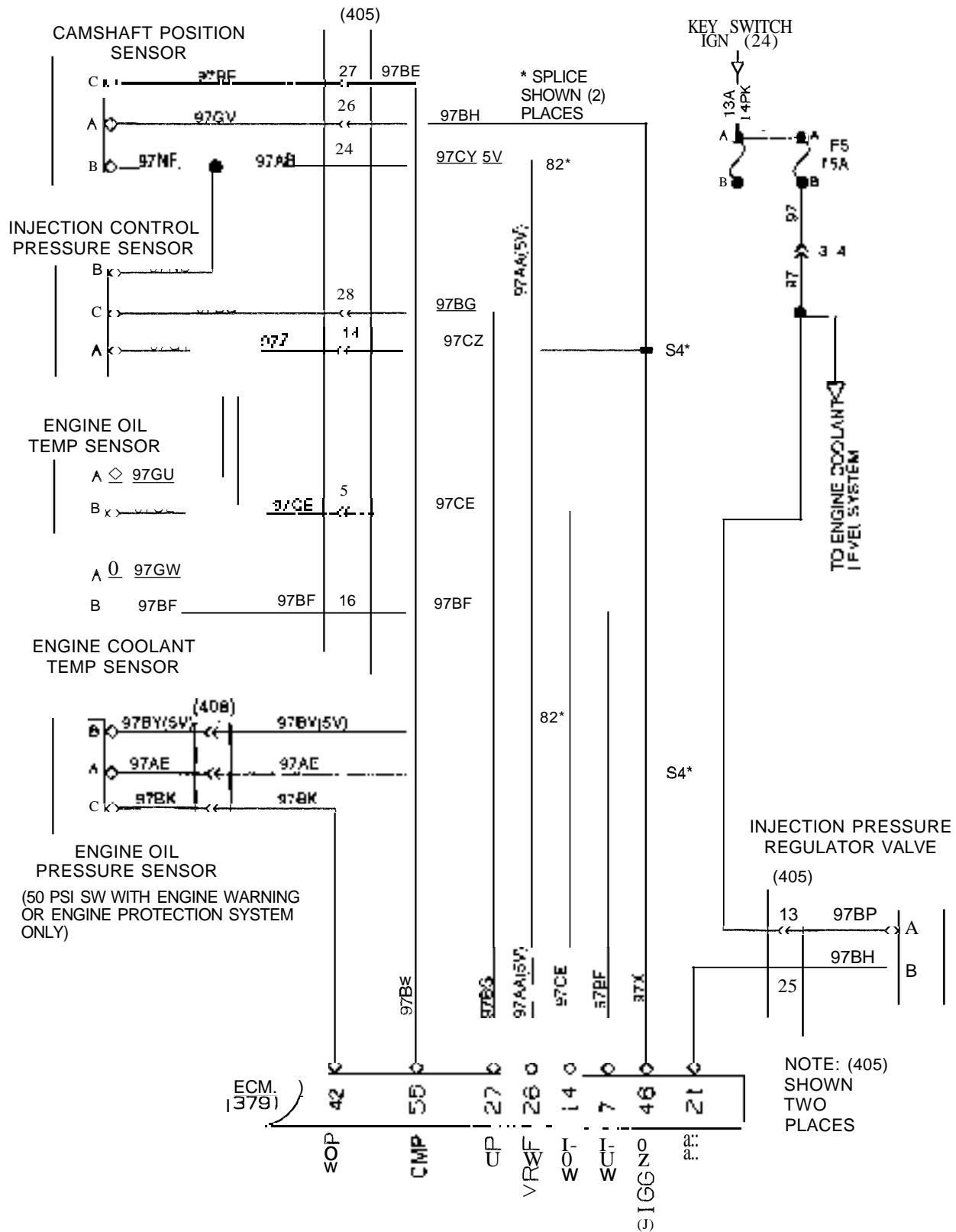
If flash code 314 is set, this indicates that the oil pressure has dropped below the critical level. The specification for the critical level is 2.0 PSI (14kPa) @ 700 RPM or 5.0 PSI (34 kPa) @ 1400 RPM or 12.0 PSI (152 kPa) @ 2000 RPM.

Code 314 may be caused by a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set this code.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE OIL PRESSURE SENSOR (EOP)

SENSOR CIRCUIT DIAGRAM



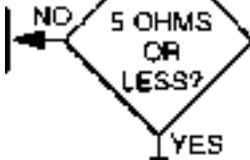
ENGINE OIL PRESSURE SENSOR (EOP)

ENGINE OIL PRESSURE (EOP) SENSOR DIAGNOSTICS

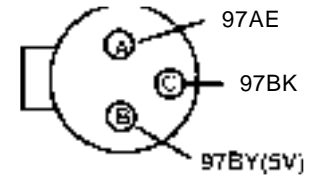
Refer to circuit diagram on page 120.

KEY OFF- Remove connector from oil pressure sensor. At harness connector, measure resistance to ground at terminal A.

Locate open in ground circuit and repair.

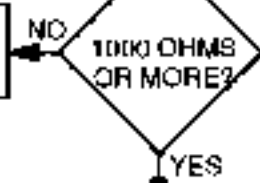


ENGINE OIL PRESSURE SENSOR CONN.



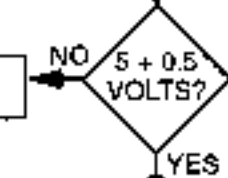
KEY OFF- At oil pressure sensor connector, measure resistance to ground at terminals B and C.

Locate short to ground in circuit with less than 1000 ohms, then repair.



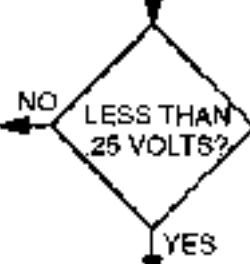
KEY ON- Measure voltage to ground at connector terminal B.

Refer to VREF Diagnostics



KEY ON- Measure voltage to ground at terminal C and A.

Locate short to unwanted voltage source and repair



Continued On Next Page

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE OIL PRESSURE SENSOR (EOP)

ENGINE OIL PRESSURE (EOP) SENSOR DIAGNOSTICS (Continued)

KEY OFF- Install breakout box at ECM connector (379). Measure resistance between ECM terminal 42 and EOP connector terminal C.

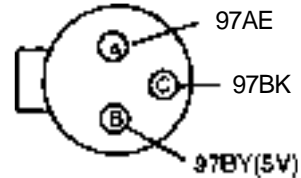
Locate open in signal circuit between ECM connector (379) and EOP connector and repair.

NO

5 OHMS OR LESS?

YES

ENGINE OIL PRESSURE SENSOR CONN.



Attach connector to EOP sensor. With key ON and engine running, measure voltage between breakout box terminals 42 and 46. Use table and compare readings with actual engine oil pressure.

Replace the engine oil pressure sensor.

NO

VOLTAGE AGREES WITH TABLE

YES

VOLTS	PSI
1.39	5
1.89	10
2.90	20
3.81	38

Refer to ECM diagnostics. VPM may not be programmed with Oil Pressure Monitoring.

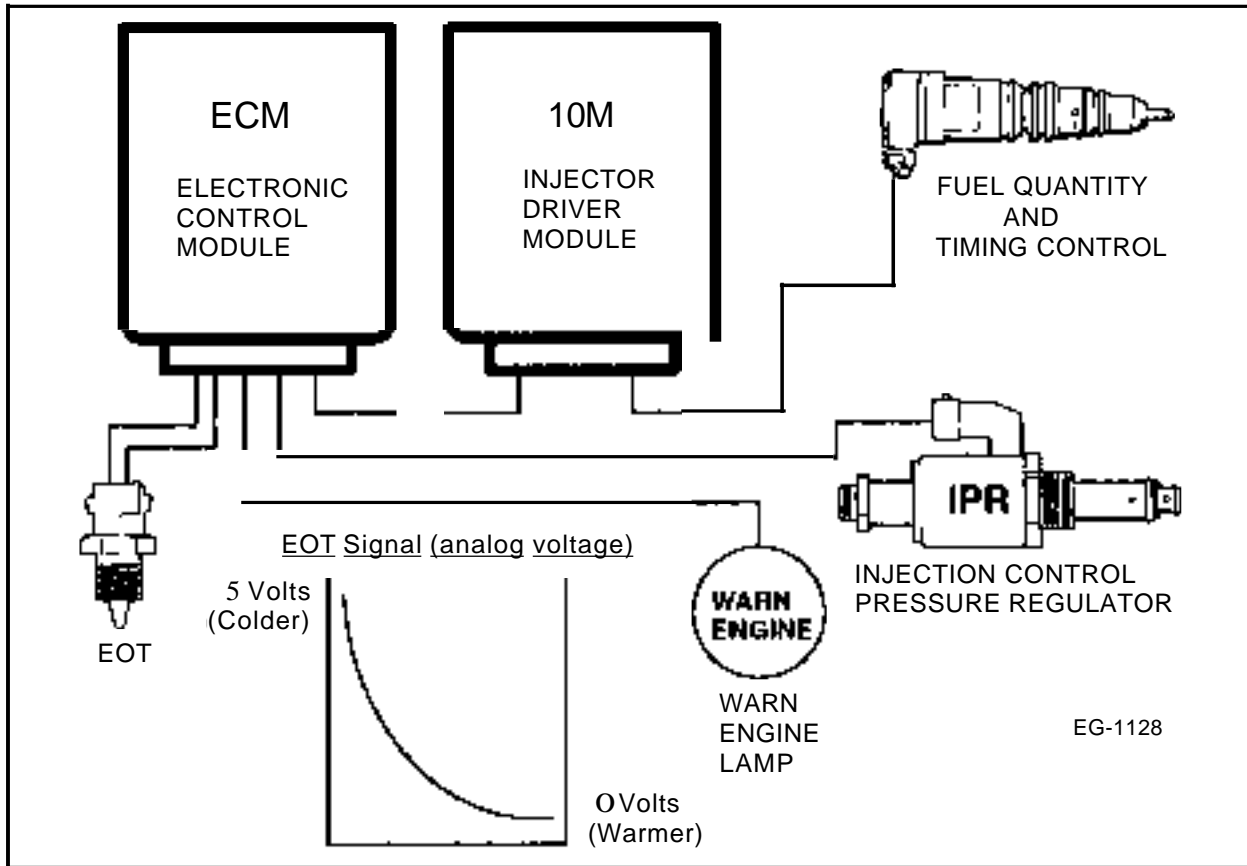
ELECTRONIC CONTROL MODULE (ECM) (379)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE OIL TEMPERATURE SENSOR (EOT)

ENGINE OIL TEMPERATURE (EOT) SENSOR



SIGNAL FUNCTIONS

The Engine Oil Temperature (EaT) sensor is a thermistor type sensor that has a variable resistance which changes when exposed to different temperatures. When interfaced with the ECM, it produces a 0 to 5 volt analog signal that indicates temperature.

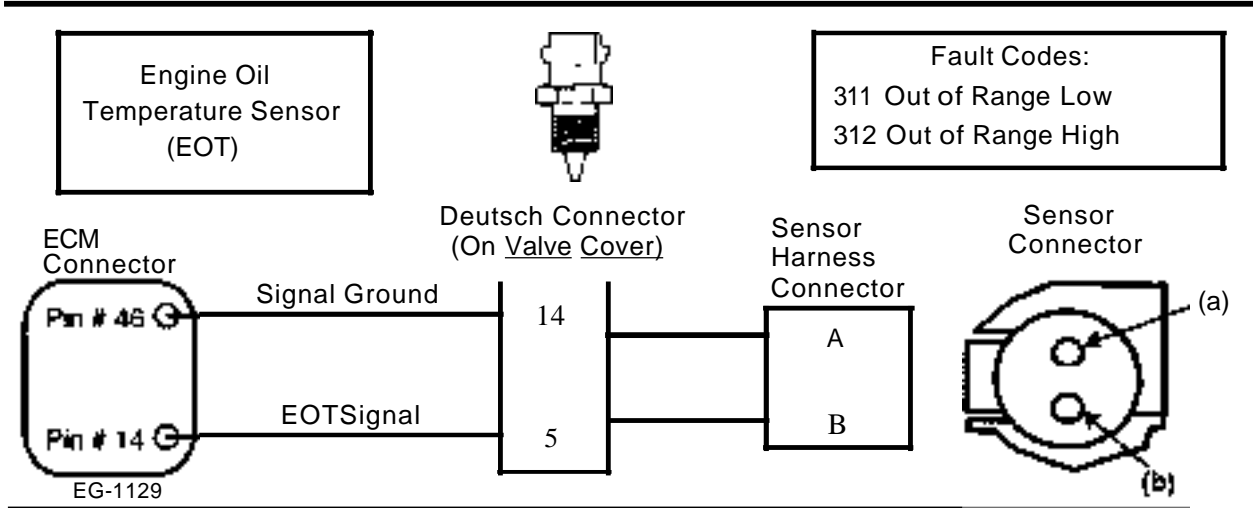
Cranking Fuel Quantity/Timing Control - The EOT signal is used to determine the timing and quantity of fuel required to optimize starting over all temperature conditions.

Temperature Compensation - Fuel quantity and timing is controlled throughout the total operating range to compensate for oil viscosity changes due to temperature variations and insure that adequate torque and power is available.

FAULT DETECTION/MANAGEMENT

An EaT signal that is detected out of range high or low by the ECM will cause the ECM to ignore the EOT signal and default to the engine coolant temperature (ECT) sensor. The WARN engine lamp will also be illuminated as long as the fault condition exists. If both the EOT and ECT sensors are not functioning, the ECM will assume a 212°F (100°C) value for engine oil temperature.

ENGINE OIL TEMPERATURE SENSOR (EOT)



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground, check with key OFF, if > 5 ohms the harness is open.
S to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
8 to Grd.	4.8 - 5.0v	Pull up voltage, if no or low voltage, circuit has open or high resistance or short ground.
A to Grd.	0 - .25v	If greater than .25 volts, signal ground wire is shorted to V Ref. or battery

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from harness connector to 60 pin connector - Signal ground
#14 to B	< 5 ohms	Resistance from harness connector to 60 pin connector - EDT Signal

Test Points (+) #14 to (-) #46		Operational Voltage Checks (Check with breakout box installed in line with the ECM)		
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
0.53 v	248	120	1.19 K ohms	
0.96 v	205	96	2 K ohms	
1.37v	176	80	3.84 K ohms	
4.37v	32	0	69.2 K ohms	
4.60 v	-5	-20	131.0 K ohms	

Circuit Faults:	Fault Code Descriptions
311 = Signal was less than 0.2 volts for more than 0.1 seconds.	311 Out of Range Low
312 = Signal voltage was greater than 4.8 volts for more than 0.1 seconds.	312 Out of Range High

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

ENGINE OIL TEMPERATURE SENSOR (EOT)

ENGINE OIL TEMPERATURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Engine Oil Temperature (EaT) sensor. The ECM monitors engine oil temperature via the EaT sensor signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment. This insures that adequate power and torque are available under all operating conditions.

OPERATION

The Engine Oil Temperature Sensor is a thermistor type sensor which changes resistance when exposed to different oil temperatures.

When the temperature of the oil is decreased the resistance of the thermistor increases which causes the signal voltage to increase. As the temperature of the oil is increased, the resistance of the thermistor decreases, causing the signal voltage to decrease.

The EDT sensor is supplied a regulated 5 volt reference signal at terminal 8 from ECM terminal 14. A return circuit (ground) is supplied at terminal A from ECM terminal 46. As the oil temperature increases or decreases, the sensor changes resistance and provides the ECM with the oil temperature signal voltage at terminal 14. This signal voltage is then read by the ECM to determine the temperature of the oil.

ECM DIAGNOSTICS

With the ignition key "ON", the ECM continuously monitors the EOT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the ECM detects a fault, it will use the value of the Engine Coolant Temperature signal, in place of the EDT signal. If the ECT sensor is not sending a cor-

rect signal, the ECM will default to -4°F (-20°C) for starting or 212°F (100°C) for engine running operation.

EOT sensor faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will become an Inactive code. EaT codes will cause the Engine Warning light to be illuminated.

FLASH CODE 311

ATA CODE PID 175 FMI 4

ENGINE OIL TEMPERATURE SIGNAL OUT OF RANGE LOW

Code 311 out of range low, will be set if the signal voltage was less than 0.2 volts for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of -4°F (-20°C) for starting or 212°F (100°C) for engine running operation. This code will cause the ECM to illuminate the Engine Warning light.

Code 311 may be set due to a short to ground in the signal circuit or a defective sensor.

FLASH CODE 312

ATA CODE PID 175 FMI 3

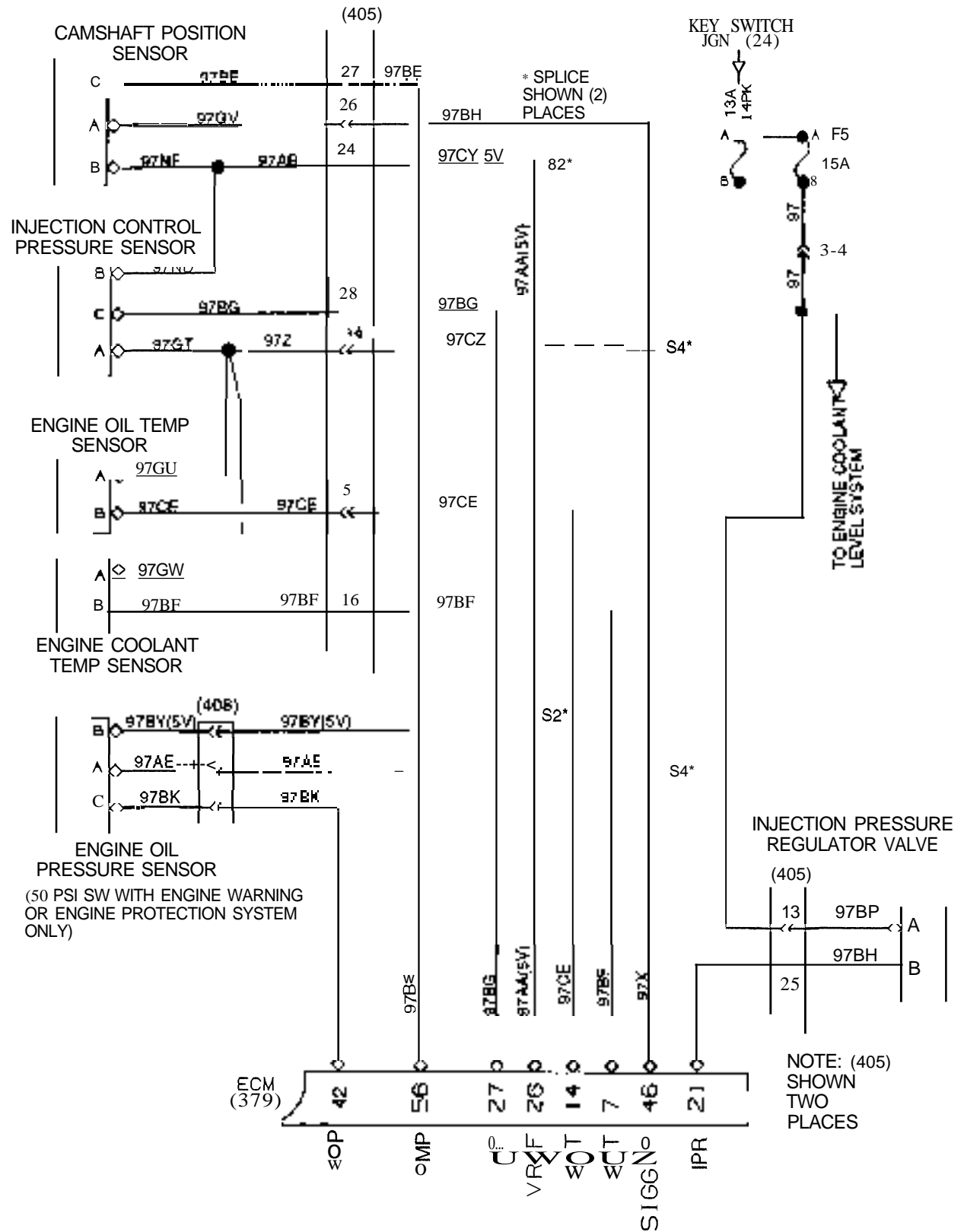
ENGINE OIL TEMPERATURE SIGNAL OUT OF RANGE HIGH

Code 312 out of range high, will be set if the signal voltage is more than 4.8 volts for more than 0.1 seconds. If this code is set, the ECM will default to ECT temperature or a default value of -4°F (-20°C) for starting or 212°F (1 aaOC) for engine running operation. This code will cause the ECM to illuminate the Engine Warning light.

Code 312 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause code 312 to be set.

ENGINE OIL TEMPERATURE SENSOR (EOT)

SENSOR CIRCUIT DIAGRAM

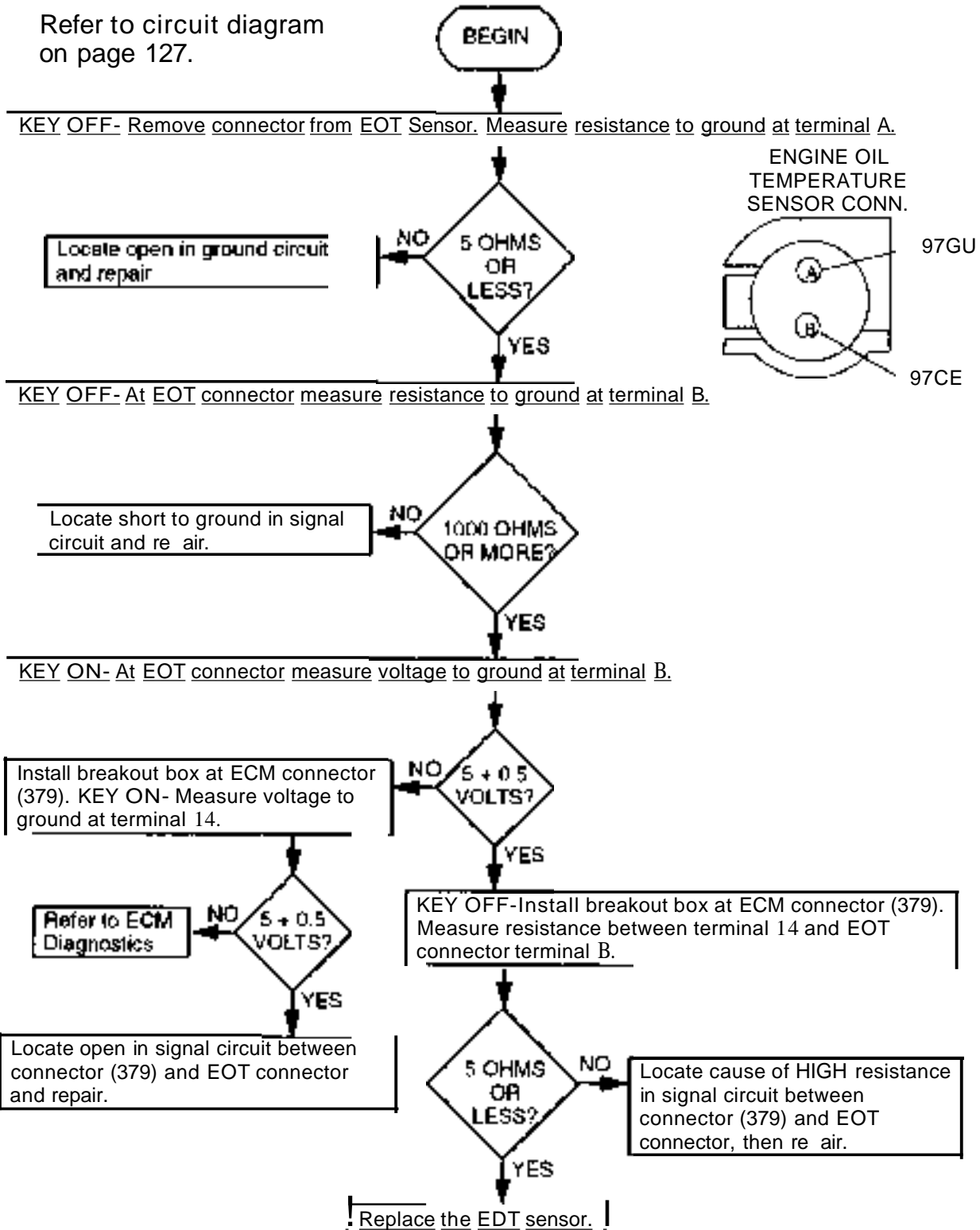


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

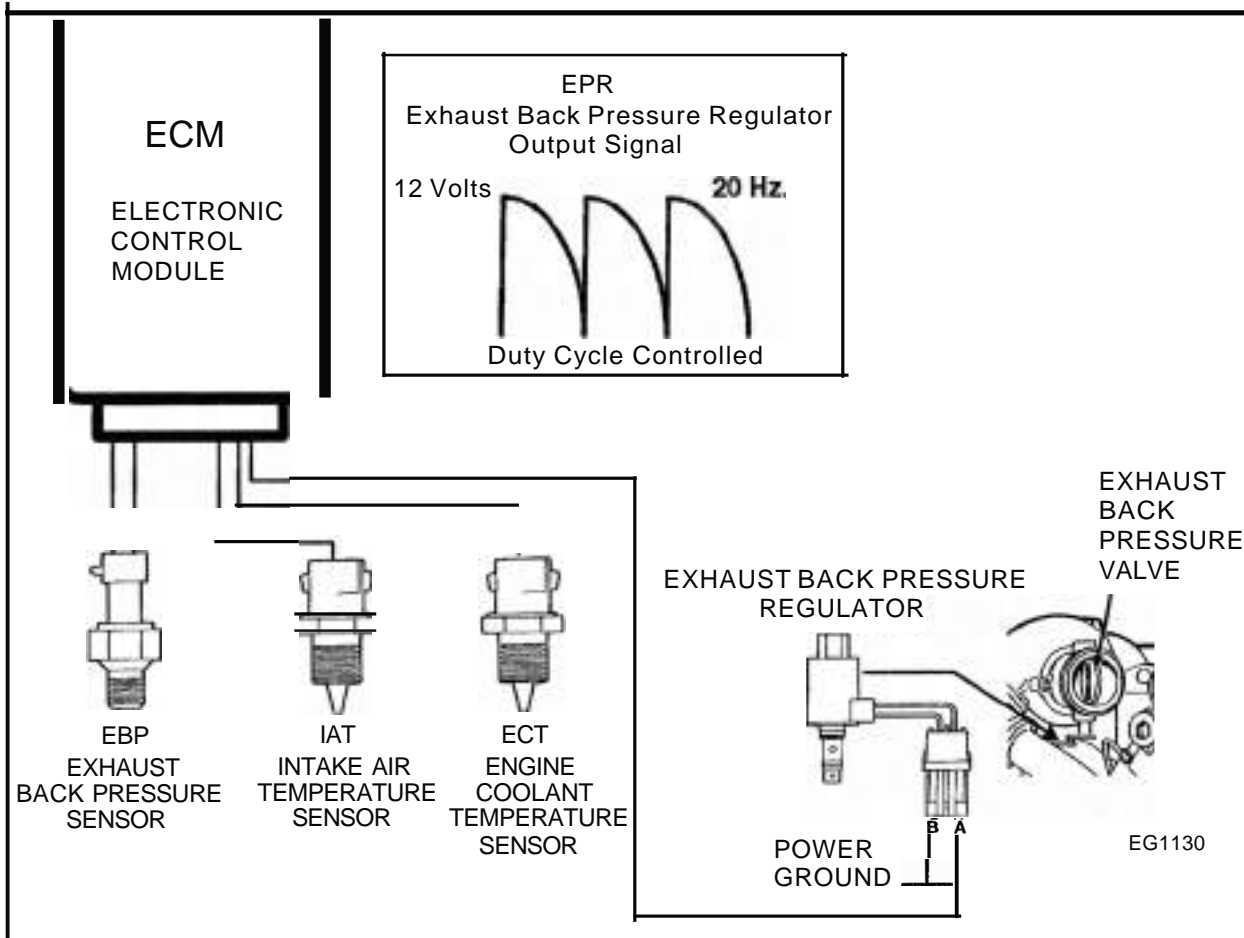
ENGINE OIL TEMPERATURE SENSOR (EOT)

ENGINE OIL TEMPERATURE (EOT) SENSOR DIAGNOSTICS

Refer to circuit diagram on page 127.



EXHAUST BACK PRESSURE (EPR) REGULATOR



OUTPUT FUNCTIONS

Exhaust Back Pressure Regulator - Is a variable position valve that controls exhaust back pressure during cold ambient temperatures to increase cab heat and decrease the amount of time needed to defrost the windshield. The ECM uses the measured exhaust back pressure, (ambient) intake air temperature, engine coolant temperature and engine load to determine the desired exhaust back pressure. Valve position is controlled by switching the output signal circuit to 12 volts inside the ECM. On/off time is modulated from 0 to 99 % dependent upon the exhaust back pressure desired.

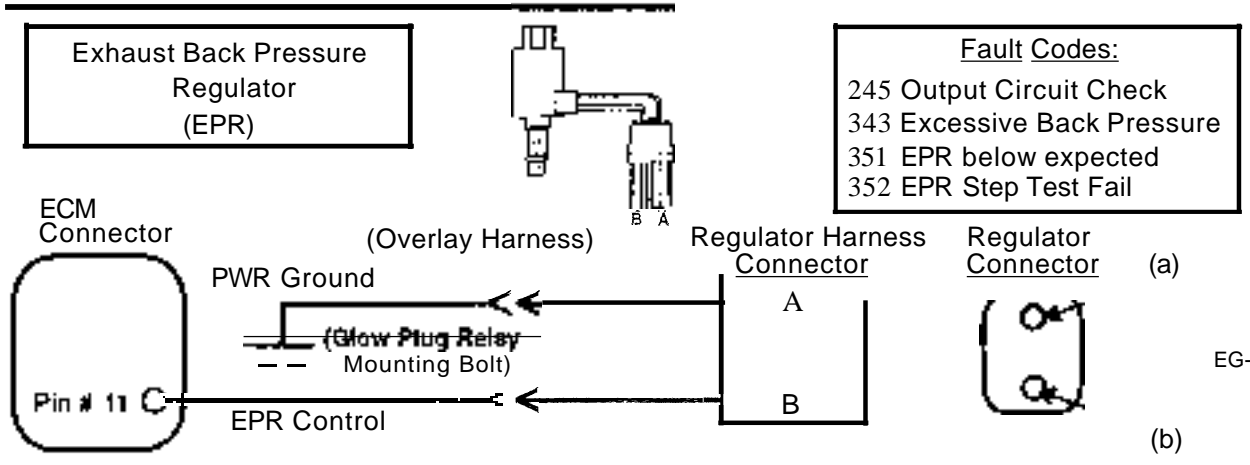
FAULT DETECTION/MANAGEMENT

An open or shorted to ground control circuit can be detected by an on demand output circuit check performed during the engine off test.

Problems with either the Exhaust Back Pressure Device or the tube between the exhaust manifold and the EBP sensor can be detected during the exhaust back pressure step test, in which the ECM commands and then measures a specific preprogrammed pressure then measures time for pressure decay during the engine running test.

If the ECM detects an EBP or IAT sensor fault it will disable the exhaust back pressure regulator.

EXHAUST BACK PRESSURE REGULATOR (EPR)



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Regulator Connector Disconnected, Ignition off, all accessories off.)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance greater than 5 ohms indicates an open circuit or bad ground.
S to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
Pwr. Grd. to Pin #11	2.5 to 20 ohms	Resistance through EPR circuit including regulator, check w/regulator connector connected (unnecessary to check next points if okay).
A to Grd.	< 5 ohms	Resistance from regulator connector to Pwr. Ground.
S to #11	< 5 ohms	Resistance from regulator connector to 60 pin connector.

Circuit Fault Code Descriptions

245 = Output circuit check detected during Standard test, indicates high or low resistance in circuit.

Exhaust Back Pressure System Fault Code Descriptions

- 343 = EPR pressure was greater than 77 in. Hg. (260 kPaG) for 3 seconds. (3.3 volts)
- 351 = Exhaust backpressure is below 29.61 in. Hg. (20 kPaG) for 2.5 seconds (1.19 volts) at engine speeds greater than 2300 RPM (possible plugged line)
- 352 = Indicates that EPR pressure of 22 in. Hg. (75 kPa) commanded during ESP engine running test was not obtained. (Plugged line or exhaust back pressure device failure.)

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

EXHAUST BACK PRESSURE REGULATOR (EPR)

EXHAUST BACK PRESSURE REGULATOR VALVE EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Exhaust Back Pressure Regulator (EPR) Valve. The valve controls exhaust back pressure in cold ambient temperatures to increase cab heat and decrease the amount of time required to defrost the windshield. The EPR valve consists of a solenoid, poppet and spool valve assembly and is mounted on the turbocharger pedestal. The ECM regulates exhaust back pressure by controlling the duty cycle of ON/OFF time of the exhaust pressure regulator solenoid. The increase or decrease of ON/OFF time positions a spool valve internal to the EPR which in turn either increases or decreases the amount of exhaust back pressure.

OPERATION

The EPR valve is supplied with voltage at Terminal 8 of the EPR connector from Terminal 11 of the ECM. Control of the exhaust pressure regulator is accomplished by the ECM varying the pulse width or percentage of ON/OFF time of the EPR solenoid. Normal ON/OFF time varies from 0% to 95%. A high duty cycle indicates that the exhaust back pressure valve is being closed to raise the amount of exhaust back pressure based on (ambient) intake air temperature, engine oil temperature, engine load and exhaust back pressure.

ECM DIAGNOSTICS

The ECM monitors the exhaust back pressure while the engine is in operation. If actual pressure is greater or less than the desired pressure, the ECM will set a fault code. When this occurs the ECM will discontinue exhaust pressure regulator operation leaving the exhaust back pressure valve open, creating no exhaust restriction to aid in warm up of vehicle.

Fault codes can be retrieved using the Electronic Service Tool or the Self Test Input diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will be sent as an Inactive code.

FLASH CODE 245

ATA CODE SID 35 FMI11

EPR: OCC SELF TEST FAILED

Code 245 is set only during the Engine Off Standard Output Circuit check. This test indicates the ECM

has performed an output circuit test, measure voltage drop across the EPR circuit and determined it is above or below specification. If the fault is present, the exhaust pressure regulator will be disabled.

Possible Causes: Open feed circuit, open EPR solenoid, an open or shorted EPR signal circuit.

FLASH CODE 343

ATA CODE SID 34 FMI 0

EPR: EXCESSIVE EXHAUST BACK PRESSURE

Code 343 indicates that the ECM has detected exhaust back pressure greater than 77 (in. Hg.) which is greater than the maximum allowable working range.

Possible Causes: Incorrect ESP signal due to faulty circuits or sensor, grounded EPR signal circuit, a collapsed exhaust pipe or stuck exhaust pressure regulator valve.

FLASH CODE 352

ATA CODE SID 34 FMI10

EPR: EXHAUST BACK PRESSURE ABOVE OR BELOW DESIRED LEVEL

Code 352 may be set during normal engine operation through the continuous monitor function or during the engine running standard test. It indicates the measured pressure does not meet the expected value.

Possible Causes: Incorrect ESP signal due to circuit or sensor malfunctions. ESP signal circuit may be shorted, grounded, or contain excessive resistance. The EPR valve may be sticking or blocked.

FLASH CODE 351

ATA CODE SID 34 FMI 7

EPR: EXHAUST BACK PRESSURE BELOW EXPECTED LEVEL AT HIGH ENGINE SPEEDS.

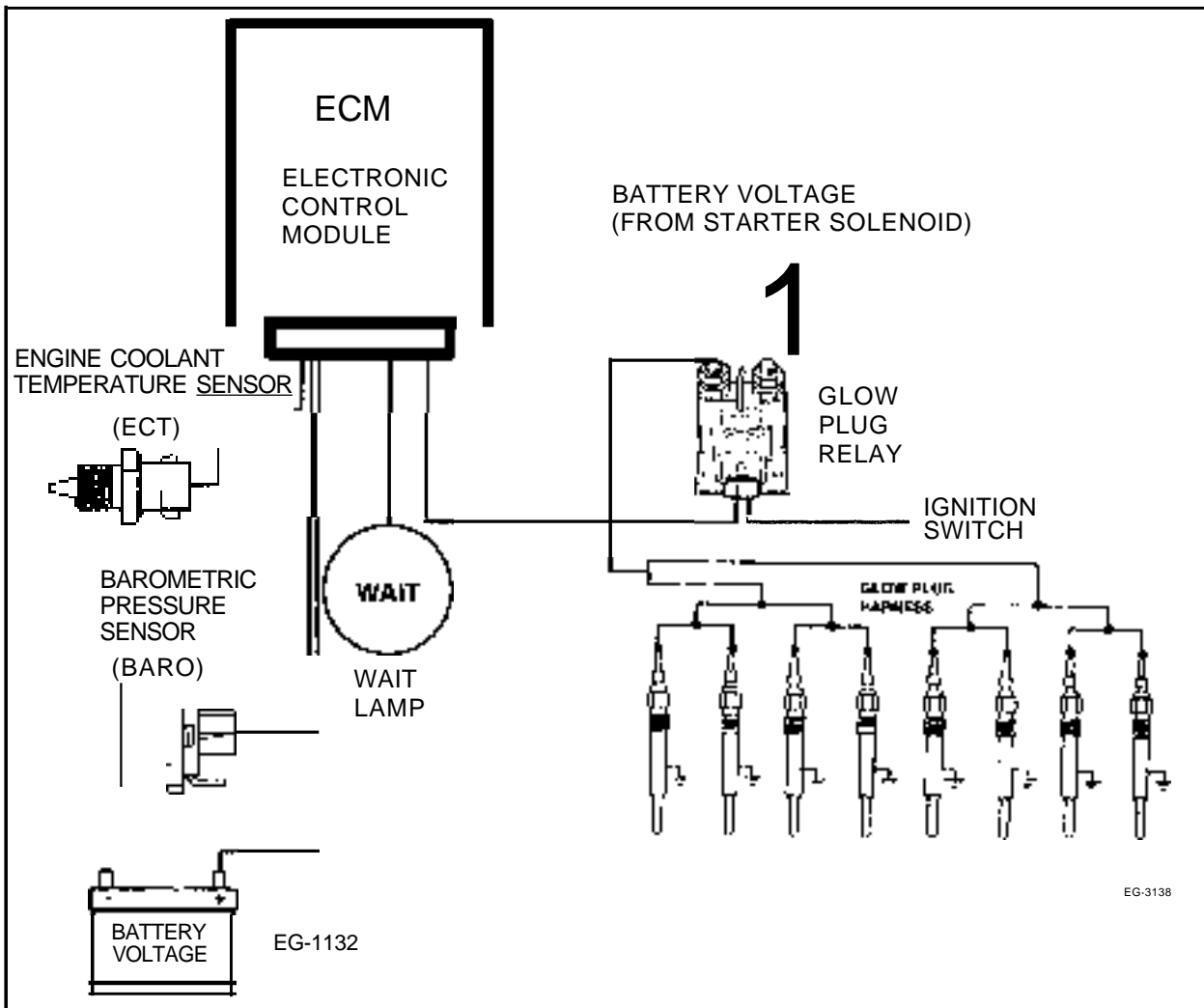
Code 351 may be set during normal engine operation through the continuous monitor function by the ECM. This code indicates the ECM did not see a minimum of 20 (KPA) pressure data from low idle operation to 2300 RPM engine operation.

Possible Causes: Incorrect EBP signal due to faulty circuit or sensor, plugged exhaust back pressure tube, or exhaust pressure valve stuck.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

GLOW PLUG CONTROLLER (GPC)

GLOW PLUG CONTROL



OUTPUT FUNCTIONS

Glow Plug Relay - Controls the current flow to the glow plugs. Glow plug relay "ON" time is controlled by the ECM and is a function of engine coolant temperature, barometric pressure and battery voltage. "ON" time normally varies between 2 to 10 seconds. (NOTE: Wait light on time is independent from glow plug relay on time). The glow plugs are self limiting glow plugs and do not require to be cycled on and off. (The glow plug relay will only cycle on and off repeatedly when there is a system voltage condition greater than 13.0 volts.)

Glow Plug Wait Lamp - Lamp that indicates to the operator when the glow plugs have been on long enough to crank the engine. It is controlled by the

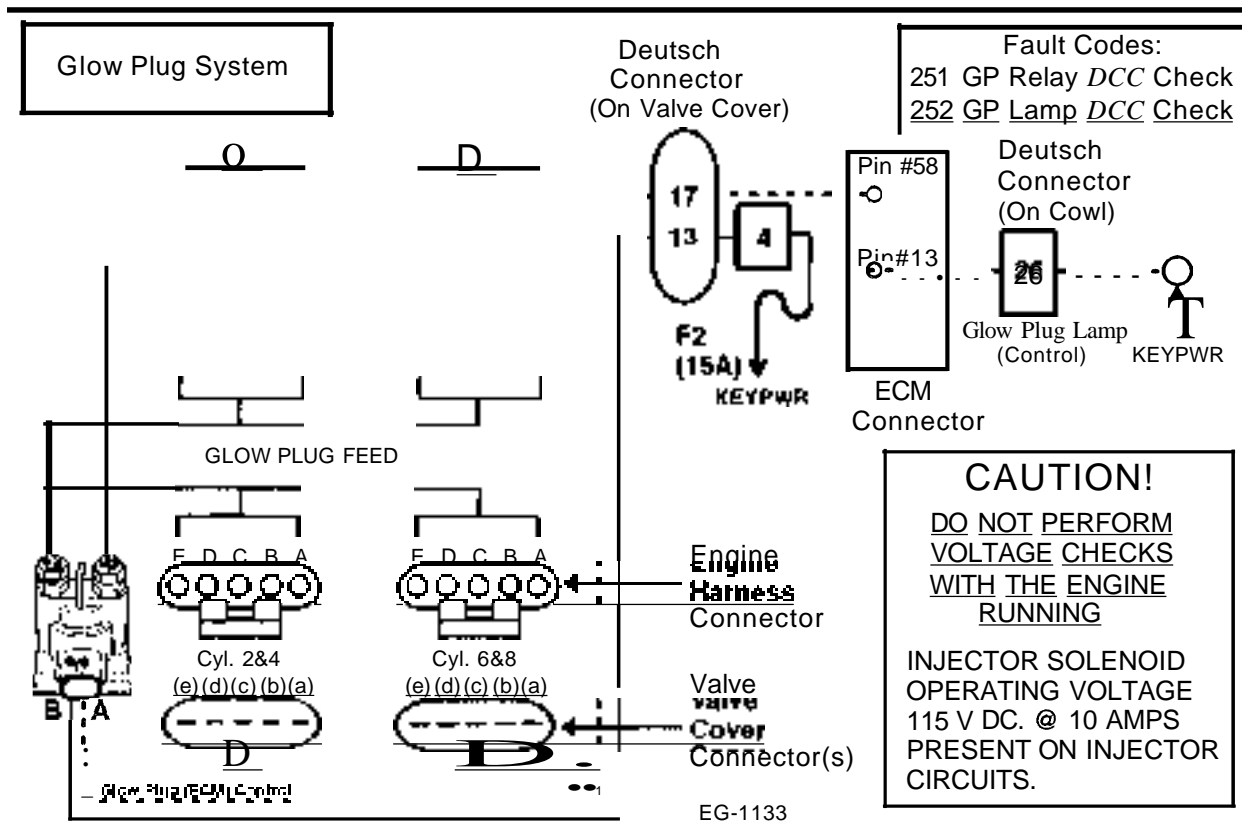
ECM. Wait light on time is a function of engine coolant temperature, barometric pressure and battery voltage. "ON" time normally varies between 2 to 10 seconds. (NOTE: Wait light on time is independent from glow plug relay on time).

FAULT DETECTION/MANAGEMENT

An open or shorted to ground glow plug relay or wait lamp circuit can be detected by an on demand output circuit check performed during the engine off tests.

Glow plug and glow plug harness problems can not be detected by the ECM.

GLOW PLUG CONTROLLER (GPC)



Glow Plug Relay Operation (Voltage Checks)

Test Points	Spec.	Comments
B+ terminal to ground	B+	Relay switch power, B+ should be present at all times (terminal with single 6 gauge wire). Check connection at starter or fusible links if no power (voltage) present.
Glow Plug Feed to Grd.	B+	Glow plug feed voltage should be present 10 to 120 sec. after key is cycled on, dependent upon battery voltage, barometric pressure (altitude) and engine coolant temperature.
B to Ground	B+	Relay coil power. Voltage should be present when ign. key is ON - Check fuse if no voltage.
Pin # 58 to Ground	0v / 12v	Glow plug control, switched to (grd) by ECM during operation. 0v = relay ON, 12v = relay off.

Glow Plug and Harness Operation

(Measure glow plug resistance to ground with the pigtail connector installed at the valve cover connector: then measure resistance from the glow plug feed stud to the harness connector.)

Test Points			Comments
Glow Plug Number	Pigtail Connector to Ground (B-)	Relay to Harness Connector	
Spec	<.1 to 6 Ohm	< 6 Ohms	Relay to Harness Connector NOTE: ALL ENGINE HARNESS CONNECTORS FOR GLOW PLUG/INJECTORS SHOULD BE DISCONNECTED BEFORE TAKING MEASUREMENTS High resistance could indicate an open circuit in the engine harness between the glow plug connector and the relay.
#1			
#3			
#5			Pigtail Connector to Ground B- High resistance could indicate an open circuit in the UVC (under the valve cover) harness or in the glow plug. Glow plug resistance should measure .1 to 6 ohms dependent upon engine temperature.
#7			
#2			
#4			
#6			
#8			

Fault Code Descriptions

251 =OCC CHK performed by ECM during engine off test. Indicates high or low resistance in GP coil circuit.
 252 =OCC CHK performed by ECM during engine off test. Indicates high or low resistance in GP lamp circuit.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

GLOW PLUG CONTROLLER (GPC)

GLOW PLUG SYSTEM

EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes a Glow Plug Control System that controls the current flow to the glow plugs. Glow plug relay "ON" time is controlled by the ECM and is a function of Engine Coolant Temperature, Barometric Pressure, and Battery Voltage. Glow plug "ON" time varies between 10-120 seconds. Glow plugs are self limiting glow plugs and do not require to be cycled on and off. The glow plug relay will cycle on and off repeatedly, if battery voltage is greater than 13.0 volts.

OPERATION

Refer to circuit diagram on page 135 for the following discussion.

Glow Plug System operation is dependent upon engine coolant temperature, barometric pressure and battery voltage. When the ignition switch is placed in the "ON" position, Terminal B (coil side) of the glow plug relay is supplied with battery voltage. Terminal A (coil side) of the relay is connected to Terminal 58 of the ECM. The ECM supplies battery ground to the glow plug relay coil via an internal driver transistor when coolant temperature, barometric pressure and battery voltage conditions require the glow plug system to warm the engine for starting.

Applying ground (8-) to terminal A causes the relay to switch and apply battery voltage (present at the large terminal containing a single wire leading to and connected to the 8+ terminal of the starter solenoid) to the other large terminal which contains two wires. These wires now supply battery power to the glow plugs in the right and left cylinder heads.

The Glow Plug Wait Lamp is also turned on by the ECM when the glow plug relay is enabled.

(NOTE: WAIT LIGHT ON TIME IS INDEPENDENT FROM GLOW PLUG RELAY ON TIME).

ECM DIAGNOSTICS

The ECM does not continuously monitor the glow plug control circuitry. An open or shorted to ground glow plug control relay on the control side (coil) circuit can be detected by an on demand output circuit check performed during the engine off test.

Fault codes can be retrieved using the electronic service tool or the STI Self Test Input Diagnostic Switch located on the vehicle dashboard. If the ignition key is shutoff, the code will be stored as an active code.

FLASH CODE 251

ATA CODE SID 38 FMI11

GPC: DCC SELF TEST FAILED

Code 251 is set only during the Engine Off Standard Output Circuit check. This indicates that the ECM has performed an output circuit test, measured the voltage drop across the glow plug relay circuit and determined it is above or below specification. If the fault is present, the glow plug relay is not operating and the glow plugs are not enabled.

Possible Causes: Open feed circuit, open glow plug relay coil, an open or shorted GPC signal circuit.

FLASH CODE 252

ATA CODE SID 36 FMI11

GLOW PLUG LAMP: Dec SELF TEST FAILED

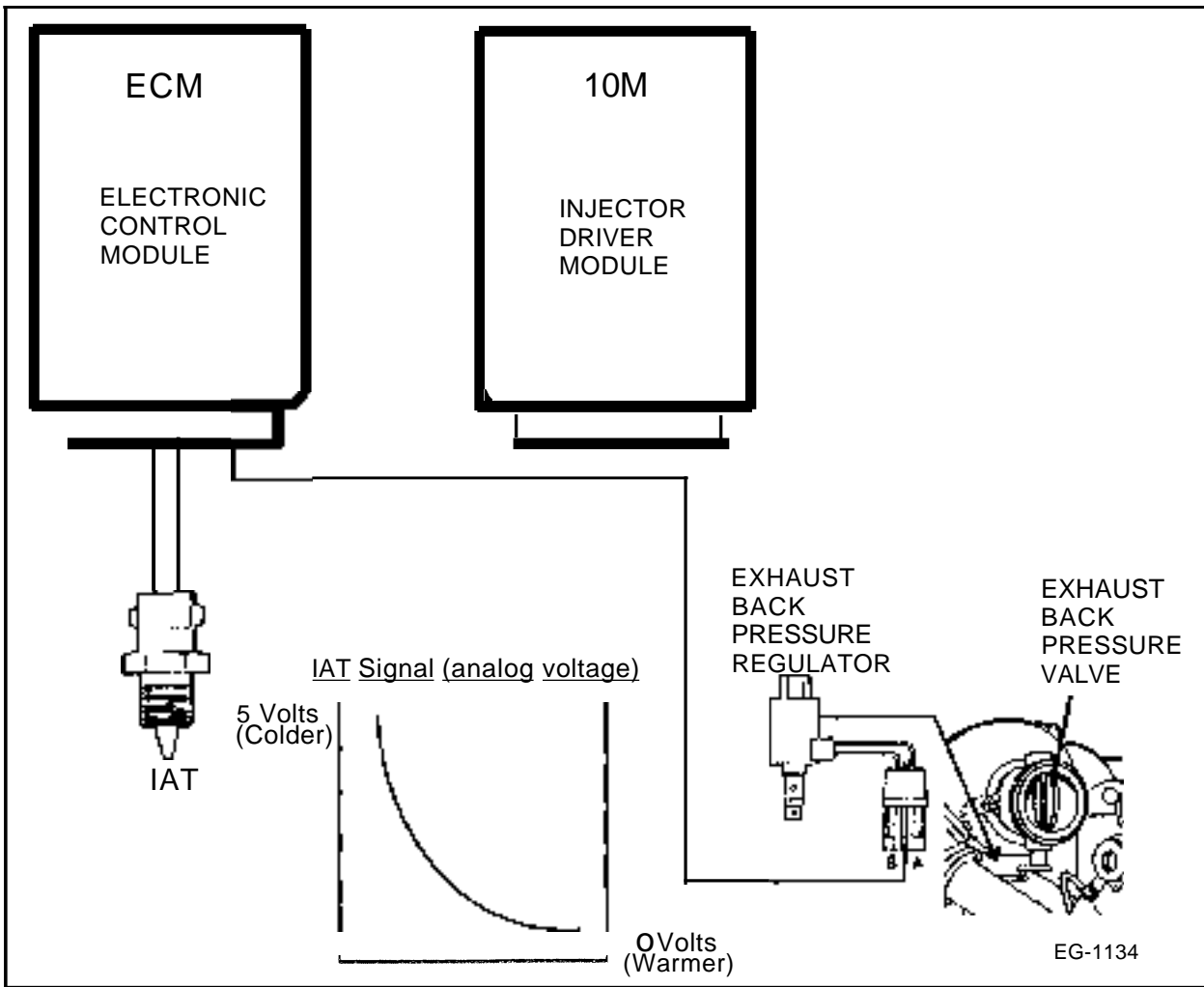
Code 252 is set only during the Engine Off Standard Output Circuit check. This indicates that the ECM has performed an output circuit test, measured the voltage drop across the glow plug Wait Lamp circuit and determined it is above or below specification.

Possible Causes: Glow plug Wait Lamp burned out, open or shorted glow plug Wait Lamp circuit.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INTAKE AIR TEMPERATURE SENSOR (IAT)

INTAKE AIR TEMPERATURE (IAT) SENSOR



SIGNAL FUNCTIONS

The Intake Air Temperature (IAT) sensor is a thermistor type sensor that has a variable resistance that changes when exposed to different temperatures. When interfaced with the ECM it produces a 0-5 volt analog signal that will deduce temperature.

Exhaust Back Pressure Device - The IAT sensor's primary function is to measure intake air temperature in order to determine when the exhaust back pressure function is needed.

FAULT DETECTION/MANAGEMENT

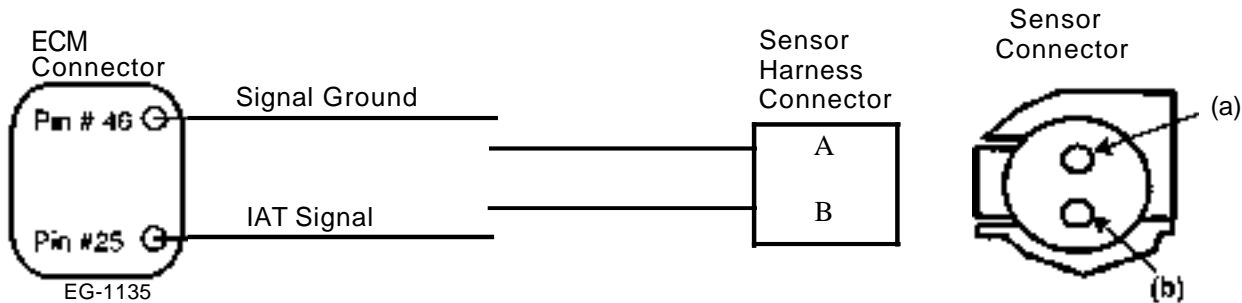
An IAT signal that is detected out of range high or low by the ECM will cause the engine to ignore the (AT signal, disable exhaust back pressure operation and assume an ambient temperature of 59° F (15° C).

INTAKE AIR TEMPERATURE SENSOR (IAT)

Intake Air
Temperature Sensor
(IAT)



Fault Codes:
154 Out of Range Low
155 Out of Range High



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis grd, check with key off, if > 5 ohms the harness is open.
8 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	4.8 - 5.0v	Pull up voltage, if no or low voltage, circuit has open or high resistance or short to grd.
A to Grd.	0 - .25v	If greater than .25 volts, signal wire is shorted to V Ref. or battery

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from harness connector to 60 pin connector - Signal ground
#25 to B	< 5 ohms	Resistance from harness connector to 60 pin connector - IAT Signal

Test Points (+) #25 to (-) #46		Operational Voltage Checks (Check with breakout box installed in line with the ECM)		
Voltage	Temp. ° F	Temp. ° C	Resistance	Comments
1.72 v	122	50	10.9 K ohms	
3.09 v	68	20	37.34 K ohms	
3.897 v	32	0	68.75 K ohms	
4.33 v	0	-18	120.9 K ohms	
4.537 v	-40	-40	194.3 K ohms	

Circuit Fault Code Descriptions

Circuit Faults:

154 = Signal voltage was less than .127 volts for more than 0.2 seconds.

155 = Signal voltage was greater than 4.6 volts for more than 0.2 seconds.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INTAKE AIR TEMPERATURE SENSOR (IAT)

INTAKE AIR TEMPERATURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Intake Air Temperature Sensor (IAT). The ECM measures the signal from the IAT sensor to determine the temperature of the air entering the engine. The ECM uses this data to adjust timing and fuel rate for starting in cold weather to limit smoke emissions.

OPERATION

The Intake Air Temperature Sensor is a thermistor type sensor which changes resistance when exposed to different air temperatures.

When the temperature of the intake air decreases, the resistance of thermistor increases which causes the signal voltage to increase. When the air temperature increases, the resistance of the thermistor decreases causing the signal voltage to decrease.

The IAT sensor is supplied a regulated 5 volt reference signal at terminal B from ECM terminal 25. A return circuit (ground) is supplied at terminal A from the ECM terminal 46. As the air temperature increases or decreases, the sensor changes resistance and provides the ECM with the air temperature signal voltage reading at terminal 25.

ECM DIAGNOSTICS

With the ignition key "ON", the ECM continuously monitors the IAT signal to determine if it is within expected values. If the signal voltage is above or below the expected levels, the ECM will set a fault code.

If the IAT sensor is not sending a correct signal, the ECM will default to 77°F (25° C).

IAT faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will become an Inactive code. IAT codes will cause the Engine Warning light to be illuminated.

FLASH CODE 154

ATA CODE PID 171 FMI4

*AMBIENT AIR TEMP SIGNAL OUT OF RANGE
LOW*

An out of range low code will be set if the ECM detects the signal voltage to be less than .127 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25° C) for starting.

Code 154 may be set due to a short to ground in the signal circuit or a defective sensor.

FLASH CODE 155

ATA CODE PID 171 FMI3

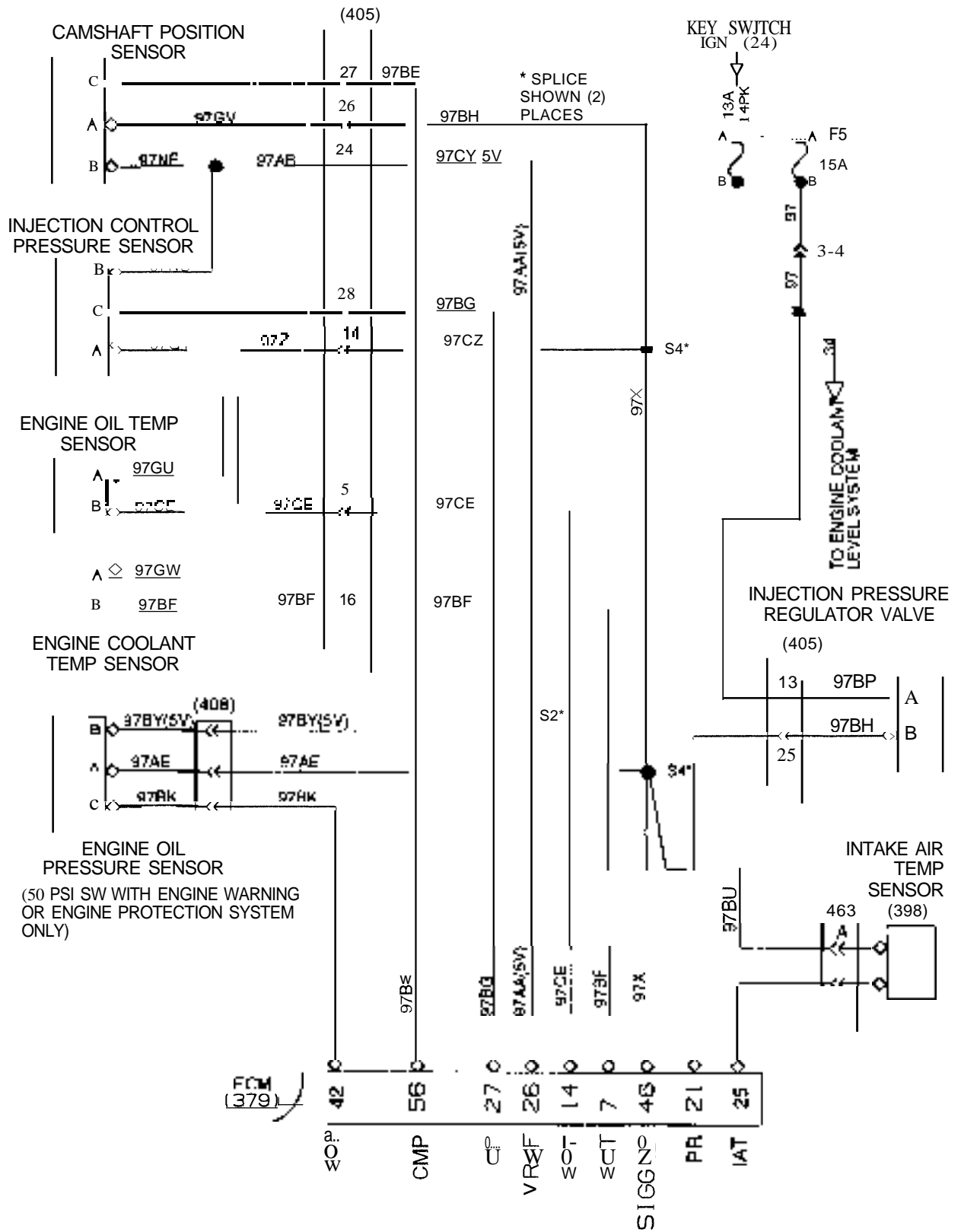
*AMBIENT AIR TEMP SIGNAL OUT OF RANGE
HIGH*

An out of range high code will be set if the ECM detects the signal voltage to be more than 4.6 volts for more than 0.2 seconds. If this fault is active, the ECM will default to a value of 77°F (25° C) for starting.

Code 155 may be set due to an open signal circuit between the ECM and the sensor or a short to a voltage source. A defective sensor may also cause code 155 to be set.

INTAKE AIR TEMPERATURE SENSOR (IAT)

SENSOR CIRCUIT DIAGRAM

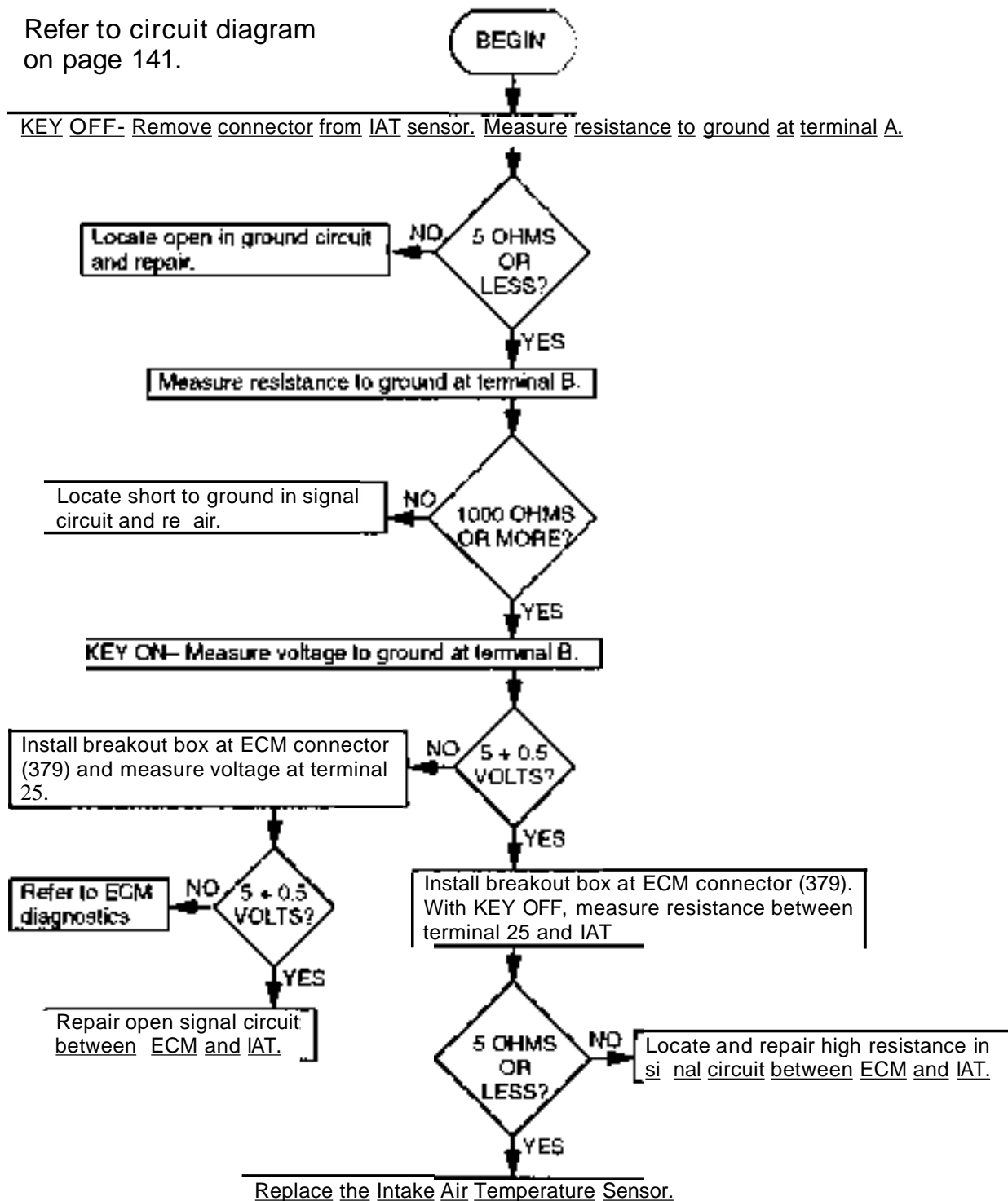


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

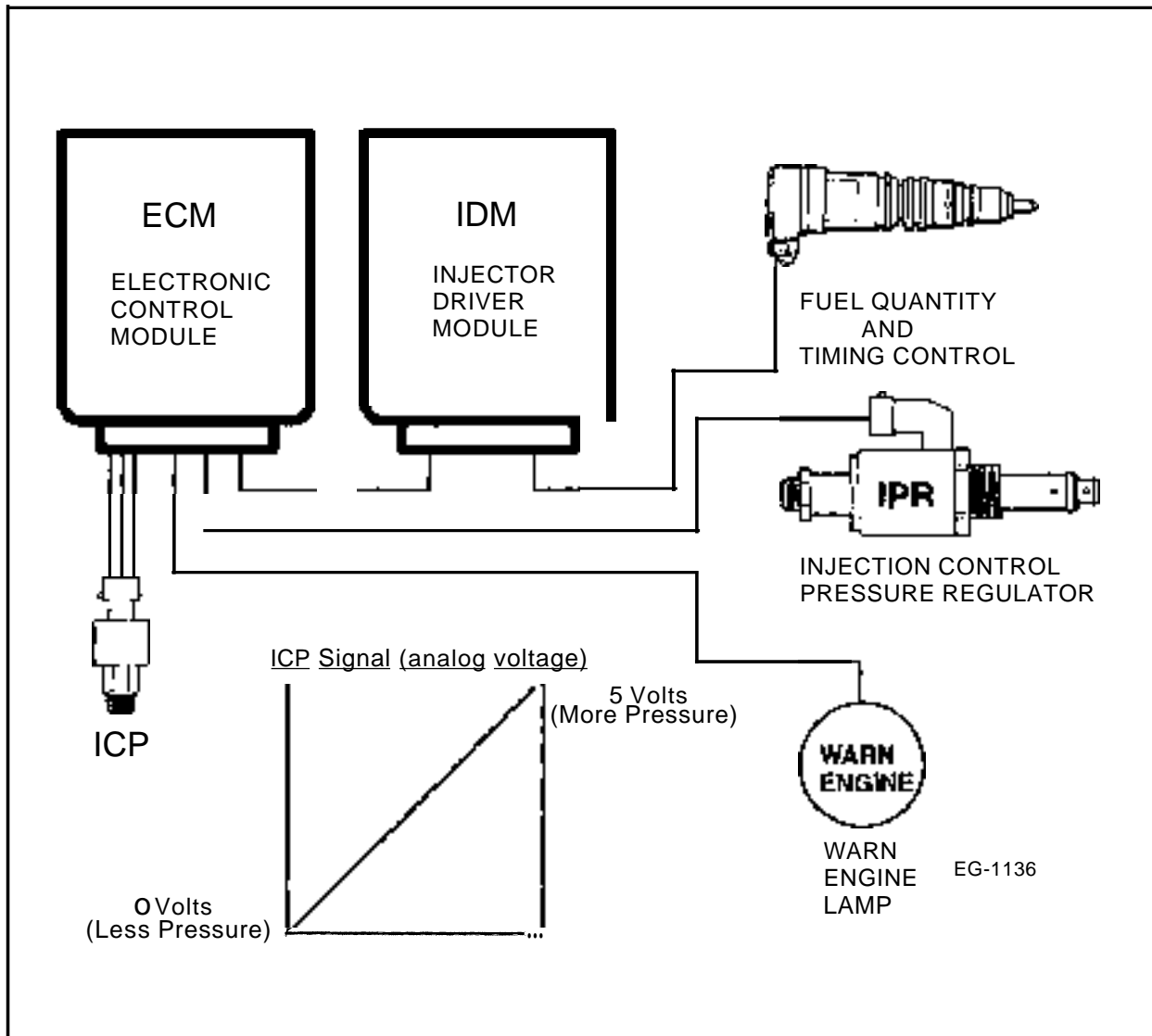
INTAKE AIR TEMPERATURE SENSOR (IAT)

TESTING IAT (INTAKE AIR TEMPERATURE CIRCUITS)

Refer to circuit diagram on page 141.



INJECTION CONTROL PRESSURE (ICP) SENSOR



SIGNAL FUNCTIONS

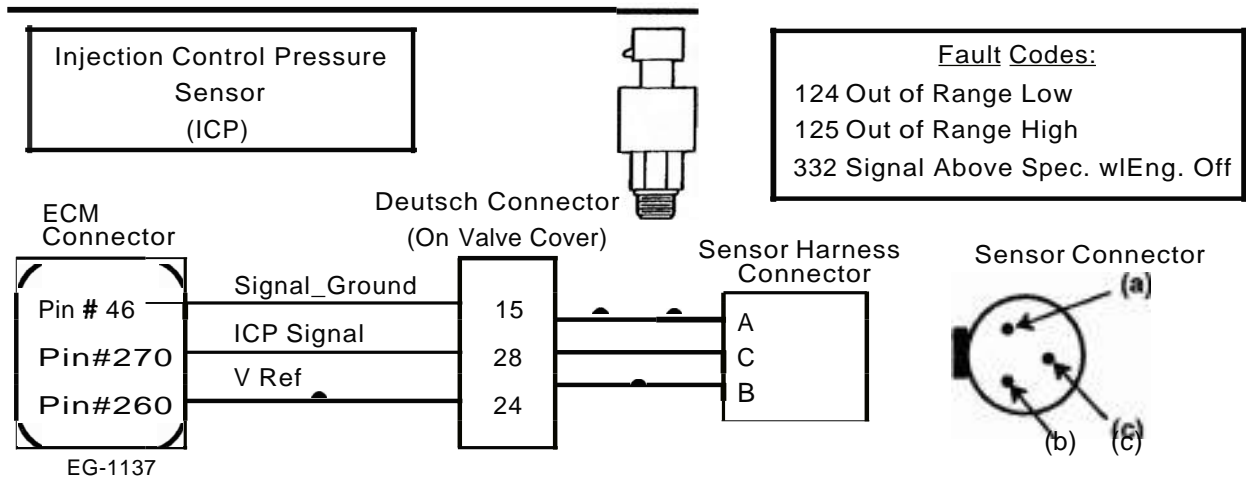
The Injection Control Pressure (ICP) sensor is a variable capacitance sensor that when supplied with a 5 volt reference signal from the ECM produces a linear analog voltage signal that indicates pressure.

The ICP sensor's primary function is to provide a feedback signal to indicate injection control pressure to enable the ECM to command the correct injector timing and pulse width and the correct injection control pressure for proper fuel delivery at all speed and load conditions.

FAULT DETECTION/MANAGEMENT

If the ECM detects a malfunctioning ICP sensor, the WARN lamp will illuminate. The ECM will go to open loop control of injection control pressure. (Operate from an estimated ICP pressure.)

INJECTION CONTROL PRESSURE SENSOR (ICP)



After removing connector always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground
(Check with Sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground check with key off, if > than 5 ohms harness is open.
8 to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
C to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks
(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
8 to Grd.	5 volts \pm .5	V Ref. check with key ON, if voltage not in spec., see V Ref circuit.
C to Grd.	0-.25 v	If greater than .25 volts, signal wire is shorted to V Ref. or battery

Harness Resistance Checks
(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector - Signal ground
#26 to 8	< 5 ohms	Resistance from sensor connector to 60 pin connector - V Ref
#27 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector - ICP signal

Test Points		Operational Voltage Checks		
(+) #27 to (-) #46		(Check with breakout box installed in line with the ECM)		
Voltage	PSI	MPA	Comments	
.15 - .25 v	0	0	Atmospheric Pressure with Key ON and Engine OFF. (Altitude dependent)	
1.0 v	580	4	Minimum required at engine cranking speed 130 RPM	
.66 - .86 v	400-480	2.7-3.3	Normal warm idle voltage signal	
3.66 v	2520	17.4	Snap accel or full load pressure signal	

Circuit Faults:	Fault Code Descriptions
124 = Signal voltage was less than .039 volts for more than 1.0 seconds.	
125 = Signal voltage was greater than 4.90 volts for more than 1.0 seconds.	
332 = Signal above 1.625 volts with engine off. (1160 psi, 8 MPa)	

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION CONTROL PRESSURE SENSOR (ICP)

INJECTION CONTROL PRESSURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes an Injection Control Pressure Sensor. The ECM measures the signal from the ICP sensor to determine the Injection Control Pressure as the engine is running to modulate the Injection Control Pressure Regulator. This is a closed loop function which means the ECM continuously monitors and adjusts for ideal Injection Control Pressure determined by operating conditions such as load, speed, and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the pressure reading is lower or higher than the value that was commanded, the ECM will set a fault code. This strategy is also used during the On Demand tests, commanded by the Electronic Service Tool and referred to as the Engine Running tests.

OPERATION

The Injection Control Pressure Sensor is a variable capacitance sensor that is supplied with a 5 volt reference voltage at terminal B by the ECM from terminal 126. The ICP sensor is also supplied with a return circuit (ground) at terminal A from ECM terminal 46. The ICP sensor sends a signal from terminal C of the sensor to ECM terminal 27.

The ICP signal voltage increases or decreases equally in proportion to an increase or decrease in injection control pressure.

ECM DIAGNOSTICS

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. If the signal voltage is higher or lower than expected, the ECM will set a fault code. The ECM will then ignore the ICP sensor signal and will use a preset value determined by engine operating conditions. If the ignition key is shut off, the code will become an Inactive code.

ICP faults can be retrieved using the Electronic Service Tool or by reading the flash codes from the warning light using the STI diagnostic switch located on the vehicle dash.

If the ignition key is shut off, the code will become an Inactive code. ICP codes will cause the Engine Warning light to be illuminated.

FLASH CODE 124
ATA CODE PID 164 FMI 4
ICP SIGNAL OUT OF RANGE LOW

An out of range low code 124 will be set by the ECM if the signal voltage is less than .039 volts for more than 1.0 seconds.

Code 124 may be set due to an open or short to ground on the signal circuit, a defective sensor or an open VREF circuit.

FLASH CODE 125
ATA CODE PID 164 FMI3
ICP SIGNAL OUT OF RANGE HIGH

An out of range high code 125 will be set by the ECM if the signal voltage is greater than 4.9 volts for more than 1.0 seconds.

Code 125 may be set by an open return circuit, short to a voltage source on the Icp signal circuit or a defective sensor.

FLASH CODE 332
ATA CODE PID 164 FMI13
*INJECTION CONTROL PRESSURE ABOVE
SPECIFICATION WITH ENGINE OFF*

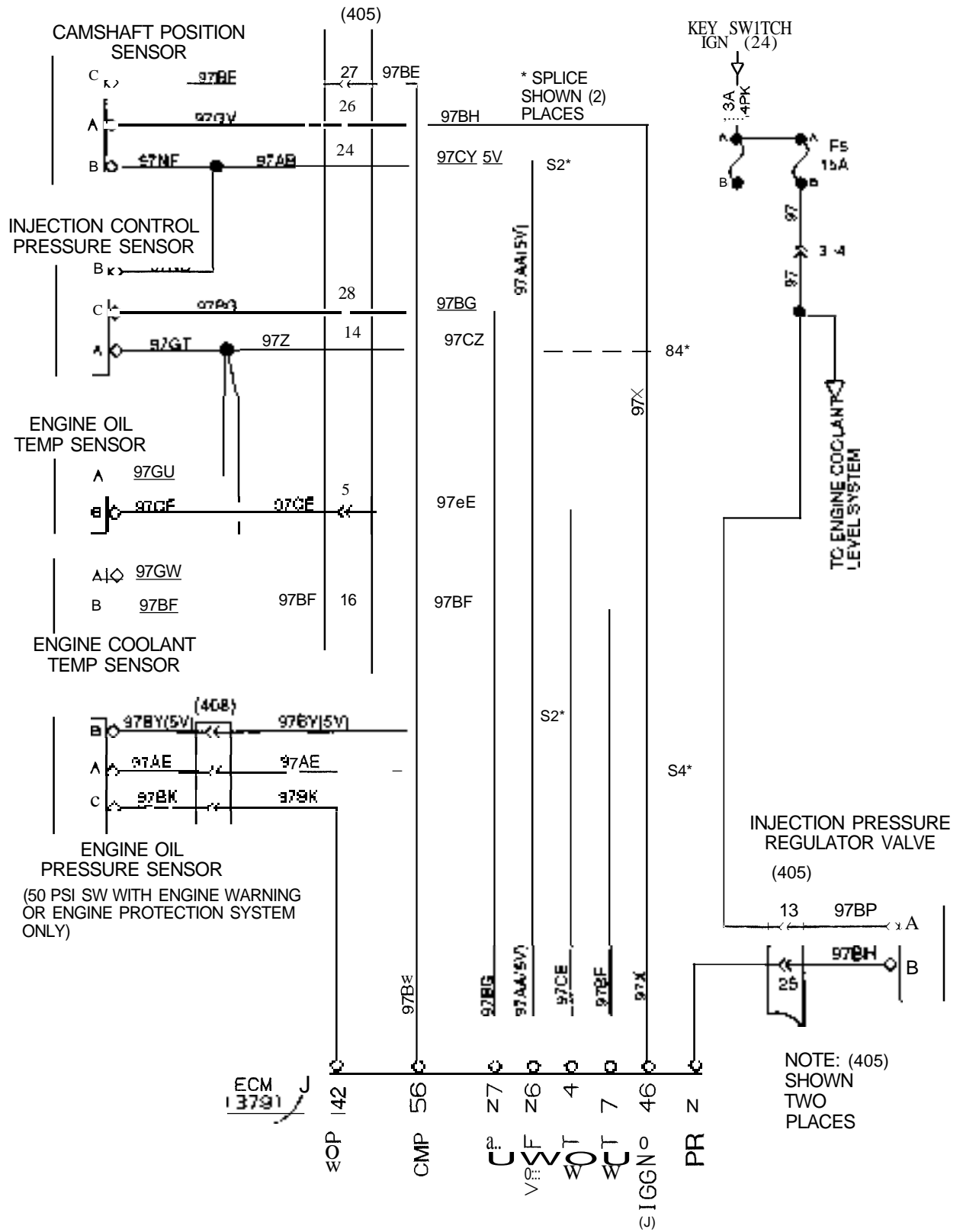
Code 332 will be set by the ECM, if the signal from the ICP sensor is higher than expected with the engine not running. If the ECM detects this fault, the ECM will ignore the ICP signal and will operate the IPR with fixed values determined from engine operating conditions.

Code 332 may be caused by a defective sensor or a biased circuit.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION CONTROL PRESSURE SENSOR (ICP)

SENSOR CIRCUIT DIAGRAM



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

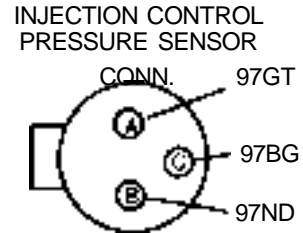
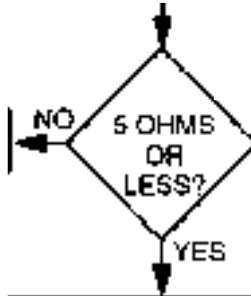
INJECTION CONTROL PRESSURE SENSOR (ICP)

INJECTION CONTROL PRESSURE (ICP) SENSOR DIAGNOSTICS

Refer to circuit diagram on page 147.

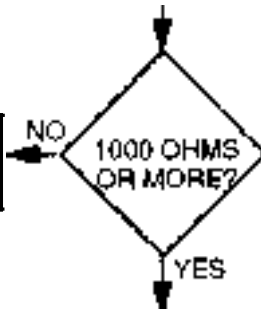
KEY OFF- Remove connector from ICP sensor. Measure resistance to ground at terminal A.

Locate open in ground circuit and repair



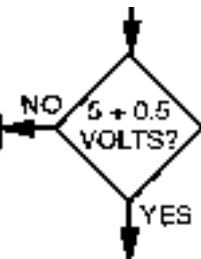
KEY OFF- Measure resistance to ground at terminals Band C.

Locate short to ground in circuit where terminal resistance is less than 1000 ohms and repair.



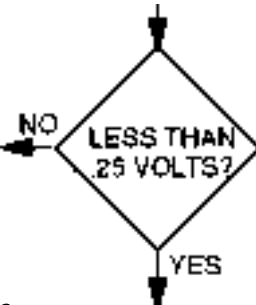
KEY ON- At ICP connector measure voltage to ground at terminal B.

Refer to VREF Diagnostics



KEY ON- At ICP connector measure voltage to ground at terminal C and A.

Locate circuit 97BG or 97GT short to unwanted voltage source and repair.



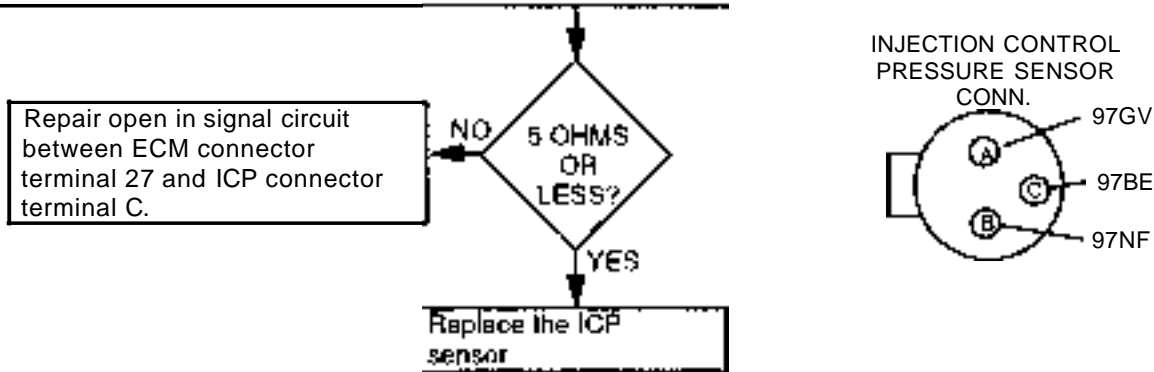
Continued On Next Page

INJECTION CONTROL PRESSURE SENSOR (ICP)

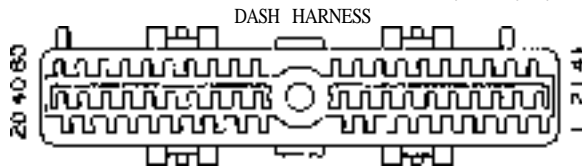
INJECTION CONTROL PRESSURE (ICP) SENSOR DIAGNOSTICS (Continued)

YES

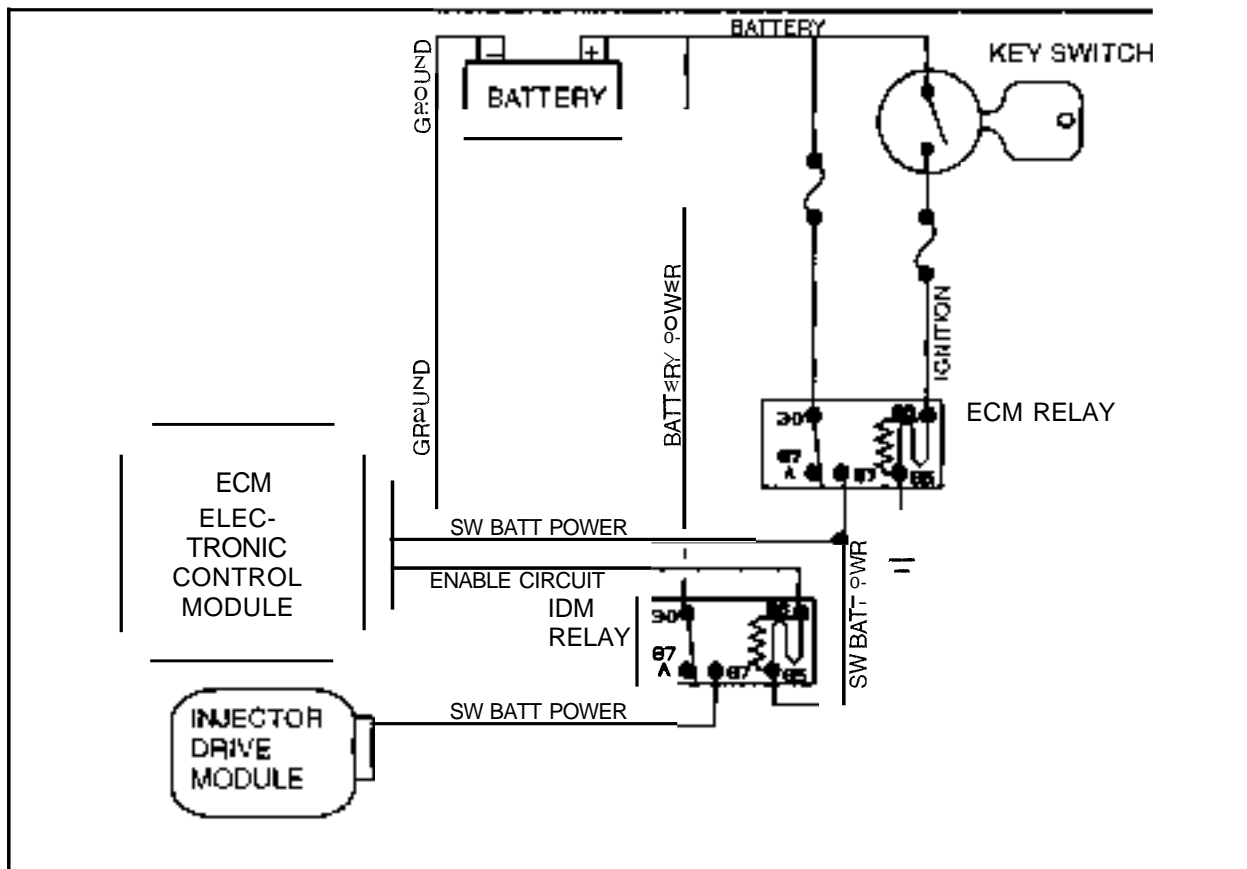
KEY OFF- Install breakout box at ECM connector (379). Measure resistance to ground between terminal 27 and ICP connector terminal C.



ELECTRONIC CONTROL MODULE (ECM) (379)



INJECTOR DRIVE MODULE (10M) POWER SUPPLY



CIRCUIT FUNCTIONS

The 10M receives switched 12 volt operating power with the key ON from the 10M power relay.

10M SWITCHED POWER

Turning the key ON energizes the ECM power relay causing 12 volt battery power to be applied to the 10M relay coil. The IDM relay is enabled when the coil is grounded through ECM terminal 33. With the relay energized (enabled), battery power is applied to the IDM at terminal 14.

FAULT DETECTION MANAGEMENT

The 10M power circuits are not continuously monitored. If the circuit is not operating the engine will not run. The ECM uses the Output Circuit Check (OCC) initiated during a Standard Test to test the 10M relay control coil circuits for opens or shorts (high and low).

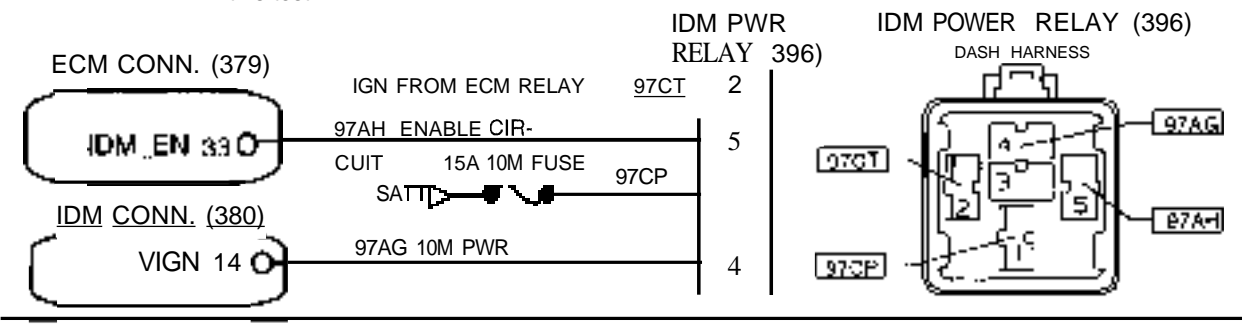
On each power up the 10M performs a self check. If internal faults are detected, a fault code will be set during an Engine Standard Test.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVER MODULE POWER CIRCUITS (10M PWR)

Injector Drive Module Power (10M PWR)	Fault Codes: 243 10M PWR Relay OCC Fault 522 10M Internal Fault 523 10M PWR Voltage Low
---------------------------------------	--

NOTE: Verify the ECM is ON (warning light turns on during self-test when key is turned on) . If the ECM is not receiving power refer to ECM Power Supply Circuits before performing this test.



Connector Checks To Chassis Ground

10M Relay removed from (396), 10M disconnected (380) and breakout box installed at ECM connection (379)

Test Points	Spec.	Comments
KEVOFF		At Connector (396) 10M PWR Relay
#1 to Grd.	12 ± 1.5 volts	< less than 10.5 v check connections, if 0 volts check for open/short to ground or blown fuse
#2 to Grd.	0volts	2 volts expected with ign. key "OFF".
#4 to Grd.	> 1000 ohms	< less than 1000 ohms, check for short to ground
#5 to Grd.	> 1000 ohms	< less than 1000 ohms, check for short to ground
KEVON		At Connector (396) 10M PWR Relay
#2 to Grd.	12 ± 1.5 volts	< less than 10.5 v check connections, if 0 volts check for open/short to ground or blown fuse
KEVON		At Connector (379) ECM Connector
#33 to 37	12 ± 1.5 volts	< less than 10.5 v check connections. ECM is defective or other condition is causing the ECM not to enable (ground) terminal 33.
KEVON		At Connector (396) 10M PWR Relay
#1 to #5	12 ± 1.5 volts	< less than 10.5 v check connections, if 2 volts repair open enable circuit between connectors (379) and (396)
KEV OFF		Test circuit Between Connectors (396) and (380) Relay & 10M Connector
(396) #4 to (380) #14	< 5 ohms	Greater than 5 ohms, repair open in ignition circuit. Less than 5 ohms, replace the IDM relay or connector (396)

Fault Code Descriptions

243 =IDM relay circuit has high or low resistance detected by ECM during an Engine Off Test. {Output Circuit Test} 522 =IDM has detected an internal fault, if no other fault codes present replace 10M. 523 =IDM power has been detected low by IDM.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5
Page 152

INJECTOR DRIVER MODULE POWER CIRCUITS (10M PWR)

INJECTOR DRIVER MODULE POWER CIRCUITS EXTENDED SYSTEM DESCRIPTION

The Injector Driver Module (10M) Power Relay acts as an ON/OFF switch that the ECM uses to turn the 10M on and off.

The ECM uses sensors to monitor Injection Control Pressure and Exhaust Back Pressure parameters. When starting the engine, if the ECM determines that any of these parameters are out of safe operating range, the ECM does not enable the 10M Power Relay, which prevents the engine from starting.

If the engine is started, and parameters are detected out of the safe operating range, the engine will derate, then disable the 10M Power Relay, which turns the 10M off, causing the engine to shut down.

With the optional Engine Protection System, the ECM also monitors Engine Oil Pressure, Coolant Level and Temperature sensor information. If these parameters are out of prescribed limits, the ECM will first derate the engine and then turn off the 10M, shutting down the engine.

Refer to the circuit diagram on page 154 for the following discussion.

The 10M PWR relay (396) controls battery power to the Injector Driver Module (10M) through connector (380) terminal 14. Battery power is available at all times to relay connector (396) at terminal 30. The feed circuit is protected by 15A, #2 ECM PWR fuse.

When the key switch is turned ON, power from ECM PWR relay (395) is applied to the IDM PWR relay control coil at terminal 85. The 10M relay control coil ground circuit (97AH) is connected to ECM connector (379) terminal 33. The ECM switches ECM terminal 33 between 0 and 12 volts to enable or disable

the IDM relay. When terminal 33 is at 0 volts, the 10M relay energizes.

When the 10M PWR relay is energized, battery power passes through the normally open relay contacts (30 to 87) and on circuit 97AG to connector (380) terminal 14 (IDM VIGN). The 10M power ground is from IDM terminal 26, through circuits 97-GM/97-GMAI 97-GMC/97-GMD/11-G to the negative battery terminal.

If the IDM is not powered, the engine will not run.

ECM DIAGNOSTICS

The ECM uses the Output Circuit Check (OCC) to test the IDM relay control coil circuit for short circuits (high or low) and opens in the circuit. Use the Prolink EST to perform the OCC test. When the test is complete, the Prolink will indicate if there were faults detected and what the Flash Code number is.

FLASH CODE 243

SID 37 FMI11

ECM: *IDM_ENABLE DCC FAULT*

If the 10M detects a fault in the 10M circuit during the OCC test, Flash Code 243 will be set. This indicates that circuit 97AH is shorted (high or low) open or no power is present in circuit 97CT to energize the 10M relay.

When Flash Code 243 occurs, it can also cause Flash Codes 253, 523, 541 or 543 to be set. Flash codes 253, 523, 541, and 543 can be caused by several conditions. This section only discusses the 10M POWER RELAY circuits that could cause the codes to set.

ECM DIAGNOSTICS (Continued)

FLASH CODE 522
SID 233 FMI 12
IDM: *10M INTERNAL FAILURE*

FLASH CODE 523
SID 233 FMI4
IDM: *10M POWER VOLTAGE LOW*

Code 523 can be caused by:

- A. Faulty 10M PWR Relay control circuit (will cause code 243 to set when performing an ACC test).
- B. Excessive voltage drop in circuit 97AG.
- C. Low voltage in 97CP to the 10M PWR Relay from #2 ECM fuse.
- O. A defective 10M PWR Relay.

TROUBLESHOOTING

The test included in this section systematically checks the entire 10M Power Relay System.

If Flash Codes 243, 253, 523, 541 or 543 are active, perform the following test. Refer to the circuit diagram located in this section while using test procedure.

BEFORE TROUBLESHOOTING

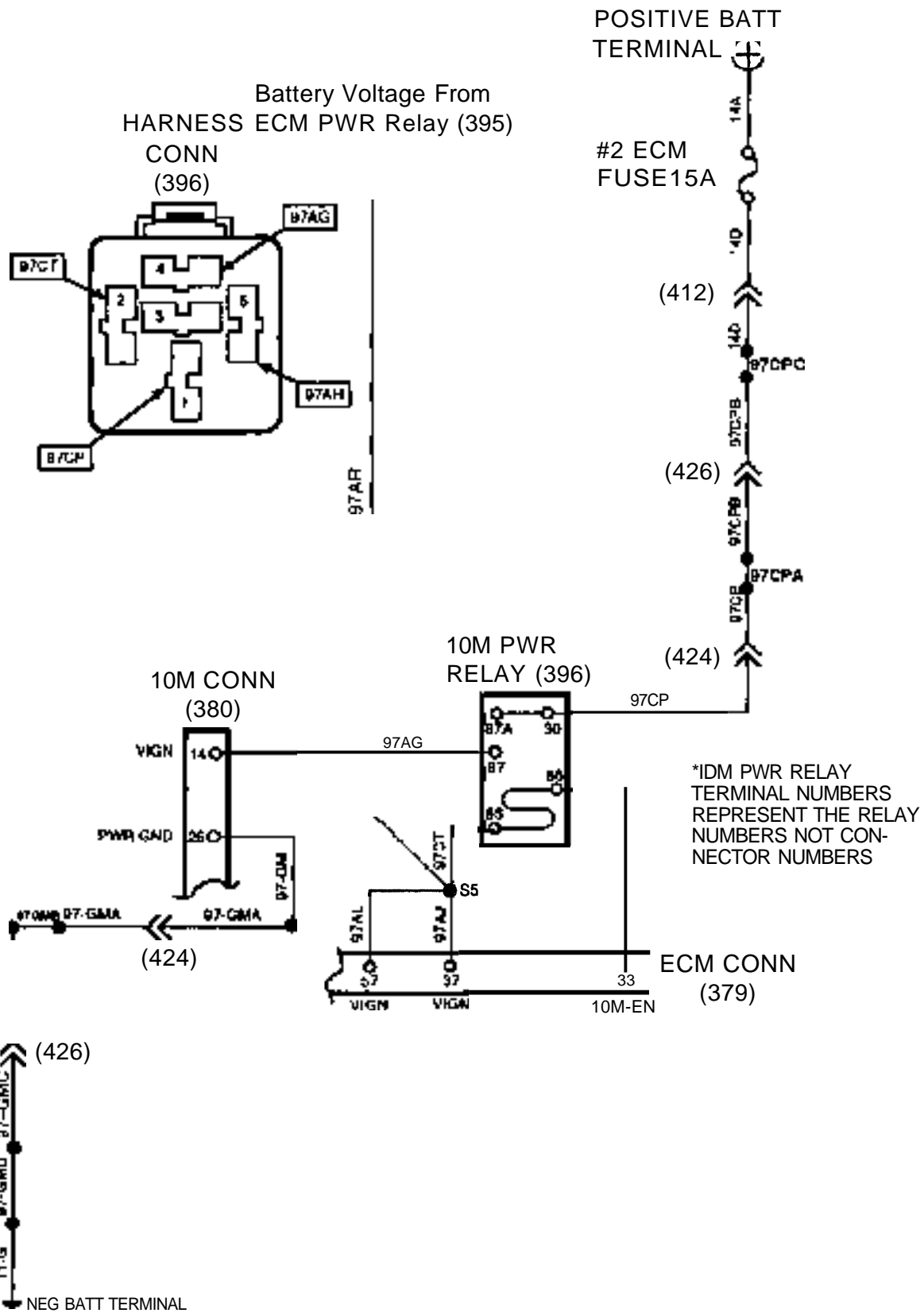
Before Performing the test(s) included in this section:

- A. Make sure batteries are fully charged! Check battery cables and grounds for clean, tight connections free of damage and corrosion. Voltage tests will give inaccurate readings if batteries are not fully charged.
- B. Inspect connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. the wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue is present that must be removed.
- C. Inspect suspect circuit grounds for clean, tight connections, free of damage.

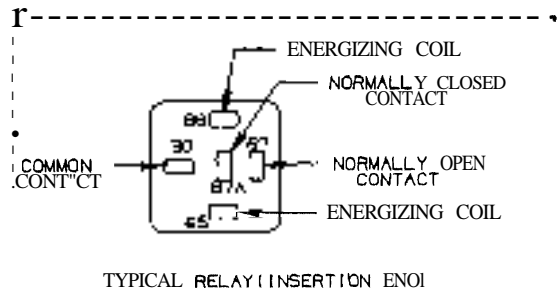
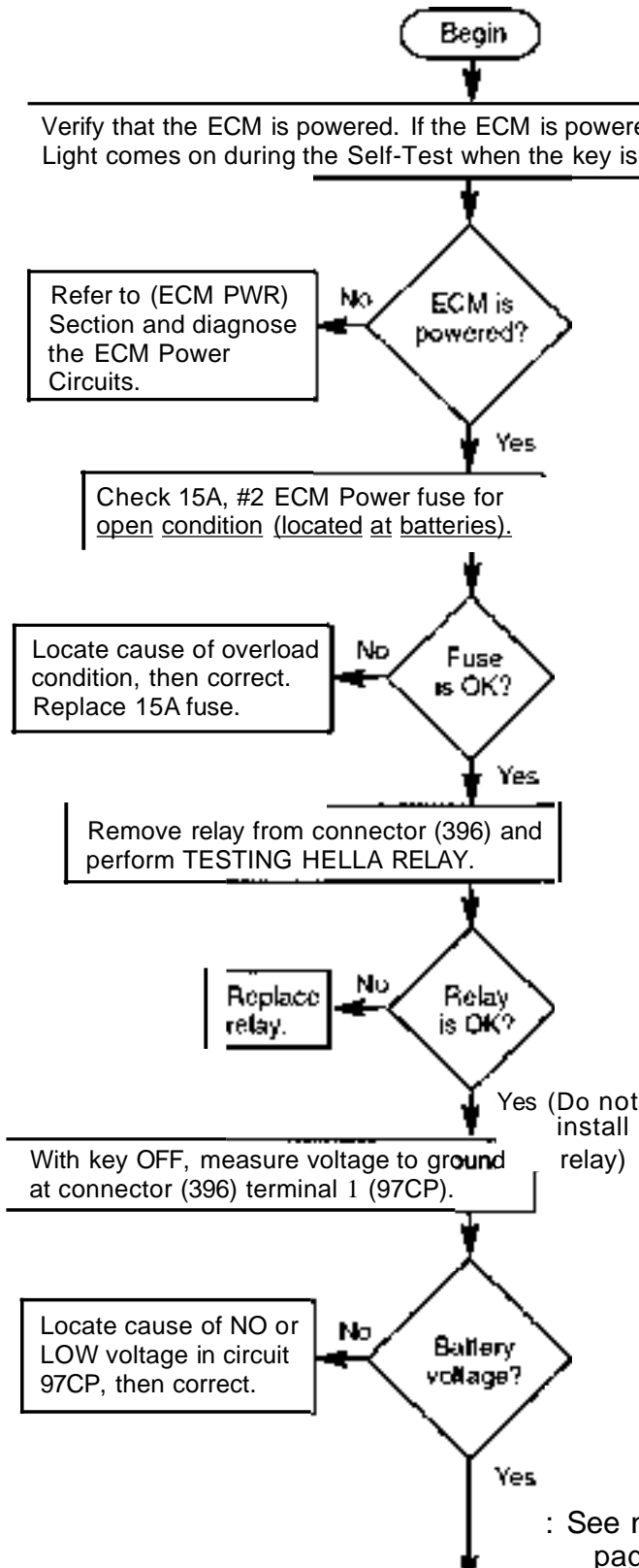
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVER MODULE POWER CIRCUITS (10M PWR)

INJECTOR DRIVER MODULE POWER SUPPLY CIRCUIT DIAGRAM

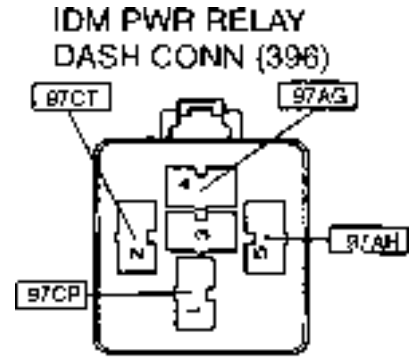


TESTING 10M PWR RELAY AND RELATED CIRCUITS



TESTING HELLA RELAY

- : With relay removed:
- 1. Connect (+) battery lead to terminal 85 and (-) lead to terminal 86.
 - A. If relay energizes making an audible click sound, go to step 2. Otherwise replace the relay.
- 2. With relay energized, measure resistance between terminals 30 and 87.
 - A. If resistance is less than 2 ohms, go to step 3. Otherwise replace the relay.
- 3. Disconnect battery leads from relay and measure resistance between terminals 30 and 87.
 - A. If resistance is 100K ohms or more, the relay is good. Otherwise replace the relay.

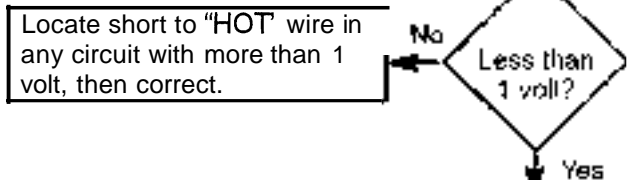


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

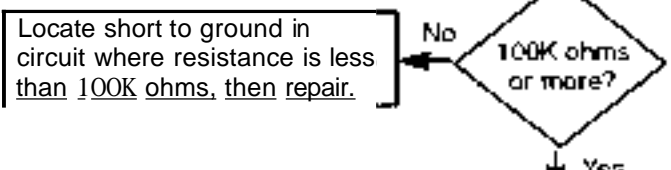
INJECTOR DRIVER MODULE POWER CIRCUITS (10M PWR)

TESTING 10M PWR RELAY AND RELATED CIRCUITS (Continued)

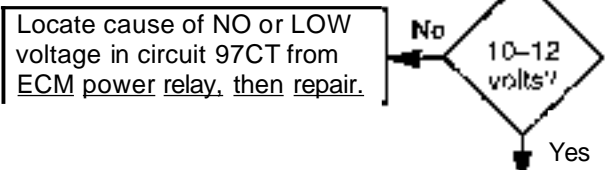
KEY OFF - Remove connectors (379) from ECM and (380) from 10M. Turn key ON and measure voltage to ground at connector (396) terminals 4 and 5.



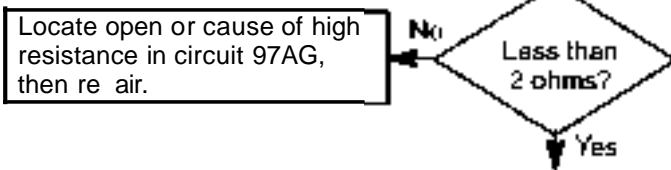
KEY OFF- At connector (396) measure resistance to ground at terminals 4 & 5.



KEY ON- At connector (396) measure voltage to ground at terminal 2



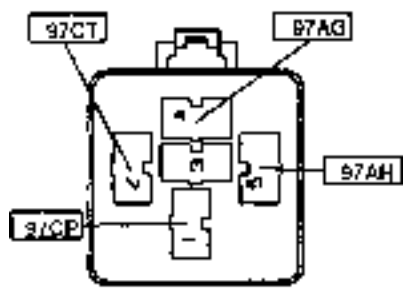
KEY OFF- Measure resistance between connectors 396 terminal 4 and 380, terminal 14.



KEY OFF- At 10M connector (380), measure resistance to ground at terminal 26.

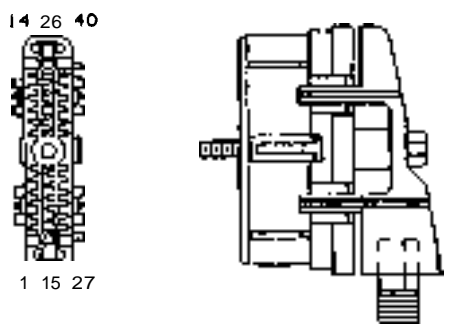
: See next: page

IDM POWER RELAY (396)
DASH HARNESS



CONNECTOR-lee1747C91
TERMINAL - 16616Z7CI

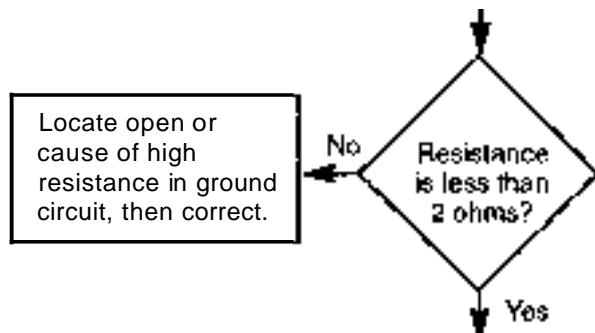
10M CONNECTOR (380)



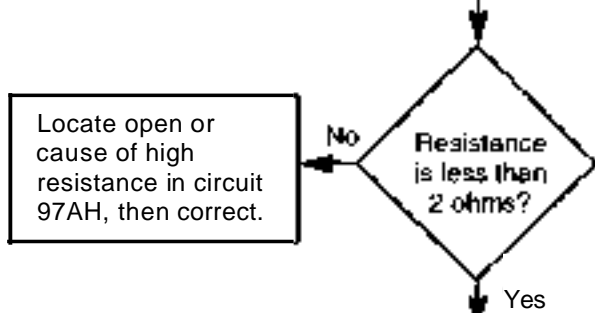
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVER MODULE POWER CIRCUITS (10M PWR)

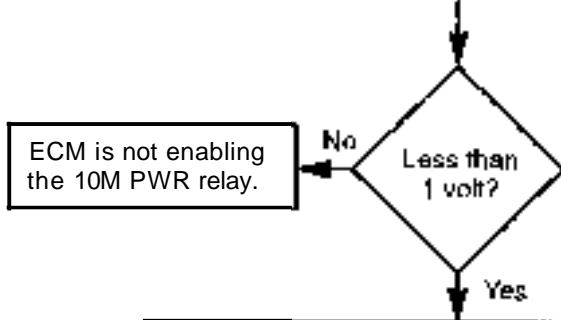
TESTING IDM PWR RELAY AND RELATED CIRCUITS (Continued)



With key OFF, install breakout box between harness connector (379) and ECM. Measure resistance between connector (396) terminal 5 (97AH) and breakout box terminal 33.

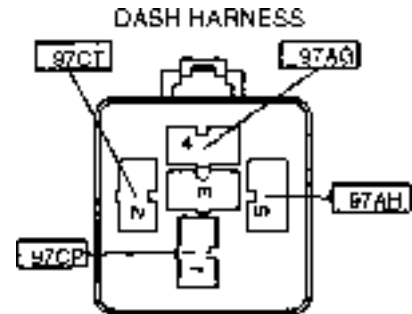


Install relay in (396) and connect harness to 10M. With key ON, at breakout box measure voltage between terminals 33 and 60.



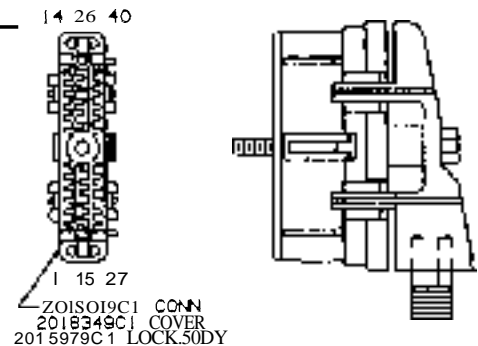
10M Power Relay Circuits are performing correctly.

IDM POWER RELAY (396)



CONNECTOR-Jeel717C91
TERMINAL-100102701

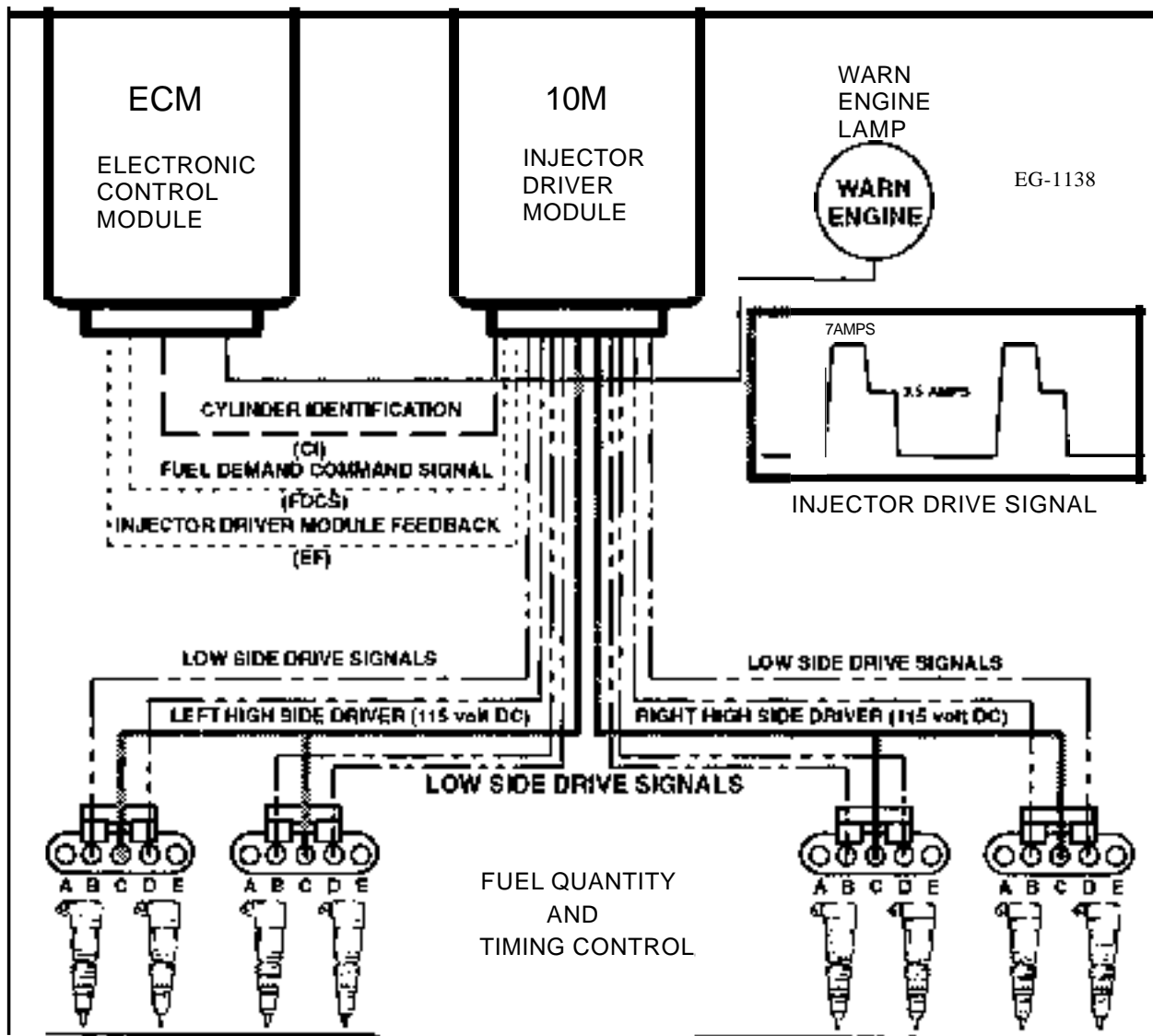
IDM CONNECTOR (380)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVE CIRCUITS (INJ)

INJECTOR DRIVE CIRCUIT OPERATION



SIGNAL FUNCTIONS

High Side Drive Outputs (Right and Left Bank)-
The high side drive output function is to supply to the injectors a power supply of 115 volt DC at a maximum of 10 amps. This power supply is available to the injectors on a continuous basis.

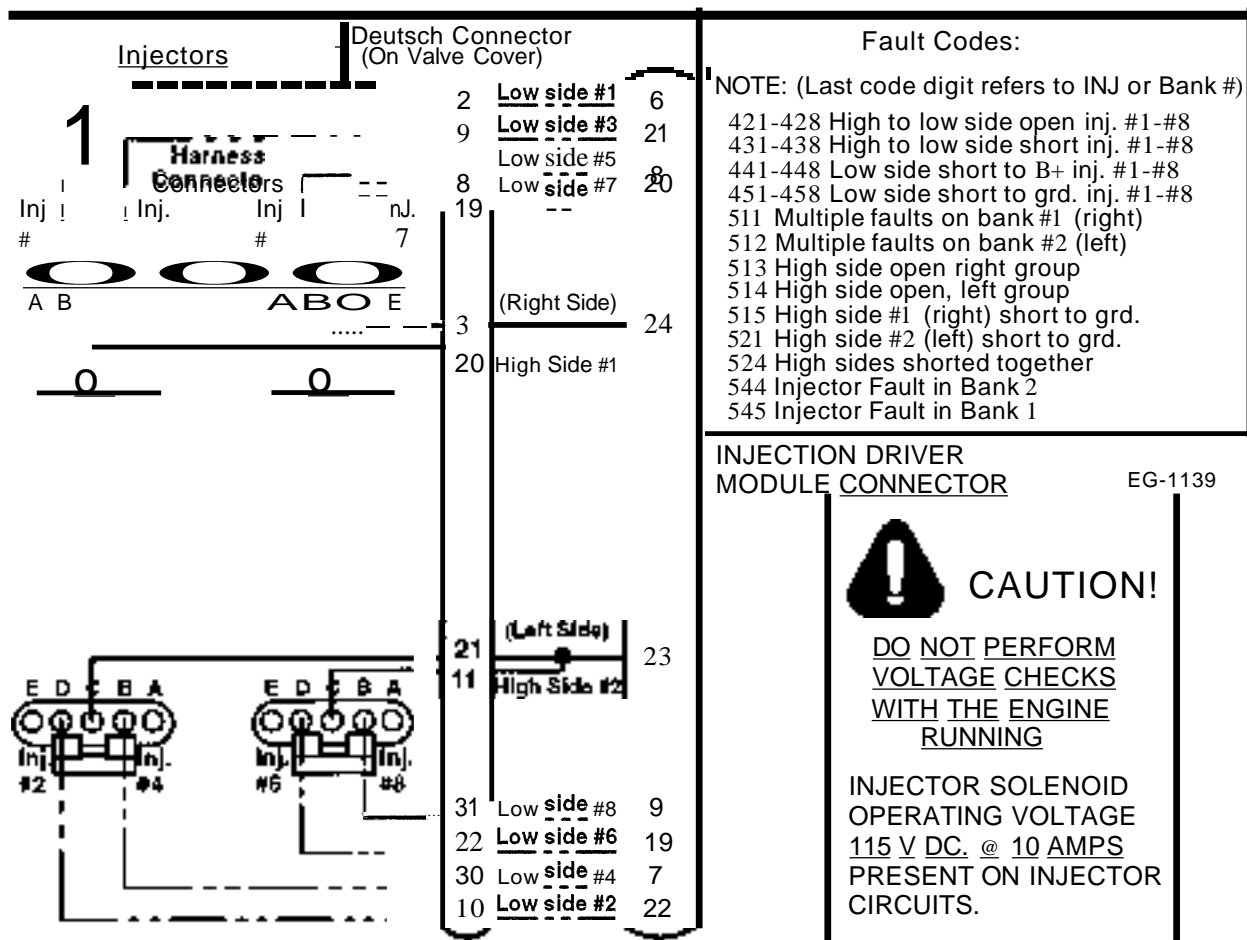
Low Side Drive Outputs - The low side drive outputs control the injector on time (fuel quantity), timing (in relation to TDC) and sequencing (firing order). The 10M controls (fires) each individual injector by completing the ground circuit to each injector solenoid. A valid Cylinder Identification (CI) and Fuel Demand Command Signal (FOCS) must be sent from the ECM to the 10M before an injector will be allowed to fire.

FAULT DETECTION/MANAGEMENT

The Injector Driver Module (IDM) is capable of detecting, while the engine is running individual injector open and shorts to either ground or battery. It is also capable of detecting right or left bank high side opens or shorts to ground. A special On-Demand Buzz test will also allow the operator to enable all injector solenoids while the engine is off to verify circuit operation. IDM detected diagnostic fault codes will not be transmitted if the EF line is not functioning, however, the engine will function normally.

If a short to ground condition is detected on an individual injector, (low side), the 10M will discontinue the power to the bank with the shorted injector, enable the WARN engine lamp and operate the engine on four cylinders.

INJECTOR DRIVE CIRCUITS (INJ)



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

NOTE: Test all injector harness and valve cover connectors at Test Points indicated.
Engine Harness Connector Check to Chassis Ground

Test Points	Spec.	Comments
B	> 1000 ohms	Injector low side - codes 451-458 may be set if shorted to grd.
C	> 1000 ohms	Injector power feed high side - codes 515 or 521 may be set if shorted to grd.
D	> 1000 ohms	Injector low side - codes 451-458 may be set if shorted to grd.

Valve Cover Gasket Connector to Chassis Ground
(Check with pigtail connector installed on gasket connector)

Test Points	Spec.	Comments
B	> 1000 ohms	Injector low side - codes 451-458 may be set if shorted to grd.
C	> 1000 ohms	Injector power feed high side - codes 515 or 521 may be set if shorted to grd.
D	> 1000 ohms	Injector low side - codes 451-458 may be set if shorted to grd.

Under Valve Cover Harness and Injector Solenoid Resistance Checks
(Check with pigtail connector installed on gasket connector)

Test Points	Spec.	Comments
B to C	3.4 ± 2 ohms	Resistance thru injector solenoid and UVC harness - codes 421-428 may be present if open, codes 431-438 may be present if injector or harness shorted together.
C to D	3.4 ± 2 ohms	

Engine Harness to 10M connector checks (measure to appropriate pin)

Test Points	Spec.	Comments
8 to IDM	< 5 ohms	Injector low side - code(s) 421-428 present if open present.
C to IDM	< 5 ohms	Injector pwr. feed high side-code(s) 513 or 514 present if open, code 524 indicates sides shorted together.
D to 10M	< 5 ohms	Injector low side - code(s) 421-428 present if open present.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVE CIRCUITS (INJ)

INJECTOR DRIVE CIRCUIT EXTENDED SYSTEM DESCRIPTION

FUNCTION

SYSTEM DESCRIPTION

The Navistar engine control system includes an ECM (Electronic Control Module) and an IDM (Injector Drive Module). The ECM provides the 10M with two important output signals which control fuel injector operation. The ECM uses the fuel quantity control strategy and input from the engine sensors to determine how long each fuel injector is actuated in order to provide the proper fuel quantity at any given engine operating condition. The ECM determines and provides a fuel output signal, FOCS (Fuel Demand Command Signal), by combining the desired length of each injection with the result of the injection timing control strategy which determines when each injection will occur. The second output signal, (CI) Cylinder Identification, enables the 10M to determine the correct injector firing order.

The 10M processes the FDCS and CI signals sent by the ECM to control injector operation. It amplifies the FDCS signal to make it powerful enough to operate the injectors and distributes it to each injector according to the CI signal.

OPERATION

The IDM contains two solid state high side drivers. Each driver supplies a continuous 115 volts DC. Right bank high side driver supplies cylinders 1,3,5 and 7 with 115 volts at terminal 24 of the 10M to terminals 3 and 20 of the valve cover connector. Left bank high side driver supplies cylinders 2,4,6 and 8 with 115 volts at terminal 23 of the IDM to terminals 21 and 11 of the valve cover connector. The IDM turns each injector on by switching on a solid state device (Low Side Driver) to ground the injector solenoid return circuit. The 10M contains a low side driver for each of the injectors.

IDM DIAGNOSTICS

The 10M monitors the voltage on the driver circuits and is capable of detecting an open or shorted circuit. If the IDM detects a short to ground or a multiple fault in a driver, the IDM will discontinue operation of that driver which would cause the engine to operate on the remaining bank of 4 cylinders. The IDM will transmit a message to the ECM that a fault has been detected. The ECM will respond by illuminating the Engine Warning Light and compensating for inoperative cylinders to keep the engine running if mechanically possible.

Faults detected by the 10M will be stored in the 10M and transmitted to the ECM during an "Engine Off Standard Test". These faults will be transmitted as Inactive faults. Faults can be retrieved using the Electronic Service Tool or the STI Self Test Input Diagnostic Switch located on the vehicle dash.

NOTE: THE LAST DIGIT OF THE FLASH CODE INDICATES THE AFFECTED CYLINDER NUMBER. FOR EXAMPLE, CODE 421 INDICATES CYLINDER NO. 1 HAS AN OPEN CIRCUIT BETWEEN THE IDM HIGH SIDE DRIVER AND THE LOW SIDE (SIGNAL RETURN) TO THE IDM. THE SID NO.S 1-8, INDICATE CYLINDER NO.S IN A SIMILAR MANNER.

**FLASH CODE 421 THROUGH 428
ATA CODE SID 1 THROUGH 8 FMI 5
HIGH SIDE TO LOW SIDE OPEN**

Flash Codes for High Side to Low Side Open indicate an open circuit between the IDM high side driver and the low side (Signal return) to the 10M.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the Engine Warning light when this situation occurs.

Possible causes: Open wire in injector harness, open injector return circuit or injector solenoid.

**FLASH CODE 431 THROUGH 438
ATA CODE SID 1 THROUGH 8 FMI 4
HIGH SIDE SHORTED TO LOW SIDE**

Flash codes for High Side Shorted to Low Side indicate the return voltage is too high due to a short circuit between the high side driver and return circuit.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the Engine Warning light when this situation occurs.

Possible causes: Shorted injector solenoid or wiring harness.

**FLASH CODE 441 THROUGH 448
ATA CODE SID 1 THROUGH 8 FMI 3
LOW SIDE SHORTED TO B+**

Low Side Shorted to B+ indicates the IDM has detected continuous battery voltage on the signal return circuit.

The ECM will compensate for engine misfire to keep the engine operating. The ECM will not illuminate the Engine Warning light when this situation occurs.

A short circuit in the injector wiring harness will set these codes.

INJECTOR DRIVE CIRCUIT**EXTENDED SYSTEM DESCRIPTION (Continued)**

FLASH CODE 451 THROUGH 458
ATA CODE SID 1 THROUGH 8 FMI 6
LOW SIDE SHORTED TO GROUND

Flash codes for Low Side Shorted to Ground indicate the return circuit shorted to ground.

If the 10M detects this fault, it will disable the entire bank of cylinders associated with the cylinder indicated.

Possible causes: Shorted injector solenoid or wiring harness to ground.

FLASH CODE 511
ATA CODE SID 151 FMI11
BANK1 HAS MULTIPLE FAULTS

Multiple Faults indicates more than one fault was detected by the IDM, such as an open and a short circuit in cylinders 1,3,5, and 7.

With flash code 511 active, the 10M will disable the drivers for cylinders 1,3,5 and 7. The ECM will compensate for misfire to keep the engine operating and will illuminate the Engine Warning Light.

FLASH CODE 512
ATA CODE SID 152 FMI11
BANK2 HAS MULTIPLE FAULTS

Multiple Faults indicates more than one fault was detected by the 10M, such as an open and a short circuit in cylinders 2,4,6 and 8.

With flash code 512 active, the 10M will disable the drivers for cylinders 2,4,6 and 8. The ECM will compensate for misfire to keep the engine operating and will illuminate the Engine Warning Light.

FLASH CODE 513
ATA CODE SID 151 FMI5
HIGH SIDE OPEN, RIGHT GROUP

With High Side Open Right Group (Bank 1), the 10M has detected an open circuit to the injectors on cylinders 1,3, 5, or 7.

With flash code 513 active, the drivers for cylinders 1, 3,5, and 7 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the Engine Warning light.

FLASH CODE 514
ATA CODE SID 152 FMI5
HIGH SIDE OPEN LEFT GROUP

With the High Side Open Left Group (Bank 2), the 10M has detected an open circuit to the injectors on cylinders 2,4,6 and 8.

With flash code 513 active, the drivers for cylinders 2,4,6 and 8 are inoperative. The ECM will compensate for misfire to keep the engine operating and will illuminate the Engine Warning light.

FLASH CODE 515
ATA CODE SID 151 FMI6
HIGH SIDE BANK1 SHORT TO GROUND OR B+

Flash code 515 indicates the IDM has detected the high side driver for cylinders 1,3, 5 and 7 has excessive current draw.

With flash code 515 active, the driver for cylinders 1, 3, 5 and 7 will be disabled. The ECM will compensate for engine misfire to keep the engine running. This code will cause the Engine Warning light to be illuminated.

FLASH CODE 521
ATA CODE SID 152 FMI 6
HIGH SIDE BANK2 SHORT TO GROUND OR B+

Flash code 521 indicates the 10M has detected excessive current draw on high side driver for cylinders 2, 4, 6 and 8.

With flash code 521 active, the driver for cylinders 2, 4, 6 and 8 will be disabled. The ECM will compensate for engine misfire to keep the engine operating and will illuminate the Engine Warning light.

FLASH CODE 524
ATA CODE SID 151 FMI3
BOTH HIGH SIDE SWITCHES SHORTED TOGETHER

Flash code 524 indicates a short circuit between the two high side drivers.

With this code active, the Engine Warning light will be illuminated.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTOR DRIVE CIRCUITS (INJ)

INJECTOR DRIVE CIRCUIT EXTENDED SYSTEM DESCRIPTION (Continued)

FLASH CODE 544
ATA CODE SID 152 FMI14
INJECTOR FAULT BANK #2

Flash code 544 indicates ECM has detected more than one injector in Bank #2 (Left Bank) with low voltage.

FLASH CODE 545
ATA CODE SID 151 FMI14
INJECTOR FAULT BANK #1

Flash code 545 indicates ECM has detected more than one injector in Bank #1 (Right Bank) with low voltage.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

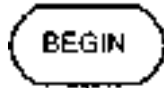
INJECTOR DRIVE CIRCUITS (INJ)

INJECTOR DRIVE CIRCUITS

Refer to circuit diagram on page 163.

KEY OFF- Remove connector (380) from 10M. Measure resistance to ground at terminals 6,7, 8,9, 19,20,21,22,23,24.

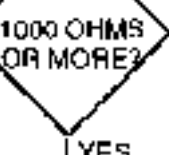
NO
Locate short to ground in circuit having less than 1000 ohms and repair.



YES

Disconnect positive battery terminal and measure resistance between negative battery terminal and connector (380) terminals 6,7,8,9,19, 20, 21, 22, 23, 24.

NO
Locate short to ground in circuit having less than 1000 ohms and repair.



YES

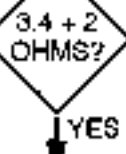
At 10M connector (380), measure resistance from terminal 24 (high side) to terminals 6,8,20 & 21, (low side). Then measure resistance from terminal 23 (high side) to terminals 7, 9, 19 and 22 (low side)"

Measure resistance (at the injector) of any injector and circuit having more than 10.5 ohms.



NO

NO
Replace the injector



YES

Repair open in circuit between injector and connector (380).



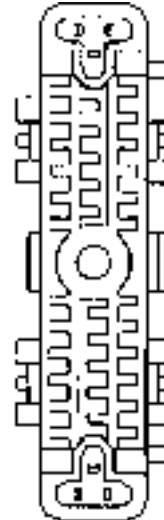
YES

NO
Replace the 10M

Continued On Next Page

(10M) INJECTOR DRIVE MODULE (380)
DASH HARNESS

14 26 40



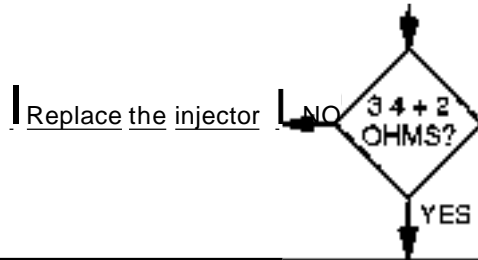
1 15 27

INJECTOR DRIVE CIRCUITS (INJ)

INJECTOR DRIVE CIRCUITS (Continued)

YES

Measure resistance of injector in circuit having less than 1.4 ohms resistance.

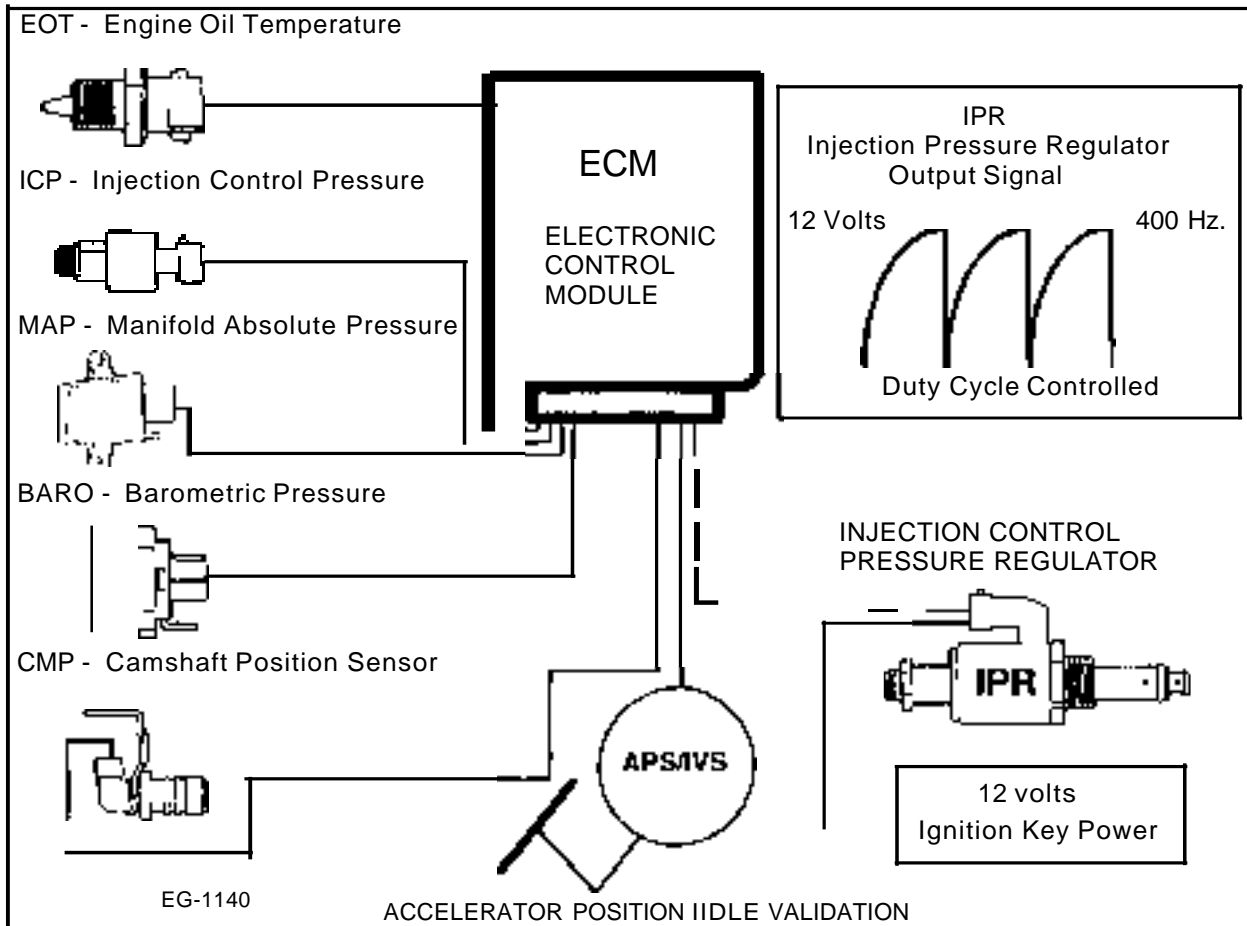


Locate circuit where resistance between high and low sides is less than 1.4 ohms and repair.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION PRESSURE REGULATOR (IPR)

INJECTION PRESSURE REGULATOR (IPR)



OUTPUT FUNCTIONS

Injection Pressure Regulator - Is a variable position valve that controls injection control pressure. The ECM uses many input variables to determine the desired injection control pressure.

Battery voltage is supplied to the IPR when the ignition key is in the on position. Valve position is controlled by switching the output signal circuit to ground inside the Electronic Control Module (ECM). On off time is modulated from 0-50% dependent upon the desired injection control pressure.

FAULT DETECTION/IMANAGEMENT

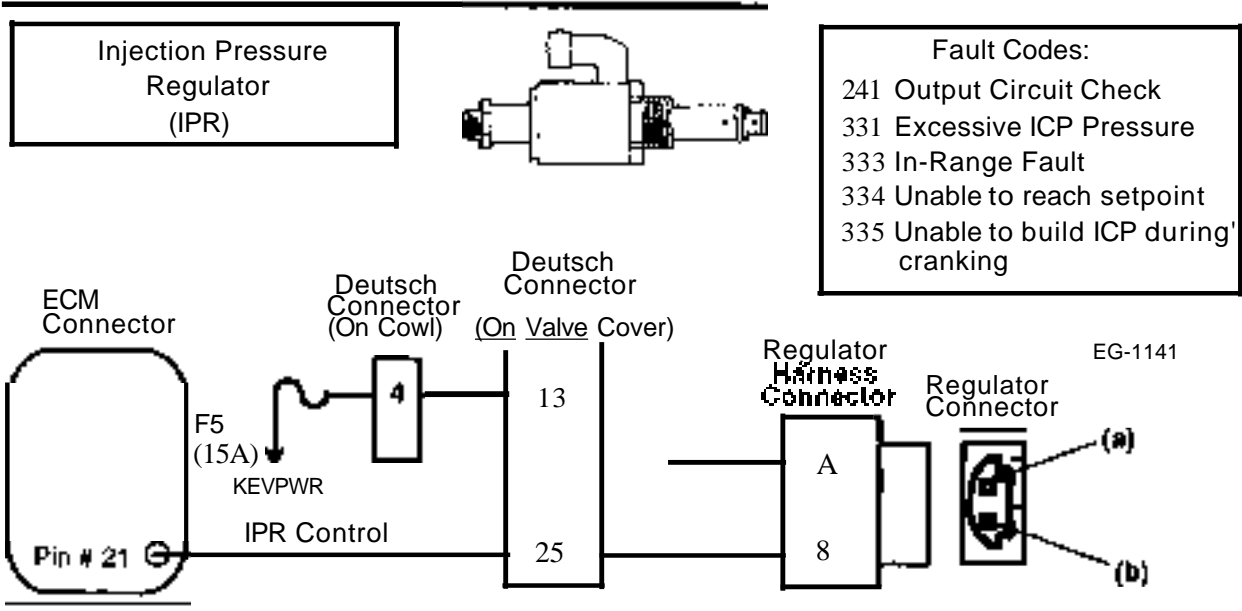
An open or a short to ground control circuit can be detected by an on demand output circuit check performed during the engine off test.

The ECM is capable of detecting, while the engine is running, if desired injection control pressure is equal to measured injection control pressure. If the measured injection control pressure does not reasonably compare to the desired injection control pressure, the ECM ignores the measured ICP signal and attempts to control the engine with the desired value. (If the problem was in the sensor circuit, this strategy causes little performance deterioration, if the problem is in the control circuit, engine performance will probably still be unsatisfactory).

A faulty IPR or problem with the high pressure oil system can be detected by the engine running test during the injection control pressure step test. During this test, the ECM commands and measures two specific pre programmed pressures. A fault code is set, if the pressures can not be maintained.

NOTE: THE ENGINE WILL NOT OPERATE WITH AN IPR CIRCUIT THAT IS NOT FUNCTIONING.

INJECTION PRESSURE REGULATOR (IPR)



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Ground (8-)
(Check with IPR Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
B to Grd.	> 1000 ohms	A short to ground will command full IPR pressure, code 331 may be set.

IPR Voltage Check
(Check with regulator connector disconnected)

Test Points	Spec.	Comments
A to Grd.	B+	Battery voltage from F2, check with key on (GP relay coil is supplied from same fuse).
8 to Grd.	O- .25v	If greater than .25 volts, signal wire is shorted to V Ref. or battery.

Harness Resistance Checks
(Check with breakout box installed) (IPR connector reconnected.)

Test Points	Spec.	Comments
#21 to F5	5 to 20 ohms	Resistance through entire IPR circuit including regulator, check with regulator connector connected.
#21 to B	< 5 ohms	Resistance from 60 pin connector to regulator connector.
F2 to A	< 5 ohms	Resistance from power supply (F2) to regulator connector.

Fault Code Descriptions

- 241 = Output circuit check detected during Std. test, indicates high or low resistance in circuit.
- 331 = ICP pressure was greater than 3675 PSI (25 MPa) for 1.5 seconds. (possible grounded IPR control circuit.) (Refer to injection control pressure diagnostics if not electronic fault.)
- 333/334 = (1) If set during normal engine operation indicates engine is operating in open loop control and ICP pressure is above or below desired pressure. (Refer to ICP control system diagnostics.)
(2) If set during engine running test, indicates ICP system failed step test and could not maintain commanded pressure.
- 335 = ICP unable to build pressure during cranking.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION PRESSURE REGULATOR (IPR)

INJECTOR PRESSURE REGULATOR EXTENDED SYSTEM DESCRIPTION FUNCTION

The Navistar engine control system includes a Injection Pressure Regulator (IPR) valve that controls oil pressure in the high pressure injection control system which is used to actuate the injectors. The IPR valve consists of a solenoid, poppet and spool valve assembly and is mounted in the high pressure oil pump. The ECM regulates injection control pressure by controlling the duty cycle or (on/off time) of the injection control pressure solenoid. This increase or decrease of "on/off" time positions a poppet valve and spool valve internal to the IPR, which in turn either maintains pressure in the injection control pressure system or vents pressure to the oil sump via the front cover. (Refer to manual Sec. 1.2, Injection Control Pressure System for a more complete description of the IPR operation and function.)

OPERATION

The IPR valve is supplied with voltage at terminal A of the IPR connector when the ignition key is turned on thru fuse F5. Control of the injection control system is accomplished by the ECM grounding the IPR circuit from terminal B of the IPR valve thru pin #21 of the ECM. Precise control is accomplished by varying the pulse width or percentage of "on/off" time of the IPR solenoid. The frequency of the pulse-width to the IPR is 400 Hz, normal "on/off" times varies from 80/0 to 500/0. A high duty cycle indicates a high amount of injection control pressure being commanded, a low duty cycle is an indication of less pressure being commanded.

ECM DIAGNOSTICS

The ECM monitors the Injection Control Pressure while the engine is in operation. If the actual pressure is greater or less than the desired pressure, the ECM will set a fault code. When this occurs, the ECM will ignore the ICP sensor and control the engine using pre programmed values for the IPR.

The Electronic Service Tool is used to Perform the Engine Running Standard Test which enables the ECM to vary the command signal to the IPR and monitor the performance of the Injection Control Pressure system. If the system does not respond within the specified parameters, the ECM will set a fault code.

Fault codes can be retrieved using the Electronic Service Tool or the Self Test Input diagnostic switch located on the vehicle dash. If the ignition key is shut off, the code will be stored as an Inactive code.

FLASH CODE 241

ATA CODE SID 42 FMI11

INJECTION CONTROL PRESSURE REG. oec

SELF TEST FAILED

Code 241 is set only during the Engine Off Standard Output Circuit Check. This test indicates the ECM has performed an output circuit test, measured voltage drop across the IPR circuit and determined it is below or above specification.

If this fault is present, the engine will not run. The ECM will not illuminate the Engine Warning light if this code is active, however, this code will be transmitted at the completion of the Output Circuit Check, using the STI switch or the Electronic Service Tool.

Possible causes: Open feed circuit or fuse to the IPR, open IPR solenoid, or an open or shorted IPR signal circuit.

FLASH CODE 331

ATA CODE PID 164 FMI 0

*INJECTION CONTROL PRESSURE
ABOVE SYSTEM WORKING RANGE*

Code 331 indicates the ECM has detected injection control pressure greater than 3675 PSI (25 MPA) which is greater than the maximum allowable working pressure.

When this code is active, the ECM will illuminate the Engine Warning light.

Possible causes: Incorrect ICP signal due to faulty circuits or sensor, grounded IPR signal circuit, a malfunction in the injection control pressure system or a sticking or blocked IPR valve. Refer to Injection Control Pressure system diagnostics in Section 2.

FLASH CODE 333

ATA CODE PID 164 FMI10

*INJECTION CONTROL PRESSURE ABOVE/BE-
LOW DESIRED LEVEL*

Code 333 may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test. It indicates the measured pressure does not match the expected value. The ECM will illuminate the Engine Warning light.

When this code is active, the ECM will ignore the ICP sensor signal and will control the IPR from programmed values to keep the engine operating. Perform ICP sensor diagnostics to determine if the problem exists in the ICP sensor/circuit. If diagnostic testing indicates the ICP sensor/circuit is functioning properly, perform additional diagnostic tests on the injection control pressure system. Refer to Injection Control Pressure system diagnostics in Section 2.

Possible causes: Incorrect ICP signal due to circuit or sensor malfunctions. IPR signal circuit may be grounded or contain excessive resistance. The IPR valve may be sticking or blocked. Injection control pressure system may not be functioning properly.

INJECTION PRESSURE REGULATOR (IPR)

ECM DIAGNOSTICS (Continued)**FLASH CODE 334****AIA CODE PID 164 FMI7*****INJECTION CONTROL PRESSURE UNABLE TO REACH SETPOINT-POOR PERFORMANCE***

Code 334 indicates an injection control system response time fault and may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test.

While the driver of the vehicle rapidly presses his foot down on the accelerator pedal, the ECM compares the actual vs the desired injection control pressure and looks for a large pressure difference (1300 PSI/9MPA) for a short period of time (3 seconds). If the injection control system does not respond quick enough Code 334 will be set and the Engine Warning Lamp will be illuminated.

Possible Causes: Low oil level, contaminated engine oil or aerated oil. Trapped air in the injection control pressure system (particularly after an injector or high pressure pump replacement). Defective or stuck Injection Pressure Regulator (IPR). Intermittent IPR valve wiring connection-spread IPR

harness terminals at IPR valve, poorly crimped terminals or pulled back pin. Leaking injector "O" rings. Problem with ICP sensor and sensor circuit, system biased high or low. Refer to Injection Control Pressure system diagnostics in Section 2.

FLASH CODE 335**ATA CODE PID 164 FMI1*****INJECTION CONTROL PRESSURE UNABLE TO BUILD PRESSURE DURING CRANKING***

Code 335 indicates the ECM has determined that the injection control pressure system has failed to build a pressure of at least 725 PSI/5 MPA during a programmed period of engine cranking time which will vary with engine temperature.

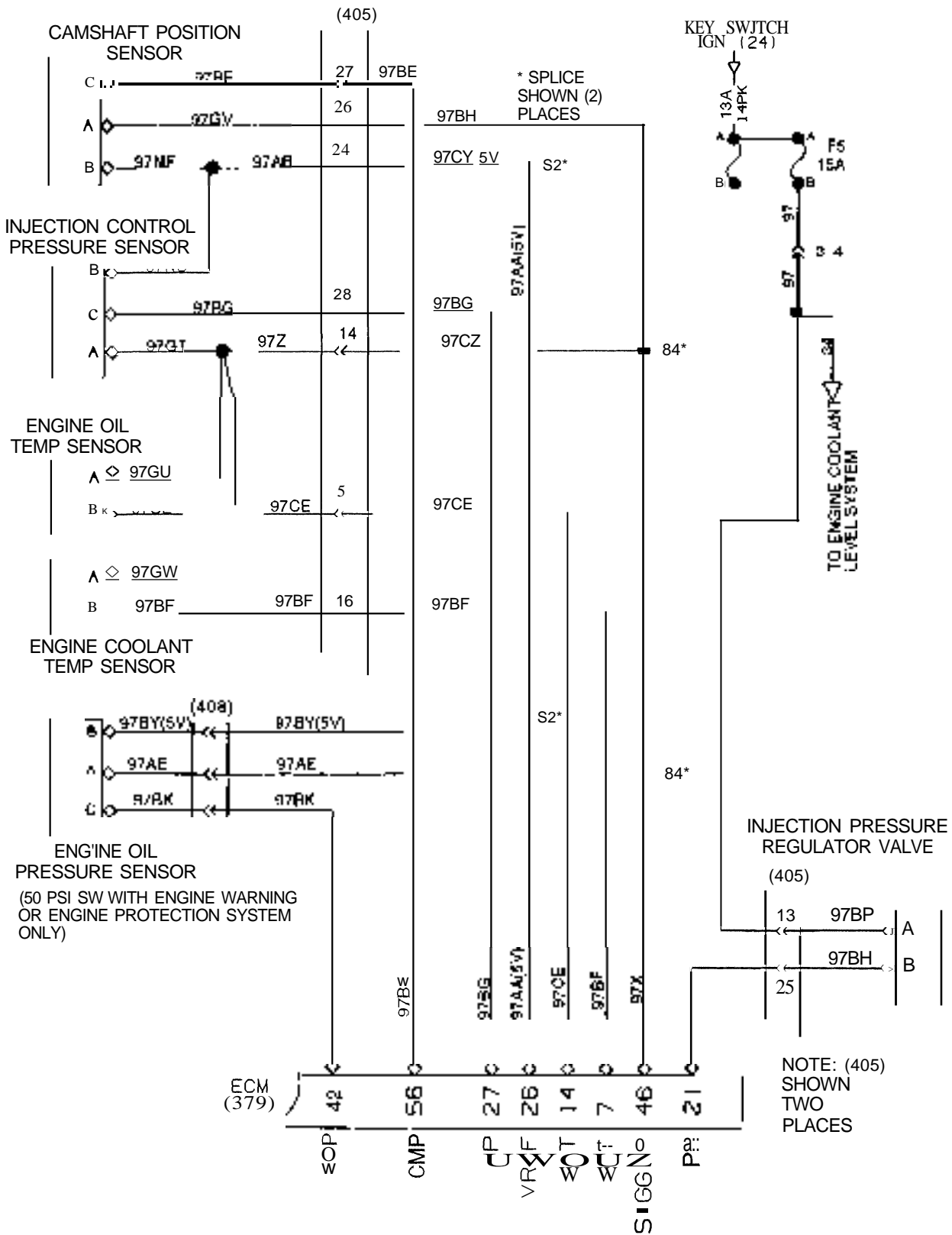
NOTE: Engine cranking speed must be greater than 130 RPM before fault detection begins.

Possible Causes: No oil in engine. Air in the injection control pressure system (particularly after an injector or high pressure pump replacement). Defective or stuck IPR regulator. Leaking injector "O" rings. Loose high pressure pump gear. Defective high pressure oil pump.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION PRESSURE REGULATOR (IPR)

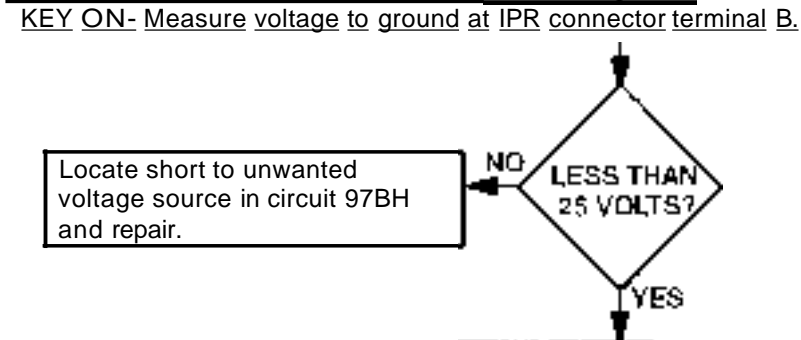
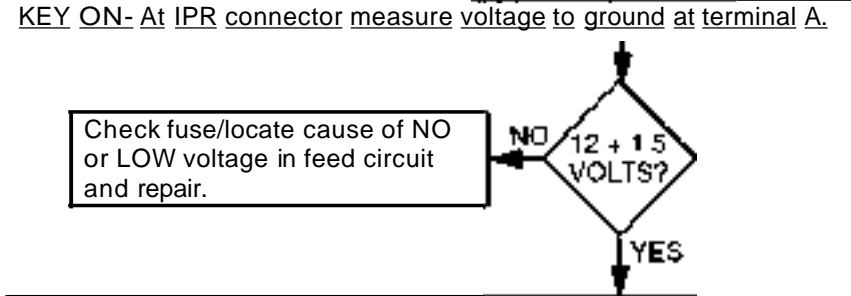
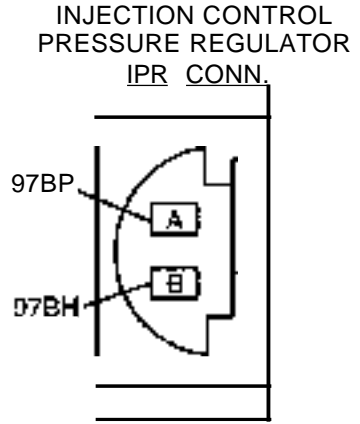
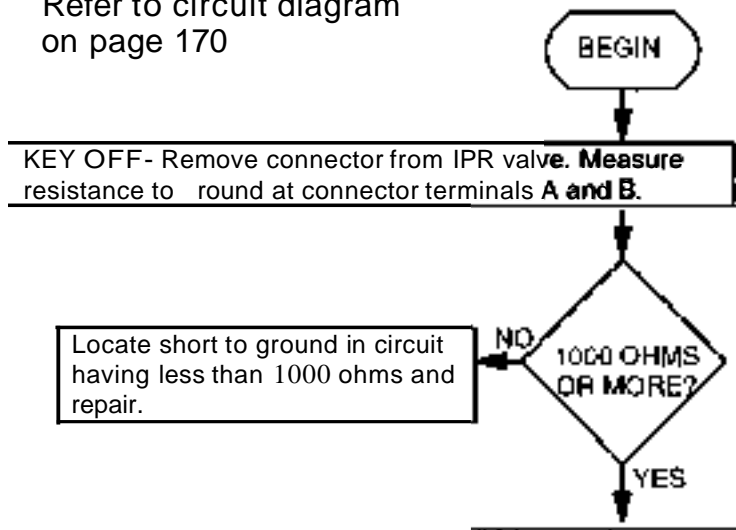
SENSOR CIRCUIT DIAGRAM



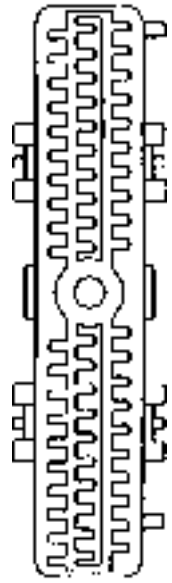
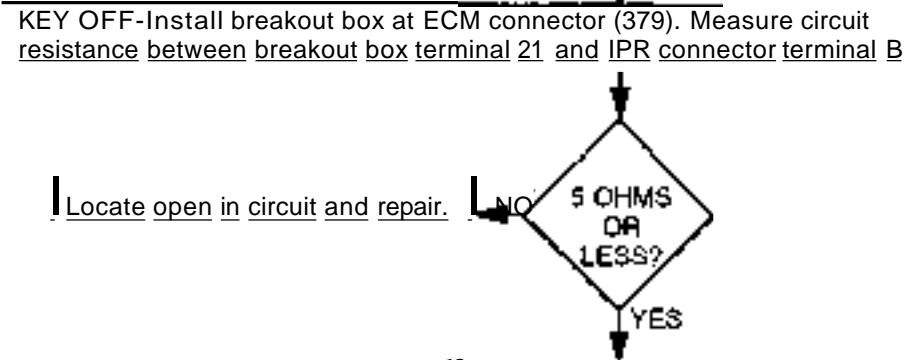
INJECTION PRESSURE REGULATOR (IPR)

INJECTION CONTROL PRESSURE REGULATOR

Refer to circuit diagram on page 170



ELECTRONIC CONTROL MODULE (379)
(DASH HARNESS)
204060

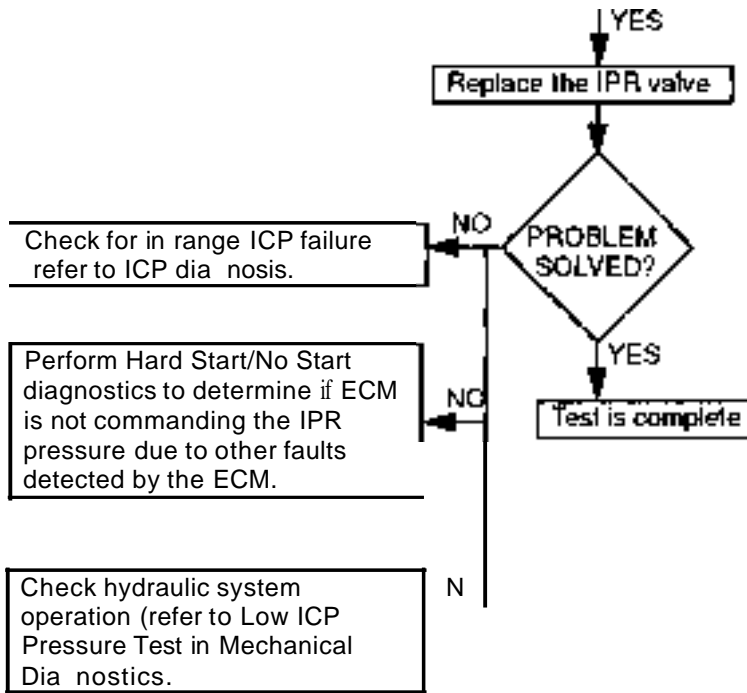


Continued On Next Page.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

INJECTION PRESSURE REGULATOR (IPR)

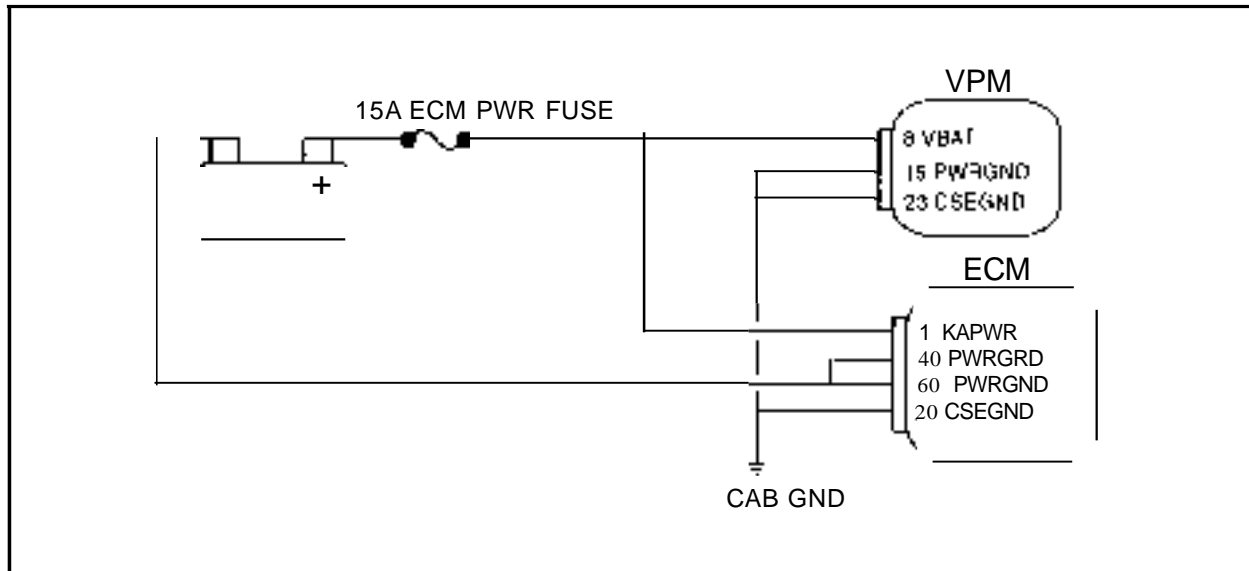
INJECTION CONTROL PRESSURE REGULATOR (Continued)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

KEEP ALIVE MEMORY POWER (KAM PWR)

KEEP ALIVE MEMORY POWER AND VPM BATTERY POWER CIRCUIT



CIRCUIT OPERATION

The Electronic Control Module (ECM) has information stored in volatile memory which is erased or lost when power is disconnected from the module. This memory is referred to as Keep Alive Memory (KAM). The ECM stores historical diagnostic information from previous engine operating cycles, learned limits from certain engine and vehicle sensors and programmable parameters sent from the VPM.

The Vehicle Personality Module (VPM) utilizes the KAM power circuit to remain powered for at least 30 minutes after each key off cycle to record accumulator values for vehicle miles, hours and fuel used.

FAULT DETECTION MANAGEMENT

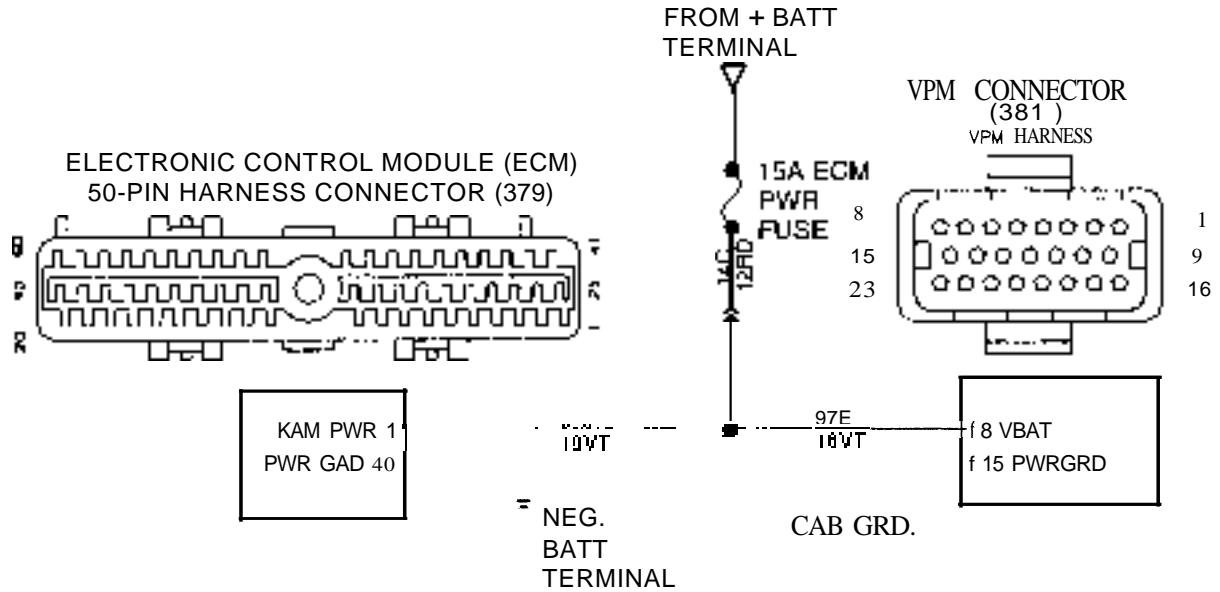
On every power up KAM memory in the ECM is checked by the processor to determine if any information in memory has been lost or can be stored correctly. A fault code will be set if power has been disconnected, information sent from the VPM does not agree with the last power up or if the memory internal to the ECM is defective.

There is no fault detection for loss of KAM power to the the VPM, however, the VPM will be unable to communicate with the Electronic Service Tool (EST) when the ignition key is in the OFF position.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

KEEP ALIVE MEMORY POWER (KAM PWR)

Keep Alive Memory Power (KAM PWR)	Fault Codes: 224 KAM Corrupt 615 Programmable Parameter KAM Corrupt
--------------------------------------	---



KAMPWR to ECM - Connector (379) with breakout box installed and key OFF

Test Points	Spec.	Comments
#1 to grd.	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to ground or blown fuse (If fuse is open the ECM will not be powered with key ON and ProLink will not read codes)
#1 to #40	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open in ground path.

NOTE: If the KAM PWR to the ECM is good and ground circuits are good, and Flash code 224 or 615 remains active, the ECM is defective.

KAMPWR to VPM - Connector (381)

Test Points	Spec.	Comments
#8 to grd.	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open/short to ground or blown fuse (If fuse is open the ECM will not be powered with key ON and ProLink will not read codes)
#8 to #15	12 ± 1.5 volts	< than 10.5 v check connections, if 0 volts check for open in ground path.

Fault Code Descriptions

224 Kam Memory 615 Programmable Parameter KAM Corrupt Memory Information

ECM KAM AND VPM BATTERY POWER EXTENDED SYSTEM DESCRIPTION

Refer to circuit diagram on page 177 for the following discussion.

The ECM Keep Alive Memory (KAM) circuit 97J provides battery power from the Positive battery terminal through ECM connector 379 to ECM terminal 1 at all times. The circuit is protected by 15 amp, #1 ECM PWR Fuse, which also supplies power to the VPM, VBAT terminal (8). KAM stores fault codes and operating constants between engine starts.

ECM DIAGNOSTICS

During normal vehicle operation, the ECM performs certain tests. When the key is turned ON, the ECM performs the Start-Up KAM Test to test its Keep-Alive Memory. The test is performed once each time the key is turned on or when the ECM resets.

The ECM performs a test to determine if the memory is working properly, but a lack of battery power to ECM terminal 1 can cause fault code(s) 224 and 653 to be set.

When power to KAM has been disrupted, there will be no inactive faults.

FLASH CODE 224
SID 254 FMI2
ECM: *KAM CORRUPT*

Flash Code 224 can be caused by:

- A. Short or open in KAM circuit. High or low voltage to ECM terminal 1 from the KAM battery supply circuits will cause code 224.

Note that if the battery cable has been disconnected, on the next key ON cycle, code 224 will be present, indicating that the KAM memory has lost power. The code will change to inactive status on the next key cycle.

- B. Faulty KAM memory in the ECM.

Conditions causing Flash Code 224 can also cause Flash Code 615 to occur.

FLASH CODE 615
SID 254 FMI 13
ECM: *PROGRAMMABLE PARAMETER KAM
CORRUPT FAULT*

If flash code 615 occurs when the KAM power supply to the ECM is good, then the KAM memory is defective. Refer to Electronic Control Module Diagnostics (ECM) in this manual section.

TROUBLESHOOTING

BEFORE TROUBLESHOOTING

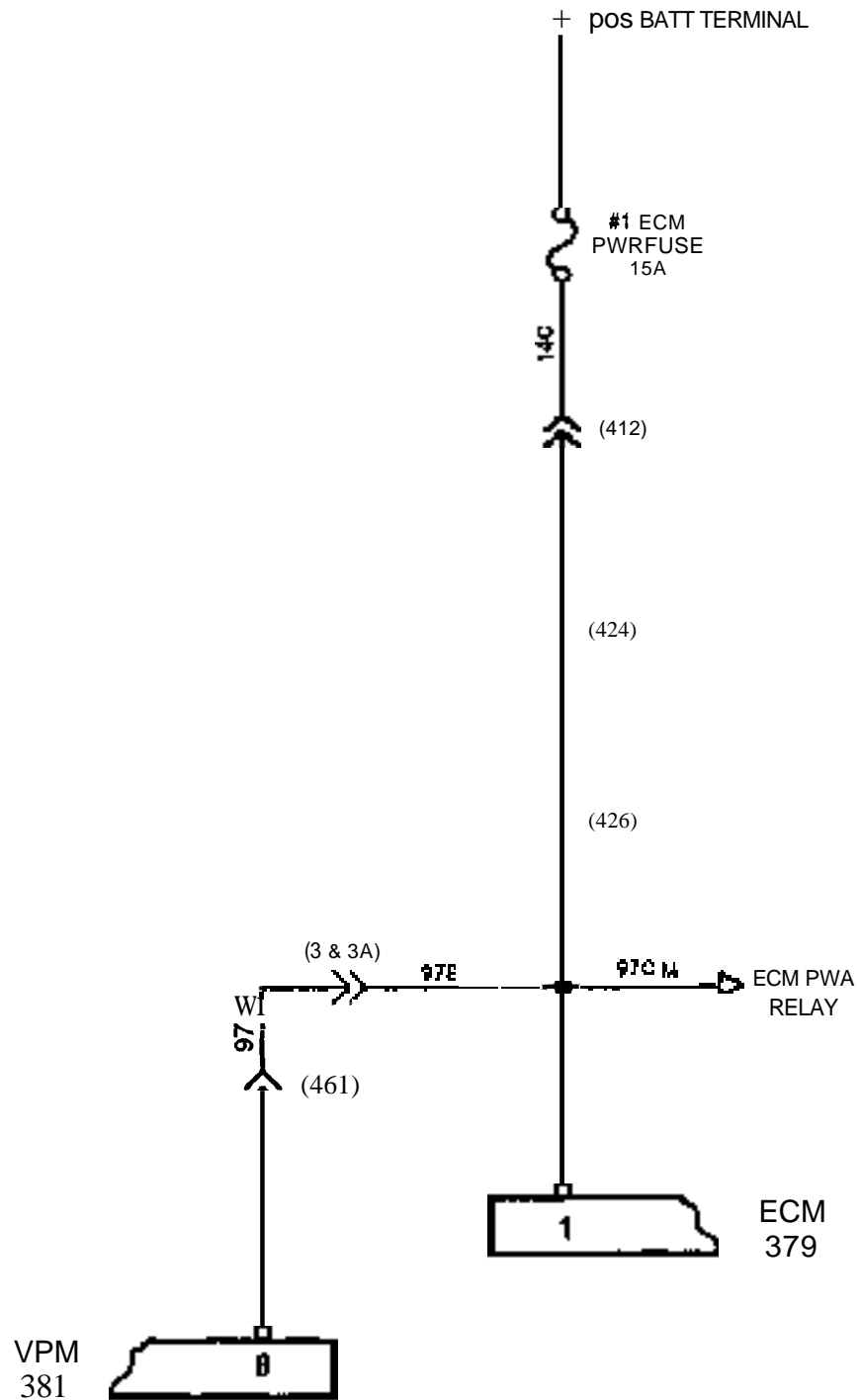
- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading readings if batteries are not fully charged.
- B. Before troubleshooting a particular circuit, inspect connectors for pushed back, loose or damaged (spread or bent) terminals, or wires with cut strands, etc. The wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect the suspect circuit grounds for clean, tight connections, free of damage or corrosion.

If Flash code 224 or 653 is active, perform KAM Power Circuit test on page 179.

KEEP ALIVE MEMORY POWER (KAM PWR)

CIRCUIT DIAGRAM

KAM CIRCUIT WITH TRUCK OR FBC MODELS

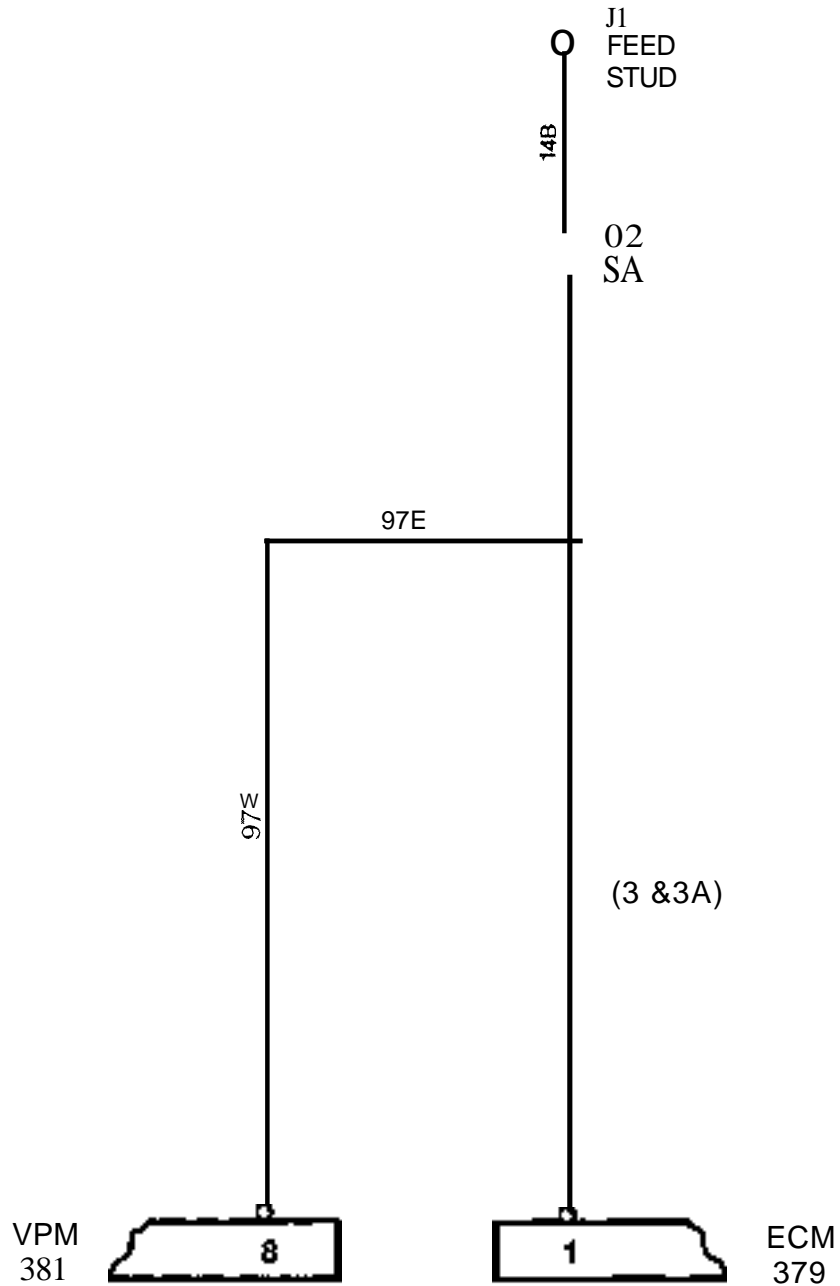


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

KEEP ALIVE MEMORY POWER (KAM PWR)

CIRCUIT DIAGRAM

KAM CIRCUIT WITH 1652SC MODEL

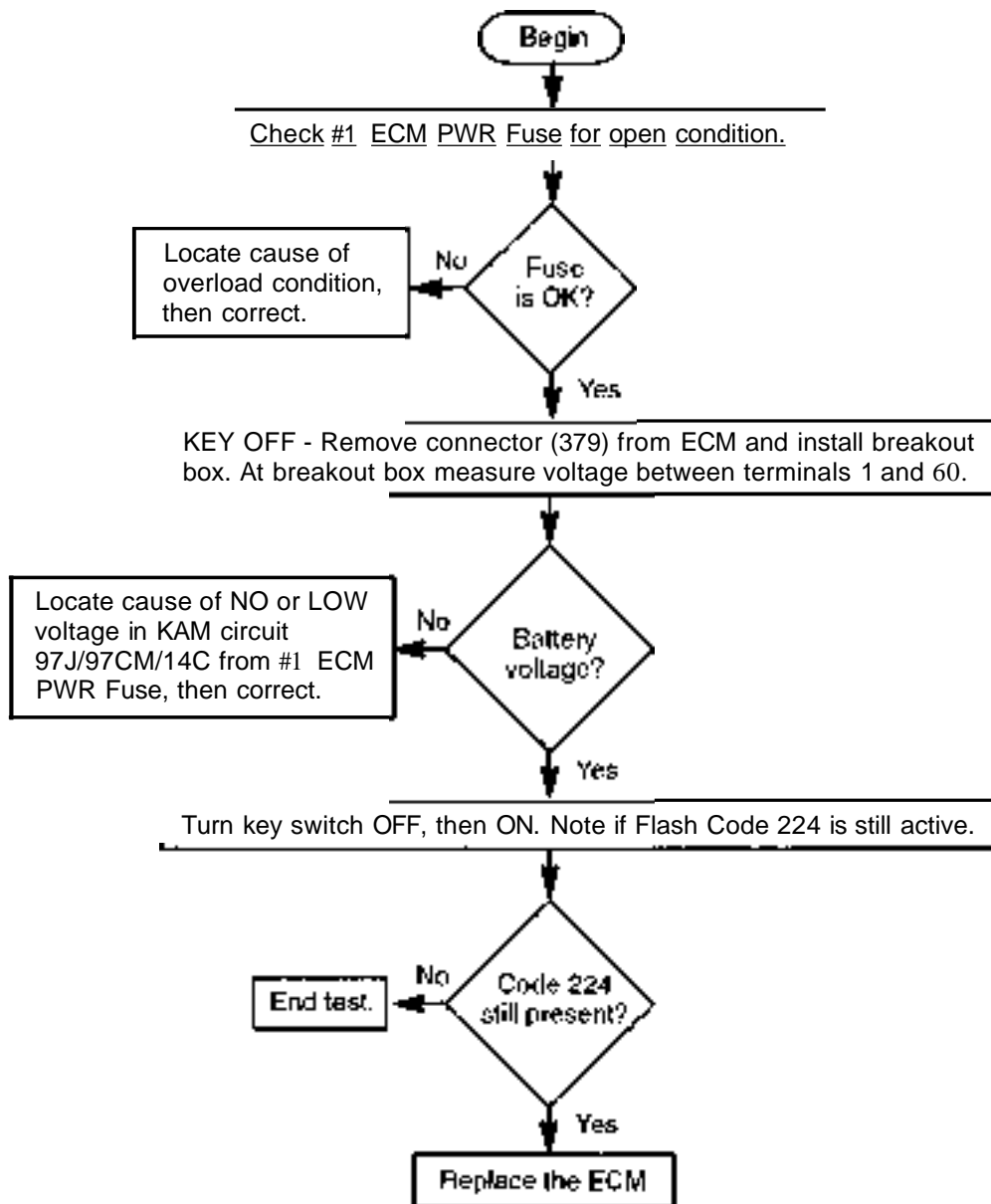


KEEP ALIVE MEMORY POWER (KAM PWR)

TROUBLESHOOTING (Continued)

KAM POWER CIRCUIT TEST

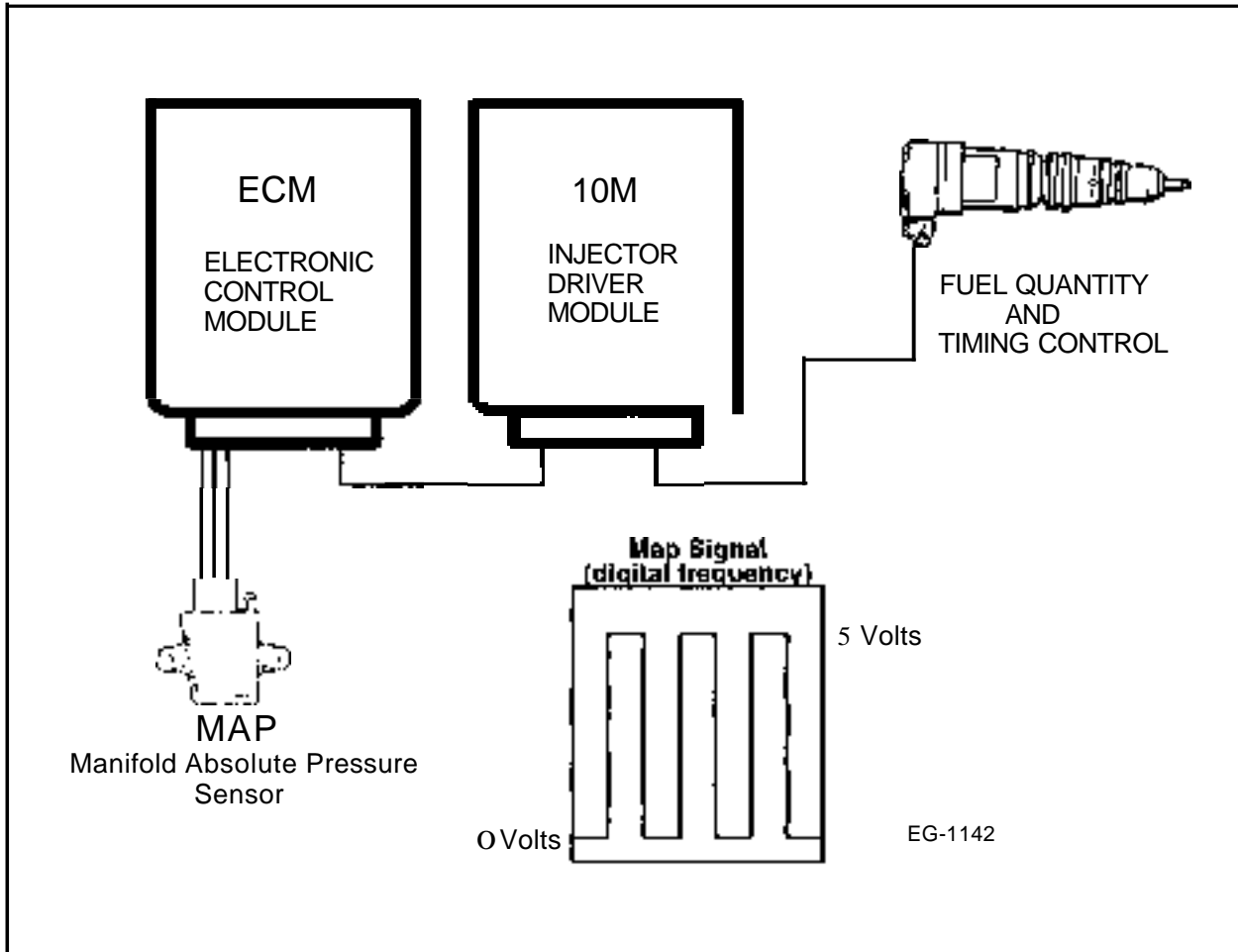
If the ECM is powered, the fuse does not need to be checked as the same fuse feeds the ECM.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR



SIGNAL FUNCTIONS

The Manifold Absolute Pressure (MAP) sensor is a variable capacitance sensor which operates on a 5 volt reference signal from the ECM to produce a digital frequency signal that indicates pressure.

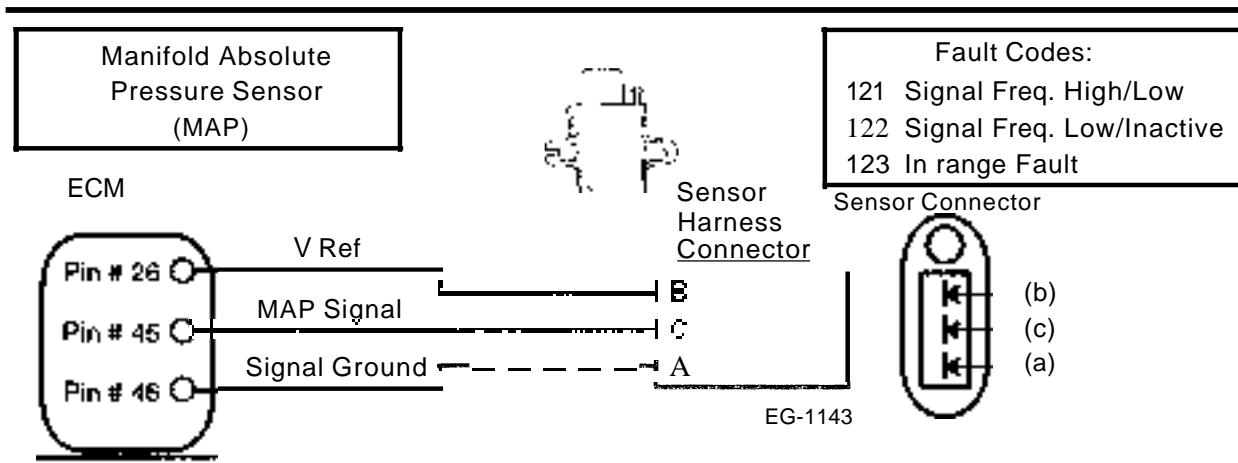
Smoke Control - The MAP signal is used to control smoke by limiting fuel quantity during acceleration until a specified boost pressure is obtained.

Dynamic Injection Timing - Optimizes injection timing for boost pressure measured.

FAULT DETECTION/MANAGEMENT

A MAP signal that is detected by the ECM to be out of range or at an incorrect value for specific conditions will cause the ECM to ignore the MAP signal and will operate the engine with the values from estimated MAP. (Operate from a calculated boost pressure signal)

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)



After removing connectors always check for damaged pins, corrosion, loose terminals etc.

Connector Checks to Chassis Ground

(Check with sensor Connector Disconnected and Ignition key off, all accessories off)

Test Points	Spec.	Comments
A to Grd.	< 5 ohms	Resistance to chassis ground check with key off, if > than 5 ohms harness is open.
S to Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.
eta Grd.	> 1000 ohms	Resistance less than 1000 ohms indicates a short to ground.

Connector Voltage Checks

(Check with sensor Connector Disconnected and Ignition Key On)

Test Points	Spec.	Comments
B to Grd.	5 volts \pm .5	V Ref. check with key ON, if voltage not in spec, see V REF circuit.
C to Grd.	4.8 - 5.0 v	Pull up voltage, if no or low voltage circuit has open or high resistance or short to grd.

Harness Resistance Checks

(Check with breakout box installed on engine harness only)

Test Points	Spec.	Comments
#46 to A	< 5 ohms	Resistance from sensor connector to 60 pin connector - Signal ground
#26 to B	< 5 ohms	Resistance from sensor connector to 60 pin connector - V Ref
#45 to C	< 5 ohms	Resistance from sensor connector to 60 pin connector - MAP signal

Test Points			Operational Voltage Checks	
(+ #45 to (-) #46			(Check with breakout box installed in line with the ECM)	
Frequency	PSI	kPAG	Comments	
90 Hz.	N/A	N/A	Out of range low limit.	
108-114 Hz.	0	a	Freq. with key on engine off, Atmospheric pressure dependent on altitude and BARO psi.	
145 Hz.	25.4	175	Frequency expected at 25 psi.	
256 Hz.	45	267	Out of range high limit	

Fault Code Descriptions

Circuit Faylts:

121 = Signal frequency was greater than 256 Hz. for more than 0.1 seconds.

122 = Signal frequency was less than 90 Hz. or inactive for more than 0.25 seconds.

System Faults:

123 = Detected high boost signal at low idle. (Restricted MAP line.)

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

MANIFOLD ABSOLUTE PRESSURE SENSOR EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Navistar engine control system includes a Manifold Absolute Pressure (MAP) sensor. The ECM measures the signal from the MAP sensor to determine intake manifold (Boost) pressure. From this information, the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

OPERATION

The Manifold Absolute Pressure sensor is a variable capacitance sensor that produces a digital frequency signal output. The MAP sensor is supplied 5 volts from the ECM at terminal 26 to terminal 8 of the sensor. A return circuit (ground) is supplied from ECM terminal 46 to terminal A of the sensor. The sensor receives intake manifold boost pressure via a hose which connects to a tap on the intake manifold to the map sensor. Pressure applied to the MAP sensor changes the capacitance of the sensor which varies the digital frequency of the signal sent to the ECM. As boost pressure increases the frequency increases.

ECM DIAGNOSTICS

The ECM monitors the MAP sensor output signal for expected values. If the ECM detects the MAP signal is greater than or less than the desired value, the ECM will set a fault code.

If an active MAP sensor fault code is set, the ECM will ignore the MAP signal. It will operate the engine using programmed default values. Active faults for the MAP sensor will cause the ECM to illuminate the Engine Warning light. These faults can be retrieved using the Self Test Input diagnostic switch located on the vehicle dash or the Electronic Service Tool. If the ignition key is turned off, the fault code will be stored as an Inactive code.

FIGURE 7 FLASH CODE 121

ATA CODE PID 102 FMI8

MAPFREQUENCYOUTOFRANGEHmH

Code 121 will be set, if the ECM detects a frequency greater than 256 Hz for more than 0.1 seconds in the MAP signal.

If code 121 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is active.

Excessive high frequency noise in the MAP signal will cause this code to be set.

FLASH CODE 122

ATA CODE PID 102 FMI11

MAP SIGNAL IS INACTIVE

Code 122 will be set, if the ECM detects a frequency less than 90 Hz or an inactive MAP signal for more than 0.25 seconds.

When code 122 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is set.

Possible causes: A defective MAP sensor or MAP sensor signal circuits may be open or shorted to ground.

FLASH CODE 123

ATA CODE PID 102 FMI2

*MAP SIGNAL ABOVE SPECIFIED LEVEL AT
LOW/OLE*

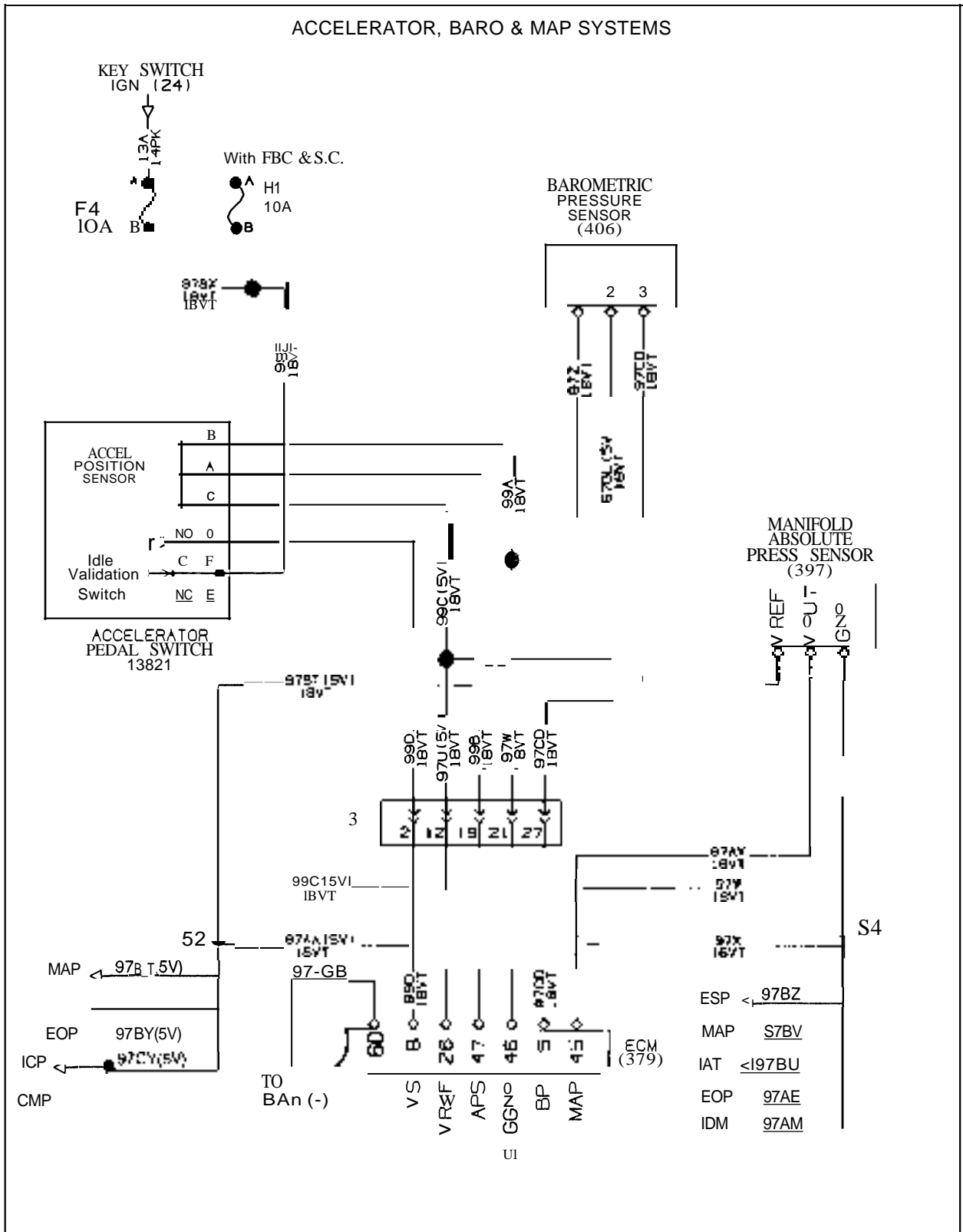
Code 123 is set when the MAP signal is greater than 16.7 PSI (115 kPa) Absolute at low idle.

When code 123 is active, the ECM will ignore the MAP signal and operate the engine using programmed default values. The ECM will illuminate the Engine Warning light when this code is set.

Possible causes: Restricted or plugged hose which supplies intake manifold boost pressure to the MAP sensor or a defective MAP sensor.

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

ACCELERATOR, BARO & MAP CIRCUITS

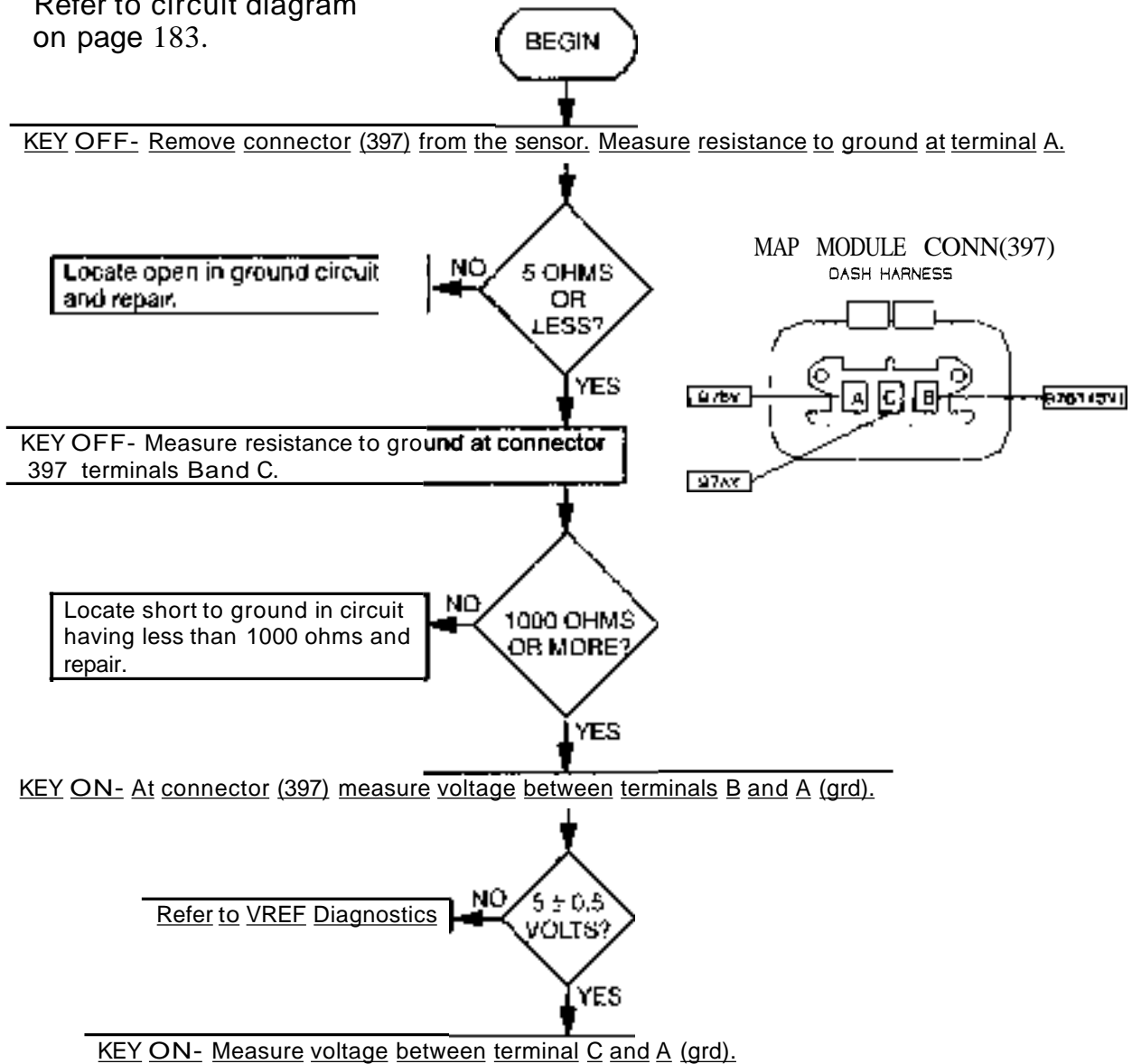


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

MAP MANIFOLD ABSOLUTE PRESSURE SENSOR

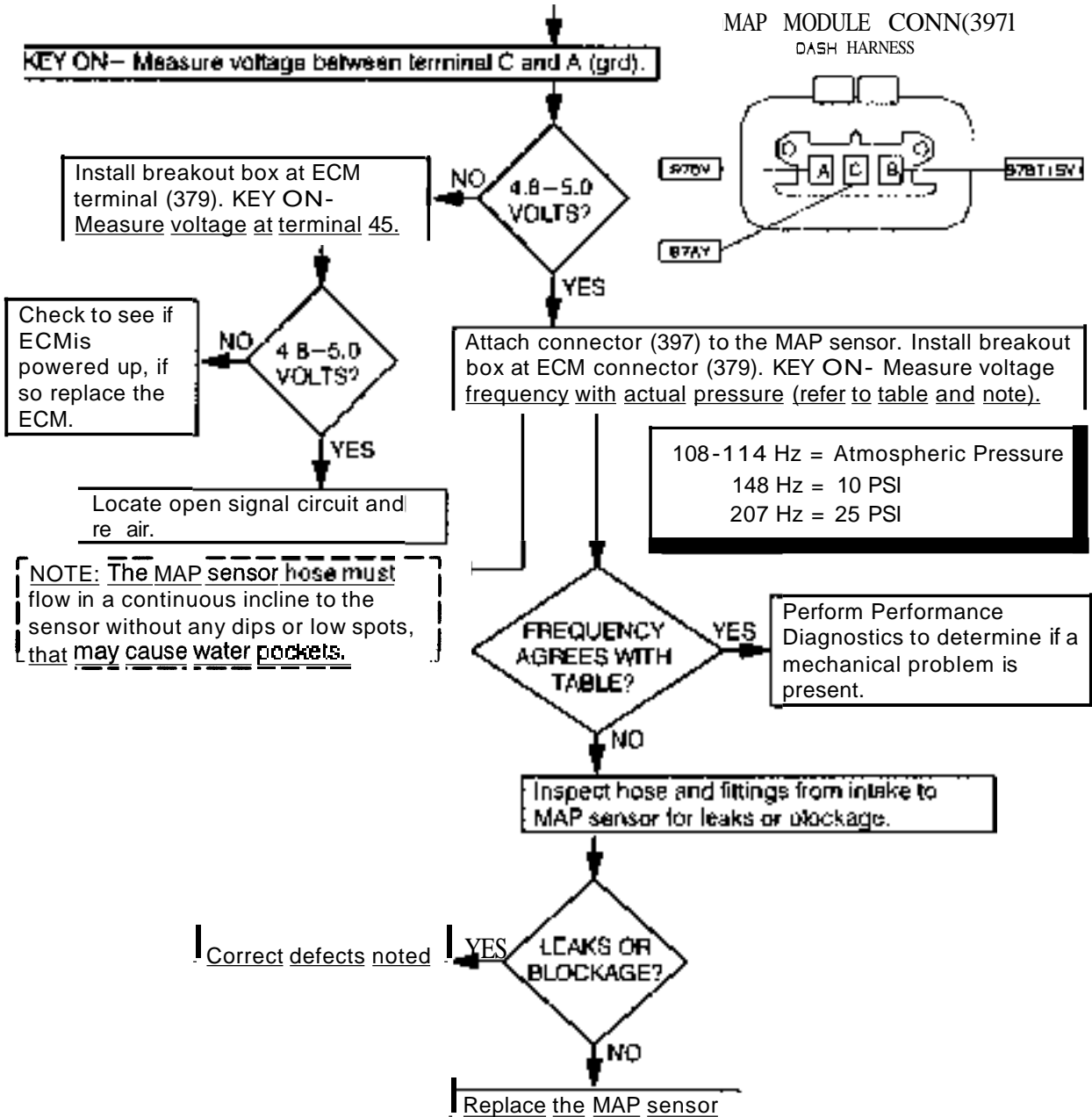
Refer to circuit diagram
on page 183.



[Continued On Next Page]

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

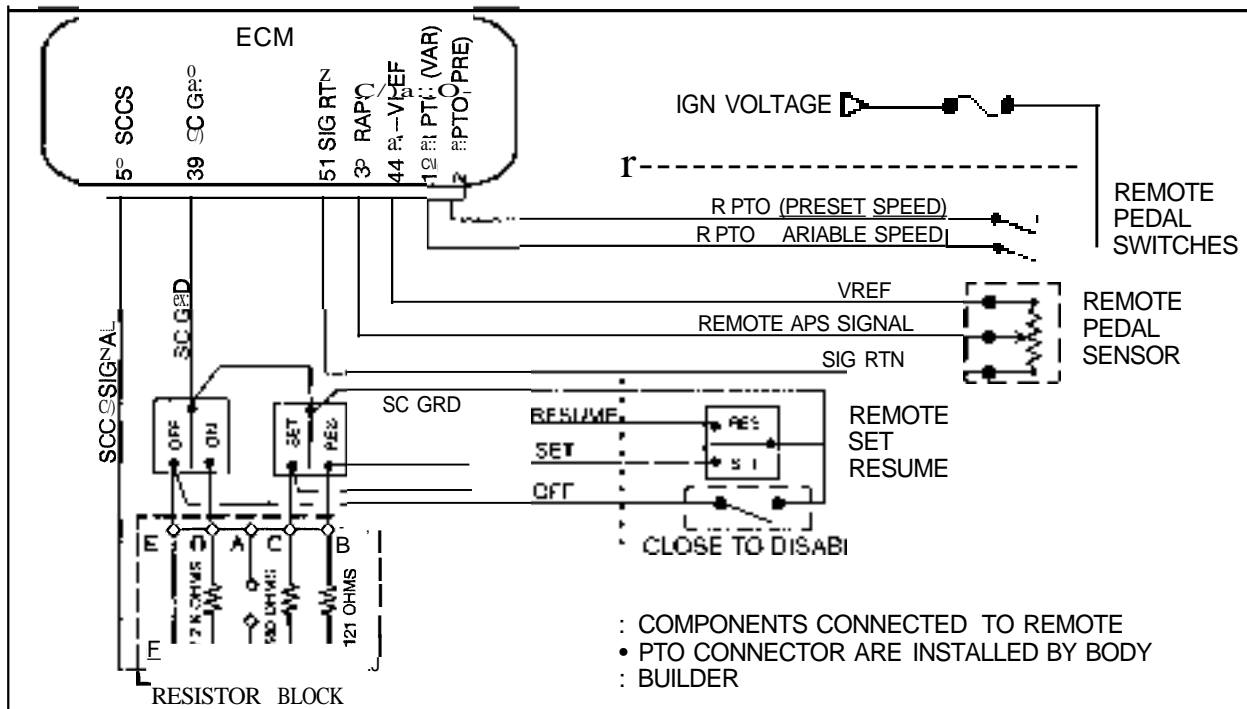
MAP MANIFOLD ABSOLUTE PRESSURE SENSOR (Continued)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (Sces)

CRUISE CONTROL, PTO, HAND THROTTLE SYSTEM



SIGNAL FUNCTION

CRUISE CONTROL

ECM terminal 50 outputs a 6.58 volt signal to the resistor block. Activating the cruise command switches causes the signal to pass through different resistance levels in the resistor block, altering the signal which is grounded at ECM terminal 39. There are five expected signals to the ECM: OFF, ON, SET, RESUME and open (no switches have been used). Refer to Extended Description on page 188 for additional detail.

REMOTE PTO CONTROLS

To use the remote controls, cruise control must be turned on using the cab cruise ON/OFF switch. The remote Set/Resume switch and disable switch are wired parallel to cab switches and operate in the same manner.

With cruise control ON:

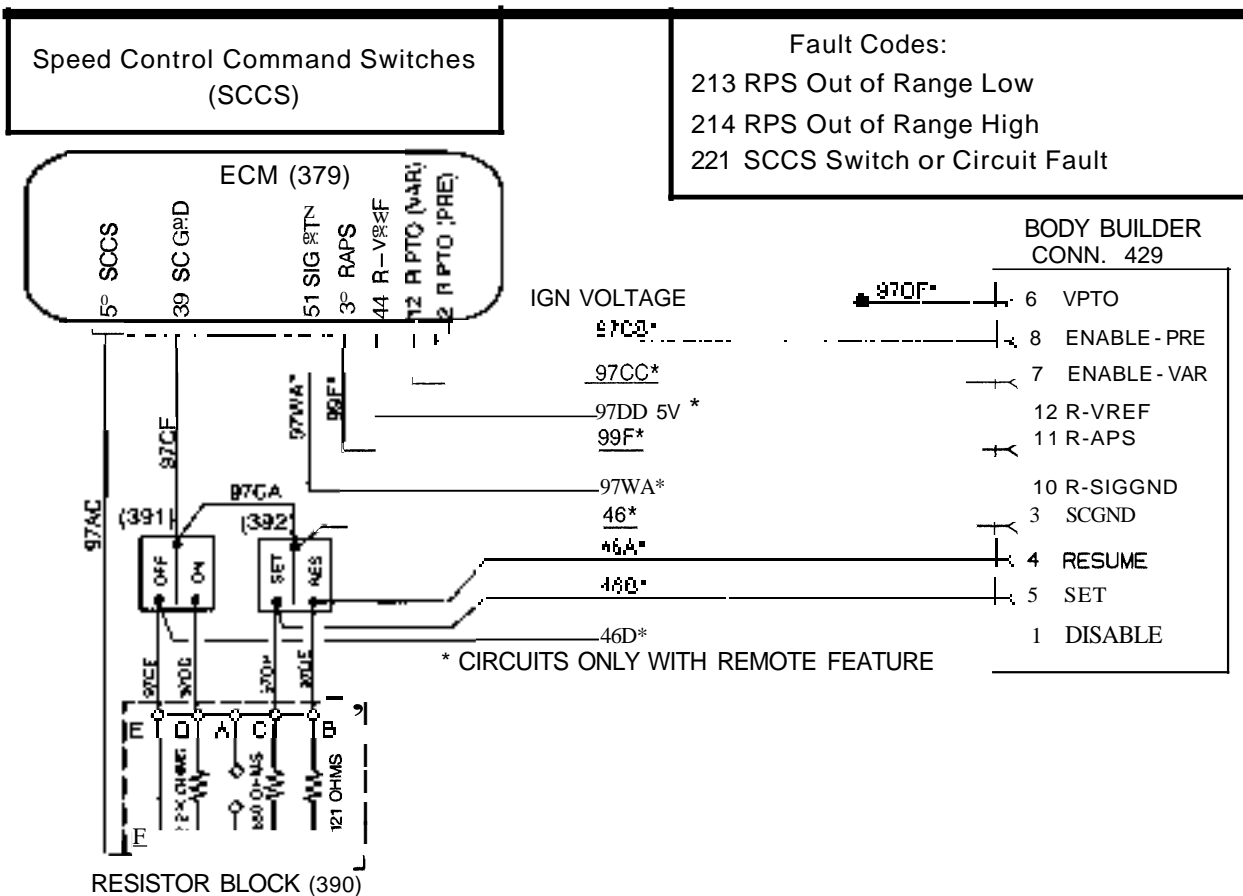
- A. Placing the remote PTO Preset switch in the ON position (closed) causes the PTO to operate at a preset engine speed (customer selected) programmed into the VPM.
- B. Placing the remote PTO Variable switch in the ON position (closed) causes the PTO to operate using remote pedal.

NOTE: IF BOTH OF THE ABOVE SWITCHES ARE ON, THE REMOTE PEDAL IS DEACTIVATED.

FAULT DETECTION MANAGEMENT

The ECM monitors the SCCS signal for the five expected signals. If an incorrect signal is detected, Flash Code 221 is logged. The ECM also monitors the R-APS signal input at ECM terminal 30 from the remote pedal sensor for out-of-range signals, high or low.

SPEED CONTROL COMMAND SWITCHES (sees)



Operational Voltage Checks

Connector (379) with breakout box installed and key ON

SCCS Sw. Positions	Breakout Test Points	Spec.	Comments
All switches in neutral position	#50 to #39	6.2V-7.1V	< than 6.2V check connections, battery condition. Greater than 7.1 V check for short to VBAT
Hold switch in OFF position	#50 to #39	0V-100mV	> than 100mV check connections, switch, resistor block and circuits for correct resistance or short to VBAT or grd
Hold switch in ON position	#50 to #39	4.4V-5.0V	<> than specified voltage drop, check connections, switch, resistor block and related circuits for correct resistance or short to VBAT or grd
Hold Set switch in SET position	#50 to #39	2.2V-3.0V	<> than specified voltage drop, check connections, switch, resistor block and related circuits for correct resistance or short to VBAT or VREF or grd
Hold Res switch in RES position	#50 to #39	700mV-800 mV	<> than specified voltage drop, check connections, switch, resistor block and related circuits for correct resistance or short to VREF or VBAT or grd

Fault Code Descriptions

213 = RPS signal was less than 0.146 volts for more than 0.5 seconds
 214 = RPS signal was greater than 4.56 volts for more than 0.5 seconds
 221 = sees voltage signal does not match expected levels (5 assigned levels for different conditions)

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (SCCS)

EXTENDED DESCRIPTION

Cruise control and PTa operation (including remote PTa) share many circuits and components, so both systems are included in this section.

The Cruise/PTa system is controlled by the ECM in response to driver input on the Speed Control Command Switches (SCCS), which are the Cruise ON/OFF and SET/RESUME switches. With a remote PTa operation, the body builder installed controls include a remote SET/RESUME switch and a PTa DISABLE switch that are also SCCS switches.

The body builder also installs a Remote pedal sensor and switches to enable the remote PTa at a preset speed or enable in the variable mode, with engine speed controlled by the remote pedal sensor. These circuits will be discussed in Remote Pedal Sensor Circuits later in this section.

The Clutch Pedal Switch supplies the Driveline Disengaged Signal (DDS) to the ECM and the Service Brake Switches supply a Brake Normally Open (BNO) and Brake Normally Closed (BNC) signal to the ECM. These signals indicate pedal positions and are used by the ECM in operating the Cruise/PTa Control System.

The Vehicle Speed Signal (VSS) and CMP signal provide vehicle speed and engine rpm information that the ECM uses in controlling the Cruise/PTa system.

ECMCONTROL

Refer to the circuit diagram on page 191 for the following discussions on circuit operation.

SCCS CIRCUITS

The ECM sends a 6.58 volt signal from ECM terminal 50 to the SCCS system. The signal goes through the SC Resistor Block Assembly to the SCCS switches (see note 1) and returns to the ECM at terminal 39. Depending on SCCS switch position (ON, OFF, SET, RESUME or when no switch is active), one of five different signals is expected when the signal returns to ECM signal ground terminal 39. These five signals are discussed in the following paragraphs.

NOTE 1: The SC Resistor Block is permanently attached to the cab harness and contains a printed circuit board, that includes three resistors. The printed circuit board can be removed by opening the

end of the resistor block assembly and pulling the board out.

NO SCCS SWITCHES ACTIVE

Note in circuit diagram that the ON/OFF, SET/RESUME (including the remote SET/RESUME) and the remote DISABLE PTa switch are normally open, momentary switches. With the key switch ON, voltage is being applied from ECM terminal 50, but the ECM expects to see an open circuit. With no switch depressed, voltage measured between ECM terminals 39 and 50 is expected to be between 6.2 and 7.1 volts. An OPEN circuit (6.2 to 7.1 Volts between terminals 39 and 50) is the signal that the ECM expects to see with no switch depressed.

CRUISE ON/OFF SWITCH IN ON POSITION

Momentarily placing this switch in the ON position causes the signal from ECM terminal 50 to go through the 2.2K ohm resistor located in the Resistor Block (390) through the ON terminal of the ON/OFF switch and returns to ECM terminal 39. With the ON switch depressed, the voltage drop in this circuit (measured between ECM terminals 39 and 50) is expected to be between 4.4 and 5.0 volts. A Voltage between 4.4 and 5.0 volts is the signal the ECM expects to see with the ON switch depressed.

CRUISE ON/OFF SWITCH IN OFF POSITION

Momentarily placing this switch in the OFF position causes the signal from ECM terminal 50 to go through the Resistor Block (390), terminals F to E, where there is no resistor, then through the OFF terminal of the ON/OFF switch returning to ECM terminal 39. With the OFF switch depressed, the expected voltage drop in this circuit (measured between ECM terminals 39 and 50) is expected to be between 0 and 100mV. A Voltage between 0 and 100mV is the signal the ECM expects to see with the OFF switch depressed.

The Remote DISENGAGE PTa Switch is a normally open (NO) momentary switch that is wired parallel to the OFF side of the ON/OFF switch. The PTa can only be turned on from the cab switch, but can be turned OFF from the remote location. When this switch is closed, the ECM expects to see the same signal as when the ON/OFF switch is in the OFF position (0 to 100mV voltage drop).

SPEED CONTROL COMMAND SWITCHES (SCCS)

CRUISE SET/RESUME IN SET POSITION

Momentarily placing this switch in the SET position causes the signal from ECM terminal 50 to go through the 680 ohm resistor located in the Resistor Block (390) through the SET terminal of the SET/RESUME switch returning to ECM terminal 39. With the SET switch depressed, the voltage drop in this circuit (measured between ECM terminals 39 and 50) is expected to be between 2.2 and 3.0 volts. A voltage between 2.2 and 3.0 volts is the signal the ECM expects to see with the SET switch depressed.

The Remote PTa SET/RESUME Switch is a normally open (NO) momentary switch that is wired parallel to the cab SET/RESUME switch. When the remote SET switch is in the SET position, the ECM expects to see the same signal as when the cab SET switch is in the SET position (2.2 to 3.0 volts).

CRUISE SET/RESUME IN RESUME POSITION

Momentarily placing this switch in the RESUME position causes the signal from ECM terminal 50 to go through the 121 ohm resistor located in the Resistor Block (390) through the RESUME terminal of the SET/RESUME switch returning to ECM terminal 39. With the RESUME switch depressed, the voltage drop in this circuit (measured between ECM terminals 39 and 50) is expected to be between 700 mV and 810 mV. A voltage between 700mV and 810mV is the signal the ECM expects to see with the RESUME switch depressed.

The Remote PTa SET/RESUME Switch is a normally open (NO) momentary switch that is wired parallel to the cab SET/RESUME switch. When the remote SET/RESUME switch is in the RESUME position, the ECM expects to see the same signal as when the cab SET/RESUME switch is in the RESUME position (700mV to 810mV).

REMOTE PEDAL SENSOR (RPS) SWITCHES

To enable the remote PTa, first the cab ON/OFF switch must be set to the ON position. With PTa enabled, the Enable PRESET switch or Enable VARIABLE switch must be turned ON. These are toggle switches, not momentary on switches.

REMOTE PRESET SWITCH

The remote Preset Switch receives ignition voltage from 5A fuse, F6 through the body builder connector 429, terminal 8. Closing this switch applies ignition voltage to ECM terminal 2. When ECM terminal 2 sees 12 volts, it turns on the PTa to the preset speed. Opening the switch turns off the remote PTa. If both the PRESET switch and the VARIABLE

switch are on, the ECM interprets this as an off signal.

REMOTE VARIABLE SWITCH

The remote Variable Switch receives ignition voltage from 5A fuse, F6 through the body builder connector 429, terminal 7. Closing this switch applies ignition voltage to ECM terminal 12. When ECM terminal 12 sees 12 volts, it turns on the PTa in the variable mode, where engine speed is controlled by the remote pedal. Opening the switch turns off the remote PTa. If both the PRESET switch and the VARIABLE switch are on, the ECM interprets this as an off signal.

REMOTE PEDAL SENSOR (RPS)

The RPS receives R-VREF (5V) from ECM terminal 44, through body builder connector (429), terminal 12. As the pedal position is changed, the wiper sends the variable RPS signal through body builder connector (429), terminal 11 to ECM terminal 30. The ECM expects to see a signal between 152 mV and 4.55 volts. This signal is interpreted by the ECM as percent of throttle, from 0 to 100 percent. The RPS sensor is grounded through body builder connector (429), terminal 10 to ECM terminal 51 (SIG RTN).

ECM DIAGNOSTICS**SCCS DIAGNOSTICS**

The ECM monitors the signal on SCCS circuit 97AC for the expected five signals discussed earlier. If a signal is detected by the ECM that does not match anyone of the five expected signals, then Flash Code 221 is set and the PTa or Cruise is disabled.

FLASH CODE 221

ATA CODE SID 244 FMI 2

ECM: SCES SWITCH OR CIRCUIT FAULT

CAUSES: Open, short (HIGH or LOW), or bias high or low in SCCS circuits or components.

The ECM monitors the R..APS signal input at ECM terminal 30 from the remote pedal sensor for out-of-range signals, high or low.

- Biased High Or Low ... A wiring or component defect that changes the circuit resistance (corroded switch contacts, poor connections, dirty or corroded terminals etc.) will alter the signal, causing the code to be set.
 - A short to a 12V or 5V circuit will change the expected signal.
-

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (SCCS)

SCCS DIAGNOSTICS (Continued)

- A short to ground changes the expected signal.

CORRECTIVE ACTION: Perform Testing SCCS Circuits on page 193.

RPS DIAGNOSTICS

The ECM monitors the R.APS signal input at ECM terminal 30 from the remote pedal sensor for out-of-range signals, high or low.

FLASH CODE 213
ATA CODE SID 29 FMI 4
ECM:RPSORL

If the ECM detects a RPS signal lower than 152 mV, this code is set and the remote pedal is disabled.

CORRECTIVE ACTION: Perform Testing RPS Circuits on page 200.

FLASH CODE 214
ATA CODE SID 29 FMI 3
ECM:RPSORH

If the ECM detects a RPS signal greater than 4.55 volts, this code is set and the remote pedal is disabled.

CORRECTIVE ACTION: Perform Testing RPS Circuits on page 200.

TROUBLESHOOTING

Before troubleshooting the Cruise/PTO control system, use the ProLink EST to:

1. Review any logged Flash Codes.
 - A. Code 221 relates directly to Cruise or Remote SCCS switches circuits. Codes 213 and 214 relate to operation of the remote PTO pedal. First resolve any other codes that may be present, because they may cause the ECM to disable the cruise **control**. Flash code 622 indicates the ECM is using Field Defaults that disable cruise and PTO operation. The cause for code 622 must be corrected.
2. Use the ProLink EST to monitor clutch switch operation. There is no diagnostic code for the DDS, Drive Line Disengagement Switch (clutch switch) operation.

If the clutch switch circuit is open, indicating that the switch is depressed, then cruise and PTO controls won't operate. If the clutch switch circuit is defective (shorted high), depressing the clutch pedal may not disengage the cruise or PTO, causing the engine to go to rated rpm when the clutch pedal is depressed.

3. Flash code 222 is a Brake Switch fault which will disable cruise and PTO operation. Use ProLink to check brake switch operation. The BND and BNC switches must be working properly for cruise control to operate.
4. Flash codes 141 and 142 are Vehicle Speed Sensor faults which will disable the cruise and PTO controls. A speed sensor that is not properly adjusted will affect speedometer and cruise control operation, and no codes will set. Correct any speedometer problems before troubleshooting the PTO system.
5. A severe INTERMITTENT connection or NOISE in the CMP SIGNAL can cause the engine to surge and the cruise control cannot properly maintain vehicle speed or PTO engine rpm will fluctuate.

CRUISE/PTO CONTROLS DO NOT OPERATE PROPERLY

BEFORE TROUBLESHOOTING

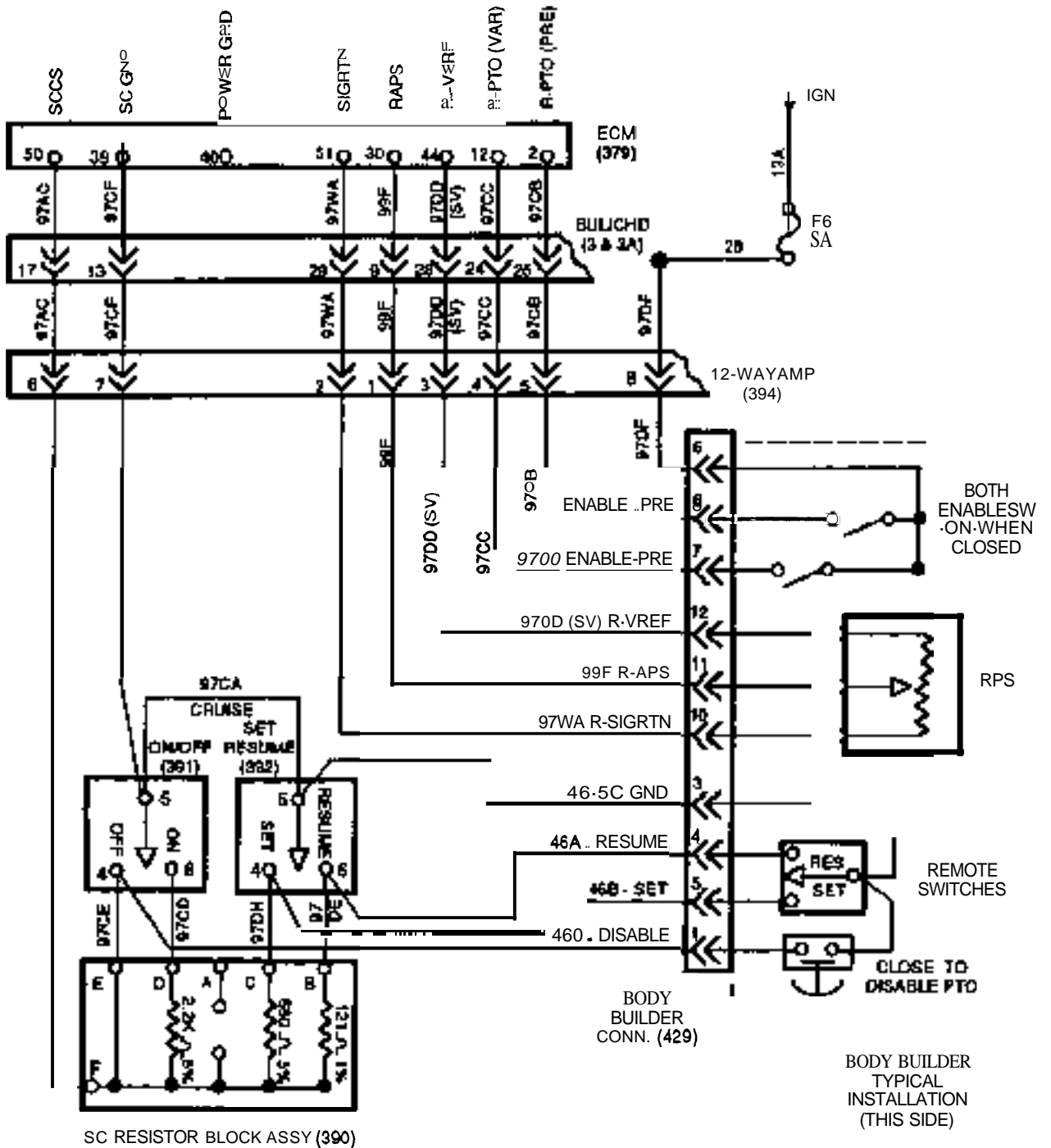
- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.
- B. Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

The ProLink EST can be used to monitor cruise switches, but if code 221 is active, the switches do not operate.

If Flash code 221 is active or if no flash code is present, perform Testing SCCS Circuits on page 193.

SPEED CONTROL COMMAND SWITCHES (SCCS)

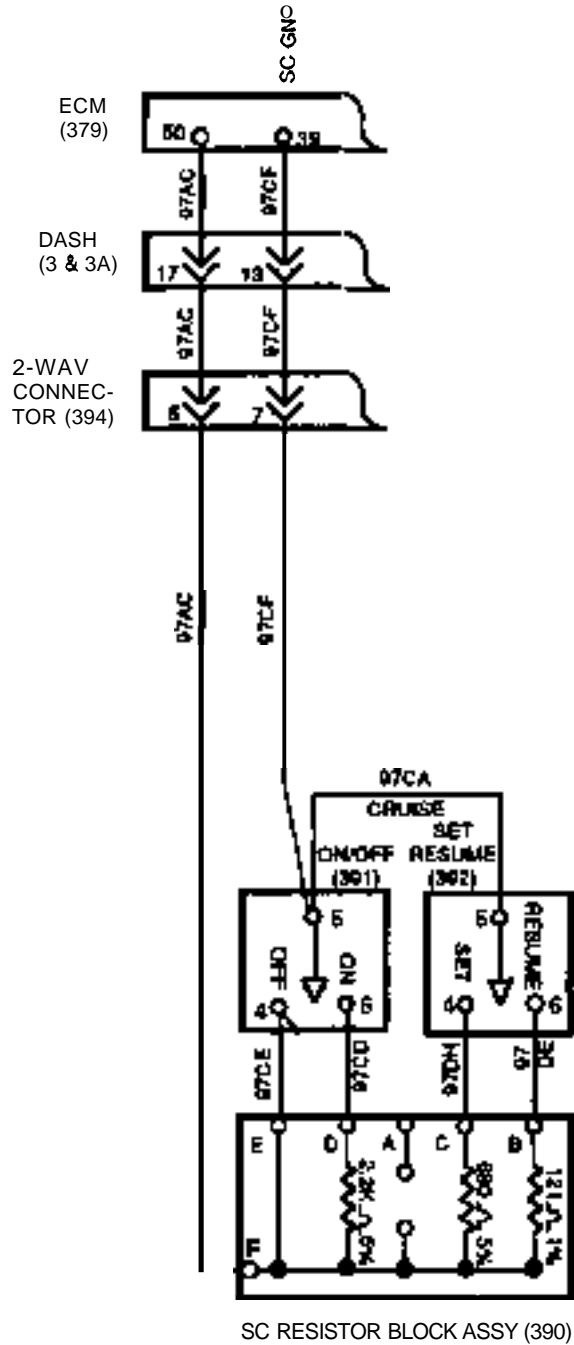
CIRCUIT DIAGRAM



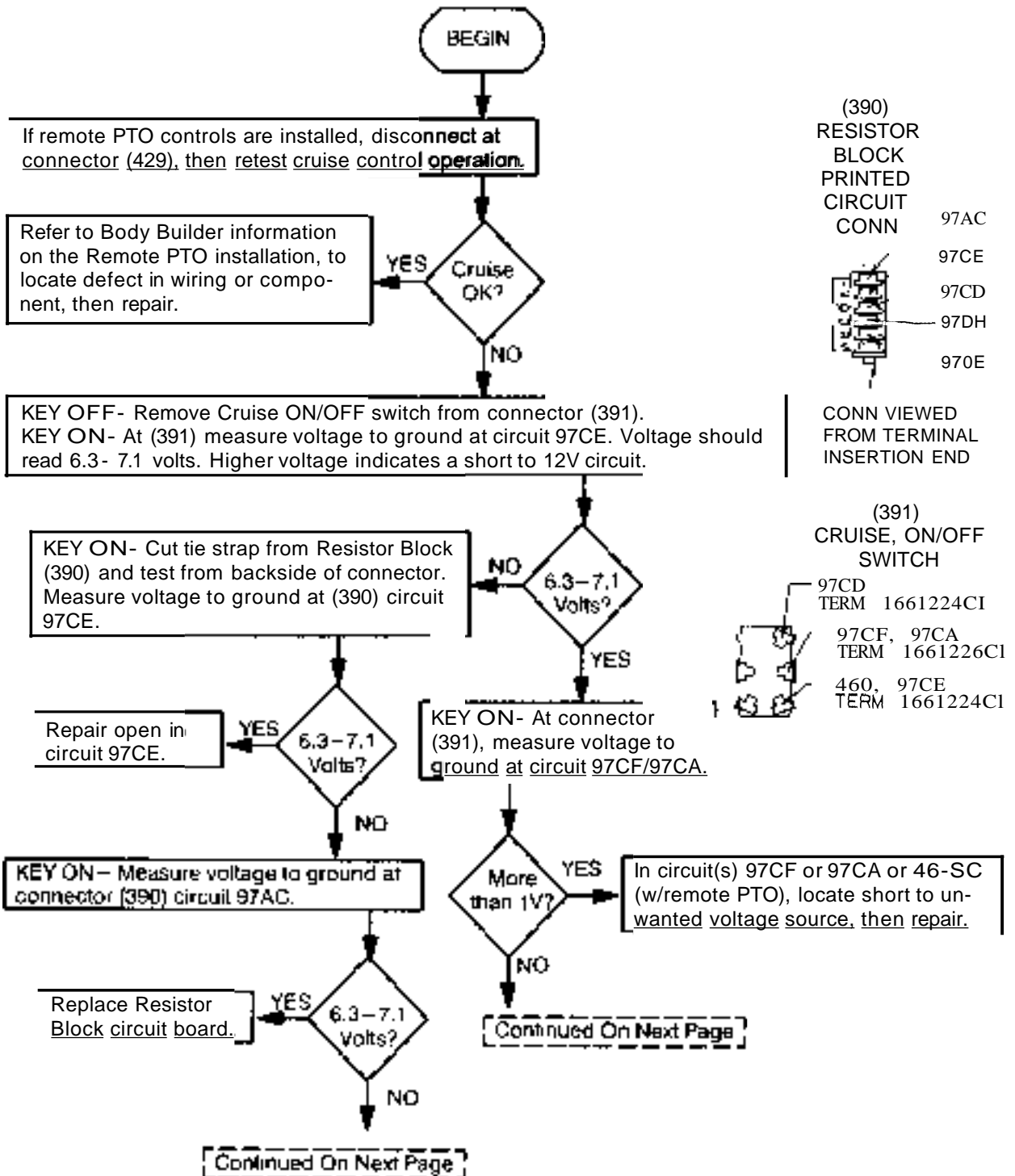
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (SCCS)

CIRCUIT DIAGRAM (WITHOUT REMOTE CONTROLS)



TESTING SPEED CONTROL COMMAND SWITCH (seCS) CIRCUITS

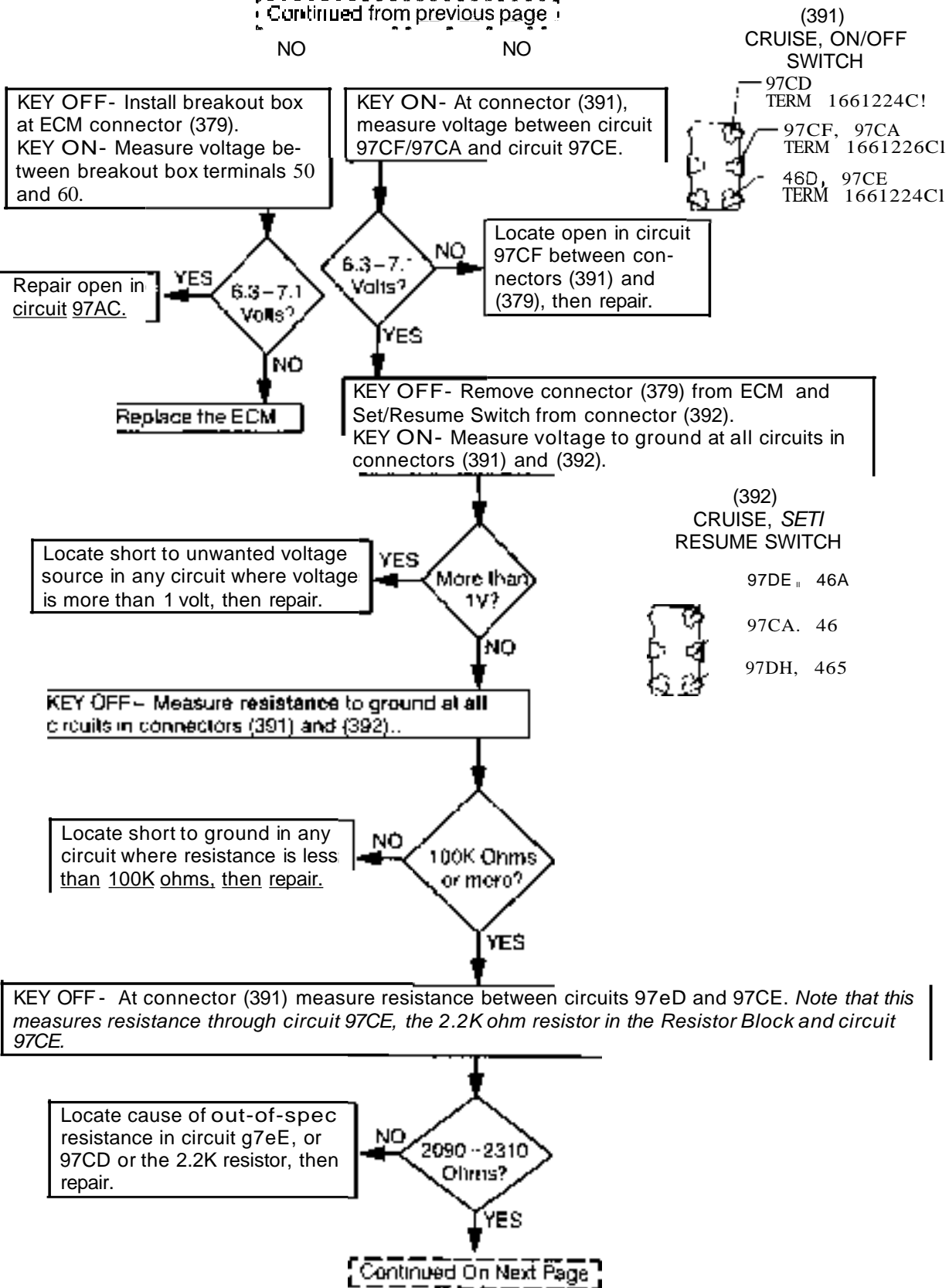


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (Sces)

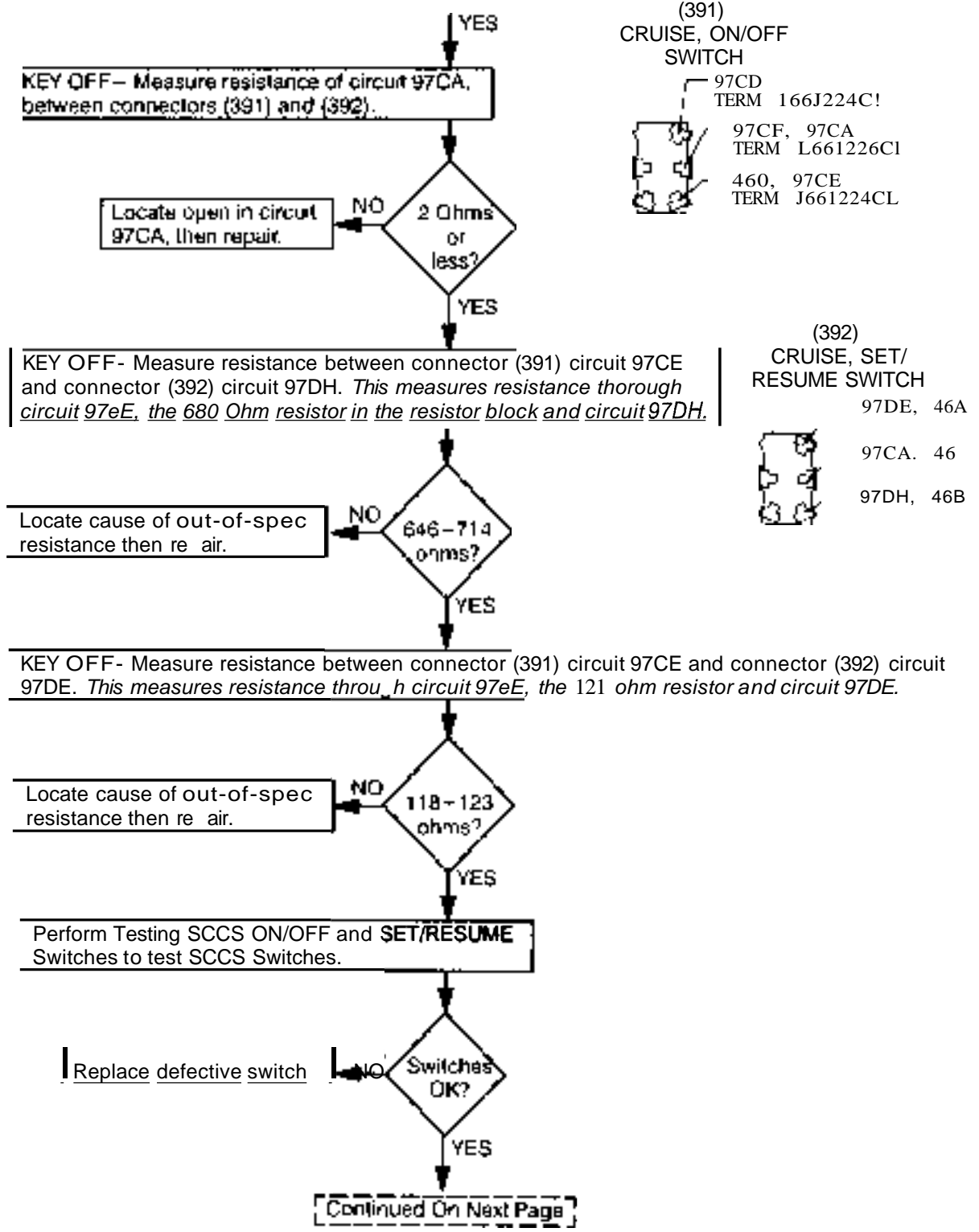
TESTING SPEED CONTROL COMMAND SWITCH (SCCS) CIRCUITS (Continued)

Continued from previous page



SPEED CONTROL COMMAND SWITCHES (sees)

TESTING (SCCS) CIRCUITS (Continued)

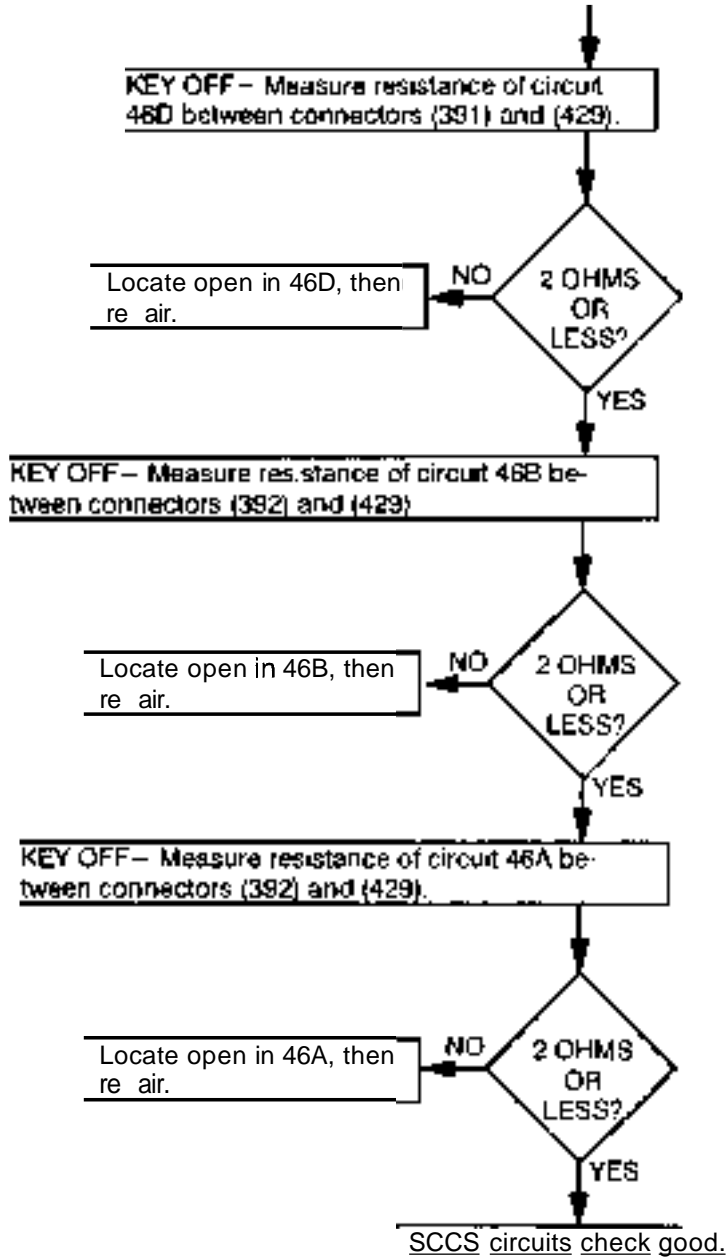


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

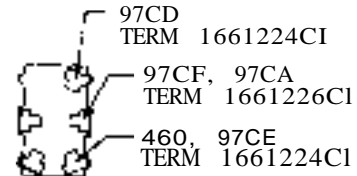
SPEED CONTROL COMMAND SWITCHES (SCCS)

TESTING (Sces) CIRCUITS (Continued)

Remote PTO controls must be disconnected from Body Builder connector (429) for the following test steps.



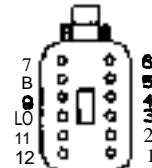
(391)
CRUISE, ON/OFF SWITCH



(392)
CRUISE, SET/RESUME SWITCH



(429)
REAR CAB BODY BUILDER CONN

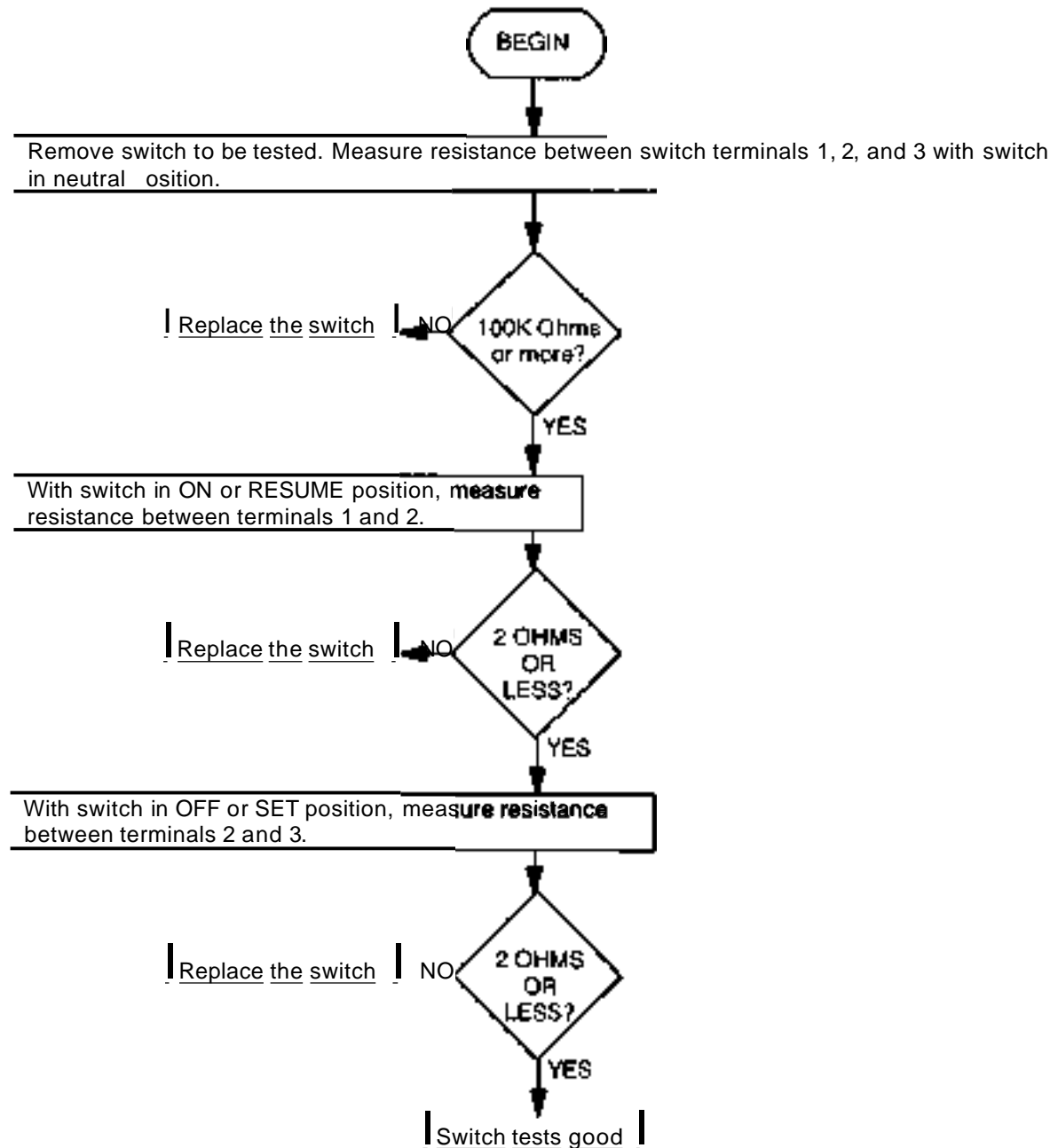


- 1 - 460
- 2 -
- 3 - 46
- 4 - 46A
- 5 - 468
- 6 - 97DF
- 7 - 97CC
- 8 - 97CB
- 9 -
- 10 - 97WA
- 11 - 99F
- 12 - 97DD

SPEED CONTROL COMMAND SWITCHES (SCCS)

TESTING SCCS ON/OFF AND SET/RESUME SWITCHES

This test can be used for either the ON/OFF or SET/RESUME switches. The switch terminal numbers are printed on the side of the switch.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (SeeS)

REMOTE PTO ONLY DOES NOT OPERATE (OR OPERATES INCORRECTLY)

NOTE: BEFORE DIAGNOSING ANY PROBLEM WITH THE REMOTE PTO, BE SURE THAT THE VEHICLE CRUISE CONTROL SYSTEM OPERATES CORRECTLY.

Remote Preset PTO Mode Does Not Operate Properly

Turning the cruise control on using the cab Cruise ON/OFF switch, then turning the remote Enable Preset switch ON will cause the PTA to operate at the customer selected preset rpm. The ECM does not diagnose the Enable Preset switch circuit, therefore there are no fault codes to indicate the circuit is defective.

If the vehicle cruise control works properly, but the remote Enable Preset switch does not work, perform Testing Remote PTA Preset And Variable Enable Circuits.

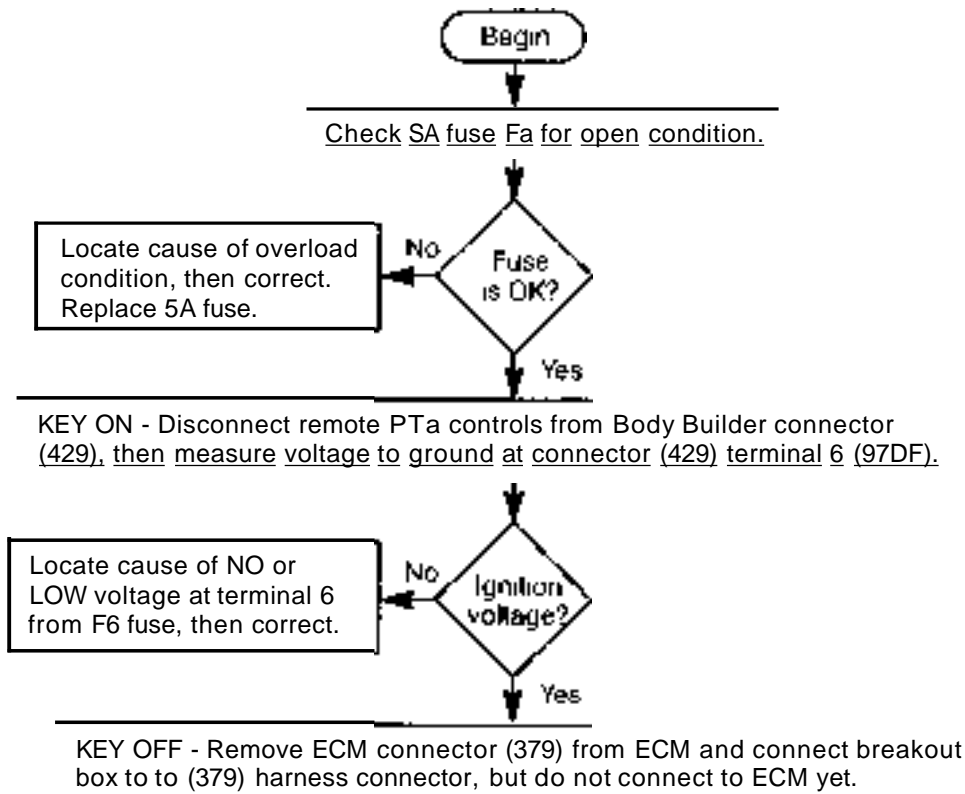
Remote Variable PTO Mode Does Not Operate Properly

Flash codes 213 and 214 indicate the ECM detected an out-at-range signal (high or low) from the remote pedal sensor (RPS). Note that the ECM does not diagnose the Enable Variable switch circuit, therefore there are no fault codes to indicate a defect in that circuit.

If the vehicle cruise control works properly, but the remote PTA does not work in the variable mode, check for flash codes. If Flash Code 213 or 214 is present or if no Flash Codes are present, perform Testing Remote PTA Preset And Variable Enable Circuits (below) and Testing Remote Pedal Sensor (RPS) Circuits on page 200.

Testing Remote PTO Preset And Variable Enable Circuits

This test checks the Navistar installed circuits, but not the body builder switches and circuits. The circuit diagram in this section shows a typical installation of the body builder switches.

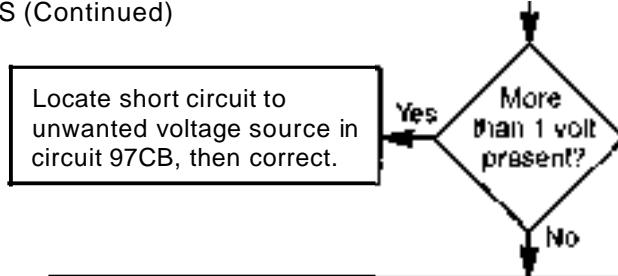


[Continued On Next Page]

SPEED CONTROL COMMAND SWITCHES (SCCS)

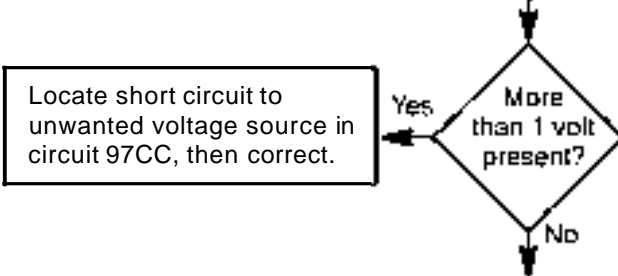
TESTING REMOTE
PTO PRESET AND
VARIABLE ENABLE
CIRCUITS (Continued)

KEY ON - Measure voltage between breakout box terminals 2 and 40.



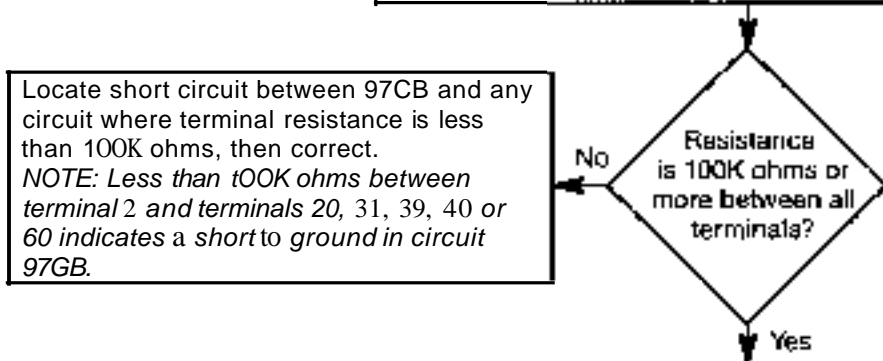
Locate short circuit to unwanted voltage source in circuit 97CB, then correct.

KEY ON - Measure voltage between breakout box terminals 12 and 40.



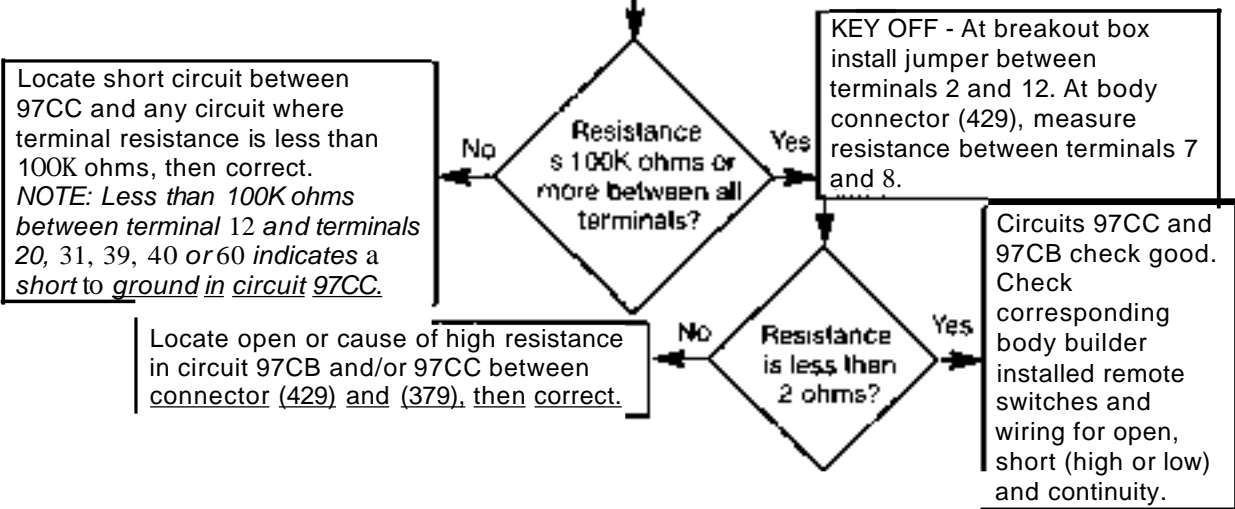
Locate short circuit to unwanted voltage source in circuit 97CC, then correct.

KEY OFF - Remove #1 ECM PWR fuse. At breakout box, measure resistance between terminal 2 and all other breakout box terminals.



Locate short circuit between 97CB and any circuit where terminal resistance is less than 100K ohms, then correct.
NOTE: Less than 100K ohms between terminal 2 and terminals 20, 31, 39, 40 or 60 indicates a short to ground in circuit 97GB.

KEY OFF - With #1 ECM PWR fuse removed, at breakout box measure resistance between terminal 12 and all other breakout box terminals.



Locate short circuit between 97CC and any circuit where terminal resistance is less than 100K ohms, then correct.
NOTE: Less than 100K ohms between terminal 12 and terminals 20, 31, 39, 40 or 60 indicates a short to ground in circuit 97CC.

KEY OFF - At breakout box install jumper between terminals 2 and 12. At body connector (429), measure resistance between terminals 7 and 8.

Locate open or cause of high resistance in circuit 97CB and/or 97CC between connector (429) and (379), then correct.

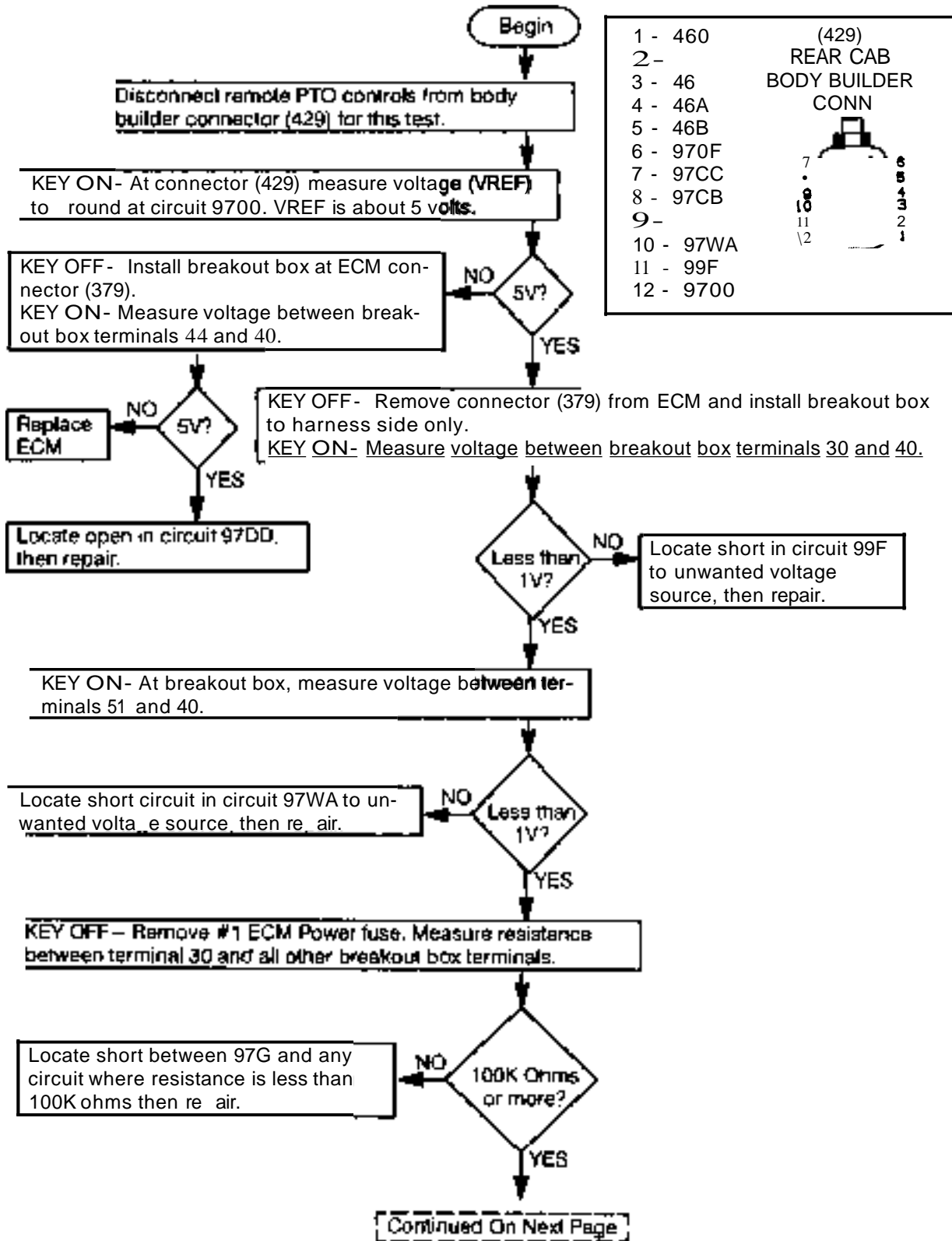
Circuits 97CC and 97CB check good. Check corresponding body builder installed remote switches and wiring for open, short (high or low) and continuity.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

SPEED CONTROL COMMAND SWITCHES (SCCS)

TESTING REMOTE PEDAL SENSOR (RPS) CIRCUITS

This test checks the Navistar installed circuits, but not the body builder installed remote pedal sensor (RPS) or connecting circuits. The circuit diagram shows a typical installation of the body builder installed RPS.

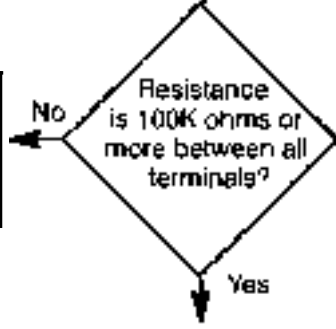


SPEED CONTROL COMMAND SWITCHES (SCCS)

TESTING REMOTE PEDAL SENSOR (RPS) CIRCUITS (Continued)

KEY OFF - At breakout box measure resistance between terminal 51 and all other terminals in breakout box.

Locate short circuit between 97WA and any circuit where terminal resistance is less than 100K ohms, then correct.



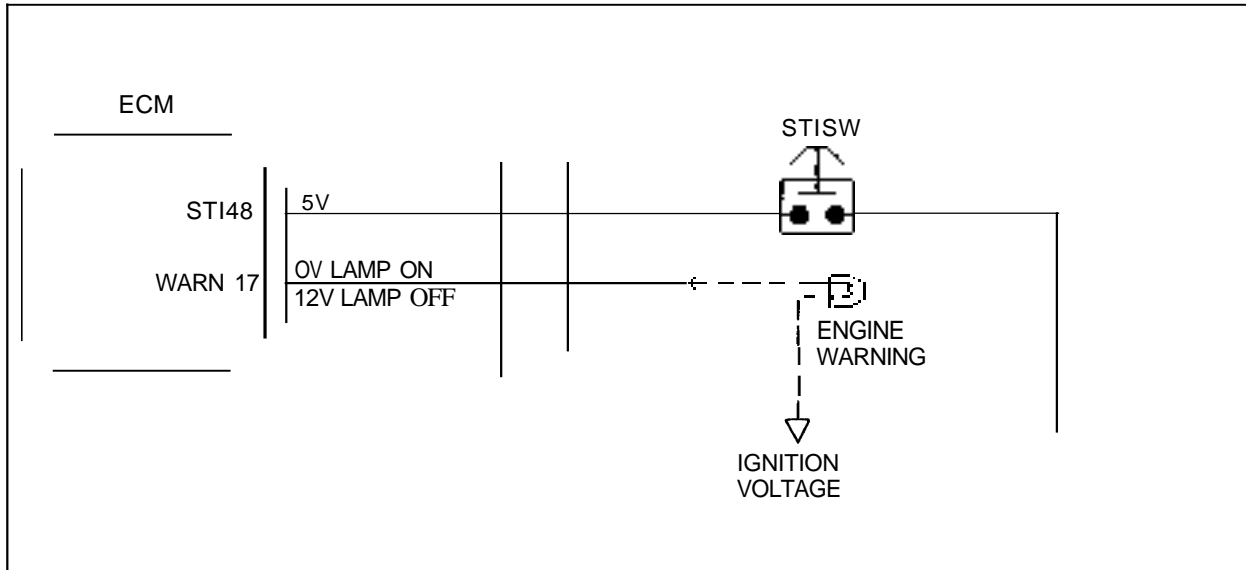
KEY OFF - At breakout box install jumper between terminals 30 and 51. At connector 429, measure resistance between terminals 10 and 11.

Locate open or cause of high resistance in circuit 99F and/or 97WA, then correct.



Navistar installed RPS circuits 97DD(5V), 99F and 97WA check good. Check corresponding body builder installed circuits for shorts (high or low) and continuity. If circuits all check good, replace the Remote Pedal assembly.

SELF TEST INPUT SWITCH AND ENGINE WARNING LIGHT



SIGNAL FUNCTION

SELF TEST INPUT (STI) SWITCH

The STI switch (or Prolink EST) can be used to run the Key On Engine Off (KOEO) Standard Tests. Faults detected during this test result in active fault codes, which are transmitted as FLASH codes with the Warning Light. If no faults are detected, the ECM will FLASH code 111 (indicates no faults detected).

ECM terminal 48 has 5 volts with the key ON and engine OFF. Depressing the STI switch grounds terminal 48, causing it to change from 5 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

ENGINE WARNING LIGHT

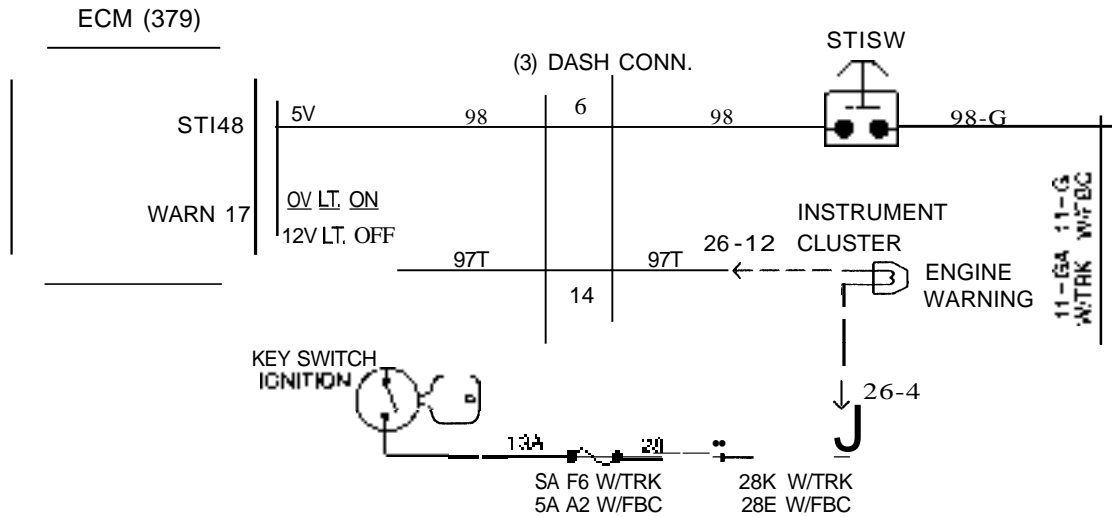
When the key switch is turned to ON, the amber Engine Warning Light (EWL) turns ON and stays ON, while the ECM runs normal startup tests, and then turns OFF. If the ECM detects a problem, the EWL remains on.

Ignition power from fuse F6 (fuse A2 w/FBC) is applied to the EWL. The ground side of the EWL is connected to ECM terminal 17, which is a ground switch. The ECM applies 12 volts (light OFF) or 0 volts (light ON), in response to engine conditions.

FAULT DETECTION MANAGEMENT

There are no ECM diagnostics for the STI or Warning light circuits.

Self Test Input! Engine Warning Light (STI/EWL)	Fault Codes: No Diagnostic Codes for these Systems
---	---



Test STI switch with ignition key "OFF"

Test Points	Spec.	Comments
Across Switch Terminals	> 1000 ohms open position	< than 1000 ohms replace switch.
Across Switch Terminals	< 5 ohms closed position	> than 5 ohms replace switch.

Test at STI switch connection with ignition key "OFF"

Test Points	Spec.	Comments
98 to grd	> 1000 ohms	< than 1000 ohms locate short to ground

Test at STI switch connection with ignition key "ON"

Test Points	Spec.	Comments
98 to grd	5 ±.5 volts	< than 4.5v check connections, if 0 volts, check for open/short to ground in ckt. 98
98 to 98-G	5 ±.5 volts	< than 4.5v check connections, if 0 volts, check for open in ground circuit

IF warning light does not turn on when key is turned ON

1. Check fuse and bulb condition.
2. Disconnect (379) from ECM and install jumper breakout box to harness. Jumper terminal 17 to ground and note if light is ON.
 - A. If light is ON, the ECM is defective.
 - B. If light does not turn ON, check circuit for open condition.
 - B. If light goes OFF, ECM is defective.

IF warning light STAYS ON after self test

1. Check for active fault conditions (use ProLink or STI flash codes).
 - A. If active fault conditions are present correct faults.
 - B. If no fault conditions are present go to step 2.
2. Disconnect (379) from ECM and note if LIGHT remains ON.
 - A. If light remains ON, check for short to ground in circuit.

EXTENDED DESCRIPTION

Refer to circuit diagram on page 205 for the following discussion.

STISWITCH

The STI switch (or Prolink EST) can be used to run the Key On Engine Off (KOEO) Standard Tests. Faults detected during this test result in active fault codes, which are transmitted as FLASH codes with the Warning Light. If no faults are detected, the ECM will FLASH code 111 (indicates no faults detected).

Depressing the STI switch with the key ON and engine OFF starts the test cycle. The KOEO Standard tests include: (1) ECM Internal Tests and (2) Output Circuit Check (OCC) tests.

The normally open (N.O.) switch has one pole connected through circuit 98 and ECM connector (379) to the ECM's STI terminal 48. The other switch pole is connected (circuit 98-G/11-GA) to the G2 ground stud.

ECM terminal 48 has 5 volts with the key ON and engine OFF. Depressing the STI switch grounds terminal 48, causing it to change from 5 volts to 0 volts, signaling the ECM to start the KOEO Standard Tests.

ENGINE WARNING LIGHT

When the key switch is turned to ON, the amber Engine Warning Light (EWL) turns ON and stays ON, while the ECM runs normal startup tests, and then turns OFF. If the ECM detects a problem, the EWL remains on.

Refer to circuit diagram on page 205 for the following discussion.

Ignition power from fuse F6 (fuse A2 w/FBC) is applied to the EWL. The ground side of the EWL is connected to ECM terminal 17, which is a ground

switch. The ECM applies 5 volts to terminal 17 (light OFF) or 0 volts (light ON), in response to engine conditions.

ECM DIAGNOSTICS

There are no ECM diagnostics for the STI or Warning Light circuits.

TROUBLESHOOTING**SELF TEST INPUT (STI) SWITCH**

If depressing the STI switch with key on and engine off does not cause the OCC tests to run (if no faults are detected code 111 should flash), perform Testing The STI Circuit on page 206.

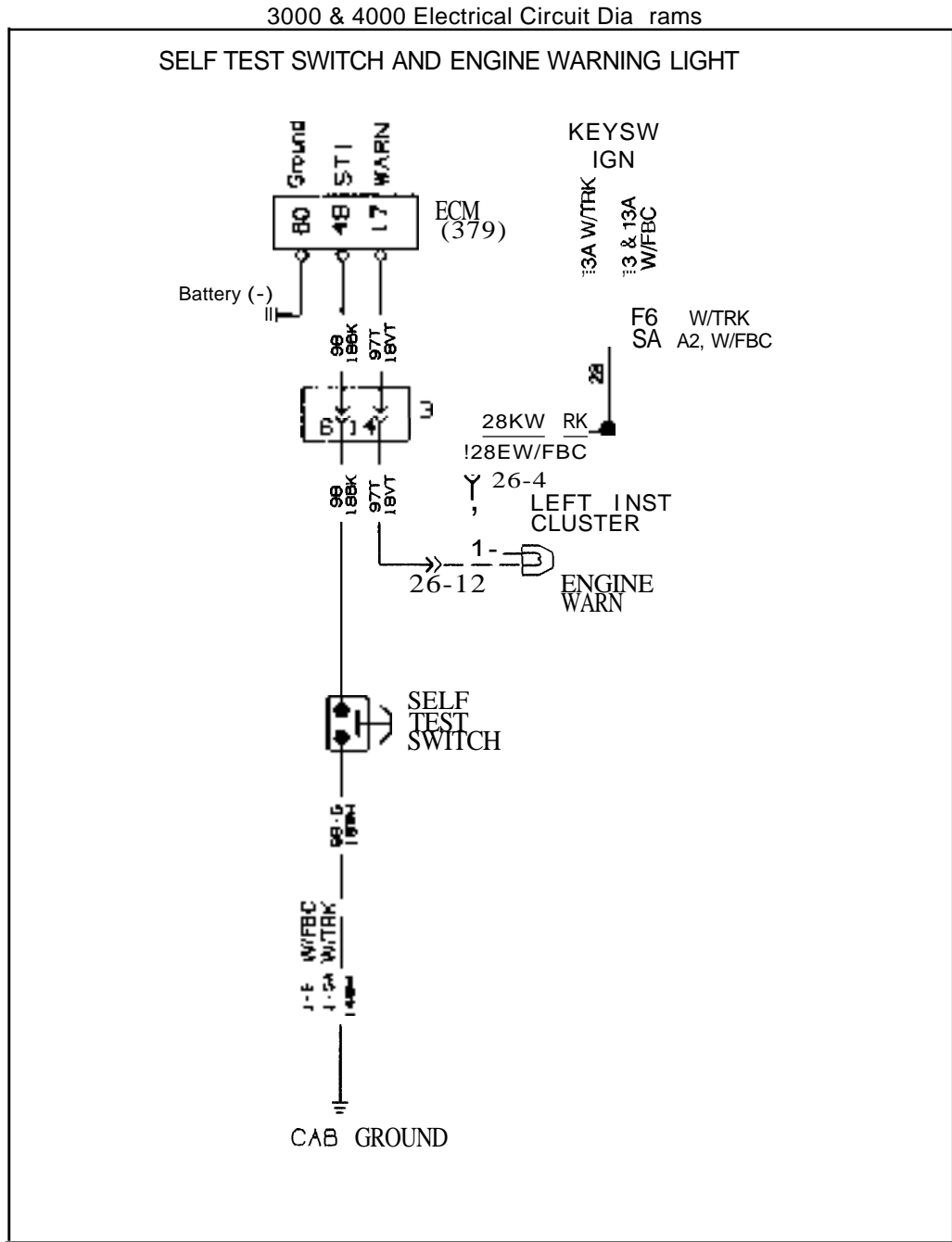
ENGINE WARNING LIGHT (EWL)

If the EWL does not turn ON during the ECM startup tests, or stays ON after the engine is running with NO ACTIVE FLASH CODES, perform Engine Warning Light Does Not Turn ON test page 207 or Engine Warning Light Stays ON test page 208.

BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.
- B. Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

CIRCUIT DIAGRAM

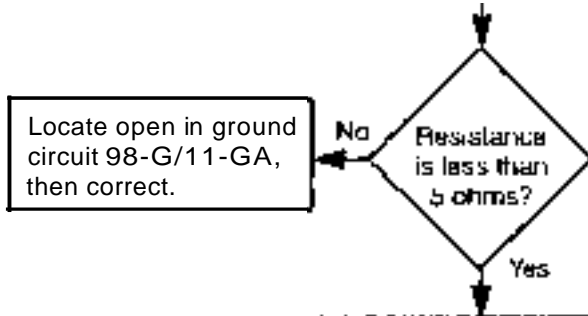


TESTING THE SELF TEST INPUT (STI) CIRCUIT

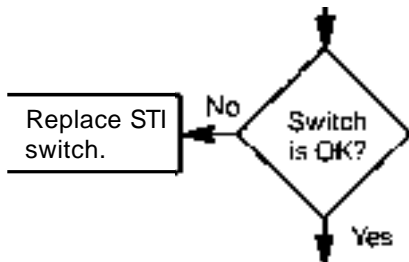
Refer to circuit diagram on page 205.



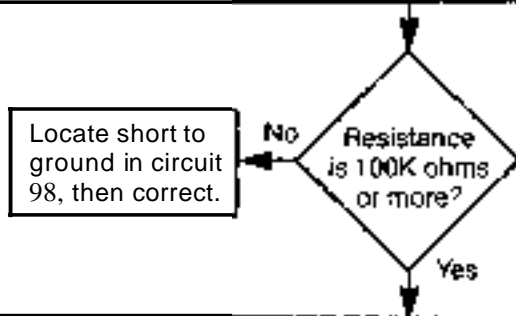
With key OFF, disconnect 98-G from STI switch. Measure resistance to ground.



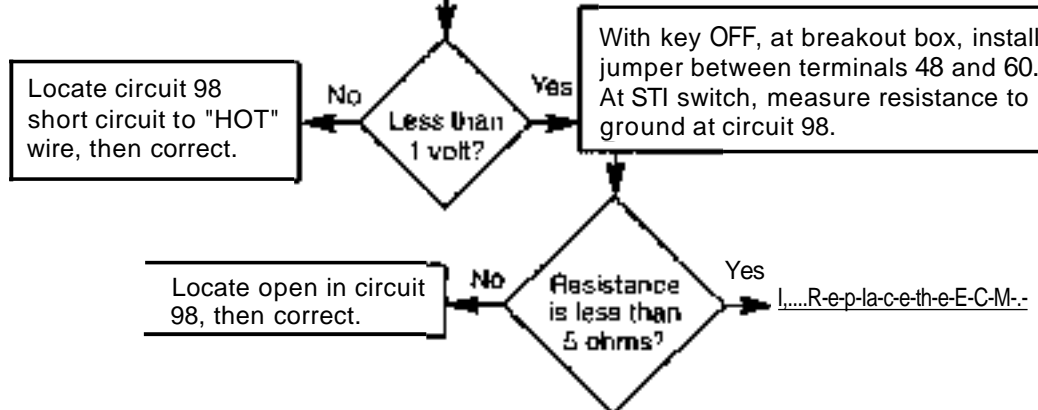
With key OFF, disconnect 98 from STI switch. Use ohmmeter to test STI switch. There should be less than 2 ohms when depressed and 100K ohms or more when released.



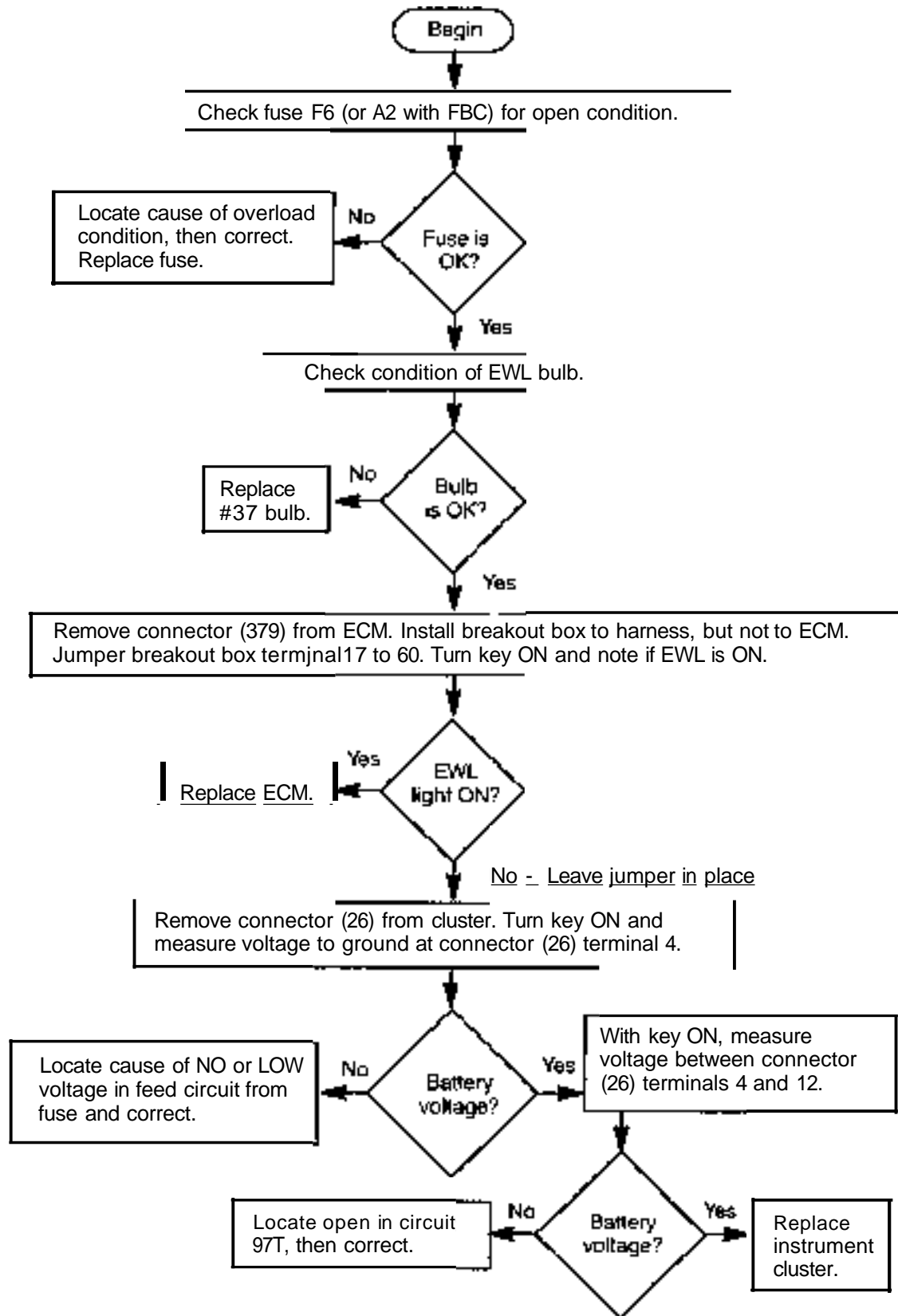
With key OFF, remove connector (379) from ECM and connect breakout box to harness, but not to ECM. Measure resistance between breakout box terminals 48 and 60.



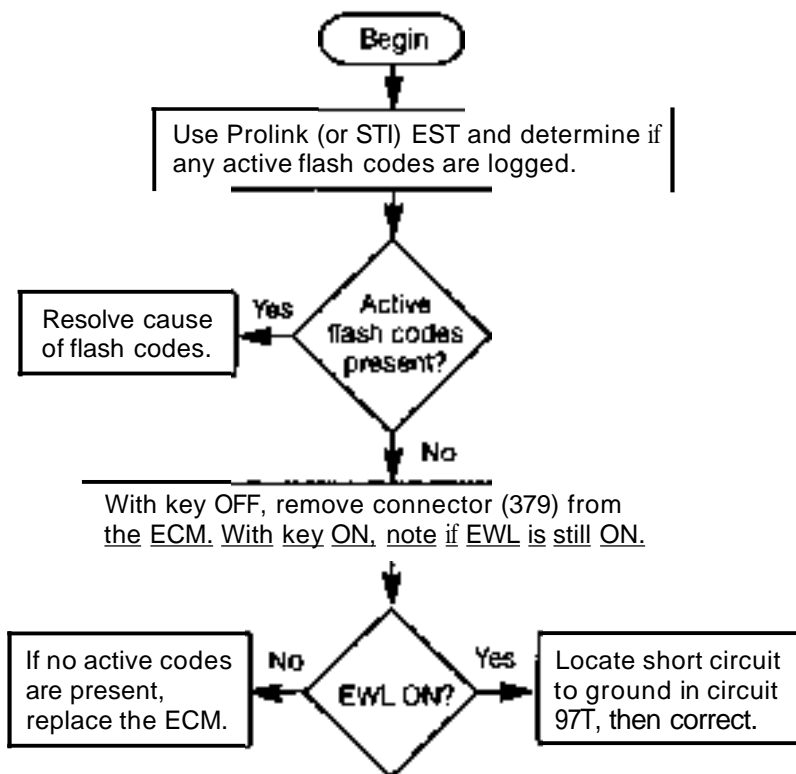
With key ON, measure voltage between breakout box terminals 48 and 60.



ENGINE WARNING LIGHT DOES NOT COME ON DURING START-UP



ENGINE WARNING LIGHT STAYS ON



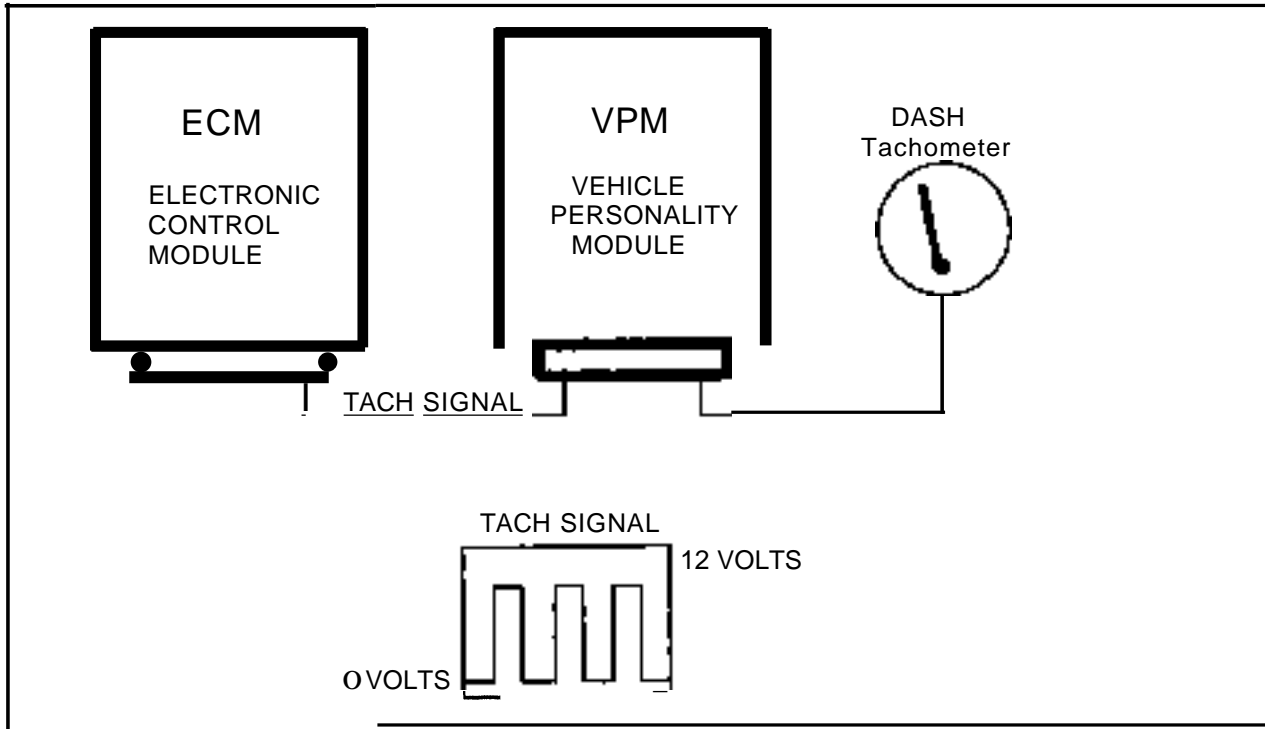
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

Section 3.5

Page 210

TACHOMETER INPUT CIRCUITS (TACH)

TACHOMETER INPUT CIRCUITS



CIRCUIT FUNCTIONS

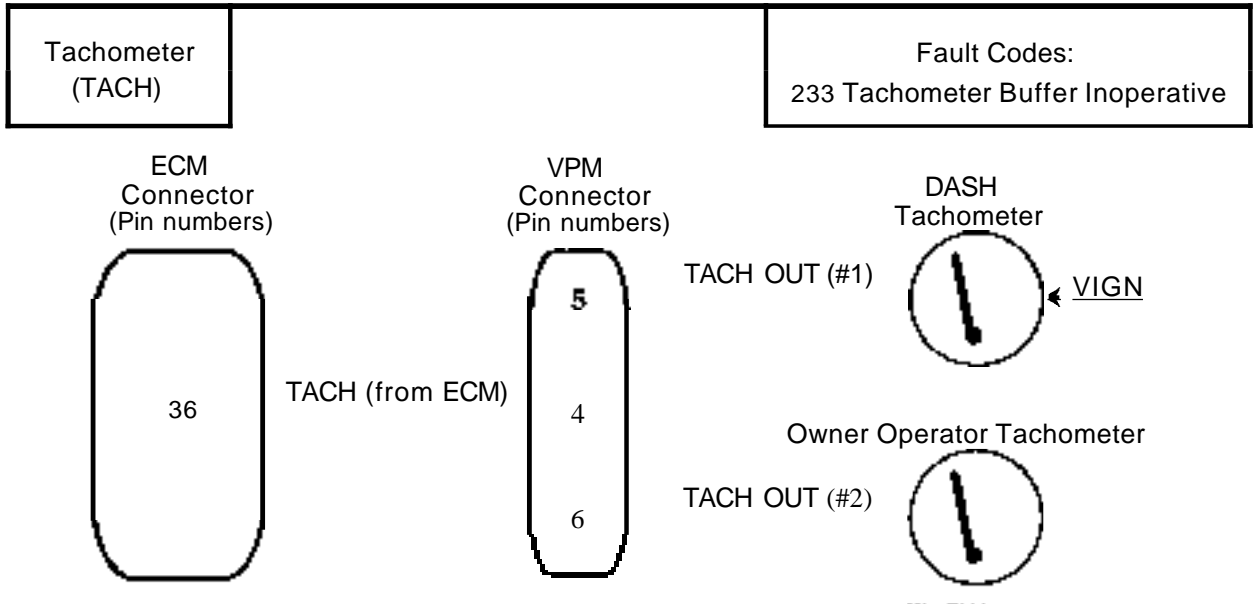
The ECM (Electronic Control Module) provides the VPM (Vehicle Personality Module) with a 0 - 12 volt digital signal that indicates engine speed. The VPM buffers this signal and supplies the instrument panel with a signal to operate the tachometer. The frequency sent by the ECM is 1/5th of the actual engine RPM.

FAULT DETECTION MANAGEMENT

The VPM can detect if the TACH signal is not being received from the ECM and will set a fault code to indicate loss of communication. No fault detection is available for communication between the VPM and the instrument panel.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TACHOMETER INPUT CIRCUITS (TACH)



Key ON Engine Off - Voltage Checks at ECM (Check with breakout box installed and the Ignition Key ON, Engine OFF)

Test Points	Spec.	Signal	Comments
#36 to #46	12 ± 1.5 v	TACH	The signal is pulled up by the VPM with the key ON and engine OFF.

Connector Checks to Ground at ECM (Check with with breakout box installed, ignition key should be in the OFF position)

Test Points	Spec.	Signal	Comments
#36 to #46	> 1000 ohms	TACH	Less than 1000 ohms indicates a short to grd either thru the harness or internal in the ECM. Disconnect the ECM from the breakout box and measure to grd again, if short is still present repair harness.

Harness Resistance Checks From ECM to VPM (Check with breakout box installed, ignition key should be in the OFF position)

Test Points	Spec.	Signal	Comments
#36 to 4	< 5 ohms	TACH	Resistance from 60 pin connector to harness connector - TACH Signal
#36 to 5	< 5 ohms	TACH	Resistance from VPM connector to TACH input at instrument panel- Dash Tach
#36 to 6	< 5 ohms	TACH	Resistance from VPM connector to TACH input - Optional Owner/Operator Tach

Key ON Engine Running - Signal Checks - TACH (Check with breakout box installed)

Test Points	Specification	Comments
#36 to #46	5 to 7 volts/140 to 540 Hz	TACH signal from the ECM is a frequency that is engine RPM + 5

Fault Code Descriptions
223 = ECM TACH signal not communicating with VPM

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TACHOMETER INPUT CIRCUITS (TACH)

DESCRIPTION

Refer to the circuit diagram on page 213 for this discussion.

TACHOMETER INPUT SIGNAL

The ECM receives signals from the CMP sensor and calculates engine speed (rpm). The ECM sends the calculated engine speed as a digital TACH signal from ECM connector 36 (circuit 970) to the VPM at connector (381) terminal 4.

The VPM buffers the TACH signal received from ECM and sends a pulse width modulated (PMW) signal to the Speedometer/ Tachometer unit at center liP connector (27).

ENGINE SPEED SIGNAL TO PROLINK EST

Engine rpm can be monitored using the ProLink Electronic Service Tool (EST) connected to the EST connector (384). It is important to note that the signal comes through different circuits.

The engine speed signal read by the ProLink EST comes from the ECM, but is sent from ECM terminals 9 and 28, through the Data Communication link, DCI (+) and DCI (-) circuits, to the VPM, then through the ATA Data Link, ATA (+) and ATA (-) circuits, to the EST connector (384).

ECM DIAGNOSTICS

If the CMP signal is not received and processed by the ECM, the engine will not start. If the engine is running, but the tachometer does not operate (or operates improperly), there are two tests to further isolate the problem.

TESTING SPEEDOMETER/TACHOMETER CLUSTER

With the key ON and engine OFF, the *Speedometer/ Tachometer* unit, located in the instrument panel, will perform a self-test, checking the tachometer gauge and the speedometer/tachometer control unit. Refer to Service Manual, Group 08, Instru-

ments for the appropriate section for information on performing this test.

KOER TACH BUFFER TEST

The KOER Tach Buffer Test must be run when engine speed is greater than 1250 rpm. This test checks the circuit (970) between the ECM and VPM for open or short (high or low) circuit condition. It also checks the internal VPM buffer circuit for open or short (high or low) conditions. If a defect is found, Flash Code 233 is set.

FLASH CODE 233

PID 190 FMI2

VPM: *TACHOMETER BUFFER INOPERATIVE*

This code is set during the KOER Tach Buffer Test if:

- A. Engine speed is less than 1250 rpm.
- B. Circuit 970 is open or shorted (high or low) between the ECM and VPM causing the VPM to receive either no signal or an invalid **signal**.
- C. The VPM internal buffering circuit is defective.

CORRECTIVE ACTION

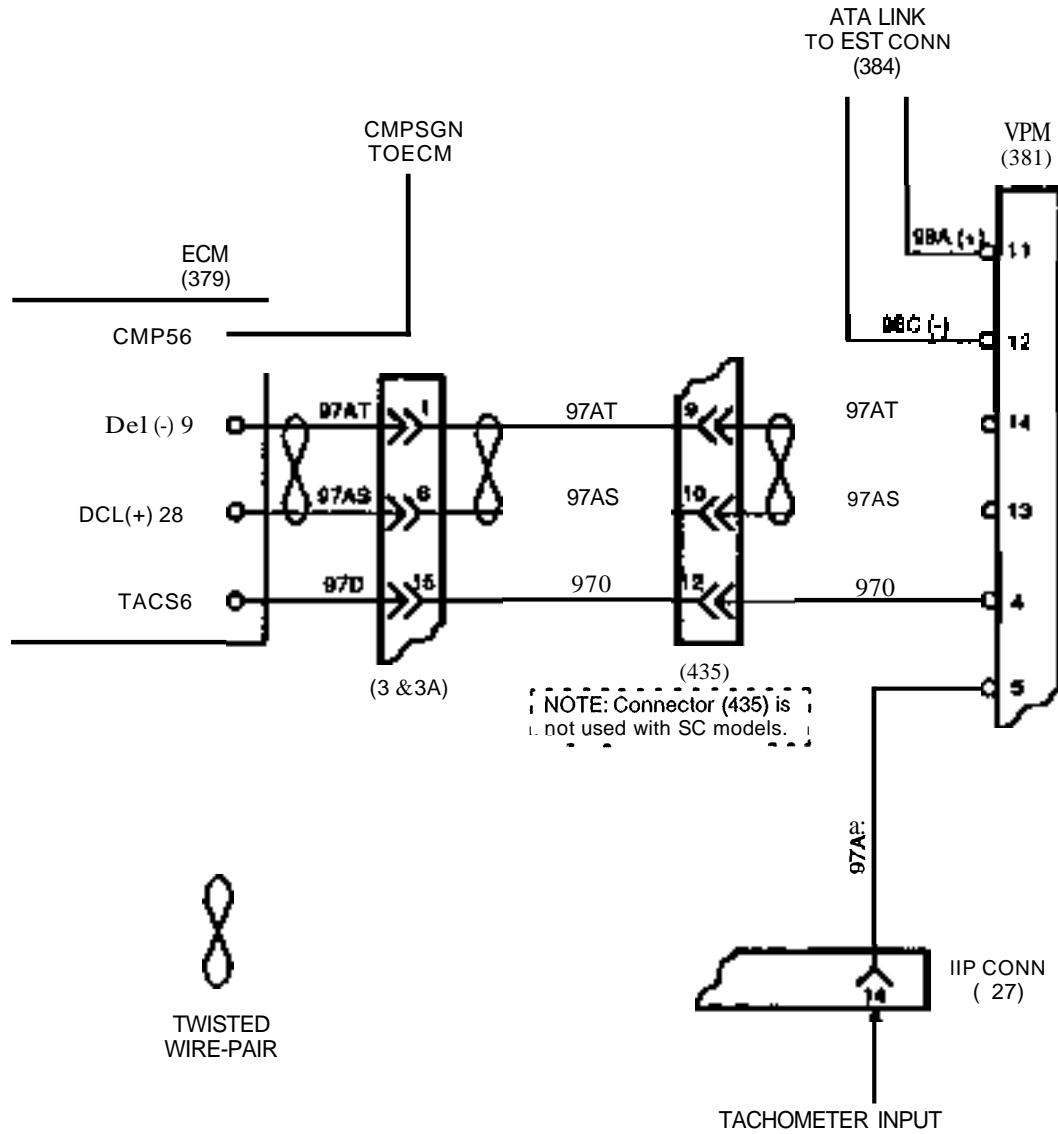
If the tachometer doesn't work and:

- A. The Speedometer/Tachometer Self-Test does not indicate a defect, perform Testing Circuit 97AR on page 214. If the self-test revealed a defect, follow service manual recommended corrective action.
- B. The Tach Buffer KOER test does not set a fault code, then check circuit 97AR between VPM connector (381) and liP connector (27) for open or short (high or low) circuit by performing Testing Circuit 97AR on page 214.
- C. If the Tach Buffer KOER test does set Flash code 233, perform Testing ECM/VPM Tachometer Circuit on page 215.

TACHOMETER INPUT CIRCUITS (TACH)

CIRCUIT DIAGRAM

TACHOMETER INPUT CIRCUIT

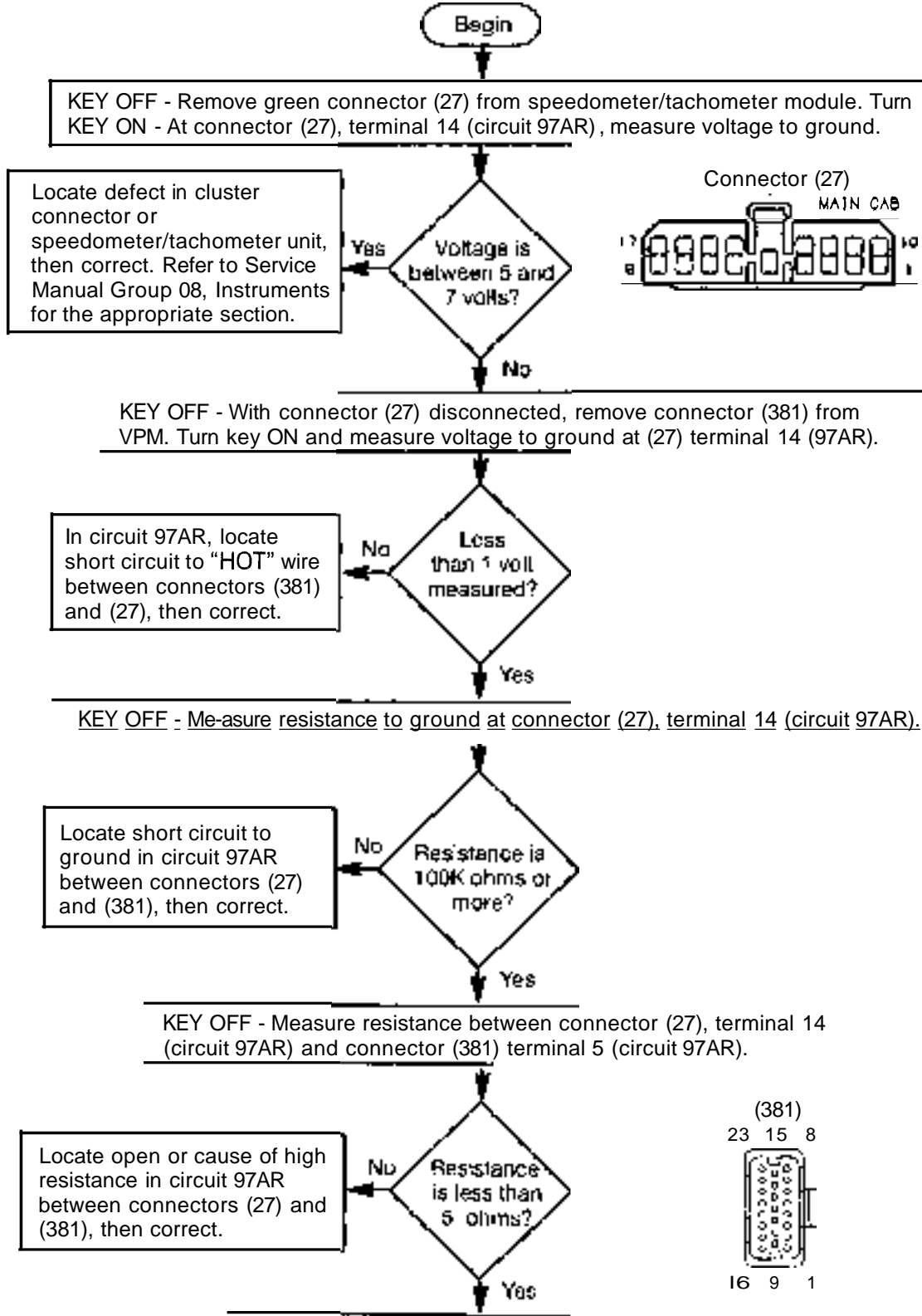


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TACHOMETER INPUT CIRCUITS (TACH)

TESTING TACHOMETER CIRCUIT 97AR

Perform Speedometer/Tachometer Self-Test before performing this test.

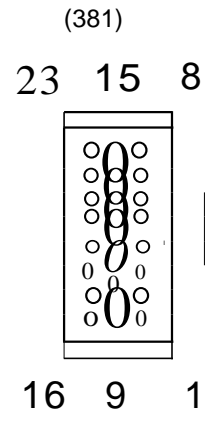
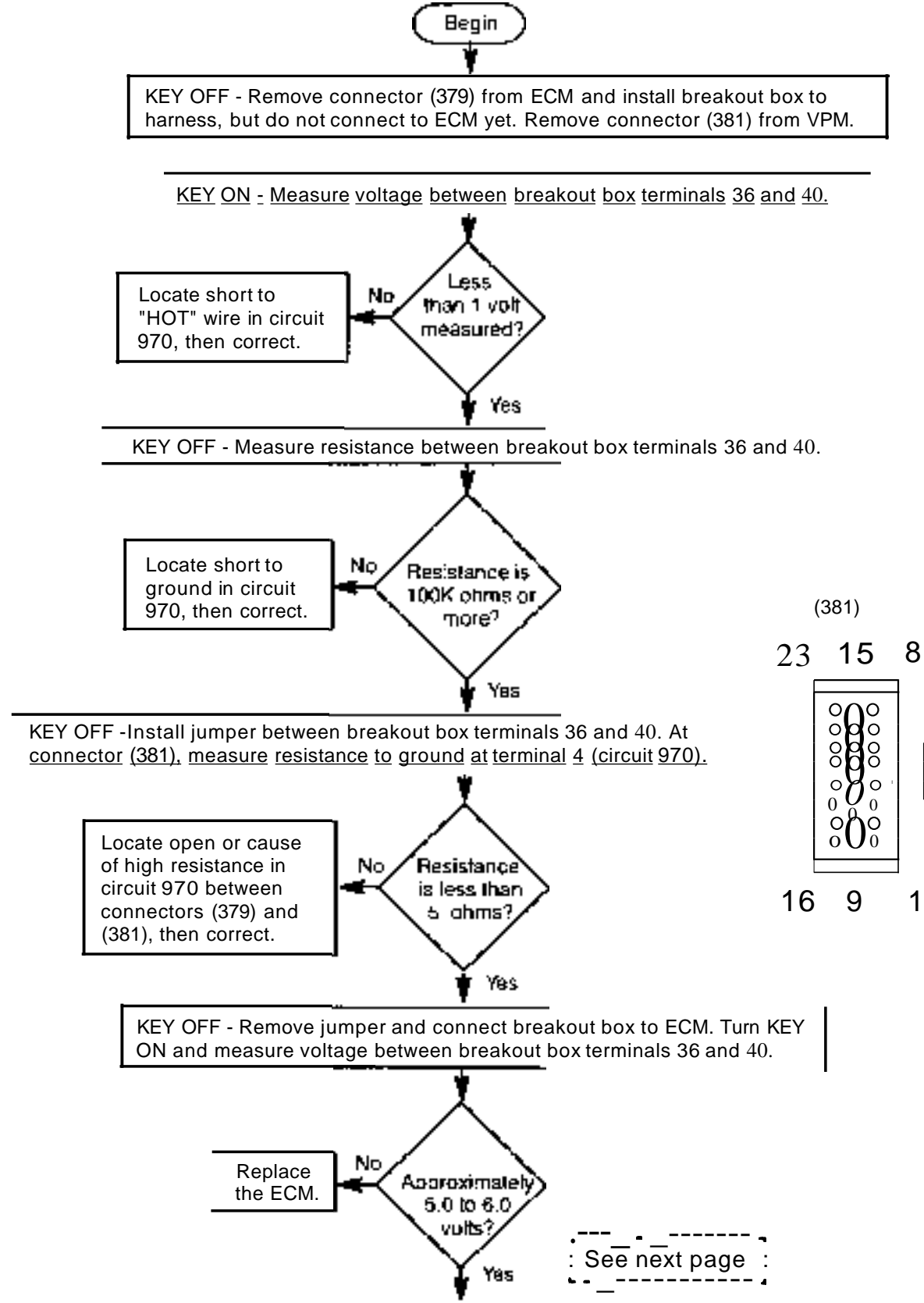


Perform Testing ECMNPM Tachometer Circuit on page 215.

TACHOMETER INPUT CIRCUITS (TACH)

TESTING ECMNPM TACHOMETER CIRCUIT

Perform this test when Flash Code 233 is ACTIVE.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

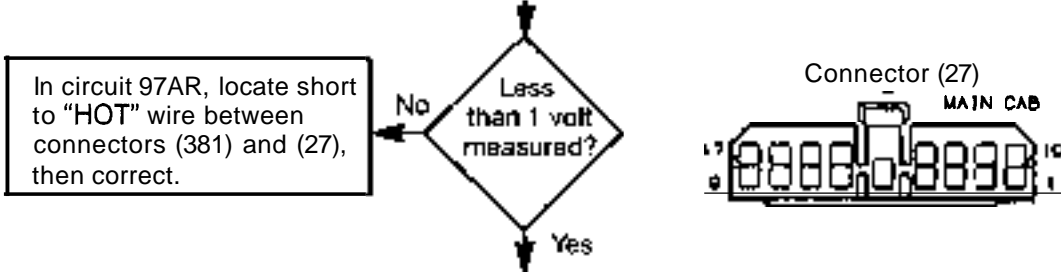
TACHOMETER INPUT CIRCUITS (TACH)

TESTING ECMNPM TACHOMETER CIRCUIT (Continued)

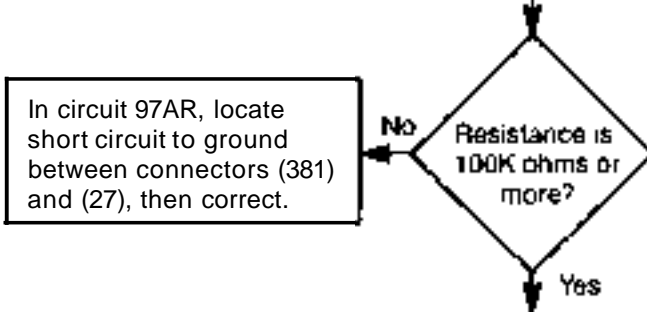
t

KEY OFF - With VPM disconnected, disconnect green cluster connector (27) from Speedometer/Tachometer cluster in instrument panel.

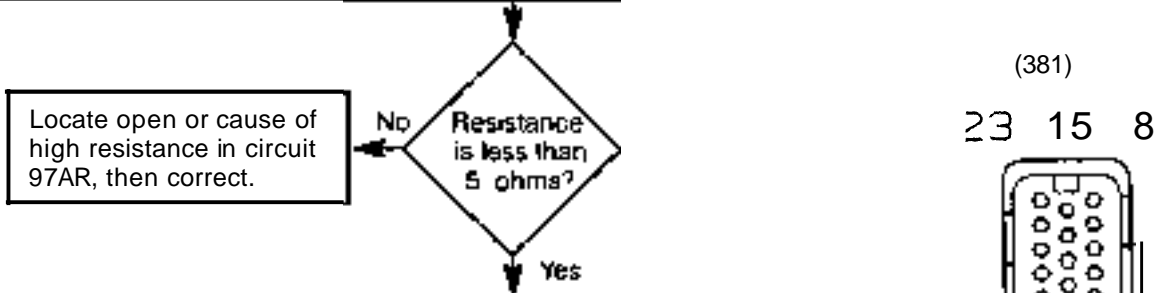
KEY ON - At harness connector (27), terminal 14 (circuit 97AR), measure voltage to ground.



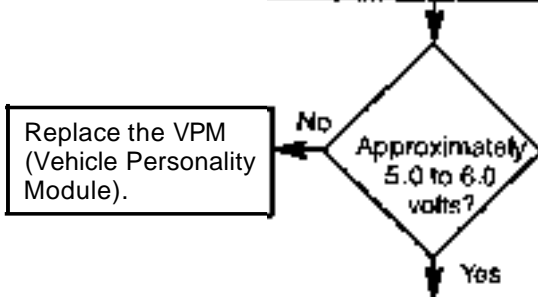
KEY OFF - At harness connector (27), terminal 14, measure resistance to ground.



KEY OFF - Measure circuit 97AR resistance between connector (381) and connector (27).



KEY OFF - Connect (381) to VPM, then turn KEY ON and measure voltage to ground at connector (27), circuit 97AR.

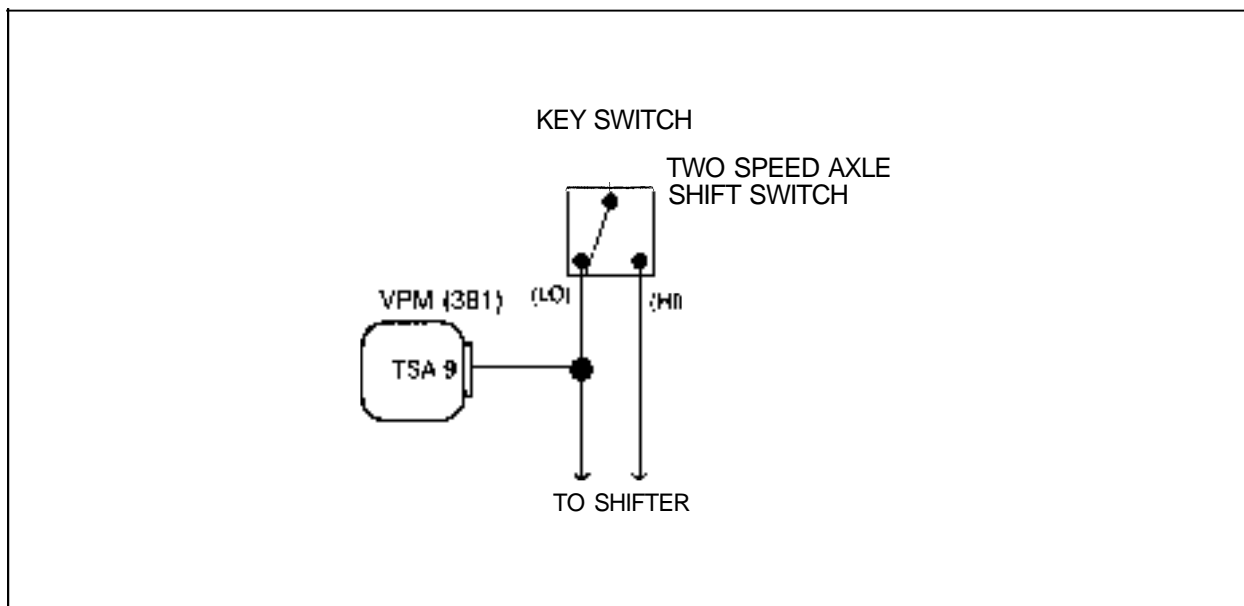


Locate defect in connector (27) or speedometer cluster causing tachometer not to work properly, then correct. Refer to Service Manual Group 08, Instruments.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TWO SPEED AXLE INPUT CIRCUIT (TSA)

TWO SPEED AXLE SPEEDOMETER CIRCUIT



SIGNAL FUNCTIONS

The VPM is programmed with the high and low rear axle ratios. The ratios are used to calculate the speedometer signal, depending on which mode the switch is in. The VPM uses the high ratio unless voltage is applied to VPM terminal 9 indicating the two speed selector switch is in the low range.

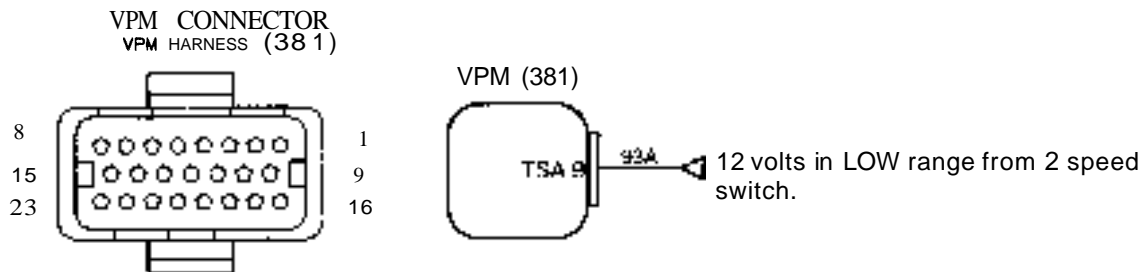
The two speed switch applies 12 volts to the VPM at terminal 9 (and to the shifter) when the switch is in the LO position.

FAULT DETECTION MANAGEMENT

There are no ECM diagnostics for the two speed circuits.

TWO SPEED AXLE INPUT CIRCUIT (TSA)

Two Speed Axle Speedometer (TSA)	<p style="text-align: center;">Fault Codes:</p> <p style="text-align: center;">There are no Diagnostic Codes for this application.</p>
----------------------------------	--



USE PROLINK EST TO PERFORM THE FOLLOWING TEST

1. Use Prolink EST to verify correct VPM programming including correct rear axle ratios (high and low)
 - A. If programmed correctly go to step 2.
 - B. If programming is not correct, make necessary programming corrections.
2. Use EST to monitor two speed switch while changing switch position several times.
 - A. If switch does not function, go to step 3.
 - B. If switch functions properly go to step 4.
3. Disconnect connector (381) from VPM. With key ON and switch in LOW position, measure voltage to ground at circuit 93A. Battery voltage (12 ± 1.5 volts) should be present.
 - A. If less than 10.5 v check connections, if 0 volts check for open/short to ground.
 - B. If battery voltage is present, replace the VPM.
4. Refer to Service Manual Group 08 Instruments, and perform Speedometer Self Diagnostic Test.
 - A. If the self test is not OK, follow the recommendations of the service manual.
 - B. If the self test is OK, road test the vehicle and have a passenger monitor vehicle speed using the Prolink. If the Prolink displays the correct speed replace the speedometer/tachometer unit. If the Prolink does not display the correct speed, replace the VPM.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TWO SPEED AXLE INPUT CIRCUIT (TSA)

EXTENDED DESCRIPTION

NOTE: THE PURPOSE OF THIS SECTION IS TO DIAGNOSE THE TWO SPEED INTERFACE WITH THE SPEEDOMETER. THIS SECTION DOES NOT DIAGNOSE TWO SPEED AXLE OPERATION.

The vehicle speed sensor reads the revolutions of the transmission speedometer gear and sends a signal to the VPM. VPM programming includes the high and low rear axle ratios. The VPM uses the sensor input and rear axle ratios to calculate the speedometer signal, depending on which range the vehicle is operating in. When voltage is applied to VPM terminal 9 from the two speed circuit, the VPM uses the low ratio.

The Two Speed Axle switch receives ACC power from 10A fuse F14. This is a normally open switch with "High" as the normal operating position. With the Two-Speed switch in the "Low" position, 12V accessory power is applied through VPM connector (381) at VPM terminal 9.

ECM DIAGNOSTICS

There are no ECMNPM diagnostics for this circuit.

TROUBLESHOOTING

If the speedometer/odometer does not correctly show vehicle speed when changing from the high to low range, or low to high range, perform Testing Two-Speed Speedometer Circuit on page 223.

BEFORE TROUBLESHOOTING

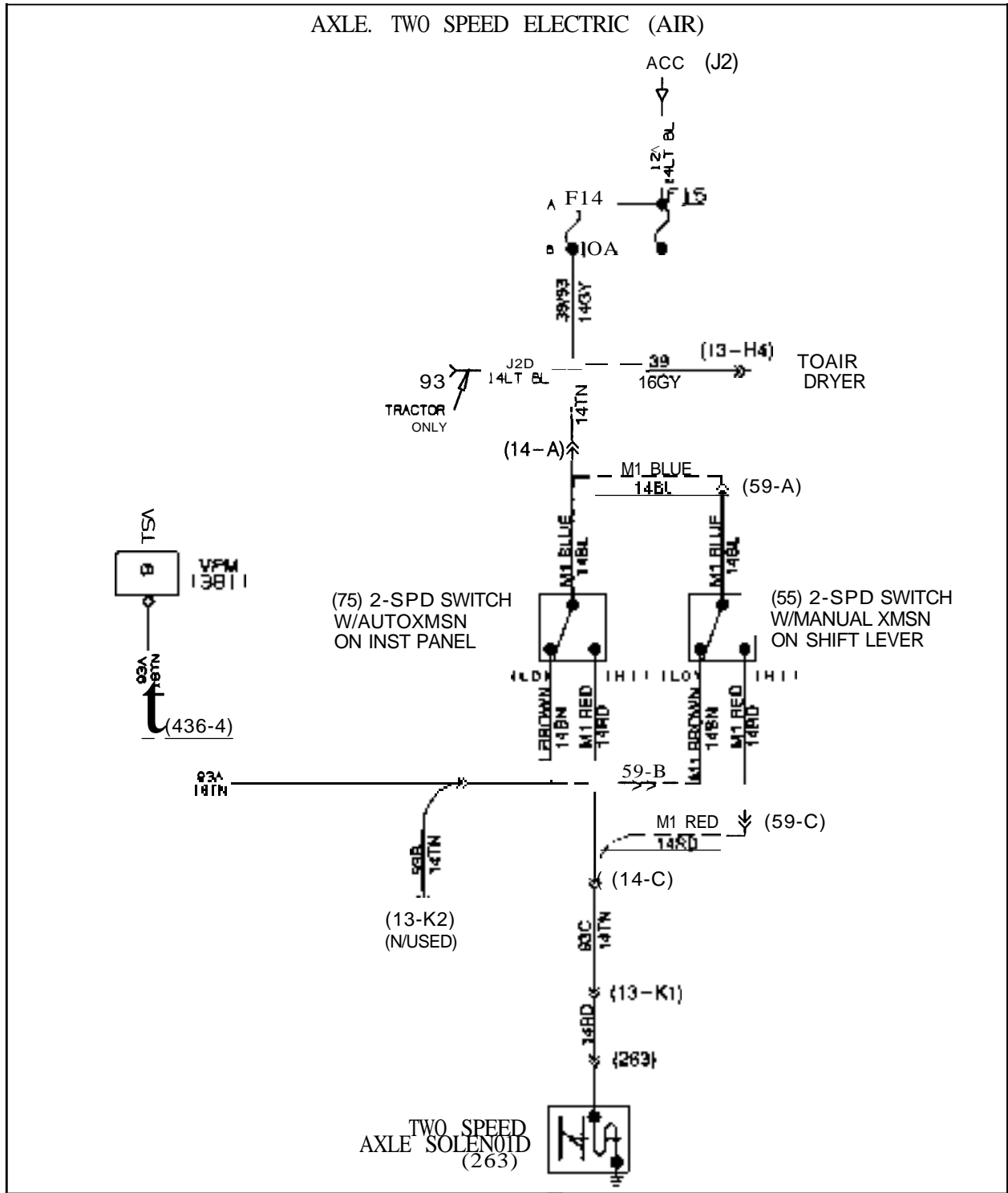
- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.
- B. Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands etc. **Wires** and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

TWO SPEED AXLE INPUT CIRCUIT (TSA)

CIRCUIT DIAGRAM TWO SPEED ELECTRIC (AIR)

3000 & 4000 Electrical Circuit Diagrams

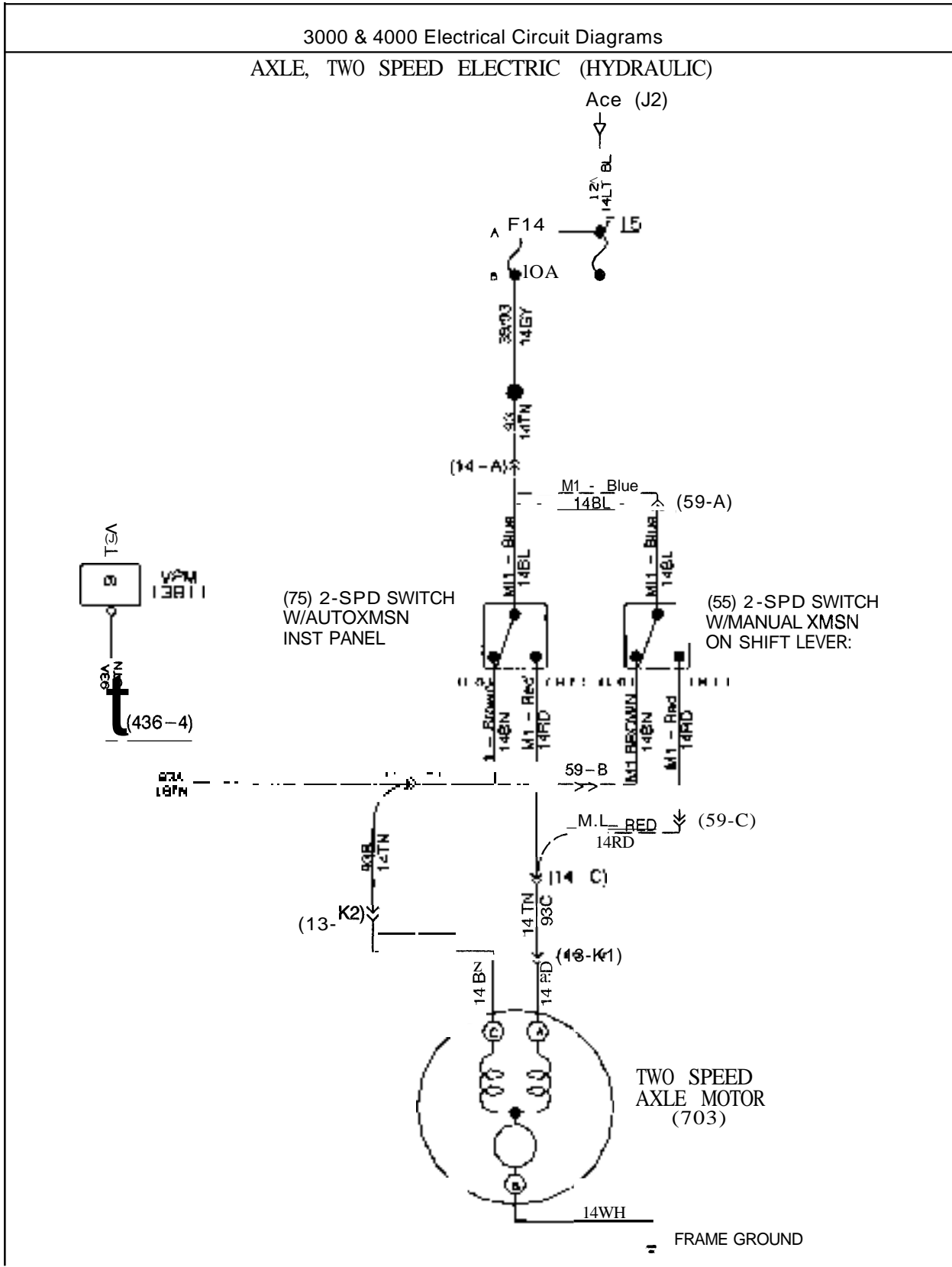
AXLE. TWO SPEED ELECTRIC (AIR)



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

TWO SPEED AXLE INPUT CIRCUIT (TSA)

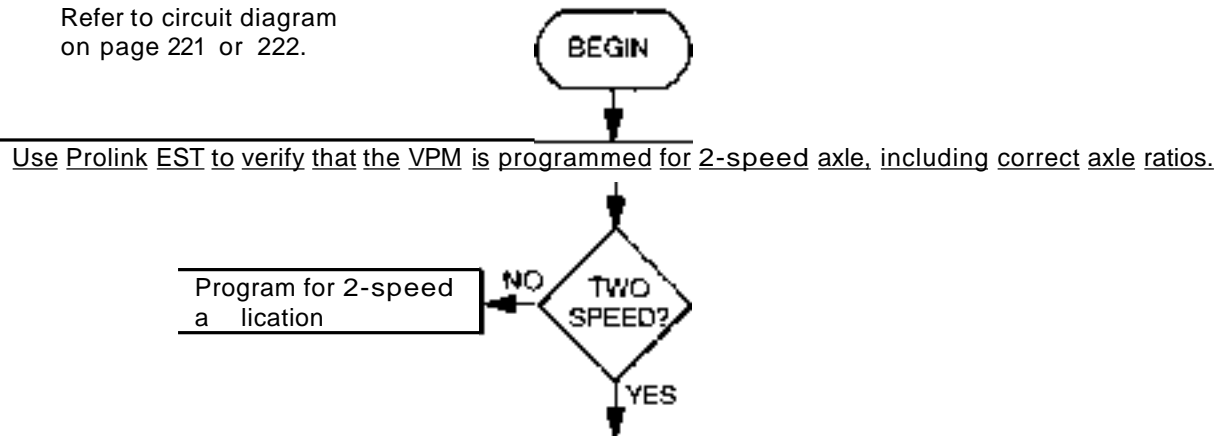
TWO SPEED ELECTRIC (HYDRAULIC)



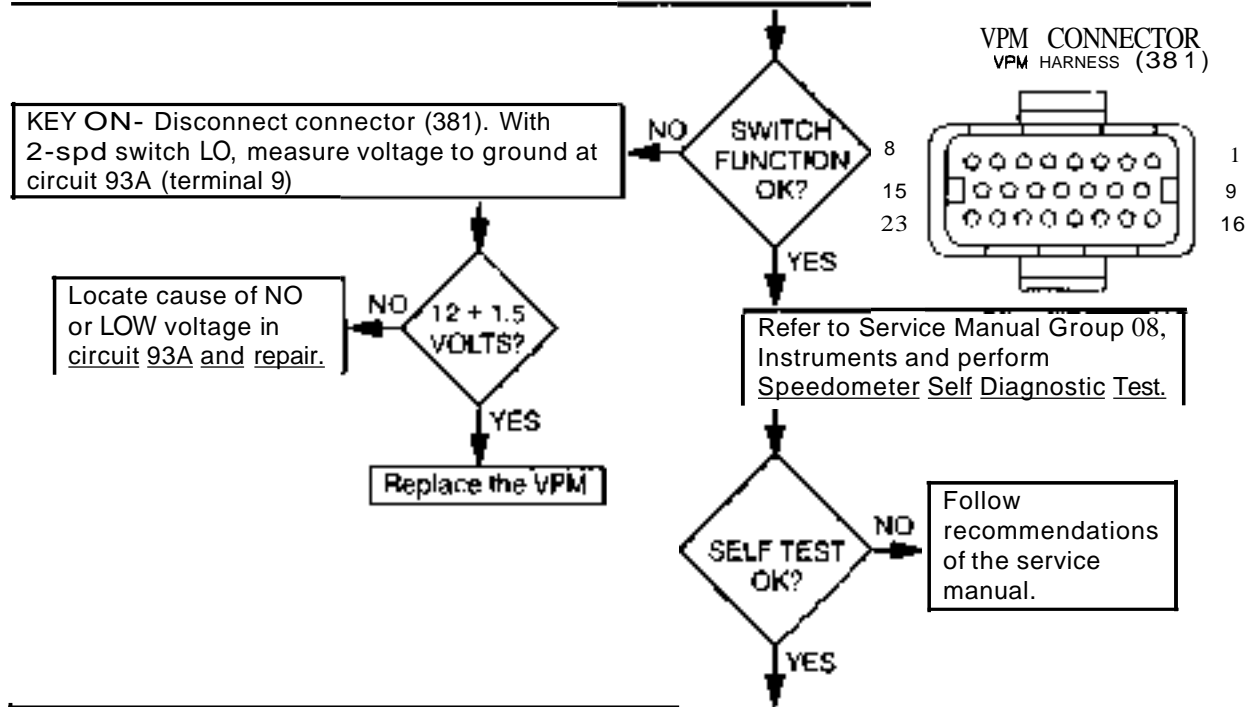
TWO SPEED AXLE INPUT CIRCUIT (TSA)

TESTING TWO-SPEED SPEEDOMETER CIRCUIT

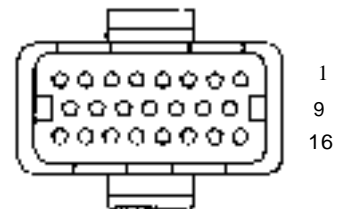
Refer to circuit diagram on page 221 or 222.



Change 2-speed switch position several times while monitoring with Prolink. Note if switch is functionin .

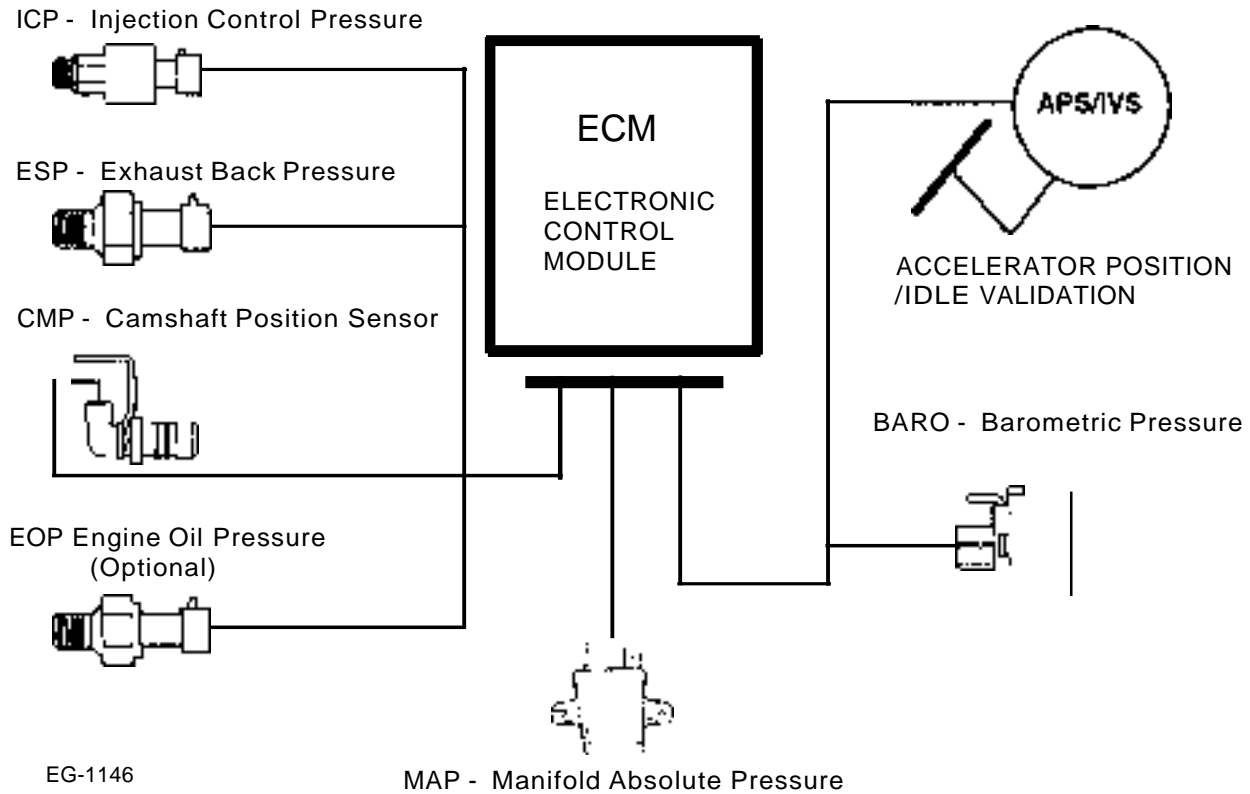


VPM CONNECTOR
VPM HARNESS (381)



Road test the vehicle and have passenger monitor vehicle speed using Prolink EST. IF EST displays correct speed replace the speedometer/tachometer unit. If the EST does not display correct speed replace the VPM.

V REF VOLTAGE REFERENCE



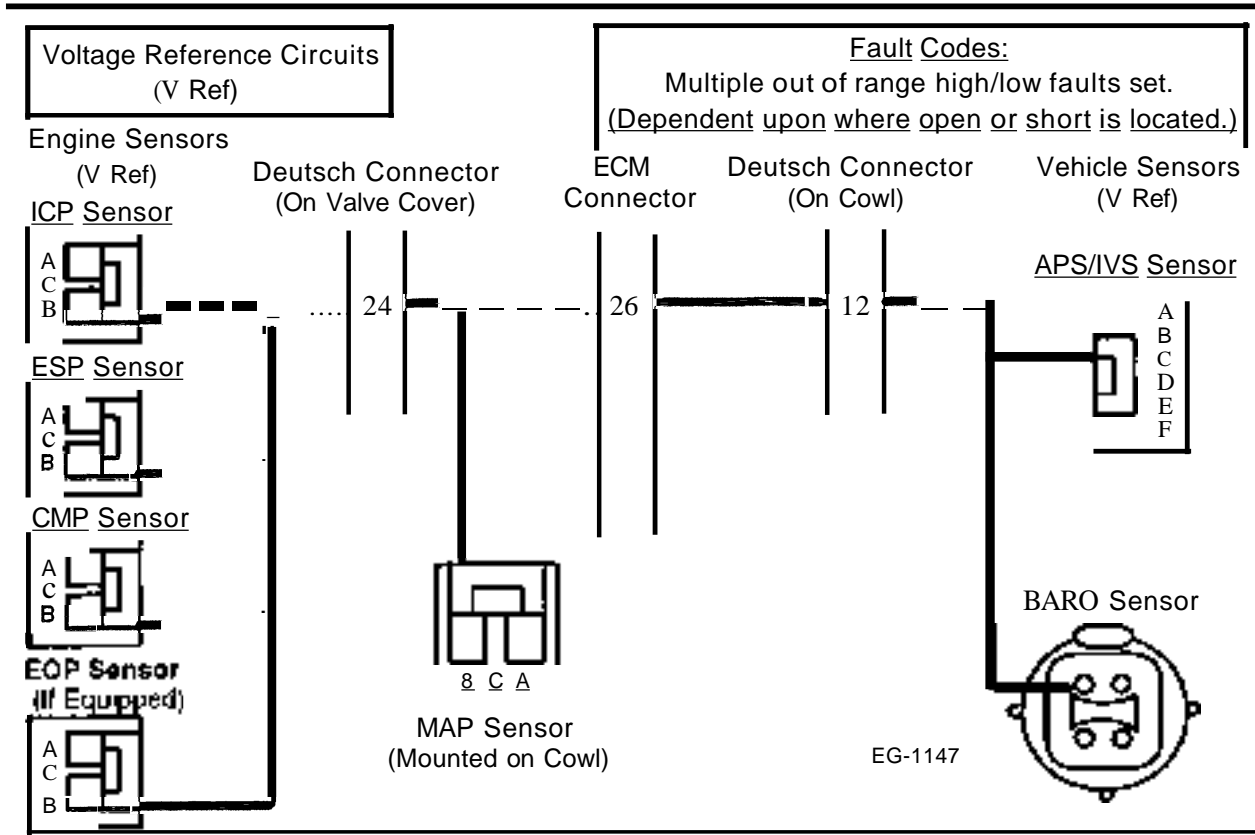
CIRCUIT FUNCTIONS

The V Ref circuit is a $5 \pm .5$ volt power supply from the ECM that provides power to the three wire engine and vehicle sensors and provides a benchmark or reference voltage for the ECM.

FAULT DETECTION/MANAGEMENT

There is no fault detection specifically for the V Ref signal directly, but if there is a V Ref circuit fault the sensor(s) in the section of the circuit affected may set an out of range high or low code. Multiple high or low codes are usually an indication of a V Ref or in some instances a Signal Ground fault condition.

VOLTAGE REFERENCE CIRCUITS (VREF)



Connector V Ref Voltage Checks

(If multiple faults set remove and measure V Ref at suspected sensor circuits)

Sensor	Test Points	Spec.	Comments
ICP	S to Grd	5 ± .5 v	Check V Ref at suspected sensors one at a time. Identifying which sensors do not have V Ref and which ones share common V Ref feed will more quickly help isolate the area of a short or open circuit. If disconnecting a sensor causes V Ref to be present at a circuit that had previously lost V Ref it is likely that the disconnected sensor had shorted V Ref to ground.
ESP	S to Grd	5 ± .5 v	
CMP	B to Grd	5 ± .5 v	
MAP	B to Grd	5 ± .5 v	
APS/IVS	C to Grd	5 ± .5 v	
BARD	B to Grd	5 ± .5v	

Connector Checks to Chassis Ground

(Check with Sensor Connector(s). Disconnected and ignition key OFF, all accessories off)

Sensor	Test Points	Spec.	Comments
ICP	B to Grd	> 1000 ohms	Resistance < 1000 ohms indicates a short to grd. If a short to grd condition is identified, remove all sensor connectors that are connected to V Ref and ECM to determine if short is in a sensor, ECM or wire harness. If the short is identified in the harness, remove the intermediate Deutsch connectors and measuring to grd will identify which part of the harness the short is located in.
ESP	B to Grd	> 1000 ohms	
CMP	B to Grd	> 1000 ohms	
MAP	B to Grd	> 1000 ohms	
APS/IVS	C to Grd	> 1000 ohms	
BARD	S to Grd	> 1000 ohms	

Harness Resistance Checks

(Check with breakout box installed on harness only)

Sensor	Test Points	Spec.	Comments
ICP	B to #26	< 5 ohms	The measurement is taken form the sensor connector to the ECM 60 pin connector. Resistance greater than 5 ohms indicates high resistance or an open in the V Ref supply circuit
ESP	B to #26	< 5 ohms	
CMP	B to #26	< 5 ohms	
MAP	B to #26	< 5 ohms	
APS/IVS	C to #26	< 5 ohms	
BARD	B to #26	< 5 ohms	

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VOLTAGE REFERENCE CIRCUITS (VREF)

VOLTAGE REFERENCE

EXTENDED SYSTEM DESCRIPTION

FUNCTION

The Electronic Control Module contains a regulated 5 volt DC voltage reference source to power engine and vehicle control sensors. The sensor signals are compared to the Voltage Reference to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

OPERATION

The ECM is supplied with Battery Voltage when the ignition key is ON at terminals 37 and 57. Ground

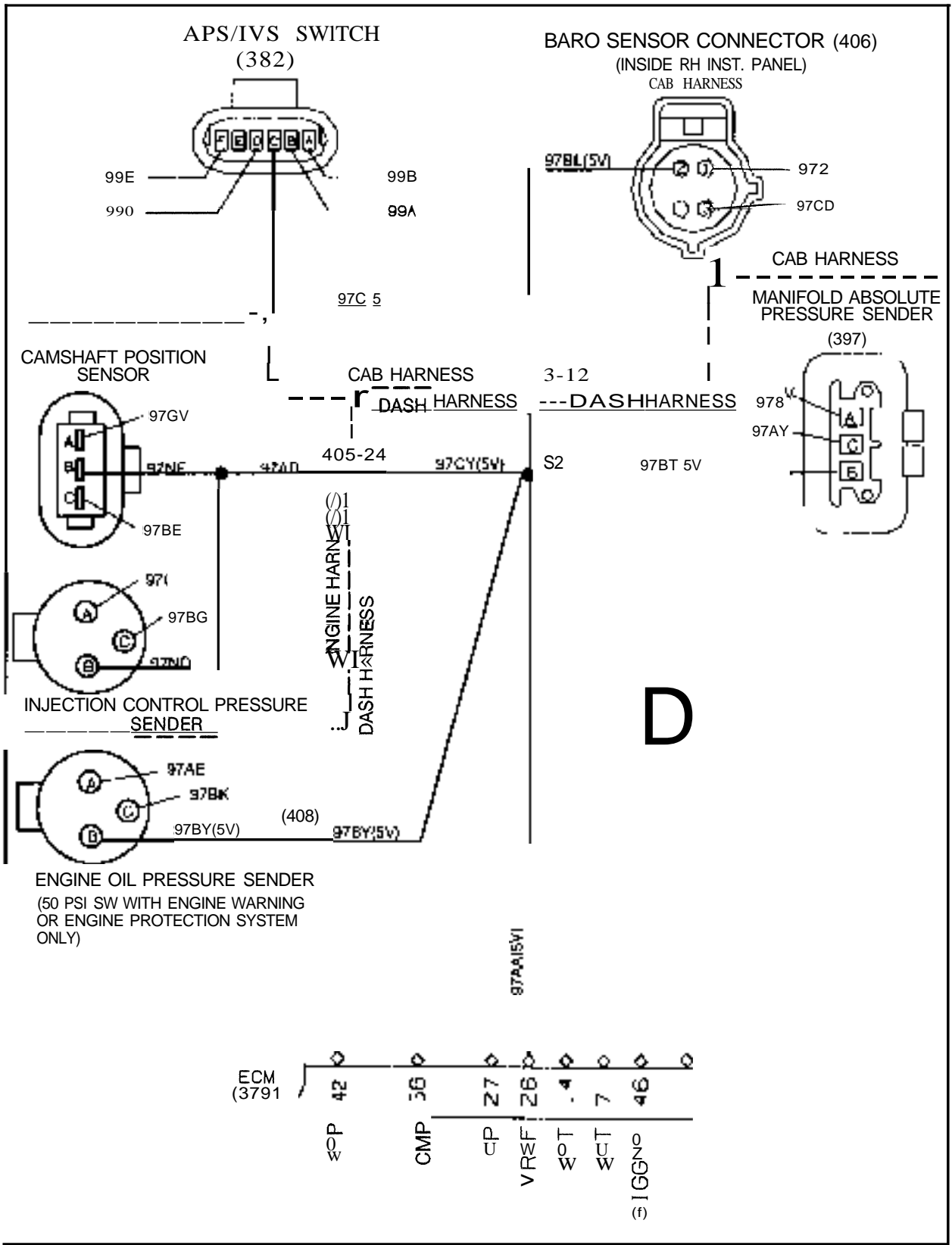
circuits are supplied at terminals 20, 40 and 60. The ECM provides a constant regulated 5 volt reference signal from terminal 26 to supply voltage to engine and vehicle sensors. A return circuit for sensors is supplied at terminal 46.

ECM VOLTAGE REFERENCE DIAGNOSTICS

If multiple sensor codes are set, it is possible that the V REF signal circuit is open or the return signal circuit is open. Follow troubleshooting procedures to determine if V REF circuits are at fault. The engine will not run without a valid V REF signal.

VOLTAGE REFERENCE CIRCUITS (VREF)

VREF CIRCUITS

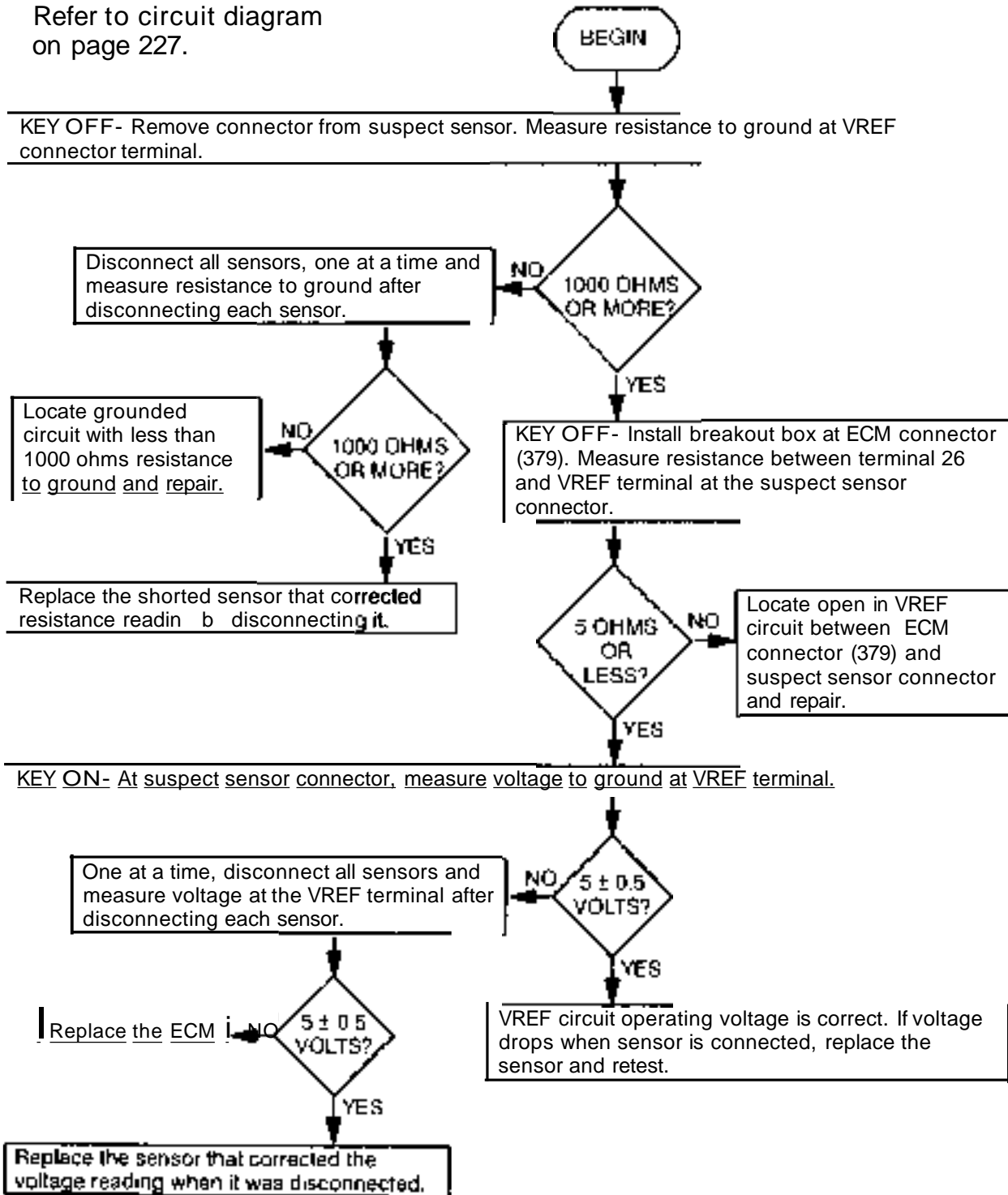


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VOLTAGE REFERENCE CIRCUITS (VREF)

VREF CIRCUITS (CONTINUED)

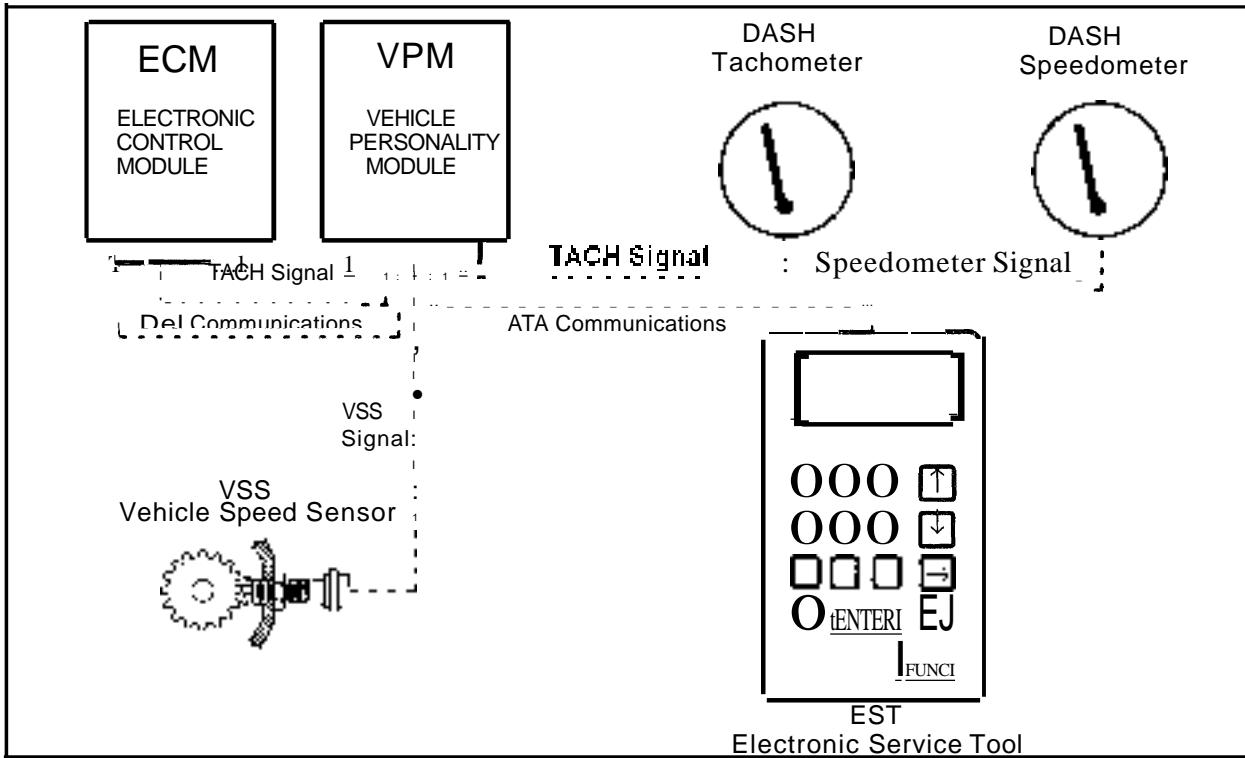
Refer to circuit diagram on page 227.



ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VEHICLE PERSONALITY MODULE (VPM)

VEHICLE PERSONALITY MODULE



CIRCUIT FUNCTIONS

The VPM (Vehicle Personality Module) serves four major functions.

Programming

- Provides the factory the ability to set Engine Ratings and Horsepower.
- Accommodates field re-programming for changes to tire size, rear axle, transmission changes etc.
- Enables and allows adjustment to "Customer Features" such as cruise control set points, road speed limiting, PTA speeds.

Diagnostics fault retrieval and command of special operator on-demand tests.

With the use of an EST (Electronic Service Tool) the VPM will allow for:

- Retrieval of continuous fault codes set in either the IDM, ECM and VPM.
- Command of special diagnostic tests such as injector tests, engine running tests, output state and wiggle tests.
- Display of engine and vehicle PID's (parameters) on a real time basis. (eg. coolant temperature, engine speed, cruise control sWitch pOSition, etc.)

Stores accumulated values/logs engine events

- Vehicle Miles/Hours/Fuel used

- Logs engine events such as over heat, low oil pressure and over speed conditions.

Drives dash tachometer and speedometer

- Receives inputs from the ECM and TACH sensor.
- Buffers signals and drives instrument panel TACH and Speedometer gauges
- Communicates vehicle speed to the ECM.

FAULT DETECTION MANAGEMENT

The VPM has the ability to detect internal fault conditions such as incorrect programming, not ever being programmed, wrong configuration of ECM and VPM, corrupted memory and lost memory Situations.

External fault conditions, such as loss of DCUATA communication, VSS and KAM (Keep Alive Power) circuit faults are covered in previous sections of this manual.

Management of a VPM detected fault will vary with the severity of the fault. The more severe faults will only allow the vehicle to operate in field defaults which will curtail horsepower (normally the lowest horsepower rating available in that engine family) and disable customer features, less severe faults will only log a code.

VEHICLE PERSONALITY MODULE (VPM)

PROGRAMMING AND SOFTWARE FAULTS

FLASH CODE 613
ATA CODE SID 252 FMI1
VPM: *VPMIECM SWMISMATCH*

FLASH CODE 614
ATA CODE SID 252 FMI13
ECM: *ECMNPM SWMISMATCH*

Codes 613 and 614 will only occur when the VPM or ECM has been changed in the field. At start-up, the ECM compares software versions in the VPM and ECM. If the versions are not compatible, codes 613 or 614 and 622 will be set. Code 622 indicates Field Defaults are being used and turns ON the Engine Warning Light.

If codes 613 and 614 are active:

1. The ECM and VPM must be software compatible. Whichever component (ECM or VPM) was recently replaced is not the correct part number (has software version that is not compatible with the component (ECM or VPM) that was not changed). Determine correct part number and install.

The component having the most recent software configuration date sets the code (613 or 614).

Example: If the VPM is replaced and the replacement VPM software version is of a later date than the ECM software in the vehicle, the fault code (613) will indicate that the ECM software is not compatible with the VPM.

Example: If the replacement VPM installed had a software date older than the ECM software, the fault code (614) would indicate that the VPM software is not compatible with the ECM.

FLASH CODE 615
ATA CODE SID 254 FMI13
ECM: *PROGRAMMABLE PARAMETER KAM CORRUPT MEMORY*

At start-up, the ECM performs tests on the KAM memory, where programmable parameter information will be stored when retrieved from the VPM. If the KAM memory test fails (bad memory or corrupt data), then Flash code 615 will be set. The engine

will operate on Field defaults turning ON the Engine Warning Light and setting code 622. If the condition causing code 615 to set is intermittent, and the condition is no longer present, the code will change to inactive status and the engine will operate normally.

Flash Code 615 can also be caused by no or low power to KAM memory at ECM terminal 1 which could cause code 224 to be set.

If code 615 is active:

1. Refer to SECTION 3: KEEP ALIVE MEMORY CIRCUIT.
 - A. If a defect is found in KAM Feed Circuit, correct defect.
 - B. If KAM power is present to ECM terminal 1, and code 615 is active, attempt to clear code 615. If code 615 continues to be set, replace the ECM.

FLASH CODE 621
ATA CODE SID 253 FMI 1
ECM: *ECM USING MANUFACTURING DEFAULTS*

SYMPTOM: Engine operates, but limited to 25 HP rating and Engine Warn Light is ON.

If the VPM is not programmed at the factory OR an unprogrammed VPM is installed in the field, then the ECM will select parameter values from the Manufacturing Default list. This list will provide only limited engine horsepower (25 HP). If the condition that caused code 621 to set is intermittent, and the condition is no longer present, the code will change to inactive status and the engine will operate normally.

If code 621 is active:

- A. Program the VPM using established programming procedures included in the Pro-link Manual.

FLASH CODE 622
ATA CODE SID 253 FMI 0
ECM: *ECM USING FIELD DEFAULTS*

SYMPTOM: Engine Warning Light ON, customer options disabled (cruise control etc.) and the engine is limited to 175 HP.

ELECTRONIC CONTROL SYSTEM' DIAGNOSTICS

VEHICLE PERSONALITY MODULE (VPM)

PROGRAMMING AND SOFTWARE FAULTS (Continued)

FLASH CODE 622
ATA CODE SID 253 FMI 0
ECM: *ECM USING FIELD DEFAULTS*
(Continued)

When the vehicle is not operating under normal operating conditions, the ECM uses either partial or full field default values stored in ECM memory, instead of programmed values that are stored in VPM memory. When the ECM is using Full Field Default values, code 622 is set. If the condition causing the ECM to operate using field defaults is intermittent, and the condition is no longer present, code 622 will become inactive and normal engine operation will resume.

Code 622 is an indicator that field defaults are being used. Other codes cause code 622 to be set. The other codes identify the condition that caused the ECM to use field defaults.

If, for any reason, the ECM is unable to download parameter values from the VPM or the parameter values received from the VPM are not valid, then the ECM selects full or partial Field Default parameter values. The Field Default parameter values are stored in the ECM. If no data is available from the VPM, full field defaults are used. If only certain data is corrupt, then partial field defaults may be used.

If code 622 is active:

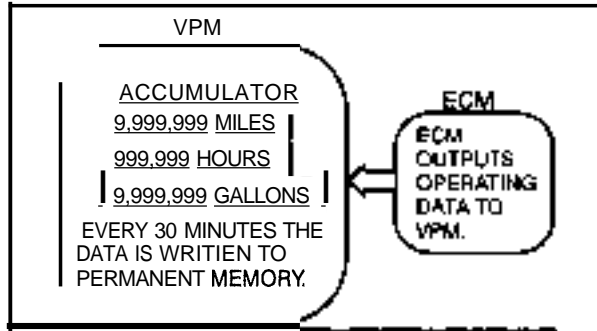
1. Review other logged codes. The specific values that the ECM is unable to download and/or reason for the communication failure must be determined and corrected. When corrected, the ECM will not use the field default mode of operation.

FLASH CODE 623
ATA CODE SID 253 FMI13
ECM: *INVALID EFRC*

This code indicates that the ECM requested, and was unable to get valid Engine Family Rating codes from the VPM. If this occurs, the code 623 is set and the engine operates on Field Defaults causing code 622 to be set. If the condition causing code 623 to set is intermittent, and the condition is no longer present, code 623 will become inactive and normal engine operation will resume.

If code 623 is active, reprogram the VPM with the proper engine family data.

VPM FUELIHOUR METER AND ODOMETER FAULTS



DESCRIPTION

The VPM (Vehicle Personality Module) records total engine hours (to 999,999 hours), total vehicle miles (to 9,999,999 miles) and total fuel used (to 9,999,999 gallons). While the vehicle is operating, the information is temporarily stored and every 30 minutes the information (new total hours, miles and gallons) is written to EEPROM memory locations in the VPM as new totals.

The accumulator totals (engine hours, vehicle miles and total fuel used) can be read using the ProLink EST. Accumulator information may be useful for maintenance purposes.

VPM DIAGNOSTICS

If the VPM attempts to write the latest total (for any of the three totals) to one of eight EEPROM locations in the VPM and the memory location is defective, then the VPM sets Flash Code (634, 635 or 641) and selects another memory location to store the information. Flash Code 645 may also be set.

If the VPM can't find a serviceable memory location to write the data, then Flash Code 642, 643 or 644 will be set.

FLASH CODE 634
ATA CODE PID 250 FMI 2
VPM: *FUEL METER MEMORY LOCATION ERROR*

Flash code 634 indicates the first attempt to write the fuel totals encountered a defective memory location. The fuel totals logged may be inaccurate although the error will not be more than 1/2 hour use of fuel.

If the fuel meter totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced. The next read/write error will result in all of the fuel meter data being lost.

VEHICLE PERSONALITY MODULE (VPM)

VPM FUEU HOUR METER AND ODOMETER FAULTS (Continued)

FLASH CODE 635
AIA CODE PID 247 FMI 2
VPM: *HOURLY METER MEMORY LOCATION ERROR*

Flash code 635 indicates the first attempt to write the engine hour totals encountered a defective memory location. The engine totals logged may be inaccurate although the error will not be more than one half an hour.

If the hour meter totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced. The next read/write error will result in the hour meter data being lost.

FLASH CODE 641
ATA CODE PID 245 FMI 2
VPM: *ODOMETER MEMORY LOCATION ERROR*

Flash code 641 indicates the first attempt to write the vehicle total miles encountered a defective memory location. The total vehicle miles logged may be inaccurate, although the error will not be more than 30 miles.

If the odometer totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced. The next read/write error will result in the odometer data being lost.

FLASH CODE 642
ATA CODE PID 250 FMI12
VPM: *FAULTY FUEL METER*

Flash code 642 indicates the write cycle of the EEPROM memory locations in the VPM have been exceeded. The fuel meter totals have been lost.

If the fuel meter totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced.

FLASH CODE 643
AIA CODE PID 247 FMI12
VPM: *FAULTY HOUR METER*

Flash code 643 indicates the write cycle of the EEPROM memory locations in the VPM have been exceeded. The hour meter totals have been lost.

If the hour meter totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced.

FLASH CODE 644
ATA CODE PID 245 FMI12
VPM: *FAULTY ODOMETER*

Flash code 644 indicates the write cycle of the EEPROM memory locations in the VPM have been exceeded. The Odometer totals have been lost.

If the odometer totals are used for vehicle maintenance or otherwise essential to vehicle operation, the VPM should be replaced.

VPM MEMORY FAULTS

FLASH CODE 645
ATA CODE SID 253 FMI 7
VPM: *RAW EEPROM MEMORY LOCATION ERROR*

Code 645 requires no action. Flash code 645 indicates an error was detected during a read or write attempt at one of the EEPROM memory locations in the VPM. The code is informational and will be logged as an inactive code. Code 645 will be logged along with another code which specifies what system or feature is affected.

If the error was in the VPM accumulators (total miles, fuel used or engine hour totals) a 634, 635, 641, 642, 643 or 645 will be logged. Refer to VPM Fuel Meter, Hour Meter and Odometer in this section for a discussion of these codes.

If the EEPROM memory location failure was storing information from one of the data lists stored in the VPM (Short List, High Priority List or Low Priority List), one of several fault codes (223, 235, 623, 624, 633, 651, 652, or 653) discussed in this section would be set because corrupt data would be read by the ECM. If for example, the ECM attempted to read the Short List and the data was bad, Flash Code 653 would be set.

FLASH CODE 651
ATA CODE SID 253 FMI10
VPM: *FEATURE MEMORY LIST CORRUPTED*

If the VPM detects an error with the Feature List, code 651 will be set.

SYMPTOMS: Engine runs on partial defaults, but Engine Warning Light is not turned on. Vehicle features such as cruise control, remote PTO and optional engine protection system are disabled.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VEHICLE PERSONALITY MODULE (VPM)

VPM MEMORY FAULTS (Continued)

FLASH CODE 651
ATA CODE SID 253 FMI10
VPM: *FEATURE MEMORYLIST CORRUPTED*
(Continued)

If code 651 is active:

1. Recycle the VPM. With the key ON, pull fuse F4 (H1 with FBC) and then reinstall the fuse.
 - A. If code 651 is inactive, end the test.
 - B. If code 651 still is active after resetting the VPM, reprogram the VPM.
 - C. If code 651 still is active after reprogramming the VPM, replace the VPM.

FLASH CODE 652
ATA CODE SID 253 FMI 2
VPM: *ENGINE/FUEL MEMORYLIST CORRUPTED*

SYMPTOMS: Engine runs on field defaults, setting code 622 and Engine Warning Light is turned ON.

This code can be set if the VPM detects an error in the engine-fuel list.

If code 652 is active:

1. Recycle the VPM. With the key ON, pull fuse F4 (H1 with FBC) and then reinstall the fuse.
 - A. If code 652 is inactive, end test.
 - B. If code 652 is still active, replace the VPM.

FLASH CODE 653
ATA CODE SID 253 FMI 12
VPM: *ENGINE RATING MEMORYLIST CORRUPTED*

SYMPTOMS: Engine runs on field defaults, with Engine Warning Light turned ON.

This code can be set if the VPM detects an error in the engine rating list.

If code 653 is active:

1. Recycle the VPM. With the key ON pull fuse F4 (H1 with FBe) and then reinstall the fuse.
 - A. If code 653 is inactive, end test.
 - B. If code 653 is still active, replace the VPM.

FLASH CODE 654
ATA CODE SID 252 FMI12
VPM: *WATCHDOG TIME-OUT FAULT*

If a VPM software fault is detected, code 654 will be set, then the VPM will reset. The driver will likely not notice the reset, but the code will be logged as an inactive code following the reset for informational purposes.

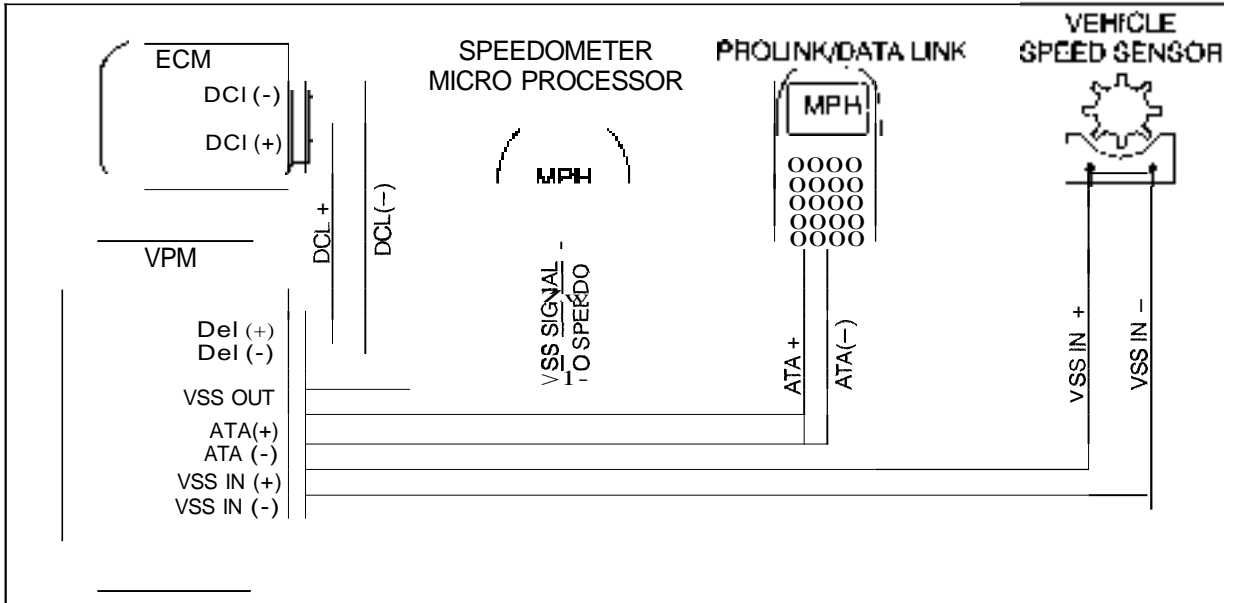
If code 621 is active:

- A. Program the VPM using established programming procedures included in the Pro-link Manual.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VEHICLE SPEED SIGNAL (VSS)

SPEEDOMETER SIGNAL



SIGNAL FUNCTION

The vehicle speed signal from the speed sensor is input to the VPM. VPM programming includes number of teeth on the sensor wheel, tire size and axle ratios. Using this information, the VPM creates a signal which is sent to the speedometer/tachometer cluster as input for the speedometer function.

The VPM also outputs a DCI formatted vehicle speed signal over the DCI data link circuit to the ECM. The ECM uses the input for controlling vehicle functions including cruise control.

Additionally the VPM outputs an ATA formatted signal over the ATA data link to the diagnostic connector where vehicle speed can be read using the ProLink EST.

FAULT DETECTION MANAGEMENT

The vehicle speed sensor signal is monitored continuously by the VPM to see that the signal is

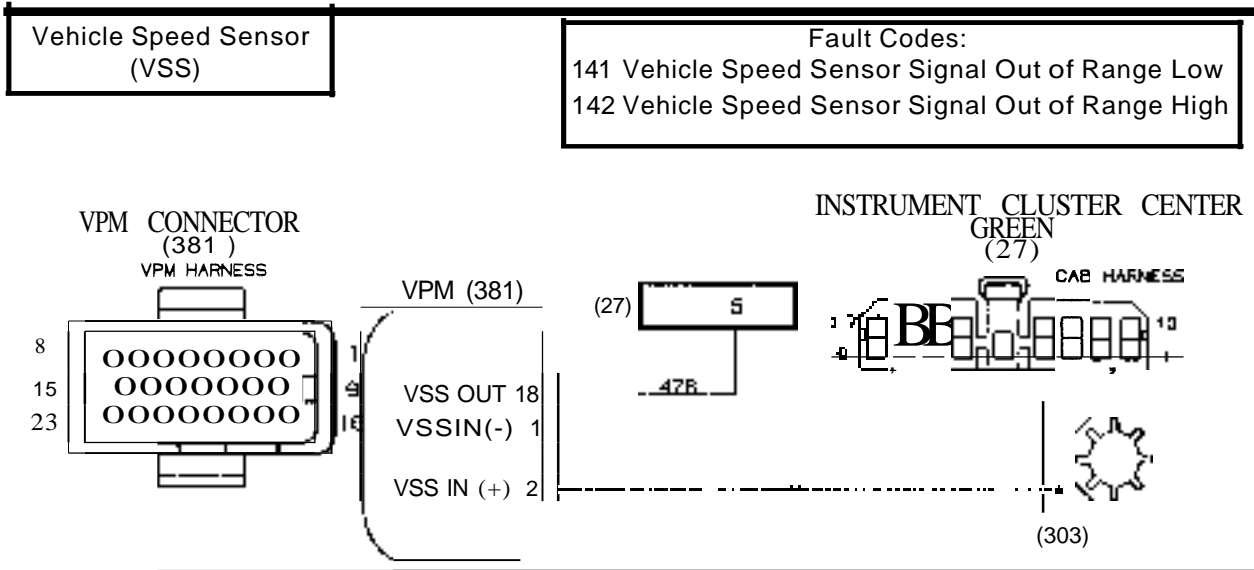
within certain range. If the VSS signal is out-of-range, the VPM sends an out-of-range high signal to the ECM, telling the ECM that the VPM detected a fault in the VSS.

When the ECM sees the out-of-range high signal, VPM Flash code 141 or 142 is set, but the Engine Warning light is NOT turned on. The ECM disables operation of the Cruise Control or PTO. If Road Speed Limiting is enabled, the ECM will limit engine speed in all gears. Torque level tailoring will use a prescribed torque curve.

FAULT CODES

NOTE: IF THE VEHICLE SPEEDOMETER DOES NOT OPERATE PROPERLY, BUT NO FAULT CODES ARE PRESENT, USE THE PROLINK TO ATTEMPT TO READ VEHICLE SPEED FROM THE ATA DATA LINK CONNECTOR. IF VEHICLE SPEED CAN BE READ USING THE PROLINK, TROUBLESHOOT CIRCUIT 478 AND THE INSTRUMENT CLUSTER.

VEHICLE SPEED SIGNAL (VSS)



VPM Harness Connector Checks to Chassis Ground
 Connector (381) with VPM disconnected and connector (27) disconnected and key OFF

Test Points	Spec.	Comments
cir 47 to grd	>100K ohms	< less than 100K ohms check for short to grd or defective sensor.
cir 47A to grd	> 100Kohms	<less than 100K ohms check for short to grd or defective sensor.
cir 47 to 47A	600 - 800 ohms (manual xmsn) 1200-1450 ohms (auto xmsn)	> than specified ohms, check for open circuit or sensor < than specified ohms, check for short between circuits or defective sensor.
478 to grd	>100 K ohms	< less than 100K ohms check for short to ground
478 to (27) 47B	< 5 ohms	> than 5 ohms check for open in circuit

VPM Harness Voltage Checks

Voltage check at Connector (381) with VPM disconnected and connector (27) disconnected and key ON

Test Points	Spec.	Comments
47 to grd	< 1.0 volt	> than 1.0 volt check for short to VREF or Batt circuit
47A to grd	< 1.0 volt	> than 1.0 volt check for short to VREF or Batt circuit
478 to grd	< 1.0 volt	> than 1.0 volt check for short to VREF or Batt circuit

Operational Voltage Checks

Connect (381) to VPM and (27) to cluster. Disconnect sensor pigtail at (303). Place rear axles on stands (front wheels blocked) and with engine at idle and transmission in gear, measure AC voltage from sensor.

Test Points	Spec.	Comments
white to black	> 2.0 A.C. volts	< less than 2.0 volts check sensor adjustment or defective sensor.

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

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Page 238

VEHICLE SPEED SIGNAL (VSS)

EXTENDED DESCRIPTION

The Vehicle Speed Signal (VSS) from the VPM is sent over the DCI data link to the ECM. The VSS information is used by the ECM to control features such as: Cruise Control, PTA, Torque Level Tailoring and Road Speed limiting.

The VPM also provides VSS input to the vehicle speedometer, tachometer and odometer unit located in the instrument panel.

Refer to the circuit diagram located in this section for the following discussion.

VEHICLE SPEED SENSOR (303)

The Vehicle Speed Sensor (VSS) is located on the transmission and sends an AC signal to the VPM. The VSS sensor contains a permanent magnet which creates a magnetic field. The AC signal is created when the 16-tooth transmission speedometer gear rotates breaking the magnetic field created by the sensor. The VSS signal is sent through the engine and cab harness to the VPM.

With a manual transmission, Navistar installs the speed sensor at the rear of the transmission. With an Allison AT/MT transmission, Allison installs the sensor at the lower right side of the transmission.

VPM (VEHICLE PERSONALITY MODULE)

The VPM (381) receives the AC signal from the vehicle speed sensor. The VPM programming includes the rear axle ratio and tire size. It uses this programmed information and the speed sensor input to create the vehicle speed signal sent to the Speedometer Unit.

From VPM connector (381), terminal 1B, an analog AC signal is input on circuit 478 to the vehicle speedometer unit through connector (27). Speedometer ground circuit 47-G from connector (27) is grounded at the cab ground stud.

The VSS signal is also formatted so that it can be sent over the Digital Communications link (DeI) to the ECM (379).

ECM DIAGNOSTICS

FLASH CODES

During vehicle operation, the vehicle speed signal (VSS) is monitored continuously by the VPM to see that the signal is within certain range. If the VSS signal is out-of-range, the VPM sends an out-of-range high signal to the ECM, telling the ECM that the VPM detected a fault in the VSS.

When the ECM sees the out-of-range high signal, VPM Flash code 141 or 142 is set, but the Engine Warning light is NOT turned on. The ECM disables operation of the Cruise Control or PTA. If Road Speed limiting is enabled, the ECM will limit engine speed in all gears. Torque level tailoring will use a prescribed torque curve.

FLASH CODE 141
ATA CODE PID 84 FMI 4
VPM: VSSORL

This code is set when the VPM detects an out-of-range low (ORI) signal from the vehicle speed sensor.

WIRING CAUSE: VSS Sensor circuit between the VPM and Sensor, shorted to ground or open.

If this code is active, perform Testing VPM to Sensor Circuits on page 241 .

FLASH 142
ATA CODE PID 84 FMI 3
VPM: VSSORH

This code is set when the VPM detects an out-at-range high (ORH) signal from the vehicle speed sensor.

WIRING CAUSE: VSS Sensor circuit shorted to VREF or VBAT circuit.

If this code is active, perform Testing VPM to Sensor Circuits on page 241.

SPEEDOMETER DOES NOT FUNCTION PROPERLY

The ECMNPM diagnostics DO NOT check for VSS sensor adjustment, so it is possible with a miss-adjusted vehicle speed sensor to get a faulty vehicle speed signal without fault code 141 or 142. The speedometer and/or odometer will operate erratically or not at all. The odometer may not function correctly.

If Flash code 141 or 142 IS NOT PRESENT, but the speedometer and/or odometer does not function properly, perform Testing Speedometer on page 245.

If Flash code 141 or 142 is present and the speedometer does not function properly, correct the cause of the Flash Codes before troubleshooting the speedometer.

If the speedometer/odometer does not function properly when the Two-Speed Axle is shifted (HIGH or LOW), refer to Two Speed Axle in this section.

VEHICLE SPEED SIGNAL (VSS)

TROUBLESHOOTING

BEFORE TROUBLESHOOTING

- A. Before troubleshooting, make sure that the batteries are fully charged! Check battery connections and grounds for clean, tight connections free of damage. Voltage tests will give misleading results if the batteries are not fully charged.
- B. Before troubleshooting, inspect circuit connectors for pushed back, loose, or damaged (spread or bent) terminals, or wires with cut strands, etc. Wires and connections must be free of damage or corrosion. When some connectors corrode, a light white residue will be present that must be removed.
- C. Before troubleshooting, inspect suspect circuit grounds for clean, tight connections free of damage.

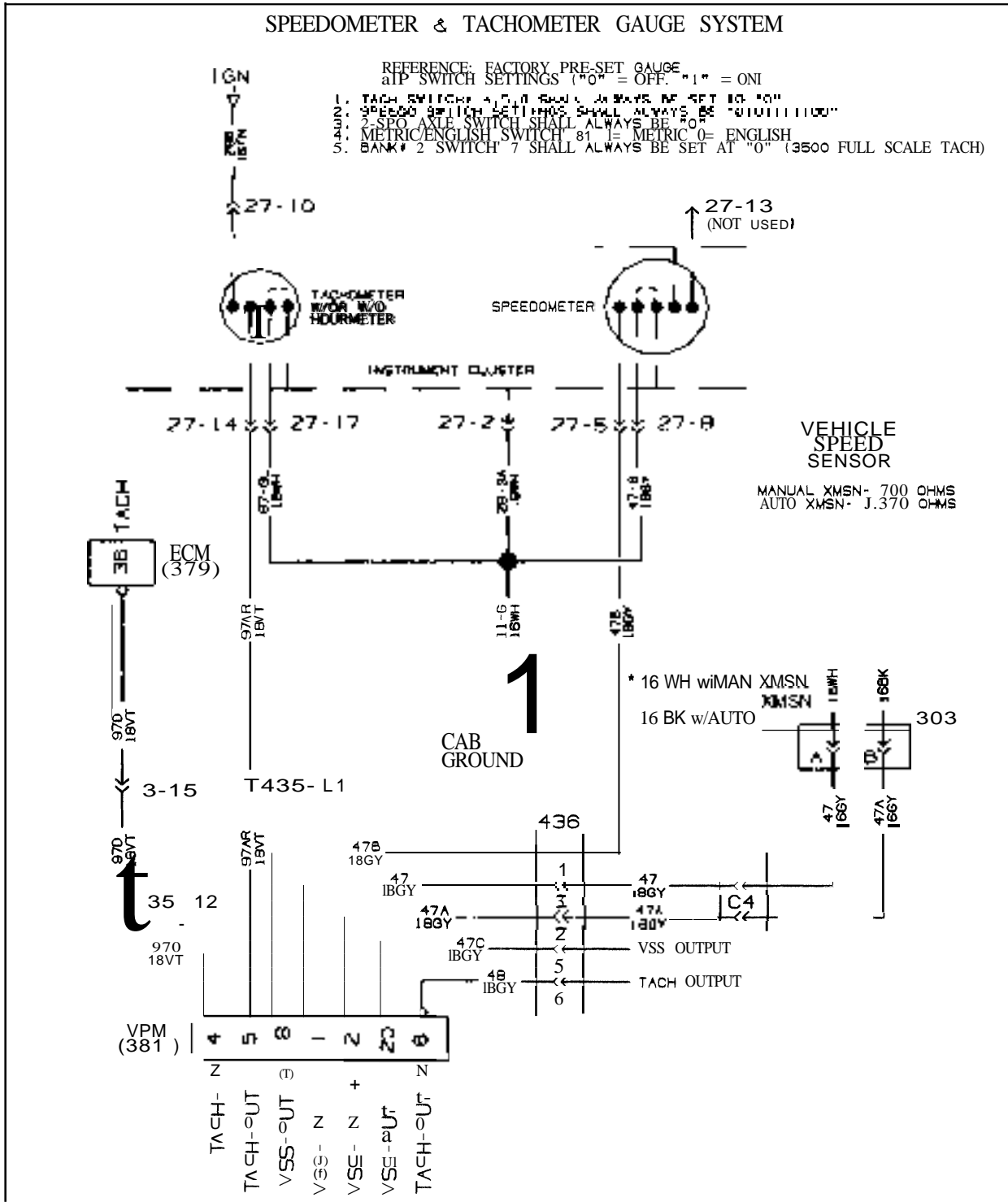
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

VEHICLE SPEED SIGNAL (VSS)

CIRCUIT DIAGRAM

3000 & 4000 Electrical Circuit Diagrams

SPEEDOMETER & TACHOMETER GAUGE SYSTEM

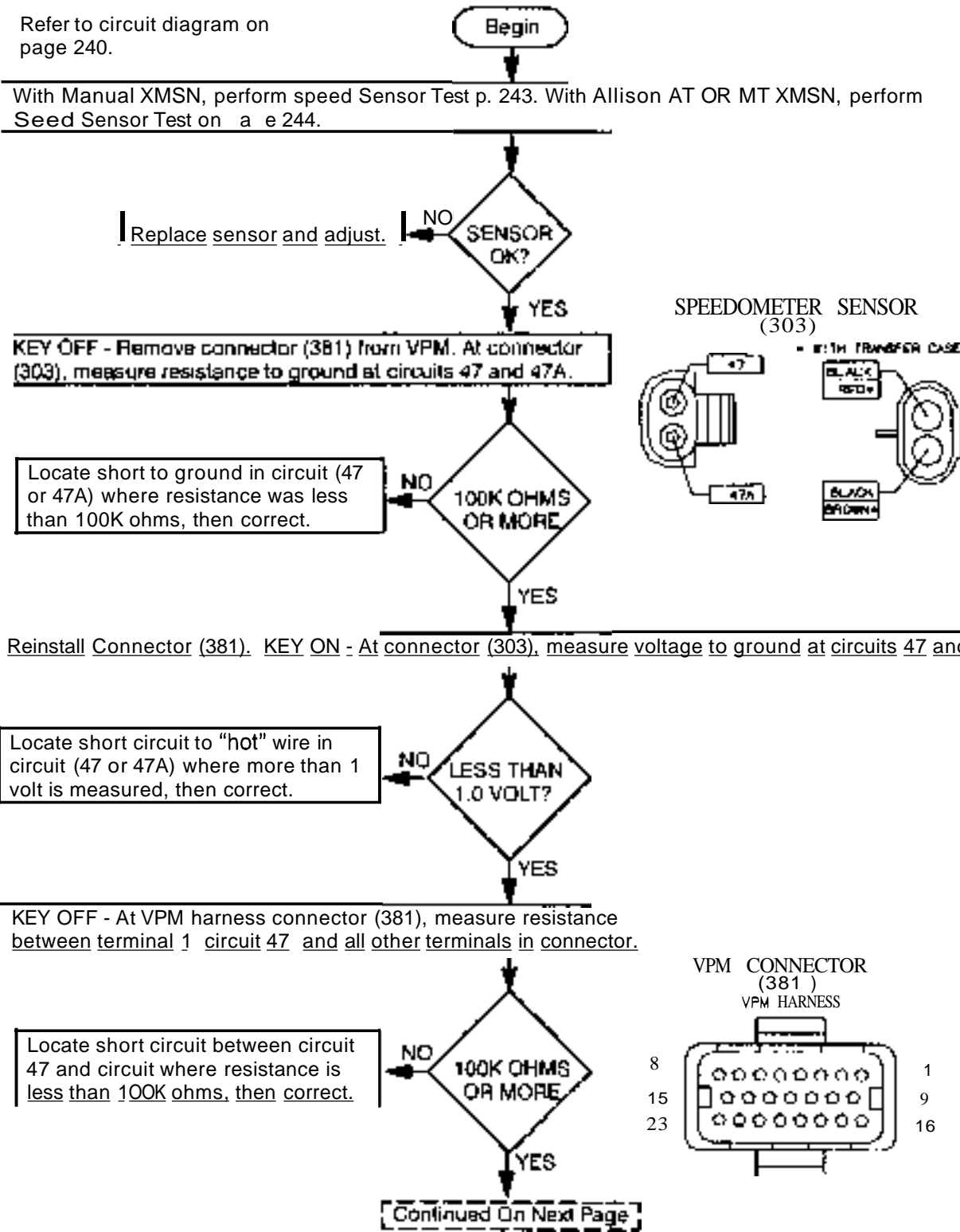


VEHICLE SPEED SIGNAL (VSS)

TESTING VPM TO SENSOR CIRCUITS

Refer to circuit diagram on page 240.

With Manual XMSN, perform speed Sensor Test p. 243. With Allison AT OR MT XMSN, perform Seed Sensor Test on a e 244.

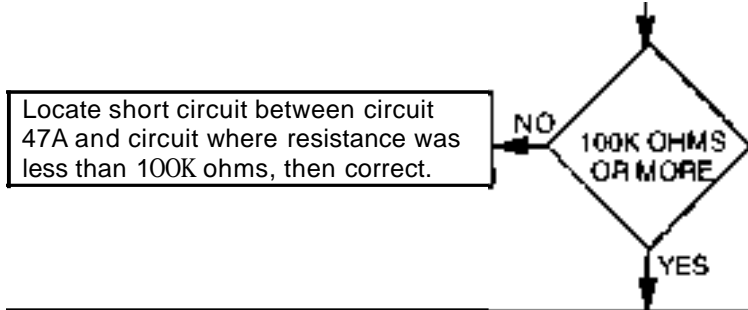


ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

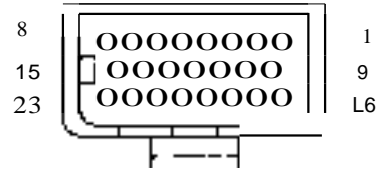
VEHICLE SPEED SIGNAL (VSS)

TESTING VPM TO SENSOR CIRCUITS (Continued)

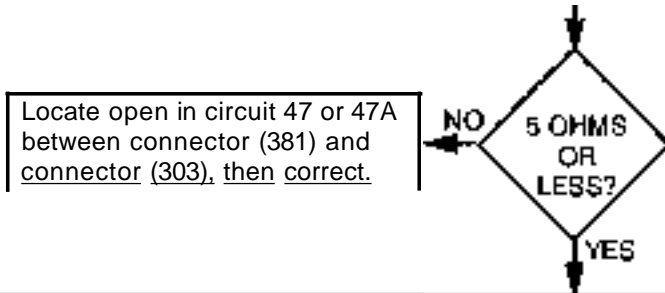
KEY OFF - At VPM harness connector (381), measure resistance between terminal 2 circuit 47A and all other terminals in connector.



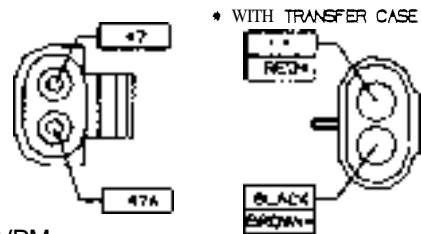
VPM CONNECTOR (381)
VPM HARNESS



KEY OFF - At engine harness VSS connector (303), install jumper between circuit 47 and 47A. At connector 381, measure resistance between circuit 47 and 47A.



SPEEDOMETER SENSOR (303)

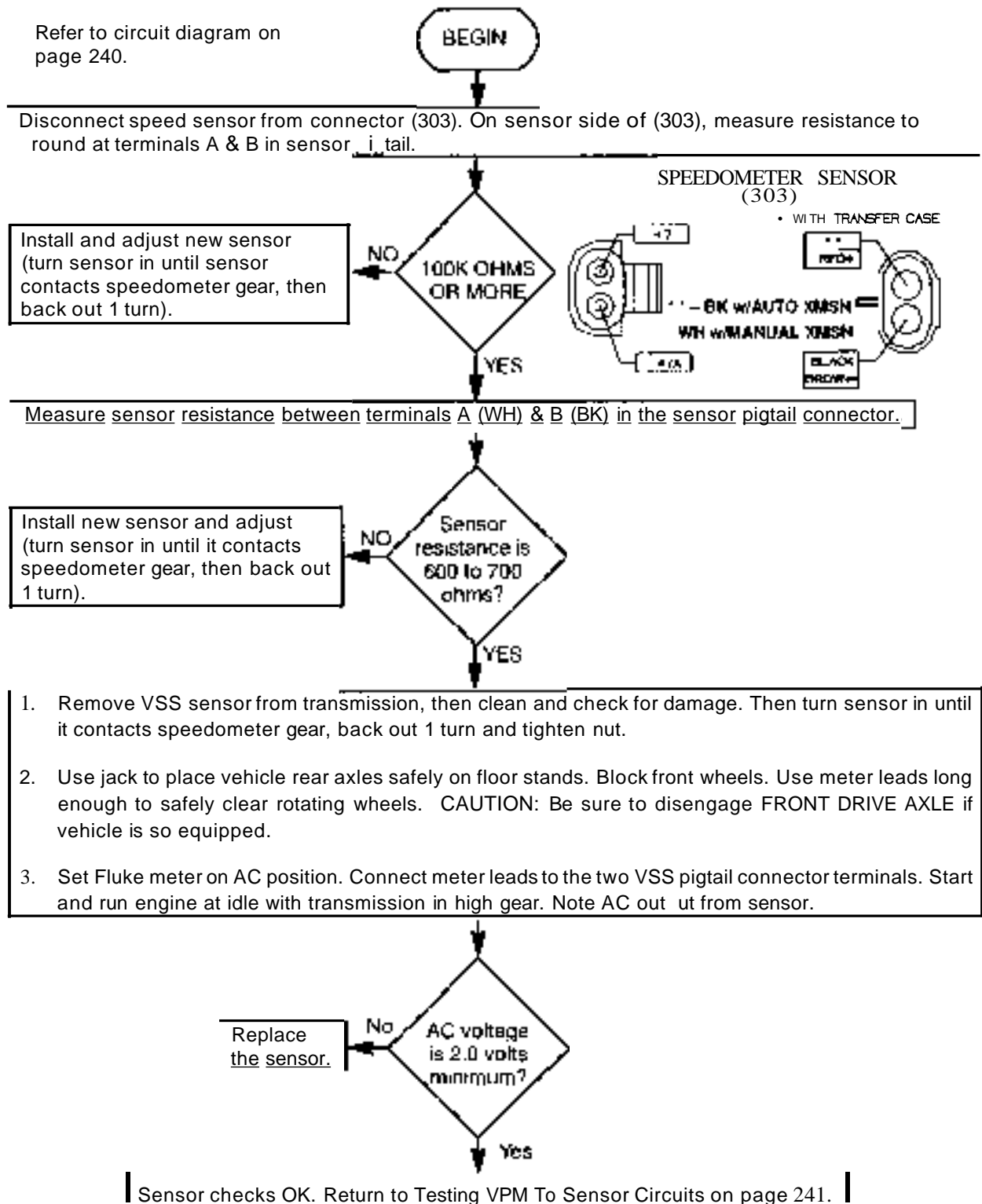


The VSS sensor and circuits 47 and 47A between the sensor and VPM check good. If code 141 or 142 is still active, replace the VPM.

* BK w/AUTO XMSN
WH w/MANUAL XMSN

VEHICLE SPEED SIGNAL (VSS)

VEHICLE SPEED SENSOR TEST WITH MANUAL TRANSMISSION



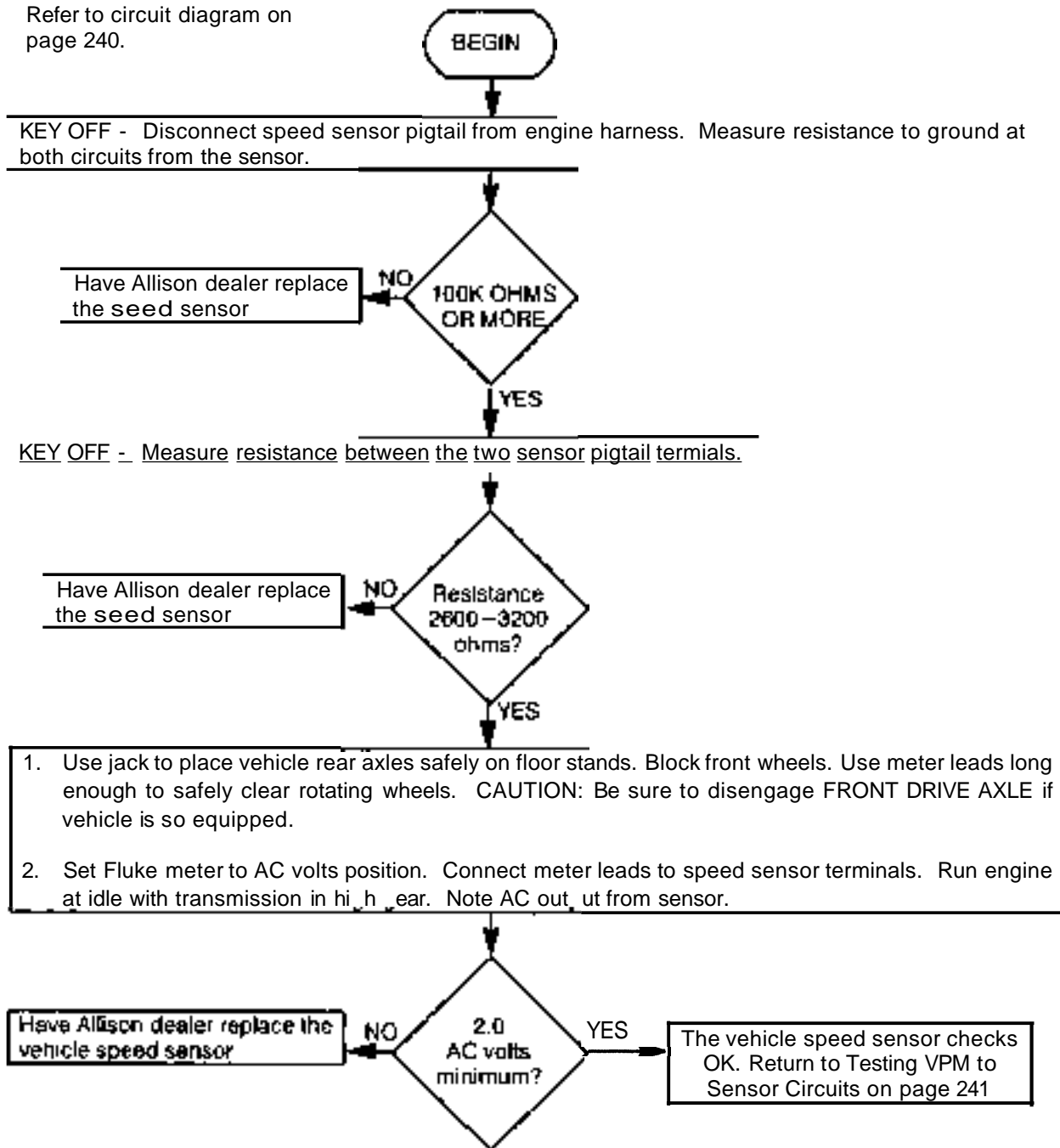
ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

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VEHICLE SPEED SIGNAL (VSS)

VEHICLE SPEED SENSOR TEST WITH ALLISON AT OR MT TRANSMISSION

Refer to circuit diagram on page 240.



VEHICLE SPEED SIGNAL (VSS)

TESTING SPEEDOMETER

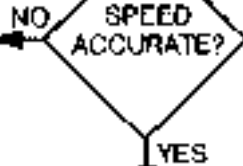
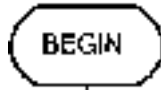
If Flash Codes are not present indicating that a VSS signal problem has been detected by the VPM or

ECM, but the speedometer and/or odometer are not functioning properly, perform this test.

Refer to circuit diagram on page 240.

Roadtest vehicle while passenger monitors vehicle speed using ProLink EST. Note if ProLink speed is accurate.

Check vehicle sensor adjustment. Remove sensor and check for damage and clean sensor. Turn sensor in until it contacts speedo gear and back off 1 turn.



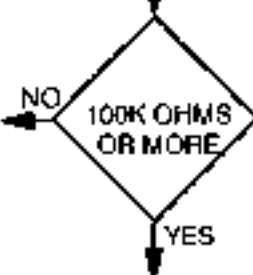
Refer to CTS-5000, Instruments and perform Speedometer/Tachometer Self Diagnostics.

Follow recommended actions in CTS-5000 to correct.



With key OFF, remove connector (27) from cluster and connector (381) from VPM. At (27), measure resistance to ground at terminal 5, circuit 478.

Locate short circuit to ground in circuit 478, then correct.



INSTRUMENT CLUSTER CENTER GREEN (27)



Continued On Next Page

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

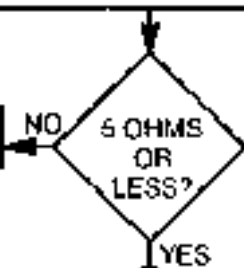
Section 3.5
Page 246

VEHICLE SPEED SIGNAL (VSS)

TESTING SPEEDOMETER (Continued)

With key OFF, at connector (27) terminal 8 (circuit 47-G), measure resistance to ground.

Locate open in ground path, then correct.

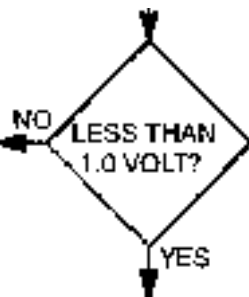


INSTRUMENT CLUSTER CENTER GREEN (27)

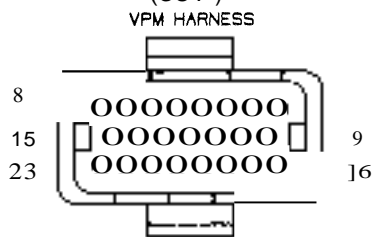


With key ON, at connector (27) terminal 8 (circuit 478), measure voltage to ground.

Locate short circuit to VREF or 12 volt circuit, then correct.

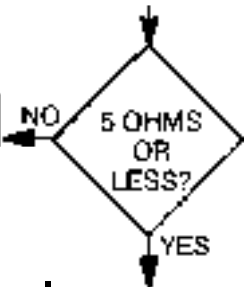


VPM CONNECTOR (381)



With key OFF, measure resistance between connector (27) terminal 8 and connector (381) terminal 18.

Locate open in circuit 478 between (27) and (381), then correct.



Replace VPM.

SECTION 4 SUPPLEMENTAL DIAGNOSTIC ANALYSIS

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CAMSHAFT TIMING

PROBABLE CAUSES

Camshaft gear to crankshaft gear assembled out of time.

PROCEDURES

- Bar engine over by hand until pointer on camshaft position sensor (CMP) is aligned with the machined timing slot on the crankshaft damper. Figure 4.1.
- Remove CMP sensor and view timing disk through the CMP hole in the front cover.
- If the engine is on the compression stroke for #1 cylinder a narrow sync vane will be observed directly in the middle of the CMP sensor hole. Figure 4.2.
- If the camshaft timing is either one tooth advanced or retarded the narrow vane will appear approximately 1/8" from either the upper or lower edge of the hole. Figure 4.3. Temporarily install CMP sensor, bar the engine over 360° until the CMP sensor pointer and the line on the crankshaft damper are aligned and re-inspect for the narrow vane on the timing disk.

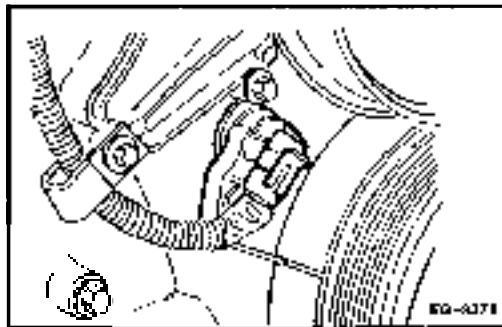


Figure 4.1. - Timing Pointer Aligned with Mark on Damper

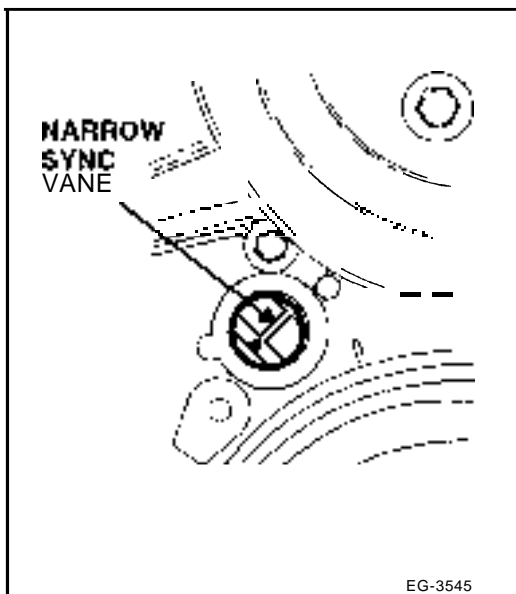


Figure 4.2. - View of Timing Disk (Camshaft Timing Correct)

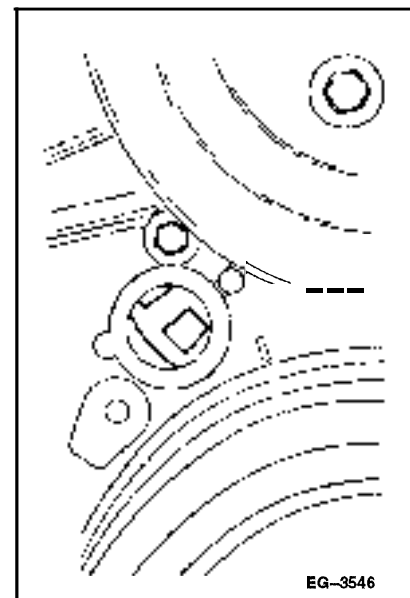


Figure 4.3. - View of Timing Disk (Not on Cyl. #1 Compression Stroke) Rotate Crankshaft 360°

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

COMBUSTION LEAKS

(COMBUSTION GAS OBSERVED IN ENGINE COOLANT IN OVERFLOW TANK OR SURGE TANK)

PROBABLE CAUSES

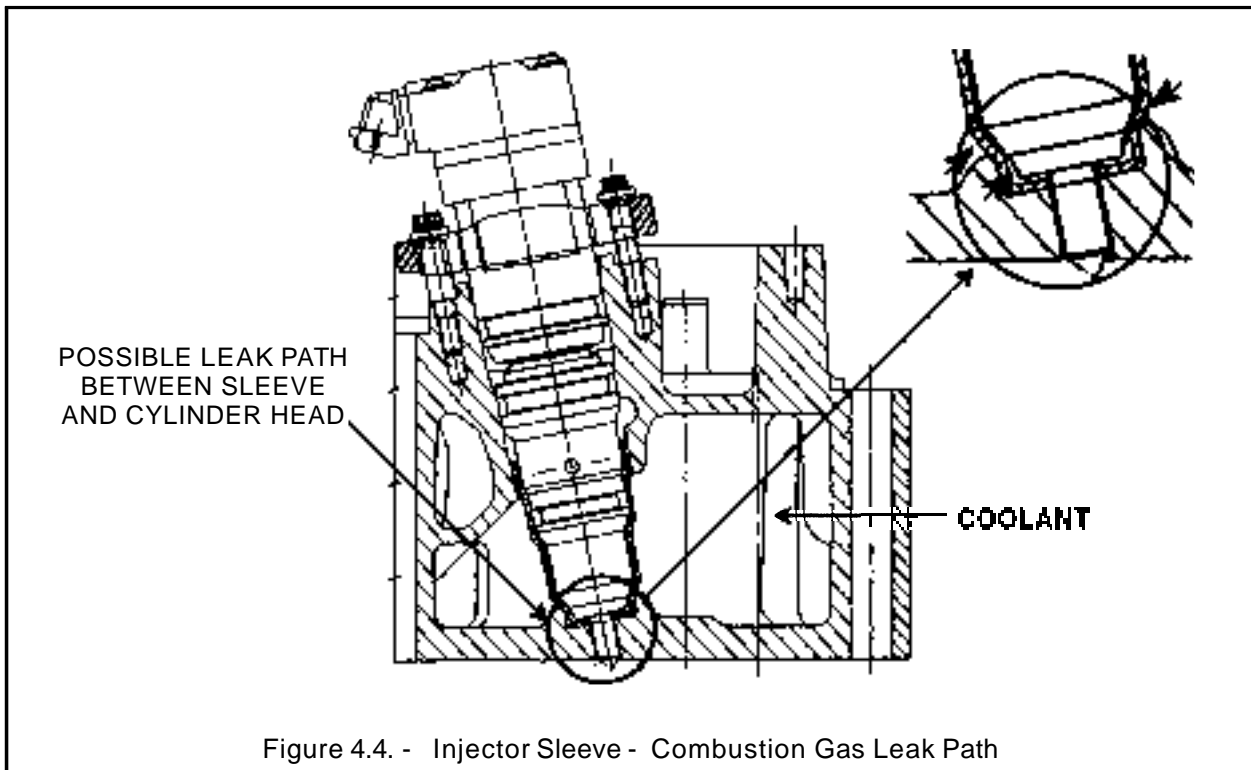
The most probable cause of combustion gas leakage to the cooling system is past the lower nozzle sleeve in the cylinder head. Figure 4.4. A blown head gasket or porous cylinder wall is possible, but should not be suspected unless special circumstances exist such as evidence of engine overheating or a very high mileage engine that has not had proper coolant conditioning.

- Pressurize cooling system to 14 PSI.
- Remove valve covers and glow plugs.
- Observe glow plug holes while barring engine over by hand to see if coolant is flooding the top of the piston and escaping out of the glow plug hole. (If the leak is a slight leak pressure may have to left on overnight and the engine inspected the next morning.)

PROCEDURES

PROCEDURE #1

- Plug in block heater to warm coolant.
- When the suspected nozzle sleeve is isolated, drain coolant and remove and replace the nozzle sleeve as per the service manual.
- Re-test after repair to confirm repair.



COMBUSTION LEAKS (Continued)

PROCEDURES (Continued)

PROCEDURE #2

- Very slight leaks may require higher pressure to be isolated.
- Plug in block heater to warm coolant.
- Remove valve cover and glow plugs.
- Remove cap from the surge tank.
- Rotate the crankshaft on the cylinder to be tested so that the valves are shut. (Or remove rocker arm pedestals to close valves.)
- Install the compression adapter. (ZTSE 4292) (Figure 4.5.) in the glow plug bore and adapt gauge end to accept shop air pressure (100 to 160 PSI).
- With shop air applied (Figure 4.5.) observe surge tank for escaping air. If the nozzle sleeve is leaking, air will escape into the cooling system when shop air pressure is applied and be seen as bubbles in the surge/overflow tank.
- When suspected nozzle sleeve is isolated, drain coolant and remove and replace nozzle sleeve as per the service manual.
- Re-test after repair to confirm repair.

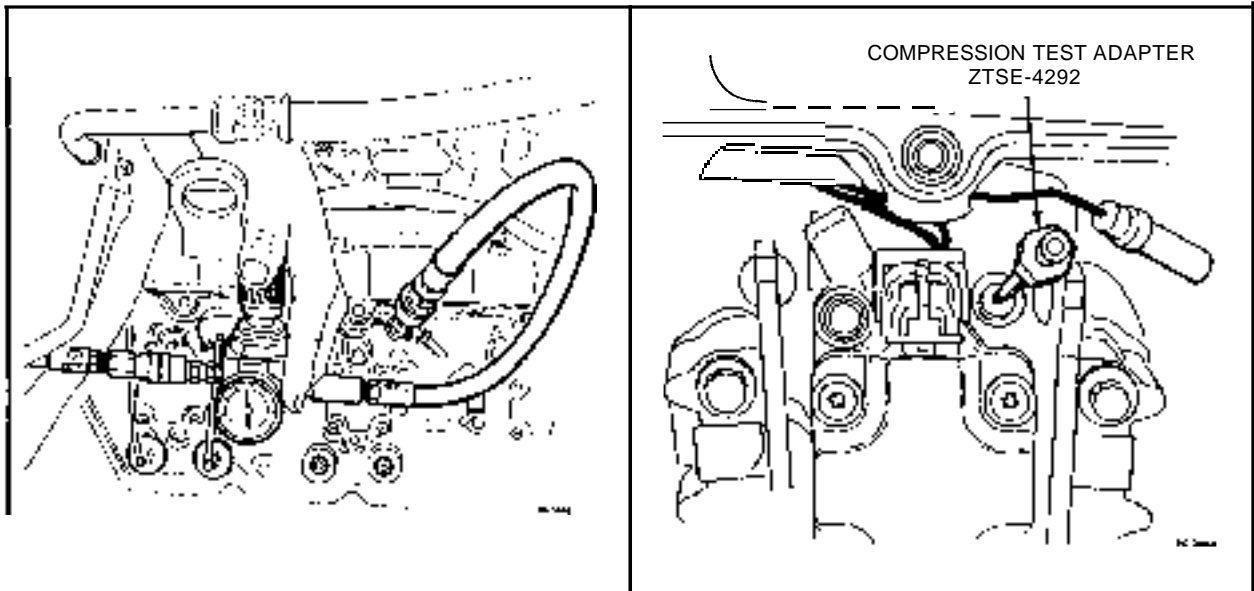


Figure 4.5. - Pressure Check for Combustion Leaks

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

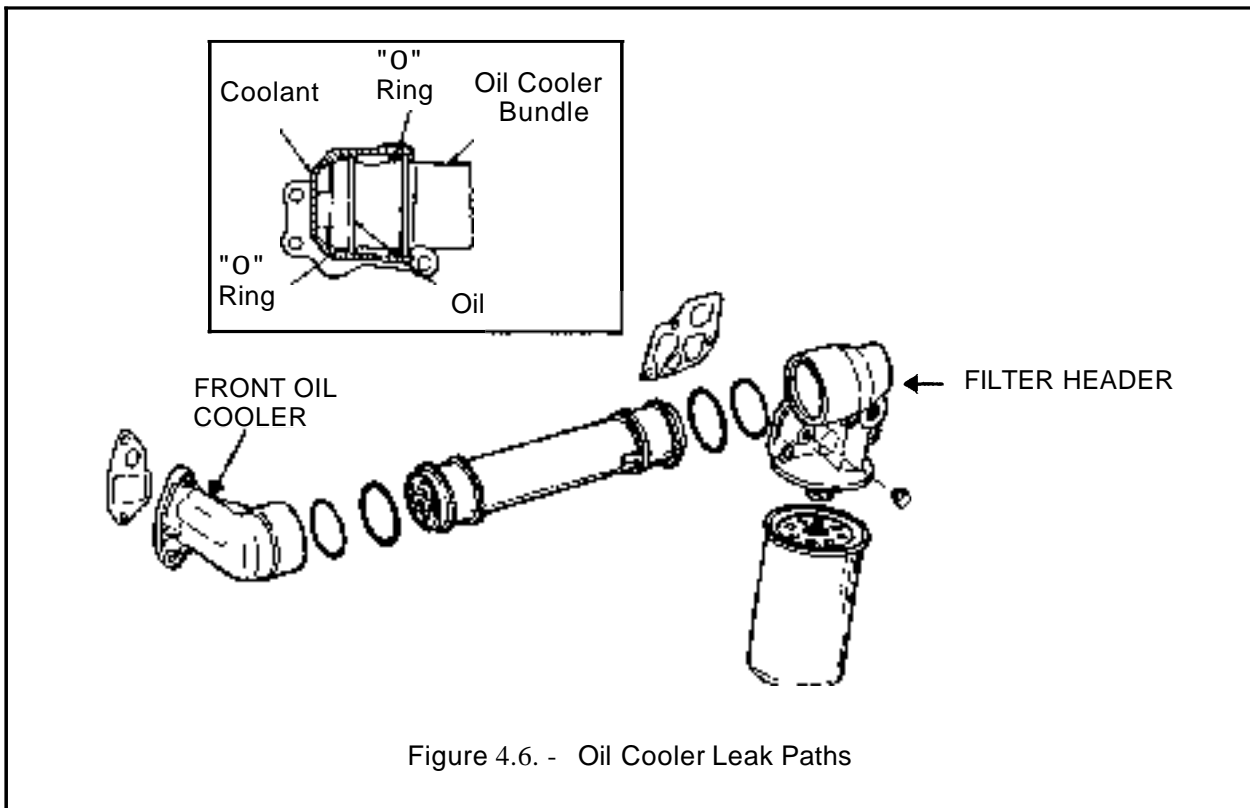
COOLANT IN LUBE OIL

PROBABLE CAUSES

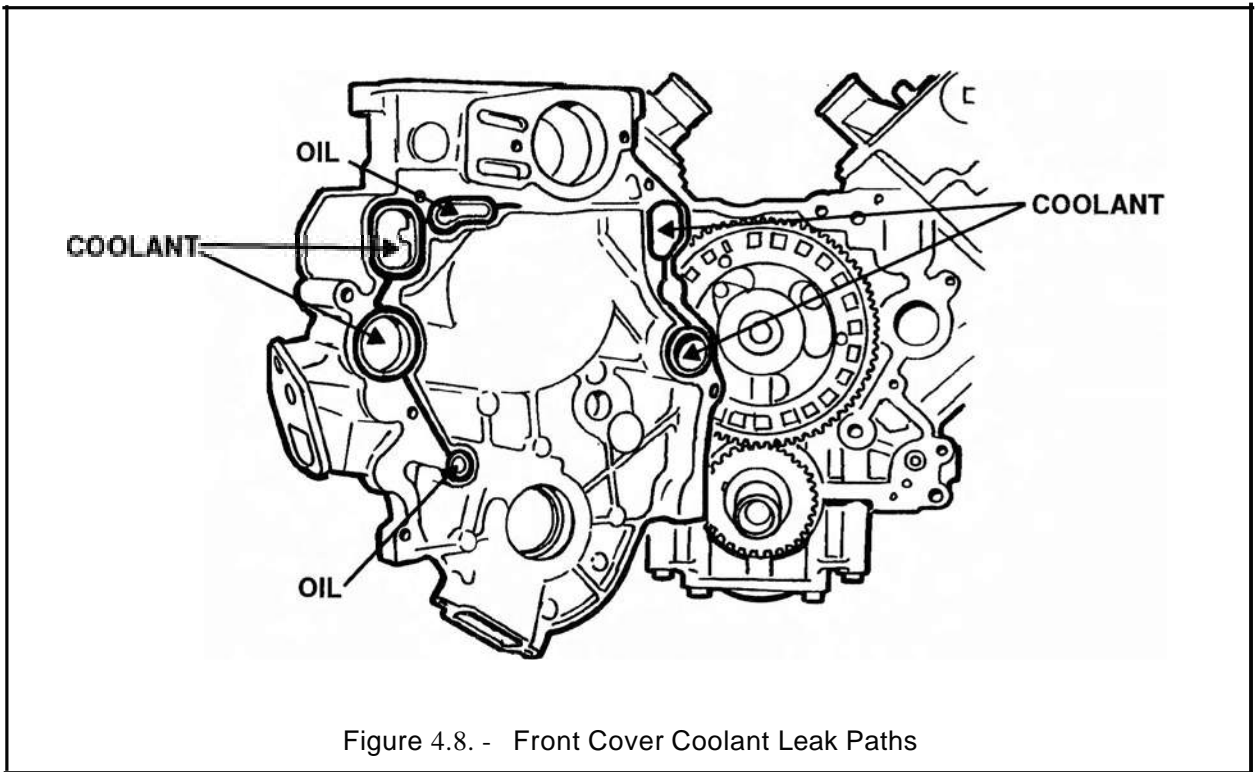
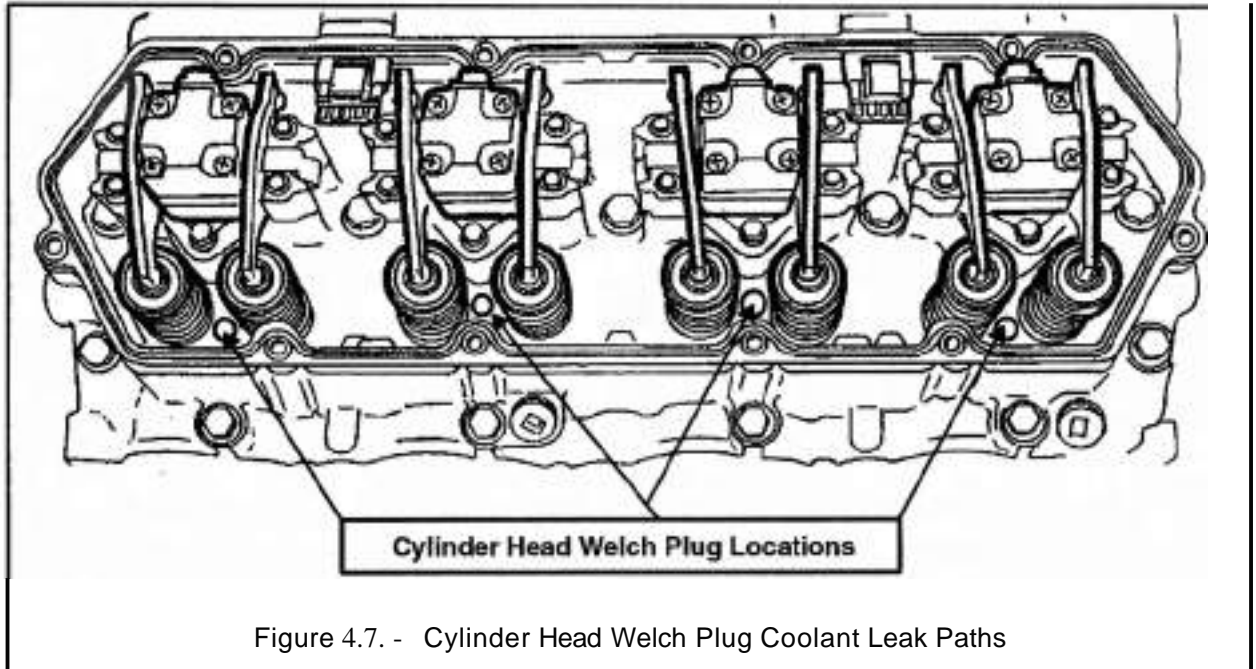
Oil cooler bundle or "O" ring failure, front cover "O" ring damage, front cover porosity, cylinder head porosity, crankcase porosity, nozzle sleeve leakage.

PROCEDURES

- Plug in block heater to warm coolant.
- Remove oil pan plug, oil filter and glow plugs.
- Pressurize cooling system to 14 PSI.
- Observe/inspect rear of oil cooler (where oil filter was mounted), (Figure 4.6.) oil pan plug for coolant or air pressure escaping.
- If: Coolant/air leak is occurring from header at the oil filter mounting header the oil cooler assembly should be removed and inspected or pressure tested.
- If the coolant is escaping out of the oil pan drain plug remove valve covers, inspect the cylinder head area (Figure 4.7. page 5) under the valve cover and welch plugs in cylinder heads for coolant leakage.
- If no leaks are found remove engine and oil pan, block off coolant inlet, outlet and heater hose connections. Pressurize the cooling system with 14 PSI of regulated air pressure.
- Inspect bottom end of crankcase for pressure leaks.
- If no leaks found, remove front cover and inspect gaskets and sealing surfaces. Figure 4.8. page 5.
- Re-test after repair to confirm repair.



COOLANT IN LUBE OIL (Continued)



SUPPLEMENTAL DIAGNOSTIC ANALYSIS

COOLANT OVERTEMP

PROBABLE CAUSES

Gauge error, low coolant level, plugged radiator, wrong radiator, stuck thermostat, no thermostat, defective water pump, broken belt, fan clutch slippage, wrong or damaged fan blade.

PROCEDURES

- Inspect radiator or surge tank for correct coolant level.
- Inspect fan blade, shroud, belt and radiator. (Verify correct part numbers.)
- Monitor ECT Engine Coolant Temperature with the EST (Electronic Service Tool) and compare

to dash temperature reading of coolant temperature.

- Monitor engine coolant temperature with manual gauge or thermocouple installed in port in front cover for existing sender and confirm over temperature.
- Remove and inspect thermostat, check for opening temperature.
- Remove radiator and have flow checked at radiator shop.

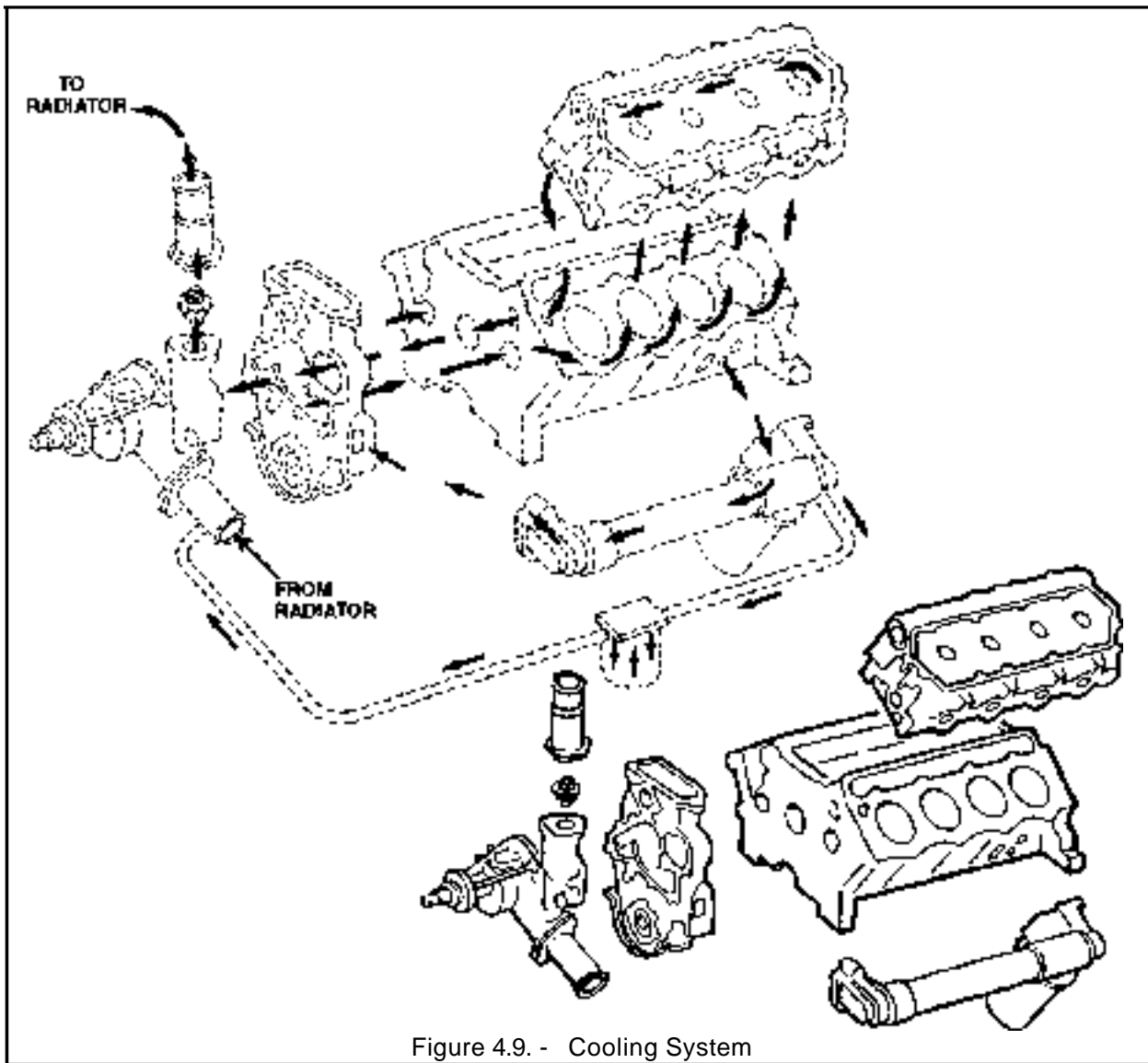


Figure 4.9. - Cooling System

EXCESSIVE FUEL CONSUMPTION

PROBABLE CAUSES

CUSTOMER EFFECTS:

Inaccurate record keeping or tank filling, winter blend or #1 fuel, high expectations.

APPLICATION EFFECTS:

Heavy loading (GVW), low rear axle ratio, large frontal area, prolonged idle times, accessory usage (PTO's etc.), tire size.

CHASSIS EFFECTS:

Brake drag, Fan clutch engagement, transmission slippage/shifting, fuel tank plumbing and venting, intake or exhaust restriction.

ENGINE EFFECTS:

Incorrect or defective thermostat, faulty (ESP) Exhaust Back pressure operation, oil aeration, fuel system leaks, base engine performance loss.

PROCEDURES

- Review customer records and fueling procedures. Measurement errors are common. Fuel consumption taken only from one tank of use is susceptible to significant error because of filling procedures and vehicle application differences during operation. Accurate fuel consumption must be measured over time, preferably over four tanks of fuel with a record of what the vehicle was towing or doing during that time.
- Loss of fuel economy is normal if winter fuels, kerosene or #1 diesel is being used.
- Review vehicle specifications to determine if fuel consumption is normal for type of application and use of vehicle. (Compare consumption with similar vehicles in same application)
- Conduct all tests on the Performance Diagnostic Sheet. These tests will test the following engine/chassis systems and determine if the following systems are functioning or if particular conditions are present. Intake and exhaust system, fuel delivery and filtration system, high pressure fuel system and injector operation, turbocharger and exhaust back pressure operation, oil aeration, base engine condition and electronic control system condition. If all tests are passed, the engine is operating normally.

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

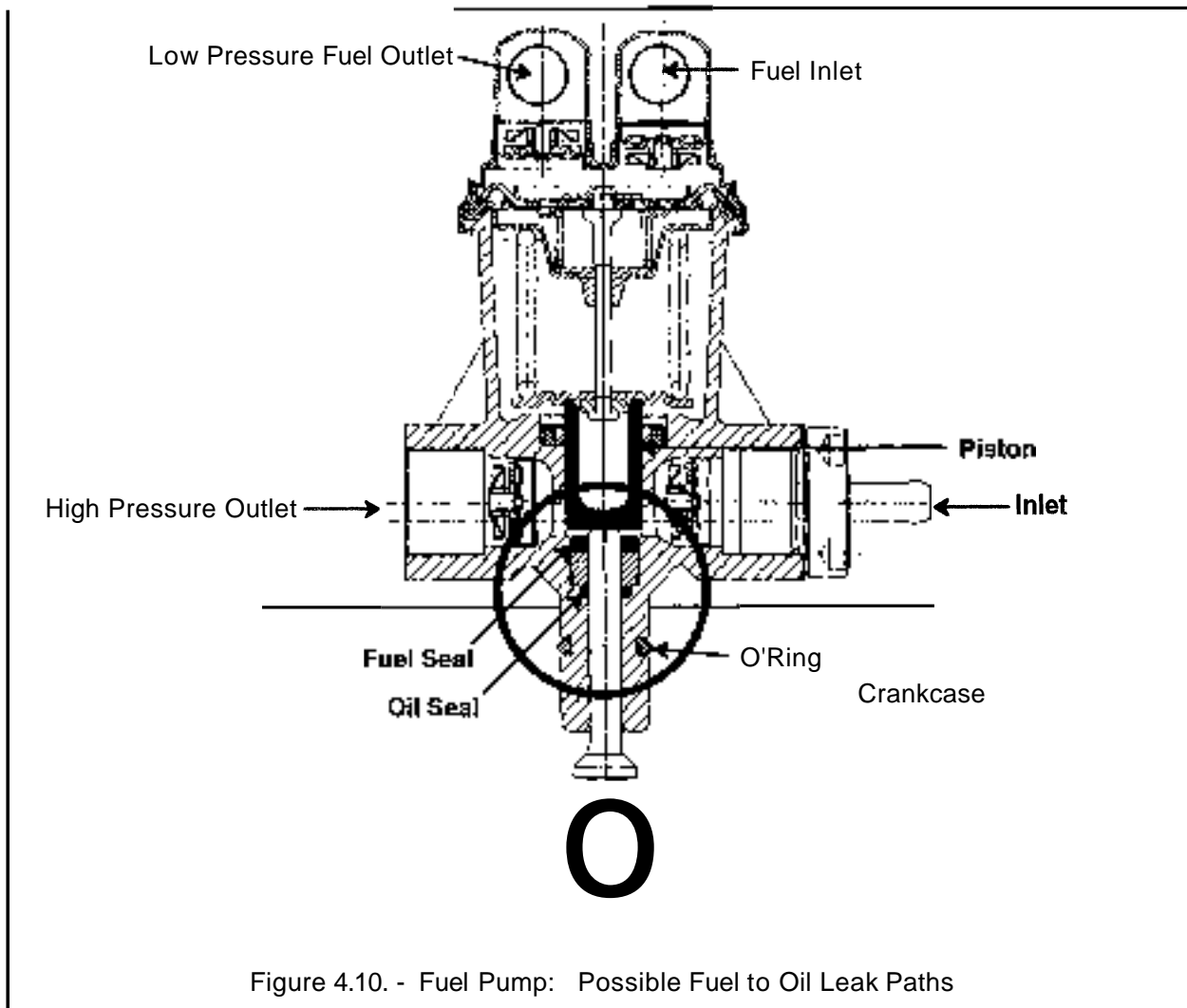
FUELOIL DILUTION

PROBABLE CAUSES

If a substantial amount of fuel is in the oil the most probable cause is a leaking tandem lift pump. A leaking nozzle sleeve or injector tip could cause fuel to contaminate the engine oil but would probably be identified as a performance problem. A porous cylinder head could also cause fuel to contaminate the engine oil but would only be likely in a very low mileage vehicle.

PROCEDURES

- Verify oil contamination. Oil contaminated with diesel fuel will have a diesel fuel odor and will cause the oil level in the engine to "grow".
- If the oil has a heavy diesel fuel odor and the oil level on the dipstick has increased overtime it is possible that the tandem lift pump is leaking fuel into the crankcase.



FUEL IN COOLANT

PROBABLE CAUSES

Injector sleeve (Upper section of sleeve to fuel galley).

PROCEDURES

- Plug in block heater to warm coolant.
- Remove fuel return lines at regulator block.
- Pressurize cooling system to 14 PSI.
- Observe fuel return lines, injector bank with fuel to coolant leak will push fuel or air out of it's return line.
- Remove injectors on suspect bank.
- With cooling system pressurized, observe upper injector sleeve to head fit for leakage. (Figure 4.11.)
- After repair, pressurize cooling system to confirm repair.

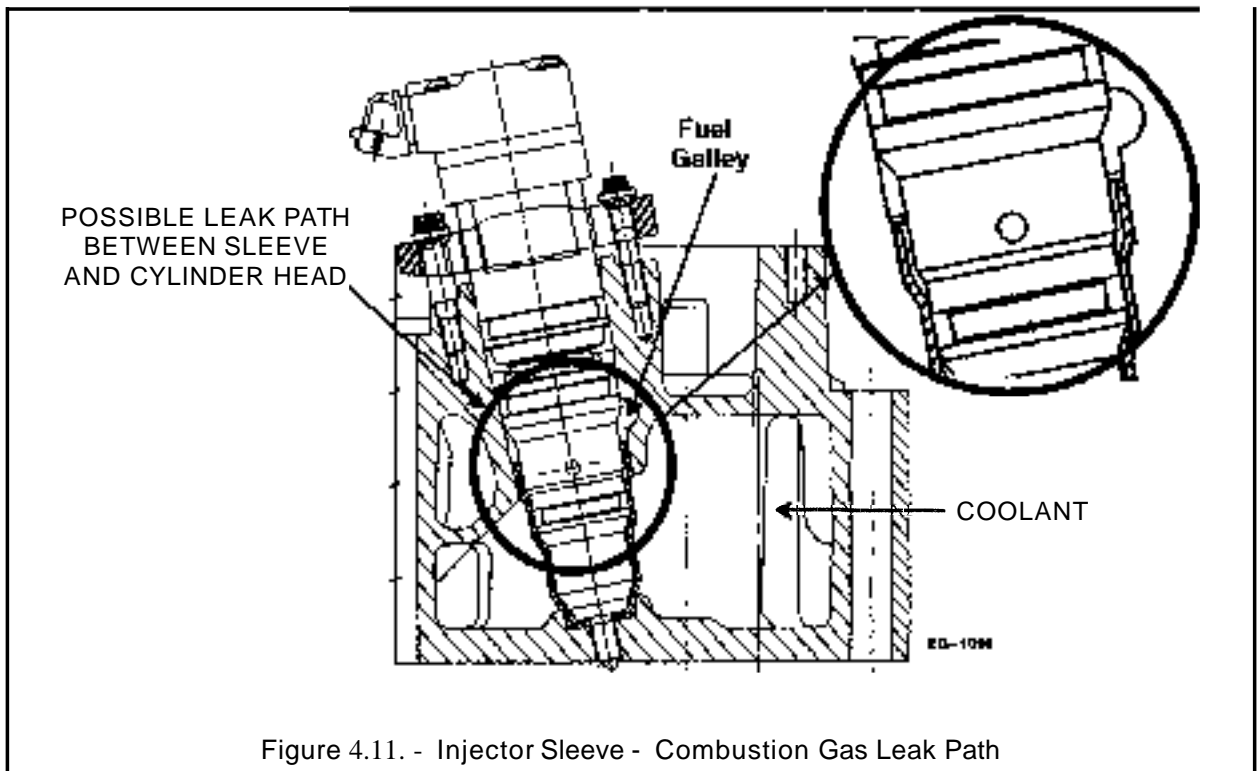


Figure 4.11. - Injector Sleeve - Combustion Gas Leak Path

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

LOW OIL PRESSURE

PROBABLE CAUSES

Inaccurate gauge reading, low oil level, oil dilution (fuel), Stuck oil pressure regulator, scored/damaged oil pump, rear main gallery plug, broken or missing piston cooling jets, front cover "O" ring leaks, missing tappet galley plug, missing bearing shells, porous oil reservoir.

PROCEDURES

- Verify oil level, check to see if contaminated with fuel.
- Verify oil pressure using a known good mechanical gauge and measuring at the oil reservoir and at the main oil galley. Oil pressure at both points should be 10 PSI minimum @ low idle and 40 PSI minimum @ wide open throttle with the engine at operating temperature.
- If the difference between the reading on the reservoir and main galley vary more than 5 PSI, swap gauges and recheck, if the reservoir still has a lower reading reservoir is most likely porous, replace reservoir.
- Remove and inspect oil cooler and regulator assembly. Oil regulator should be properly staked in the oil header housing and the regulator piston should be free to move when pressure is applied.
- Remove, inspect and measure clearances in the lube oil pump. (Figure 4.12.) Upon removal of the lube oil pump inspect the mating front cover surface for gouging or deep scratching, inspect the oil pump for damage or wear. Measure the "G" rotor to oil pump housing clearance. Specification is 0.028" - 0.032" (0.72 - 0.81 mm). Measure from surface of housing to "G" rotor dimension. Specification is 0.001" - 0.003" (0.025 - 0.076 mm).
- Remove the transmission and flywheel, inspect rear main plate for oil leaks. Massive oil leak could indicate a missing main galley plug. Figure 4.13. If leak is indicated remove rear plate and inspect plugs.
- Remove oil pan and inspect for missing piston cooling jets, bearing shells. Figure 4.14.
- Remove front cover, inspect for cut or damaged front cover "O" rings, missing tappet galley plugs. Figure 4.15.

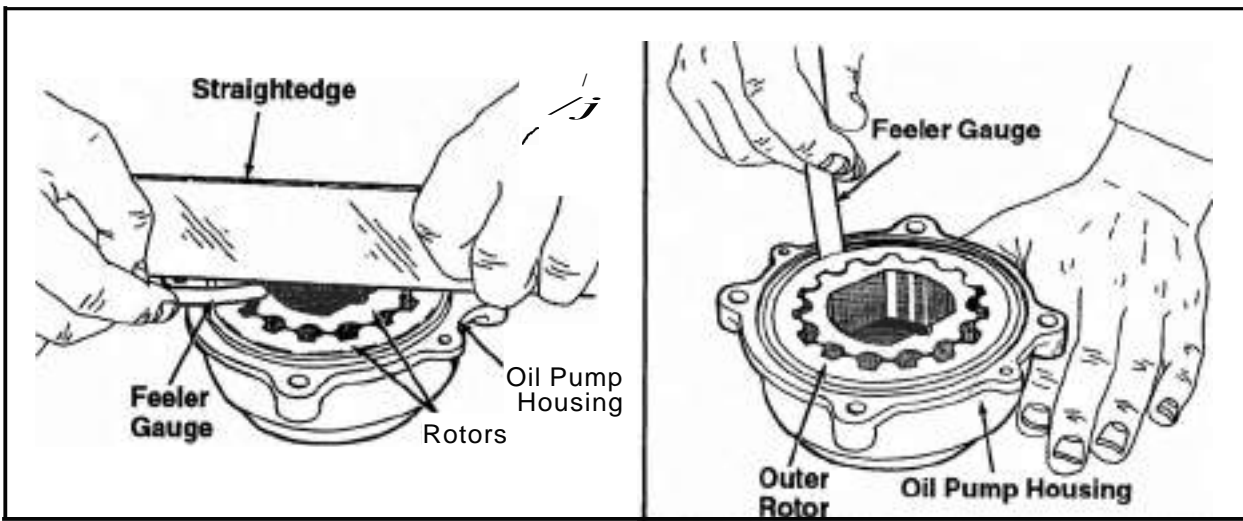
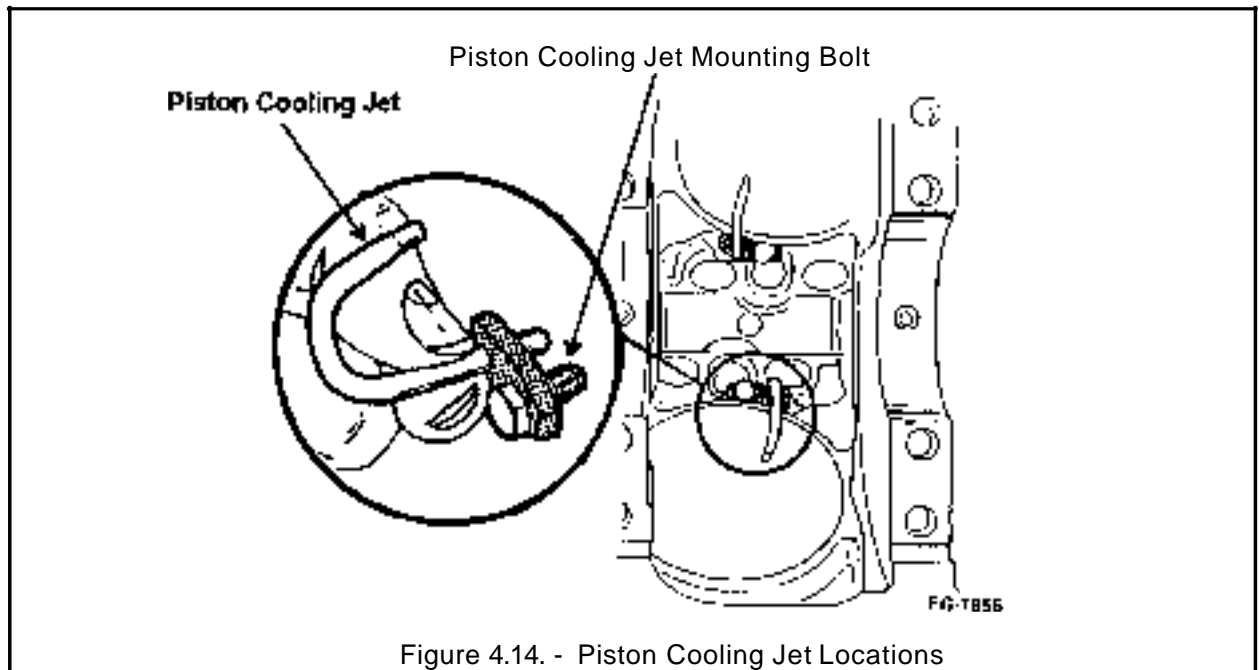
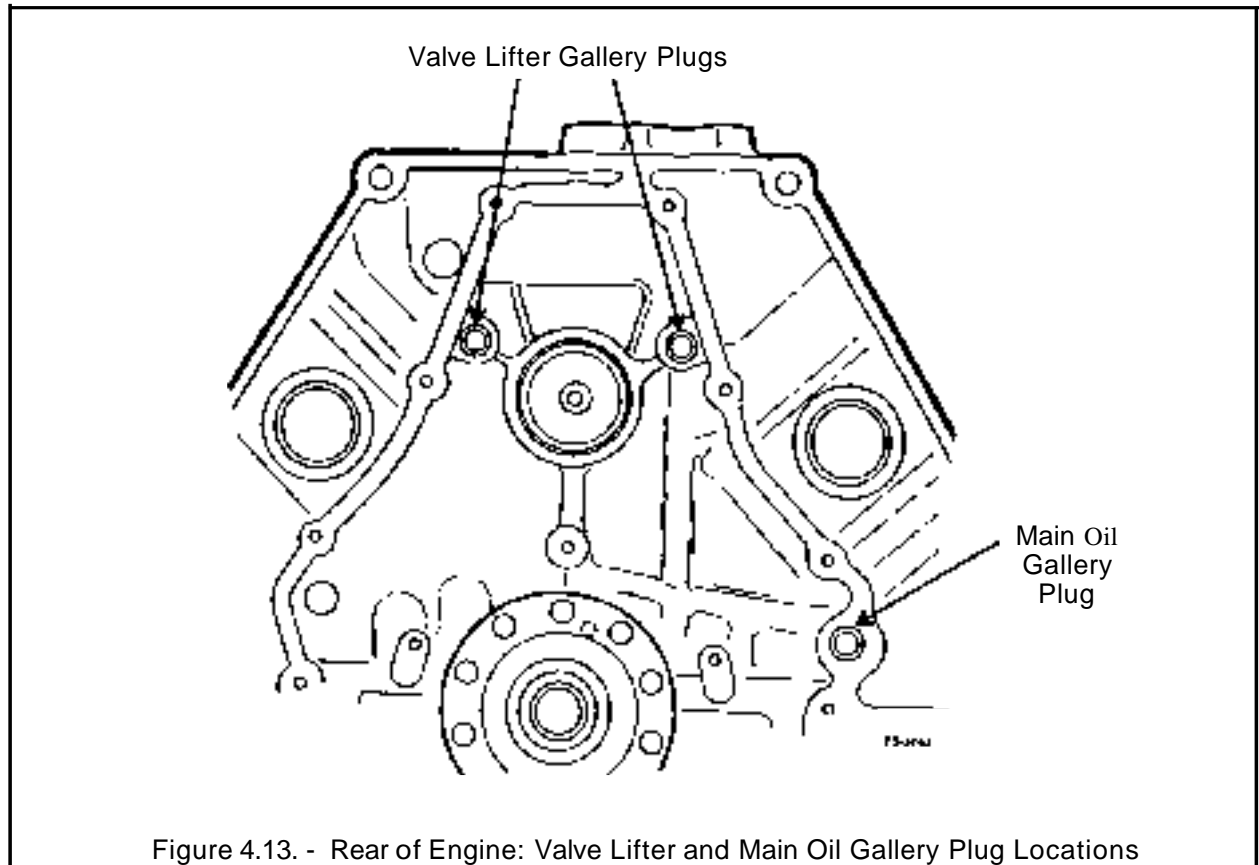
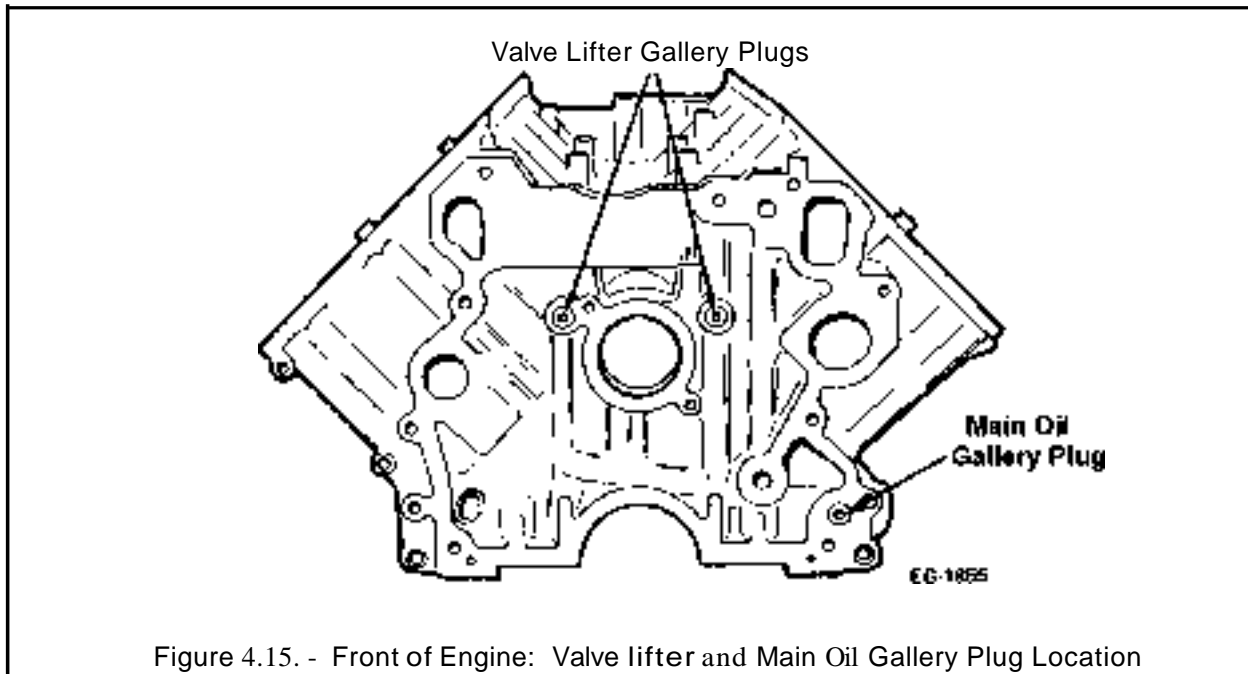


Figure 4.12. - Lube Oil Pump Inspection and Measurement

LOW OIL PRESSURE (Continued)



LOW OIL PRESSURE (Continued)



NO START - DRY RESERVOIR

PROBABLE CAUSES

To understand the cause of the no-start and identify the most probable cause to this problem it is critical to identify the failure mode.

If the engine:

"STARTED RAN APPROXIMATELY 15 SECONDS AND STALLED"

The most likely cause is the lack of oil supply by the lube system.

Or if the engine;

"DID NOT START AND RESERVOIR WAS FOUND DRY"

Possibilities include reservoir leak down: Caused by a leaking check valve in the high pressure oil pump, porous oil reservoir, or reservoir pump down which occurs during cranking and no start conditions caused by CMP circuit or other electronic control circuit failures.

PROCEDURES

"STARTED RAN APPROXIMATELY 15 SECONDS AND STALLED"

This condition assumes that the reservoir was full when the engine start was attempted, the engine started normally and would die after 15 seconds of running.

- Refill the reservoir and verify the start and stall condition.
- Remove, inspect and measure clearances in the engine lube oil pump. (Figure 4.16.) Upon removal of the lube oil pump inspect the mating front cover surface for gouging or deep scratching, inspect the oil pump for damage or wear. Measure the "G" rotor to oil pump housing clearance. Specification is 0.028" - 0.032" (0.72 - 0.81 mm). Measure from surface of housing to "G" rotor dimension. Specification is 0.001" - 0.003" (0.2 - 0.08 mm.)

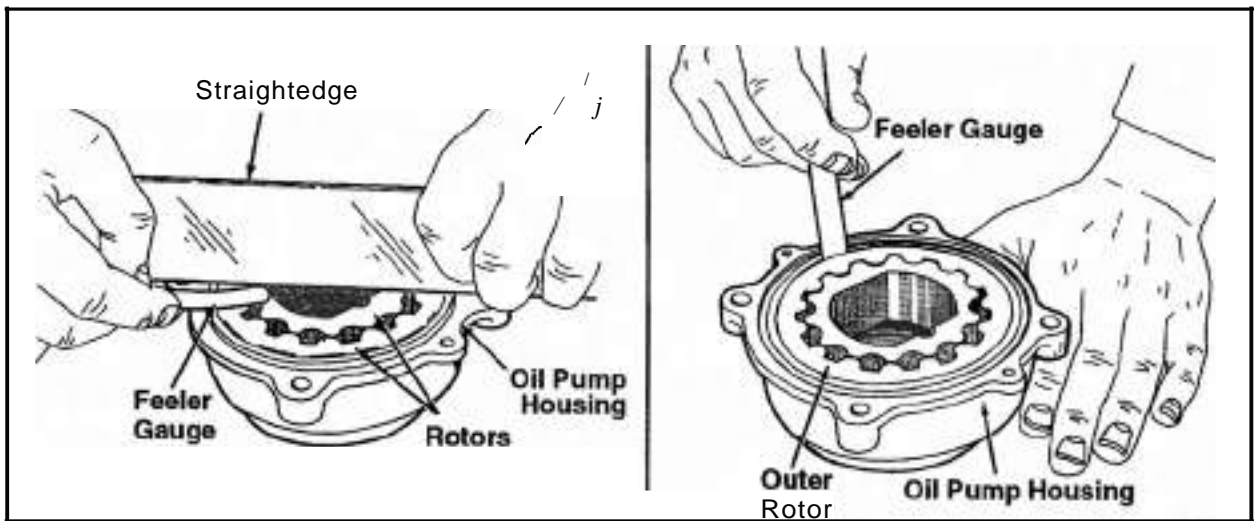


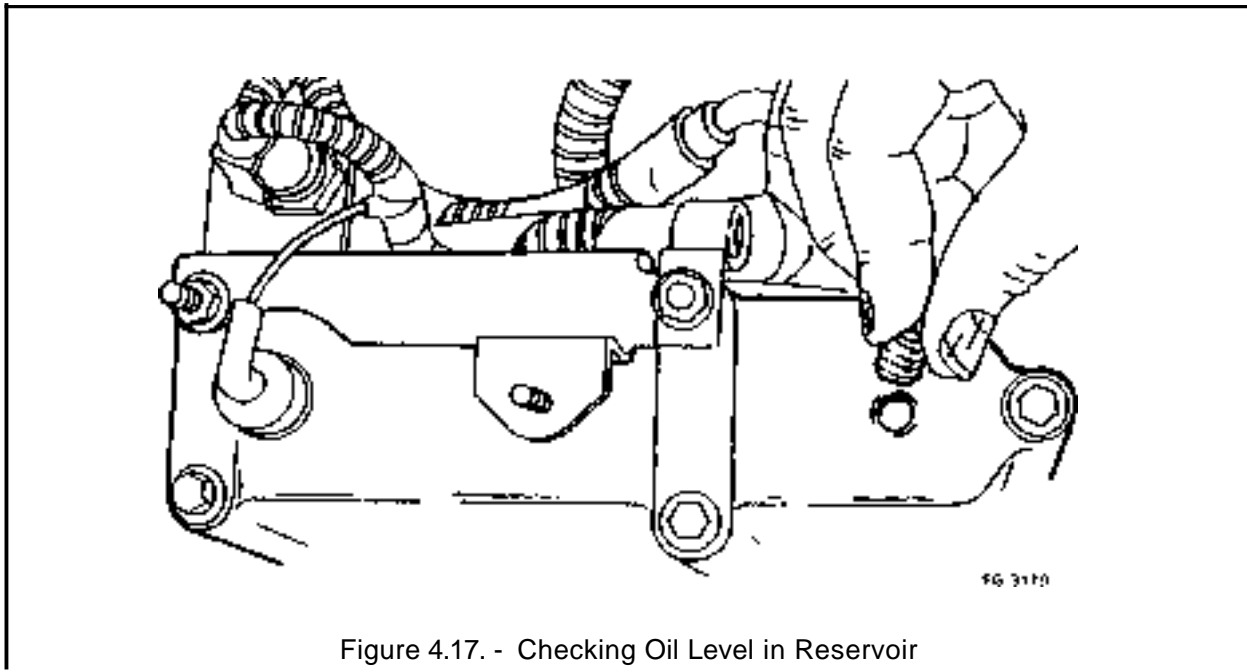
Figure 4.16. - Lube Oil Pump Inspection and Measurement

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

NO START - DRY RESERVOIR (Continued)

"DID NOT START AND RESERVOIR WAS FOUND DRY"

- Refill the reservoir and attempt to start the engine.
- If the engine does not start, perform the procedures on the Hard Start/No Start Diagnostic form. The tests on this form will discern if the essential elements required to start are present. (e.g. CMP camshaft position signal, battery voltage, fuel & fuel pressure, lep injection control pressure, etc.)
- If the engine starts, the low reservoir problem may be caused by reservoir leak down after a prolonged period of not running.
- Road test the vehicle for a minimum of 10 miles to assure that all air is purged from the injection control pressure system. Check oil level in reservoir to assure that it is full and let sit over night.
- Inspect oil level (Figure 4.17.) the next morning (prior to starting engine) to determine if leak down has occurred.
- The only paths for leakage is past a check ball internal to the high pressure oil pump or through a porous reservoir or front cover.
- Leakage past the check valve in the high pressure pump may be intermittent, the check valve internal to the pump is not serviceable. If the high pressure pump is suspect, replace it. (Figure 4.18.) (Note: The IPR injection pressure regulator valve which is mounted in the pump will not cause a leak down problem and does not require replacement when a high pressure pump is replaced.)
- Porosity through a reservoir or front cover casting is highly unlikely and if it does occur will probably be detected at very low miles. Leakage through a porous casting will also be diagnosed as a consistent problem and should not be a case of intermittent leak down. If porosity is suspected it is recommended to replace the reservoir first since it is far easier to replace than a front cover.



NO START - DRY RESERVOIR (Continued)

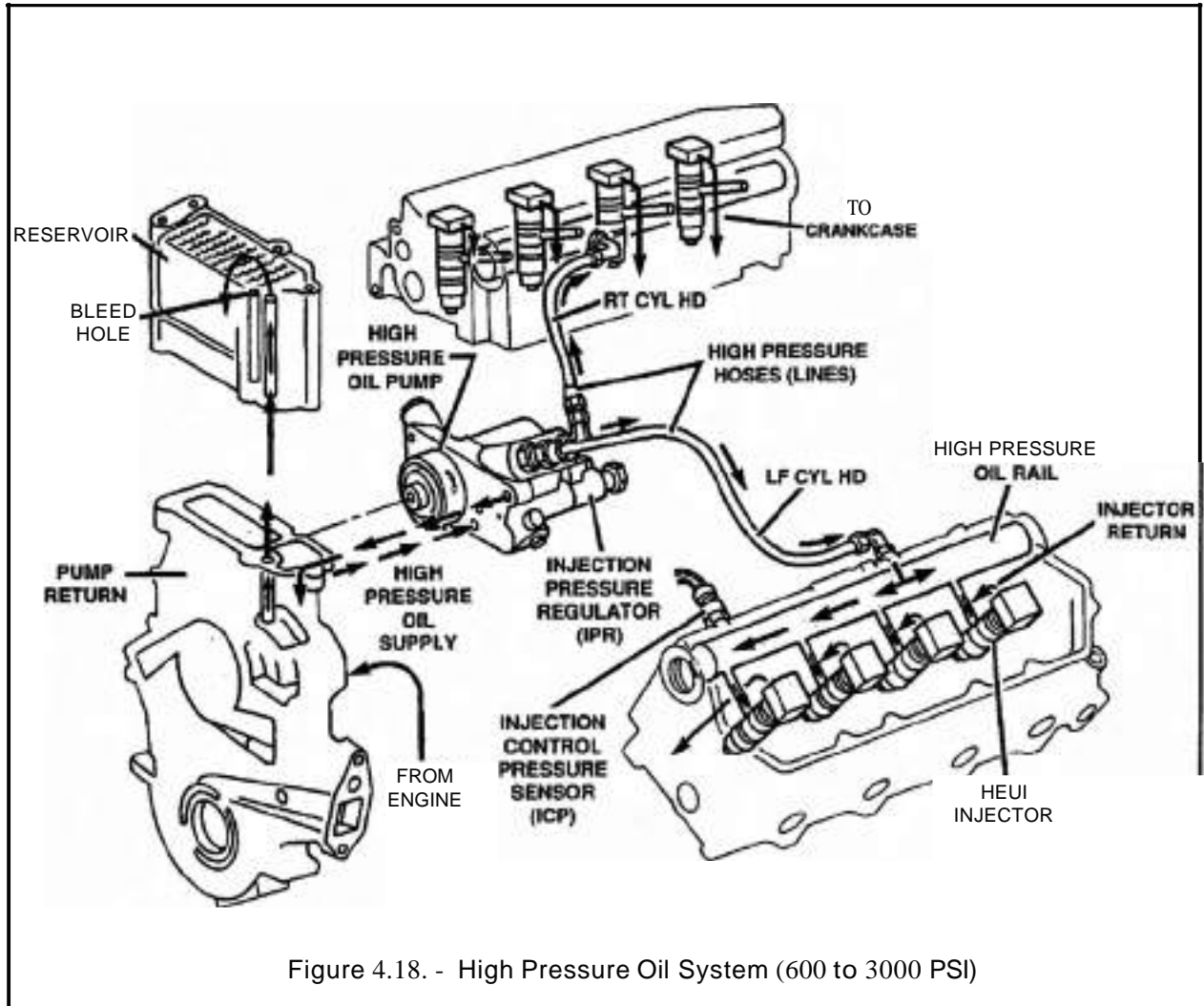


Figure 4.18. - High Pressure Oil System (600 to 3000 PSI)

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

ECM RESET

(GLOW PLUG LAMP CYCLES ON/GLOW PLUGS RECYCLE! ENGINE STUMBLE DIE/NO ACCELERATOR PEDAL AUTHORITY UNTIL RETURN TO IDLE POSITION)

A Electronic Control Module (ECM) reset occurs when the ECM momentarily "reboots" or is turned off and on while the engine is operating. If the condition occurs a single time, the engine will momentarily stumble and the ECM will go through a normal key on cycle, including turning the glow plug lamp and glow plugs on and will also attempt to validate the accelerator pedal position. If the pedal is not at the idle position when this fault occurs, pedal authority will not be allowed by the ECM until the APS is released and the engine will idle only.

PROBABLE CAUSES

- Momentary loss of power to the ECM or 10M: Defective power relays, shorted or open harness, intermittent connectors, poor grounds.
- Momentary short to ground of V ref: Shorted harness or connector, defective sensor (sensors that use Vref include - EBP exhaust back pressure, ICP injection control pressure, CMP camshaft position sensor, MAP manifold absolute pressure sensor, BARO barometric pressure sensor, APS accelerator pedal sensor.)
- Momentary short to ground of injector high side voltage: Under valve cover harness, valve cover gasket, engine harness, chassis harness are all possible sources of short to ground conditions.

PROCEDURES

- Complete tests #3, #4a and #4b on the Performance Diagnostic Form, this will determine if the ECM has detected any fault conditions that can cause a ECM reset. If the EST does not operate or is unavailable, perform Test 5 (STI Flash Codes).

NOTE: IF THE ECM IS UNABLE TO PERFORM A KOEO INJECTOR ELECTRICAL SELF TEST

(BUZZ TEST) THIS WILL SOMETIMES INDICATE AN INJECTOR CIRCUIT HIGH SIDE SHORT TO GROUND CONDITION. DISCONNECT PAIRS OF INJECTORS BY REMOVING THE CONNECTOR AT THE VALVE COVER AND ATTEMPT TO PERFORM THE BUZZ TEST. IF THE BUZZ TEST CAN BE ACCOMPLISHED WITH AN INJECTOR PAIR DISCONNECTED, THE HIGH SIDE SHORT TO GROUND HAS MOST LIKELY BEEN ISOLATED TO THE UNDER VALVE COVER HARNESS CORRESPONDING TO THE DISCONNECTED INJECTORS.

- Check all power and ground connections for the ECM and 10M.
- Monitor V ref (pin #26) and V Power (pins #37 & #57) with the breakout box installed when the fault occurs.
- Inspect the CMP sensor harness connector and the harness (particularly around the idler pulley) for a V ref or signal short to ground condition.
- Remove and inspect the CMP camshaft position sensor for possible timing disk to CMP sensor contact
- If the ECM reset condition is repeatable, disconnect the following sensors one at a time and operate the engine to determine if the reset will reoccur. ESP exhaust back pressure, ICP injection control pressure, MAP manifold absolute pressure sensor, BARO barometric pressure sensor, APS accelerator pedal sensor, and EOP engine oil pressure sensor. Inspect each harness and connector upon removal.
- Remove the valve covers and inspect the under valve cover connectors (Figure 4.19.) for possible pinching under the valve cover gasket or rub through against the push tubes.

ECM RESET (Continued)

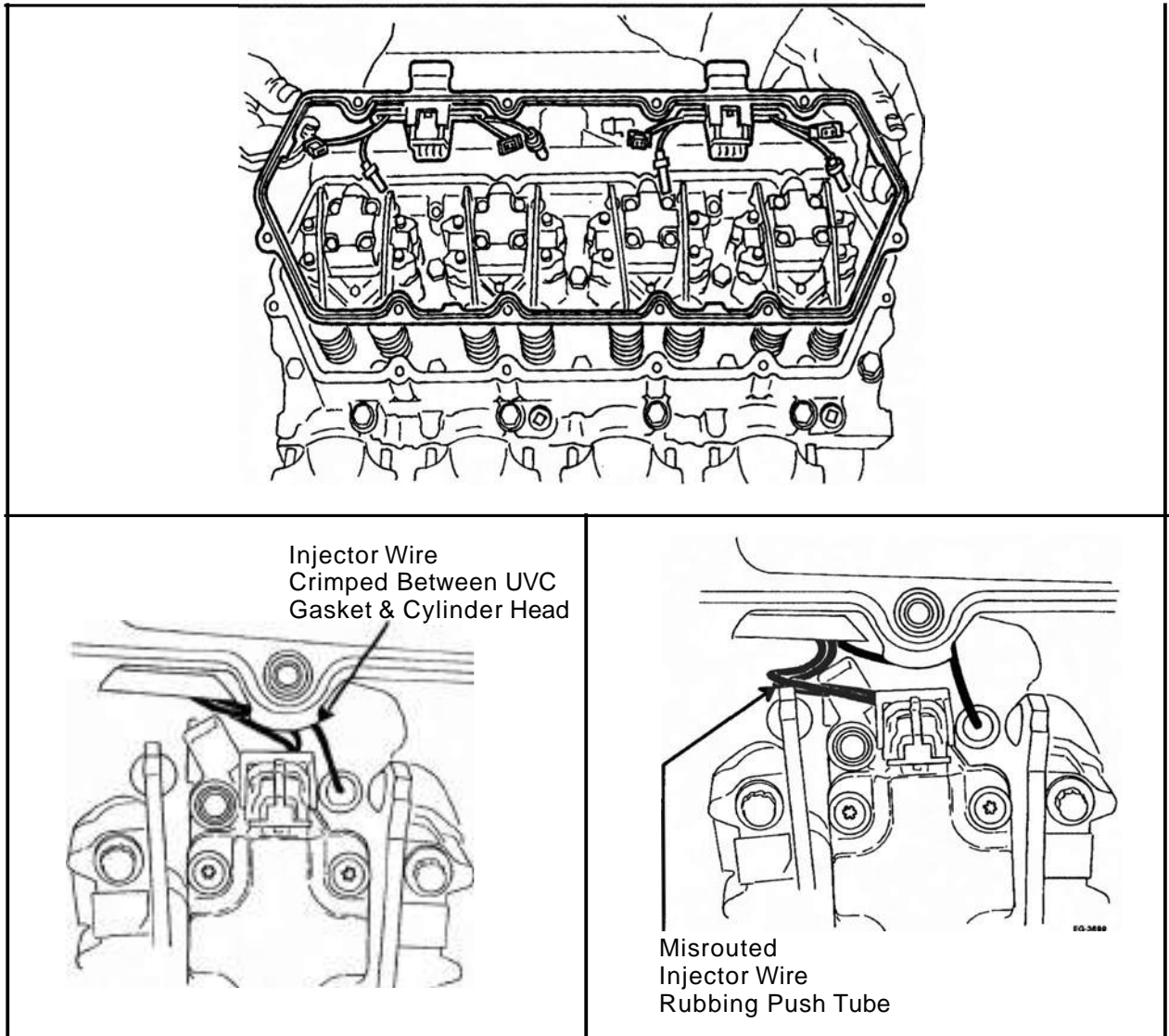


Figure 4.19. - Under Valve Cover Harness Inspection

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

ROUGH IDLE DIAGNOSTICS

PROBABLE CAUSES

Engine oil (aerated, incorrect grade, low oil level, extended oil drain interval), defective injectors, injector shorts to ground, power cylinder problems, valve train problems, low fuel pressure, aerated fuel, exhaust system to cab/chassis ground outs, loose/worn engine mounts, electronic control system faults, poor fuel quality, injection control pressure system problems.

PROCEDURES

- **Verify Complaint**
Confirm conditions when complaint is present, for example does the engine rough idle only when hot, cold, after high speed operation, does it misfire over whole speed range, is there chassis vibration are there any other conditions or observations present when the engine idles rough.
- **Inspect Exhaust System For Contact With Cab Or Bed**
Many vehicles inspected have had contact between the flat exhaust pipe that comes off of the engine to the cab. This will transmit engine vibrations to the cab, especially on acceleration when the engine twists on it's mounts. It may be improperly diagnosed as a rough idle complaint. The other exhaust ground out area observed has been in the center of the box area if a fifth wheel has been installed, the underside bracket may sometimes rub on the driveline.
- **Complete all tests on the Performance Diagnostic Sheet.** Conditions are described below that can contribute to rough idle and why each test is being performed is listed below.

CHECK ENGINE OIL LEVEL

VERIFY CORRECT GRADE

Must meet CG-4 / SH specification.

PERFORM EST TOOL - ENGINE OFF TESTS

Intermittent CMP, 10M, ICP, Injector or wiring harness faults can affect engine idle conditions the

ECM may have detected and recorded these conditions.

PERFORM EST INJECTOR BUZZ TEST

This test will verify that the injectors are working electronically.

MEASURE TRANSFER PUMP PRESSURE

Low fuel pressure will cause the engine to misfire and will cause a loss of power.

- If pressure is low, remove canister mounted on fuel regulator and remove any debris on fuel screen. Remove fuel regulator from side of fuel filter and remove any material from screen protecting the fuel de-aeration orifice.

MEASURE TRANSFER PUMP INLET RESTRICTION

If fuel pressure is low, this test will determine if the cause is a restricted fuel inlet from the fuel tank.

PERFORM AIR IN FUEL AND FUEL RETURN FLOW TEST

This test consists of installing a clear line on the return fuel line. Observing the clear line will indicate if return fuel is present and/or if air is present in the return fuel.

PERFORM EST - ENGINE RUNNING TEST

This test will test the functionality of the ICP control system, the exhaust backpressure system. The engine must be up to operating temperature to perform this test.

PERFORM CYLINDER CONTRIBUTION TEST

This test will test the contributions of the individual power cylinders. It will only detect a cylinder that is contributing very little. It's primary function is to detect a bad injector, but it is possible it could detect a base engine problem such as broken rocker arm bolts, bent push tube, broken rings or bent connecting rod.

ROUGH IDLE DIAGNOSTICS (Continued)

PERFORMANCE DIAGNOSTICS (Continued)

PERFORM INJECTION CONTROL PRESSURE TESTS

Oil Aeration Test with DVOM

Aerated oil will cause the engine to idle rough and possibly die upon de-acceleration. The most likely causes for aeration is insufficient oil level, incorrect oil grade, extended oil drain intervals and low pressure suction leaks.

Before performing oil aeration tests, verify that the ICP sensor is reading correctly by monitoring the ICP voltage signal with a DVOM or the injection control pressure using the EST with the key on and engine off. The value displayed will measure between .15 to .25 volts with a DVOM or display 0 PSI on the EST.

Oil Quality

If the oil is being aerated due to depletion of the anti-foaming agents in the oil, the problem will be most evident when the engine is hot and after prolonged operation at high engine speeds. During this test, oil aeration caused by engine oil will probably start at a low ICP signal level (1.4 to 1.5 volts or 1024 to 1060 PSI) and increase to a signal level above (1.75 volts or 1270 PSI) after 60 seconds of WOT engine operation.

CHANGE OIL (CG-4) AND RE-TEST IF THIS TEST IS FAILED

LOW PRESSURE SUCTION LEAKS

If a leak on the suction side is present, engine temperature will most likely have little effect on oil aeration. The ICP signal during this test will most likely immediately measure above 1.9 volts or 1400 PSI during the WOT test and the engine may not achieve a engine speed above 2000 RPM during this test. (It is important that all KOER and cylinder contribution tests have been performed prior to this test. A cylinder or injector not functioning will give similar test results.)

To confirm that a low side suction leak is occurring, overfill the engine crankcase with 3 quarts of engine oil, raise the rear wheels 10" off the ground and re-run this test. If a suction leak is present, (oil pickup tube or gasket leak) the added oil will seal the leak and the ICP signal should be in specification.

LOW IDLE STABILITY TEST

This test will help discern if erratic rail pressure and an associated low idle concern is caused by the ICP sensor or IPR valve. Disconnect engine harness connector at ICP sensor while engine is at idle. If engine rough idle smooths out, replace ICP sensor. If engine continues to idle rough with harness connector removed, refer to IPR and Injection Control Pressure system diagnostics.

PERFORM CRANKCASE PRESSURE TEST

The crankcase pressure test will determine the condition of the power cylinders and base engine.

INJECTION CONTROL PRESSURE BALANCE

Compare ICP Pressure of Right and Left Cylinder Head. Pressure differences between the right and left cylinder head have been found to cause poor idle and performance complaints. Install an additional ICP sensor in the right cylinder head, connect the ESP sensor connector (if vehicle is equipped with) to the additional sensor, install a breakout box and monitor the ICP signal on the left head and right head. (Use ESP signal pin) with two DVOM's installed. Compare the measured signal of the right and left cylinder head at low idle, high idle and under a load. The difference between each head should not exceed .2 volts.

To isolate if the pressure difference is caused by internal leakage in the cylinder head or by the high pressure pump, block the line feeding the right cylinder head and operate the on the left bank only. Then route the line feeding the left cylinder head to the right cylinder head. (The left high pressure line will reach the right head).

SUPPLEMENTAL DIAGNOSTIC ANALYSIS

ROUGH IDLE DIAGNOSTICS (Continued)

PERFORMANCE DIAGNOSTICS (Continued)

If there are pressure differences between the cylinder heads, leakage is occurring in the lower pressure head (e.g. loose or cross threaded oil gallery drains, injector "O" rings, bad injector).

If the pressure is the same on each cylinder head,

the initial pressure difference is caused by the high pressure pump.

COMPRESSION TEST

Perform compression test to verify base engine condition. (Figure 4.20.)

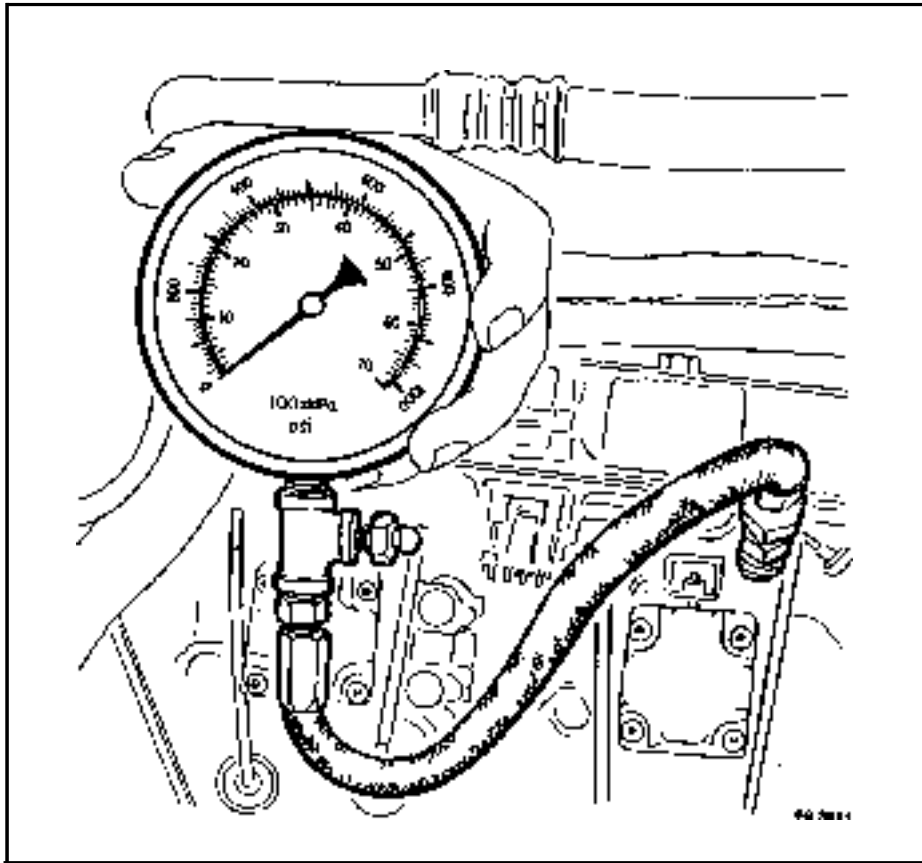


Figure 4.20. - Compression Test

- If no other faults found replace injectors.

SMOKE

BLACK SMOKE

PROBABLE CAUSES

Air intake or exhaust restriction, exhaust back pressure device closing, turbocharger failure, loose injector, altitude (very slight black smoke on hard acceleration is normal).

PROCEDURE:

- If engine has a fuel knock or there is evidence of fuel in the exhaust manifolds, remove exhaust manifolds and inspect for fuel in the exhaust ports. (Suspect loose injectors, missing or damaged "O" ring and copper gasket on bottom.)
- Inspect air inlet system and exhaust system for possible sources of restriction.
- Inspect exhaust back pressure (ESP) device at WOT to determine if closing.
- Monitor ESP signal (PID) with the EST tool while operating the engine to determine if exhaust back pressure is high.
- On a cold engine the glow plug system may remain on for up to 2 minutes after the engine starts to assist in cold smoke cleanup. Perform glow plug diagnostic procedures (test #11) on Hard Start / No Start diagnostic form to verify glow plug operation.
- If engine has a fuel knock or evidence of fuel in the exhaust, remove exhaust manifolds and inspect for fuel in the exhaust ports. (Suspect loose injectors, missing or damaged "a" ring and copper gasket on bottom.)
- If air induction system show evidence of water injection, that can cause hydraulic static lock and bend connecting rods or if the air induction system shows evidence of dusting perform a compression test.

WHITE SMOKE

PROBABLE CAUSES

No glow plug operation, loose injectors, cold engine, bent connecting rods, low compression, worn rings, coolant leaking into combustion chamber past injector sleeves.

PROCEDURE:

- In cold ambient temperatures some white smoke is normal until the engine is up to operating temperature. Insure engine is up to operating temperature (190°F) prior to verifying a smoke complaint. If the engine is unable to obtain operating temperature during a road test verify thermostat opening temperature (190°F).

BLUE SMOKE/FUEL ODOR

PROBABLE CAUSES:

- Oil consumption
- Loose injectors.

PROCEDURE:

- If engine has a fuel knock or evidence of fuel in the exhaust, remove exhaust manifolds and inspect for fuel in the exhaust ports. (Suspect loose injectors, missing or damaged "O" ring and copper gasket on bottom.)

SECTION 5 DIAGNOSTIC TOOL USE

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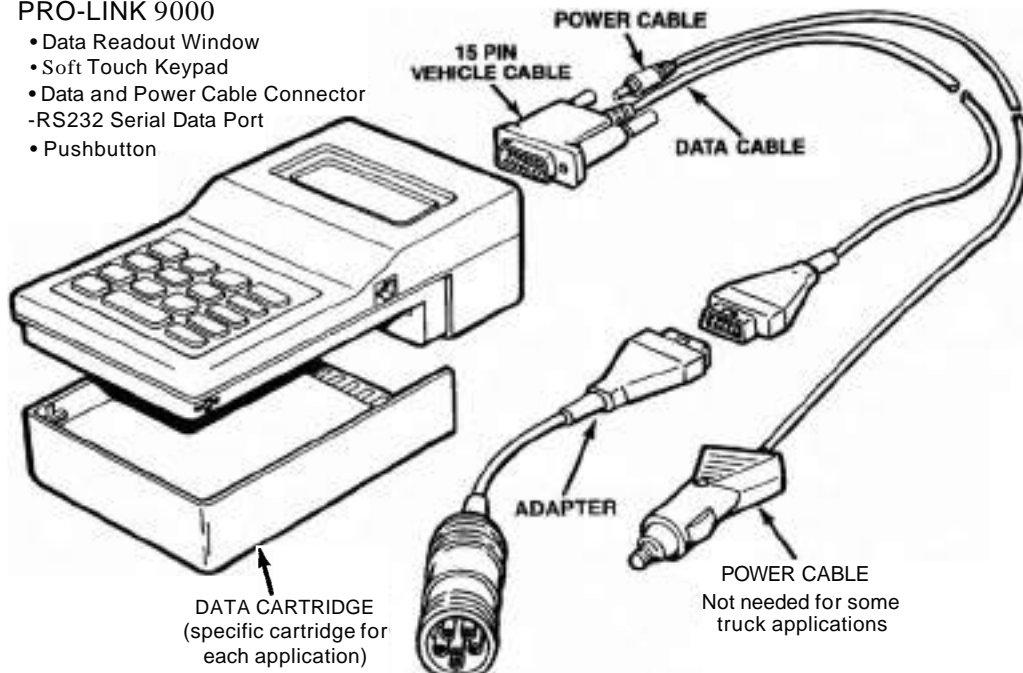
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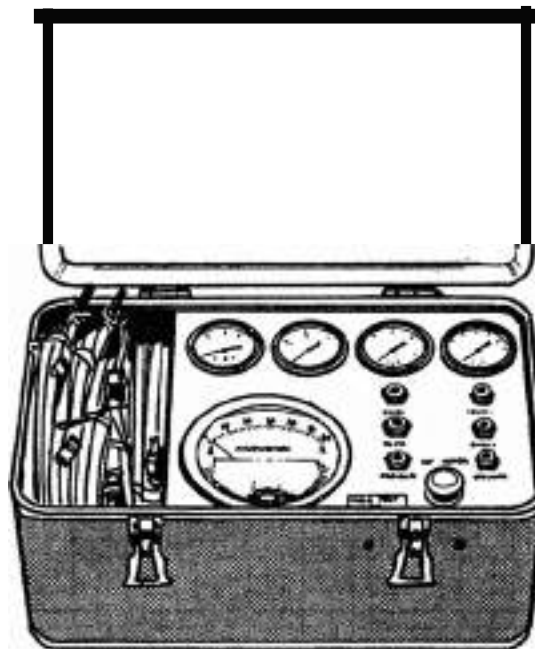
LISTED AND ILLUSTRATED IN THIS SECTION **ARE** THE NECESSARY DIAGNOSTIC TOOLS REQUIRED TO PERFORM ACCURATE DIAGNOSTICS

PRO-LINK 9000

- Data Readout Window
- Soft Touch Keypad
- Data and Power Cable Connector
- RS232 Serial Data Port
- Pushbutton



PRO-LINK 9000
{ZTSE-43661}

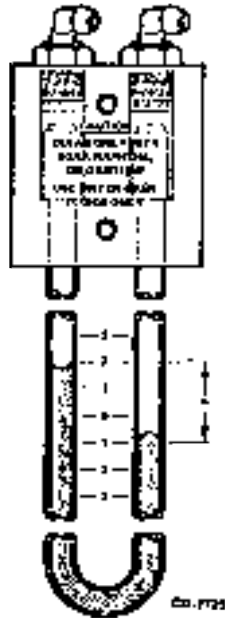


PRESSURE TEST KIT MODEL 0-200
{ZTSE-2239}

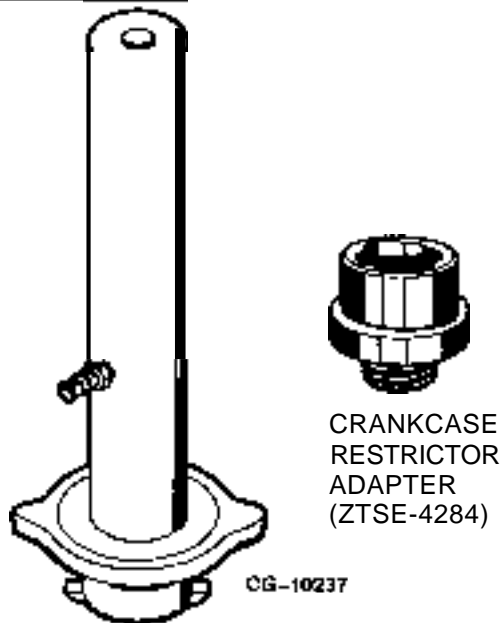
EGES-125-1

DIAGNOSTIC TOOLS

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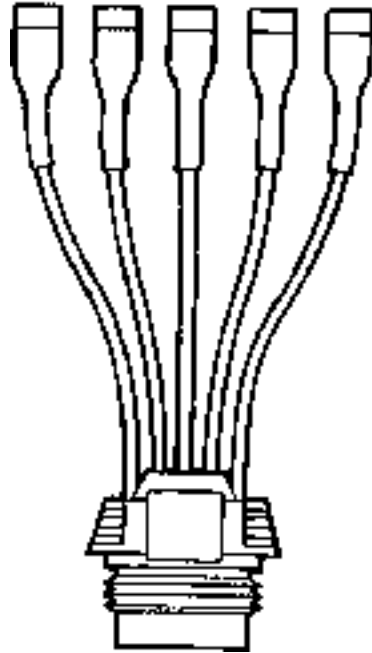
SLACK TUBE MANOMETER
DWYER NO. 1211-48



ORIFICED
RESTRICTOR TOOL
(ZTSE-4146A)

CRANKCASE
RESTRICTOR
ADAPTER
(ZTSE-4284)

TOOLS (Continued)



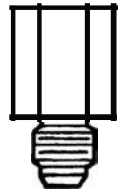
GLOW PLUG / INJECTOR BREAKOUT
(ZTSE-4345)



ICP / EBP BREAKOUT "T"
(ZTSE-4347)

DIAGNOSTIC TOOLS

TOOLS (Continued)

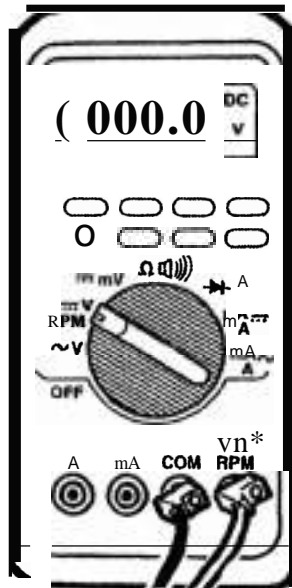


ADAPTER



PLUG

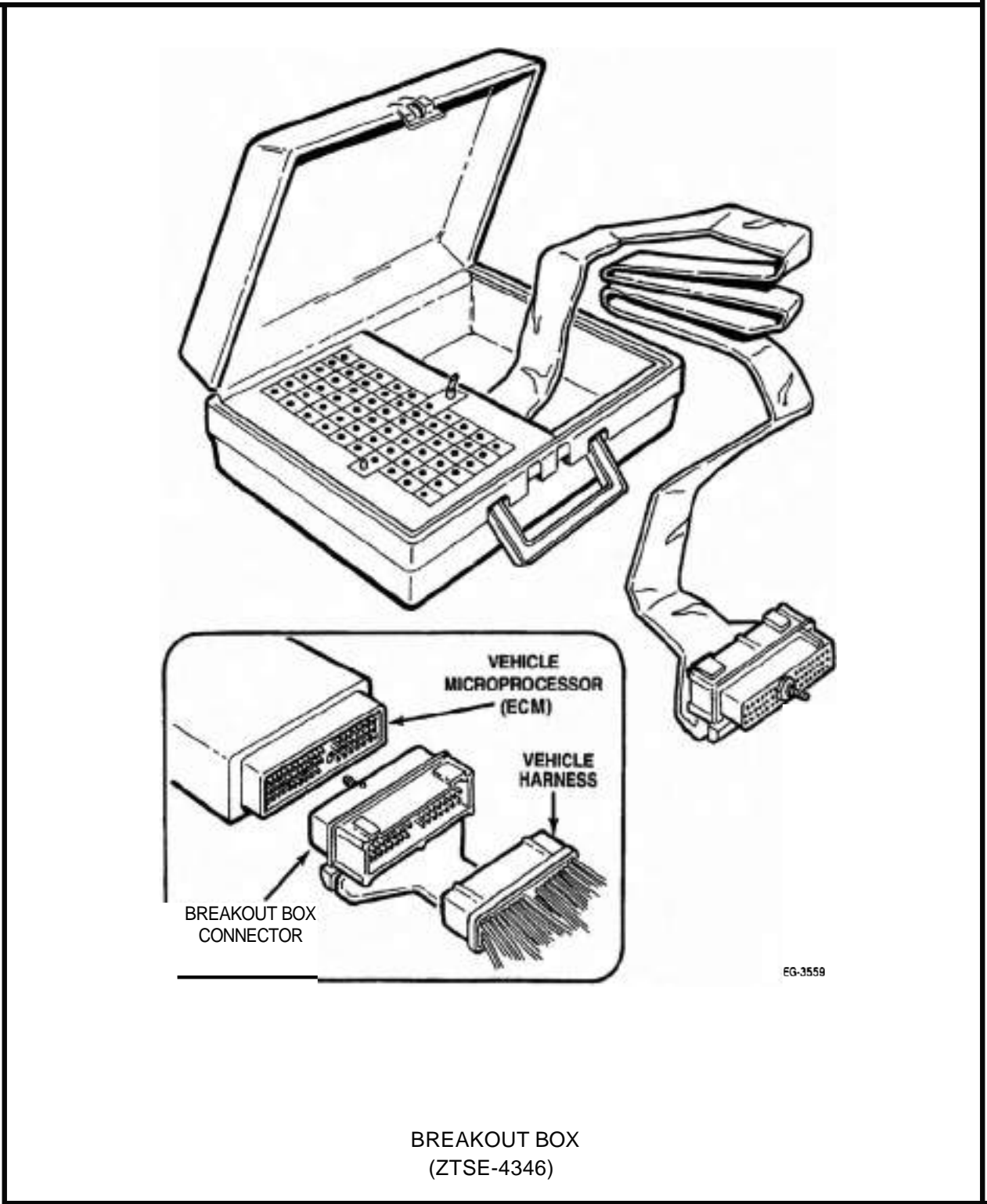
INJECTION CONTROL PRESSURE ADAPTER/PLUG KIT
(ZTSE-4359)



FLUKE 88 DIGITAL MULTIMETER
(ZTSE-4357)

DIAGNOSTIC TOOLS

TOOLS (Continued)



EG-3559

DIAGNOSTIC TOOLS

BEYERS MODEL 200 PRESSURE TEST KIT (ZTSE-2239)

DESCRIPTION

The Pressure Test Kit (Figure 5.1-1.) can be used to measure intake manifold (Boost) pressure, fuel pressure, air cleaner restriction, fuel restriction, exhaust back pressure and crankcase pressure. It may also be used to test the accuracy of the gauges within the kit.

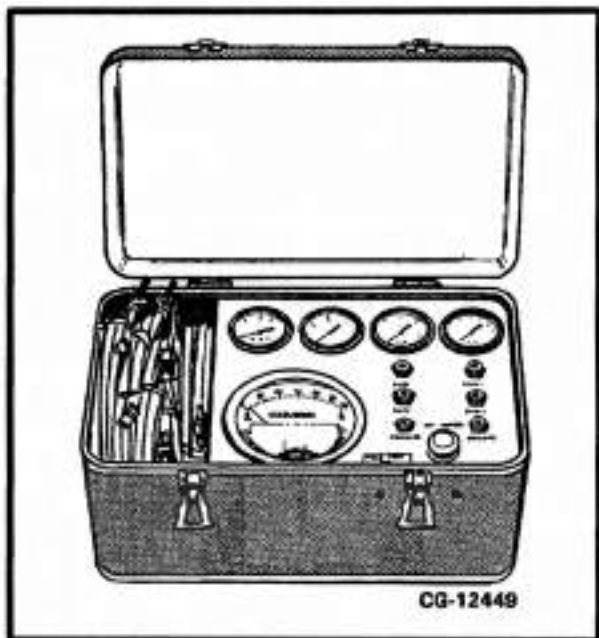


Figure 5.1-1. - Pressure Test Kit Model 200

The 0-30 psi gauge may be used to measure fuel pressure or intake manifold (Boost) pressure.

The 0-30 in. Hg. vacuum gauge (0-14.7 psi), is used to measure fuel system inlet restriction.

The 0-60 inches of water (magnehelic) gauge (0-2.16 psi), may be used to measure air cleaner restriction or crankcase pressure.



CAUTION!

THE QUICK DISCONNECTS HAVE SHUT-OFF VALVES IN THE PANEL CONNECTORS NOT IN THE PLUG. DO NOT CONNECT OR DISCONNECT LINES WHILE UNDER PRESSURE.

NOTE: When using the magnehelic gauge, be sure to plug the test line into the proper ("Pressure" or "Vacuum") port. Use the "Pressure" port to read exhaust back pressure and crankcase pressure. Use "Vacuum" port to read air cleaner restriction. In both cases, THE OPPOSITE CONNECTOR MUST BE VENTED TO THE ATMOSPHERE BY INSTALLING A QUICK CONNECTIVE PLUG IN THE PORT.

The 0-160 psi gauge may be used to check fuel pressure.

The D-300 psi gauge is not normally used for any engine diagnostic check.

OPERATING INSTRUCTIONS

Connect tubes between the test ports on the panel and the test points shown on the (REAR SIDE) of HART START NO START AND PERFORMANCE DIAGNOSTIC FORM EGED-13D-1.

DWYER SLACK TUBE MANOMETER

DESCRIPTION

The manometer (Figure 5.1-2.) is a "U" shaped tube with a scale mounted between the legs of the "U". Where the portability of the Model 200 Pressure Test Kit is not required, this manometer can be used to measure either low pressure or vacuum and may be filled with water.

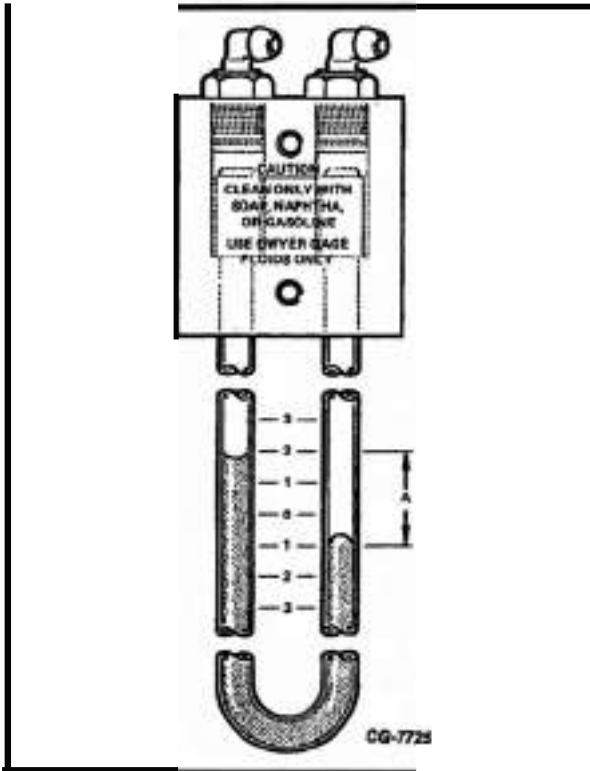


Figure 5.1-2. - Slack Tube manometer
(Dwyer No. 1211-48)
"A" Dimension Indicates Total Fluid Column

Order from: *Dwyer Instruments, Inc.*
Po. Box 373
Michigan City, Indiana 46360
Phone: (219) 872-9141

FILLING

The manometer may be filled with water, when checking very low pressures.

When filling with water, use only good drinking water without additives except for some colored water vegetable dye which enables the tester to read the scale easier. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

IMPORTANT

NEVER USE AN ANTIFREEZE SOLUTION, SODA POP, TONIC, ETC. THE INCREASE IN DENSITY CAUSES FALSE READINGS.

INSTALLING AND READING

1. Support the manometer in a vertical position. Be sure the fluid is at the zero mark on the scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Be sure the other leg is open to atmosphere.
3. Start the engine and when the engine is in the proper operating condition as specified, observe the manometer.
4. After about two minutes, record the average position the fluid level is above and below the zero mark. Add the two figures together. The sum of the two is the total column of fluid.

NOTE: At times both columns of the manometer will not travel the same distance. This is of no concern to the tester as long as the leg not connected to the pressure or vacuum source is open to the atmosphere.

CLEANING

1. Wash the tube thoroughly with a little pure soap and water. Avoid liquid soaps and solvents.

DIAGNOSTIC TOOLS

ORIFICED RESTRICTOR TOOL (ZTSE-4146A) and ADAPTER (ZTSE-4284)

DESCRIPTION

This Orificed Restrictor tool (ZTSE-4146A) in conjunction with the Restrictor Adapter (ZTSE-4284) (Figure 5.1-3.) are used to measure combustion gas flow out of the engine.

NOTE: ENGINE MODELS WHICH ARE EQUIPPED WITH A ROAD DRAFT TUBE DO NOT REQUIRE THE USE OF THE RESTRICTOR ADAPTER.

The Orificed Restrictor contains an integral oil fill cap which provides nearly effortless set-up when performing a crankcase pressure test on the T 444E Diesel Engine. The Model 0-200 Pressure Test Kit may be used to perform the crankcase pressure test.

IMPORTANT

PRESSURE READINGS OBTAINED WITH THIS RESTRICTOR MUST NOT BE USED AS THE MAIN SOURCE OF ENGINE CONDITION. OIL CONSUMPTION TREND DATA MUST ALSO BE USED IF THE PRESSURE READINGS ARE BEYOND THE SPECIFIED LIMITS. NEITHER CHANGES IN OIL CONSUMPTION TRENDS NOR CRANKCASE DIAGNOSTIC PRESSURE TRENDS CAN ESTABLISH A SPECIFIC COMPONENT PROBLEM BUT ARE ONLY INDICATORS THAT SOME PROBLEM EXISTS.

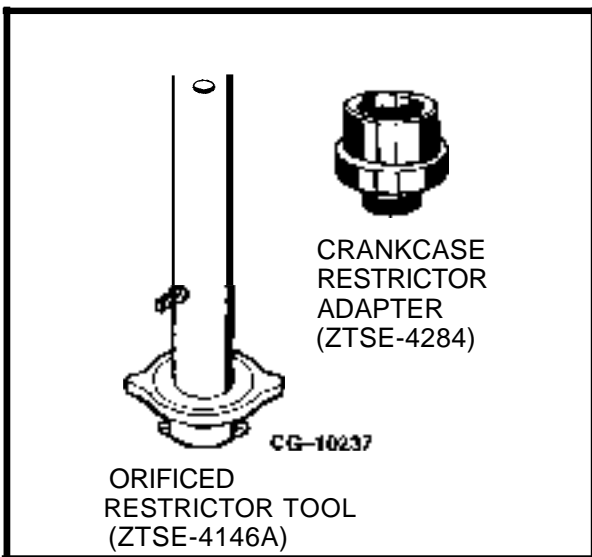


Figure 5.1-3. - Crankcase Pressure Diagnostic Tools

GLOW PLUG / INJECTOR BREAKOUT (ZTSE-4345)

DESCRIPTION

The Glow Plug/Injector breakout tool (ZTSE-4345) (Figure 5.1-4.) is used to check injector solenoid continuity and glow plug resistance to ground. Refer to Mechanical Diagnostics Section, 2.2 (Hard Start/No Start Diagnostics) for use of this tool.

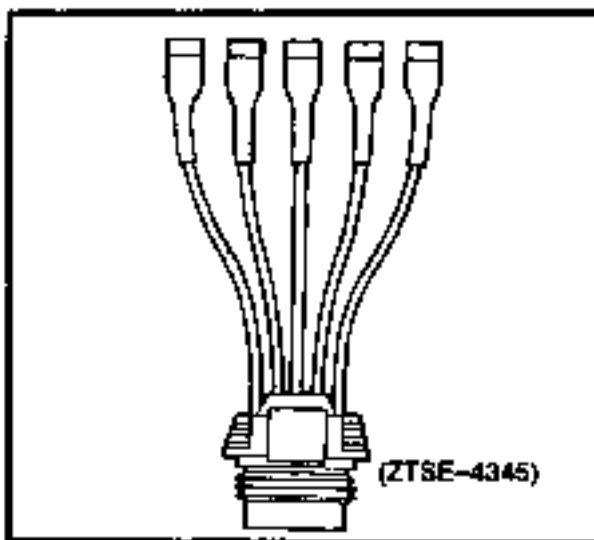


Figure 5.1-4. - Glow Plug / Injector Breakout

ICP / EBP BREAKOUT "T" (ZTSE-4347)

DESCRIPTION

ICP Injection Control Pressure / Exhaust Back Pressure Sensor Breakout "T" (ZTSE-4347) (Figure 5.1-5.) is used to gain access to Injection Control Pressure and Exhaust Back Pressure signal voltages. The "T" enables the technician to quickly connect a voltmeter to read voltage (pressure) signals at each of the sensors. Use of the "T" to measure Injection Control Pressure is shown in Hard Start/No Start Diagnostics Section 2.2. For use in measuring exhaust back pressure, refer to Performance Diagnostics Section 2.3.

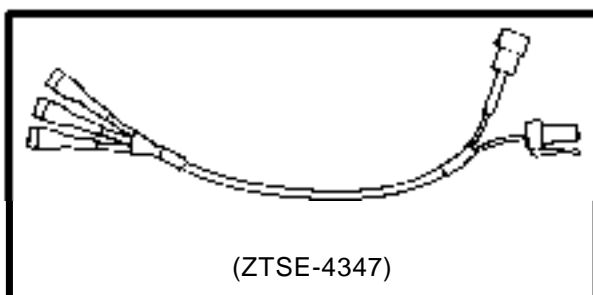


Figure 5.1-5. -ICP / EBP Breakout "T"

INJECTION CONTROL PRESSURE ADAPTER/ PLUG KIT (ZTSE-4359)

DESCRIPTION

Injection Control Pressure Adapter/Plug Kit (Figure 5.1-6.) is used in performing High Pressure Leakage Tests on the Injection Control Pressure system. The adapter allows the ICP sensor to be installed in either of the high pressure oil hoses during the leakage tests. The plug is used to block off flow of oil in the high pressure hoses. Refer to High Pressure Leakage Tests in Hard Start/No Start Diagnostics Section 2.2 of this manual for proper use of this kit.

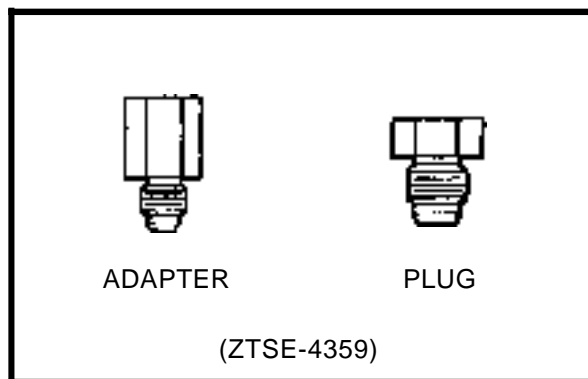


Figure 5.1-6. -ICP Adapter/Plug Kit

FLUKE 88 DIGITAL MULTIMETER (ZTSE-4357)

DESCRIPTION

The Fluke 88 multimeter (ZTSE-4357) (Figure 5.1-7.) allows the technician to troubleshoot the electrical components (sensors, injector solenoids, relays, wiring harnesses etc.) associated with the T 444E Diesel Engine. In addition, it measures engine RPM. This feature allows the technician to measure engine cranking RPM when the Electronic Service Tool (EST) is not available or is unable to receive ATA data. This meter has a high input impedance which allows testing of sensors while the engine is running, without loading the circuit which is being tested. This ensures the signal voltage measurement will not be affected by the voltmeter.

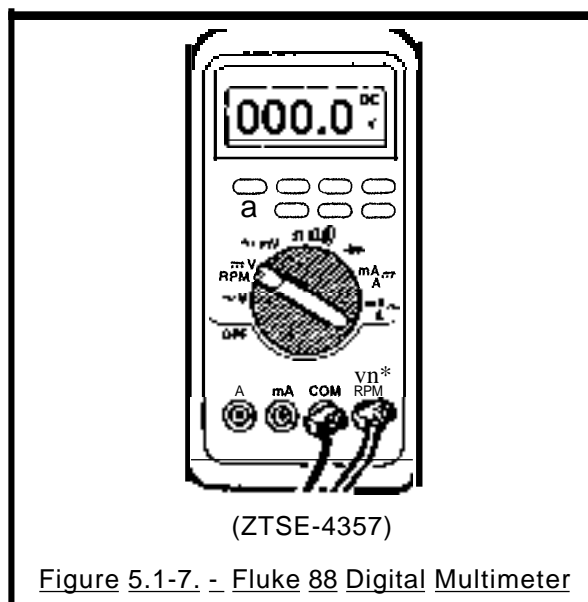


Figure 5.1-7. - Fluke 88 Digital Multimeter

DIAGNOSTIC TOOLS

BREAKOUT BOX (ZTSE-4346)

Breakout Box (ZTSE-4346) (Figure 5.1-8.) was designed to allow testing of the electronic control system components without disturbing connections or the piercing of wire insulation to gain access to the various signal voltages in the electronic control system.

2. Remove the 60 way connector from the ECM. Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter to the ECM.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.

BREAKOUT BOX INSTALLATION

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.

Readings can now be taken at the test connections in the breakout box. The numbers at the test connections correspond to the ECM terminal numbers.

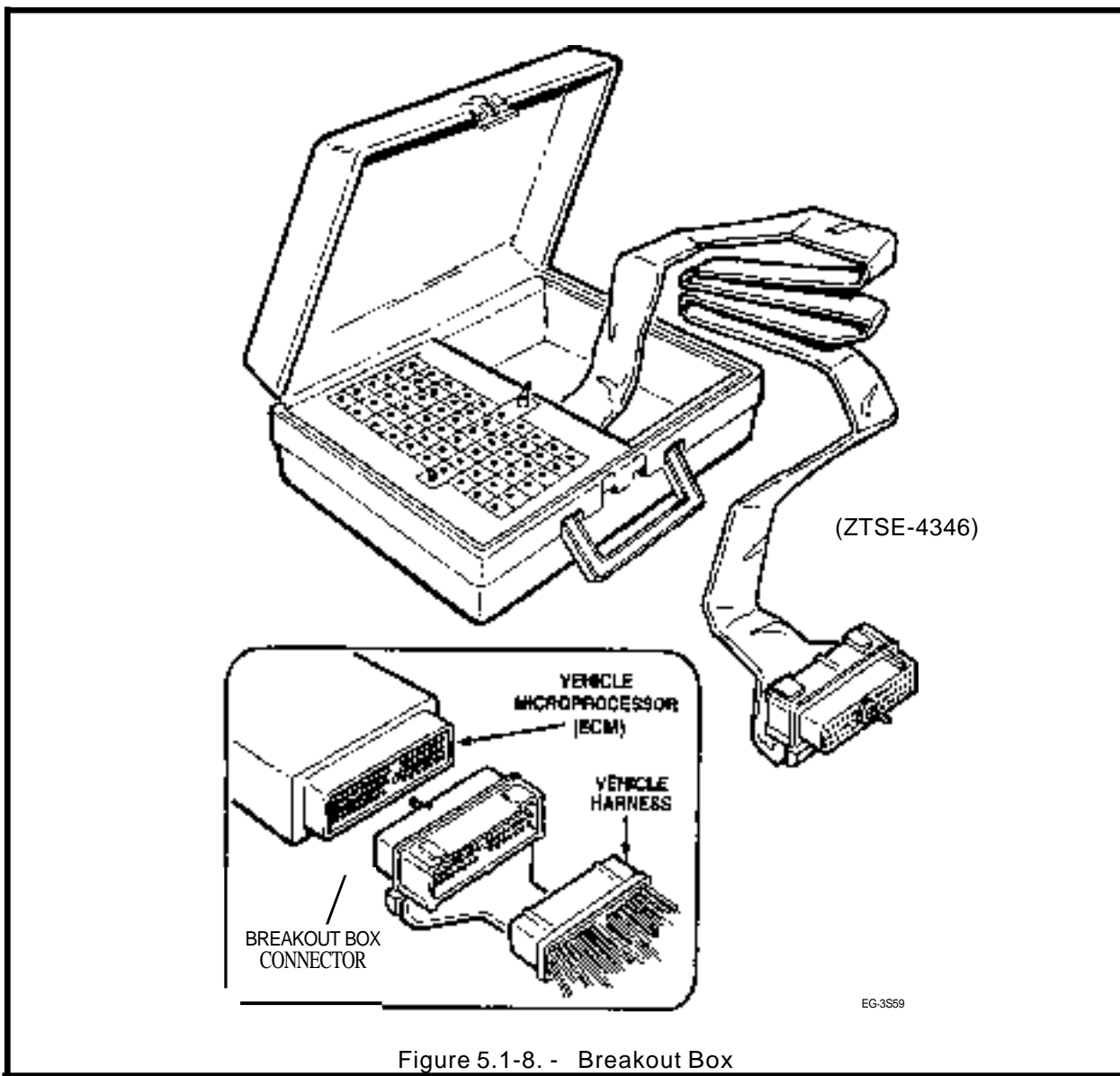


Figure 5.1-8. - Breakout Box

PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

DESCRIPTION

Fault codes can be detected and stored in three components. The IDM (Injector Driver Module), the ECM (Electronic Control Module), and the VPM (Vehicle Personality Module).

The EST (Electronic Service Tool) (Figure 5.2-1.) is used to access stored fault codes by plugging it into the American Trucking Association (ATA) data link connector located in the cab of the vehicle. This allows the tool to communicate with the VPM and gather faults from the ECM and IDM through the VPM.

DIAGNOSTIC CODE RETRIEVAL

Turn all accessories and the ignition off. Connect the EST tool to the (ATA) diagnostic connector located on the lower left kick panel inside the cab. The screen of the reader should light up as soon as the tool is plugged in.

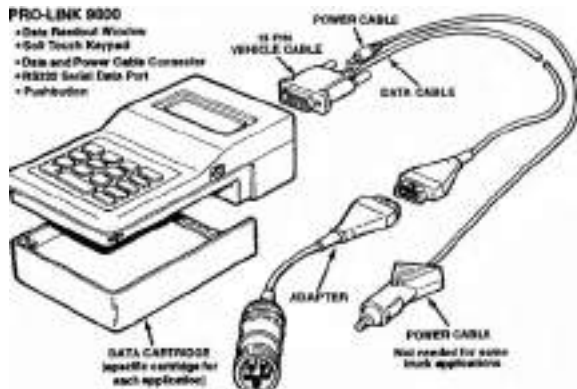


Figure 5.2-1. - Electronic Service Tool Pro-Link 9000

Turn the ignition key to the "ON" position but do not start the engine. This will allow the EST to receive data from the electronic control components on the truck. If no data is received press "ENTER" to retry. The information received will be data as to the current status of the engine.

To access the fault codes press the "FUNC" key to switch to the main menu.

NAVISTAR MRD
SELECT DESIRED
MENU
[ENGINE] ↔ PRC-L1NK

From the main menu select "ENGINE" by pressing the "←" key. This will cause the brackets to be placed around the "ENGINE" selection. Then press "ENTER".

From the next menu, select "DIAGNOSTIC CODES". The selection will have the "↑↓" symbol on the screen, which means there are other selections available. By pressing the "↓" key the other selections will display on the screen. The first screen that will appear will be "DIAGNOSTIC CODES". If another option was selected press "↓" key until "DIAGNOSTIC CODES" appears on the screen. Next press "ENTER". At this point diagnostic codes can be accessed.

NAVISTAR MRD
ENGINE MENU

↑
DIAGNOSTIC CODES

ACTIVE CODES

The first option that will appear is "ACTIVE CODES". By selecting this option, the fault codes that are currently occurring or that have occurred during the last key on cycle will be displayed. Press "ENTER". If there are any "Active Codes" the first one will appear on the screen along with a description of the code. If there are any additional codes "Active" the "↑↓" symbol will appear on the screen.

Press "↓" key to access additional codes. If there are not any codes "Active", "NO ACTIVE CODES" will appear on the screen.

NAVISTAR MRD
DIAGNOSTIC CODES

↑
ACTIVE CODES

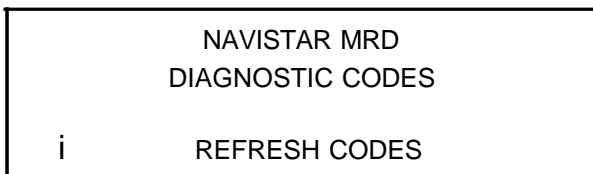
PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

DIAGNOSTIC CODE RETRIEVAL Continued

REFRESH CODES

If the fault that caused the "Active Code" is no longer malfunctioning, it will still be displayed as an "ACTIVE CODE", until the key is cycled off. To update the active codes in the EST, without turning the key off, press the "FUNC" key to return to the "DIAGNOSTIC CODES" MENU".

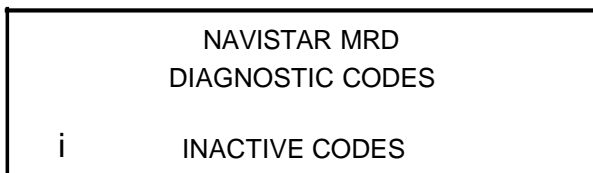
Press the "↓" key repeatedly until the "REFRESH CODES" selection appears on the screen. Press "ENTER" and the codes will update in the EST.



INACTIVE CODES

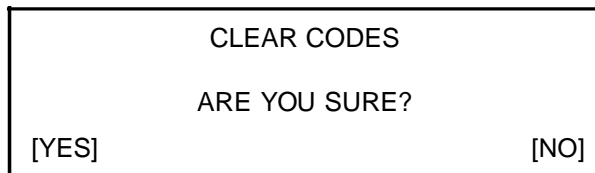
To access "Inactive Codes" press the "FUNC" key. This will access the last prior selection. Then press the "↓" key to select "INACTIVE CODES". Press the "ENTER" key.

Inactive codes are faults that have occurred in the past, and are now stored in memory. An "Active Code" will become an "Inactive" code if the key is shut off or the malfunction no longer exists (such as an intermittent problem).



CLEAR CODES

To remove the codes from the memory, the EST is equipped with a "CLEAR CODES" option. To access this option, press the "FUNC" key, this will revert back to the "DIAGNOSTIC CODES" menu. Press the "↓" key until "CLEAR CODES" appears on the screen. Press the "ENTER" key and the screen will ask "ARE YOU SURE?" Press the "←" key to select "YES". Press "ENTER" and the codes will be deleted.



DIAGNOSTIC TESTS

Diagnostic tests are "Self Tests" performed by the electronic components upon demand by the operator. The "Self Tests" check various output circuits to determine if they are functioning properly.

There are two types of self tests.

1. "ENGINE OFF"
2. "ENGINE RUNNING"

"ENGINE OFF" self tests check output circuits electrically for open or short circuits with the engine not running.

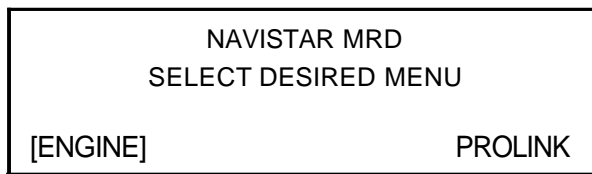
The "ENGINE RUNNING" test, checks the outputs of engine electronic controls with the engine running. The effect on engine operation is measured and compared to an expected level. If the level of operation is not within specification, a fault is recorded.

DIAGNOSTIC TESTS - Continued

ENGINE OFF TEST

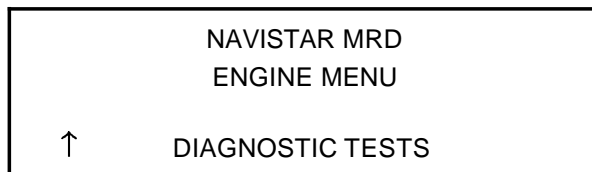
To perform "Engine Off" self tests, turn off all accessories and ignition off. Connect the EST to the ATA connector on the vehicle. Access the "ENGINE OFF TESTS" in the "DIAGNOSTIC TESTS" section of the EST.

To access this test, press the "FUNC" key. This will allow access to the last prior selection. Or press the "FUNC" key repeated until the main menu appears on the screen.

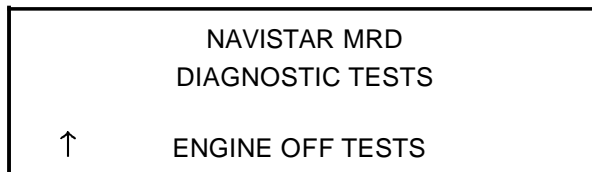


Move the brackets to engine selection by pressing the "←" key. Then press "ENTER".

Next select the "DIAGNOSTIC TESTS" menu by pressing the "↓" key, until "DIAGNOSTIC TESTS" is shown on the screen. Press enter to make this selection.



Press the "↓" key until the "ENGINE OFF TESTS" is shown on the screen. At this point, press "ENTER".



After the "ENTER" key is pressed, the EST will cause the ECM to perform a self test.

When the test is complete, the screen will display the number of new faults found in the self test. If there are any additional faults found, press "ENTER" and the faults will be displayed. If there is more than one fault found during the test, the "↑↓" symbol will be shown on the screen. Press the "↓" key to access any additional faults.

After the "ENGINE OFF TEST" has been performed several other tests are available.

At the completion of the "ENGINE OFF TEST" press the "FUNC" key to access the "ENGINE OFF TEST MENU".

The first option will be "ACTIVE CODES". By selecting this option, any active codes will be displayed.

STANDARD TEST (ENGINE OFF)

Press the "↓" key to display other options. The next option will be "STANDARD TEST". By selecting this option, the "ENGINE OFF TEST" will be repeated.

INJECTOR TEST (ENGINE OFF)

Press the "FUNC" key to continue. The next option is "INJECTOR TEST". By selecting this test the ECM will exercise (Buzz) the electronic injectors. During this test it will measure the circuits as well activate the injectors. This will allow the technician to listen to the operation of the injector without the engine running. At the completion of the test, if the electronic components detect any faults they will be recorded and displayed. Also by monitoring the noise made by the injector the technician can determine if an injector does not fire electronically.

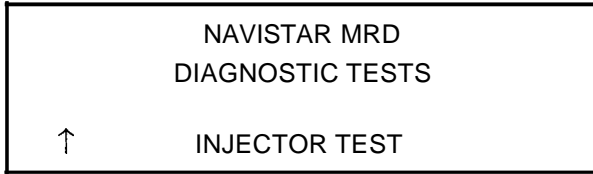
Note: This test can only be done after the Engine Off test has been completed.

Select the "INJECTOR TEST" then press the "ENTER" key.

PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

DIAGNOSTIC TESTS - Continued

INJECTOR TEST (ENGINE OFF) - Continued



Depressing the "ENTER" key will start the test.

At first all the injectors are energized, a loud buzzing noise can be heard.

Next, each injector will be energized individually. This will proceed in sequence starting at number 1 cylinder and proceeding through number 8 cylinder. All eight injectors should be heard as the injectors fire.

After the injectors are fired individually the complete sequence will repeat several times.

At the end of the test, the screen will indicate if any faults were found. If faults are indicated, press the "ENTER" key. This will display any faults that were recorded. If there are multiple faults the "↑↓" symbol will appear on the screen. Press the "↓" key to display the other faults.

OUTPUT STATE TEST

The next test available is the "OUTPUT STATE TEST". This will signal the ECM to energize the output circuits for testing.

There are two modes of operation during this test. The first is "OUTPUT ARE LOW" and the other is "OUTPUTS ARE HIGH".

When in the "OUTPUTS ARE LOW" mode the ECM will pull down the output voltage to ground. This will actuate the output components that are controlled by the ECM grounding the circuits. During this test "OUTPUTS ARE LOW" will be displayed on the screen.

When in the "OUTPUTS ARE HIGH" mode the ECM will pull up the output voltage to 12 volts. This will actuate the output components that are controlled by the ECM energizing the control circuits with 12 volts. During this test, "OUTPUTS ARE HIGH" will be displayed on the screen.

During this test, the following components will be exercised, IDM Enable relay, EPR (Exhaust Back Pressure Regulator), IPR (Injection Pressure Regulator), Eel (Engine Crank Inhibit Relay), EDL (Engine Data Link Relay), OWL (Oil/Water Light & Alarm), VRE (Vehicle Retarder enable) relay and WARN engine light.

To access this test press the "↓" key until "OUTPUT STATE TEST" appears on the screen. Press "ENTER" to start the test.

Press the "ENTER" key to switch from "OUTPUTS ARE LOW" to "OUTPUTS ARE HIGH". The mode will change each time the "ENTER" key is pressed.

To end the test press the "FUNC" key.

While the test is being performed the technician can measure output circuits to be certain the ECM outputs are functioning properly.

VSS TEST

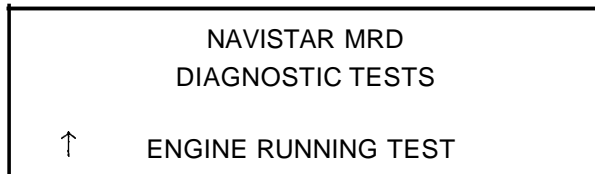
Not available at present.

ENGINE RUNNING TEST

The "ENGINE RUNNING TEST" will test engine outputs and performance with the engine running. This will allow the technician to determine if the outputs are within proper operating specifications.

Engine running tests can only be performed with the engine above 160° F (71° C) and no vehicle speed.

To access the "ENGINE RUNNING TEST", from the "DIAGNOSTIC TESTS" menu, press the "↓" key until "ENGINE RUNNING TEST" is displayed on the screen. Press the "ENTER" key to start the test.



Pressing the "ENTER" key will begin the test. The ECM will raise the engine low idle and command full ICP (Injection Control Pressure). The ECM will then measure what the actual pressure is and compare it to the commanded value.

DIAGNOSTIC TESTS - Continued

ENGINE RUNNING TEST - Continued

After testing Injection Control Pressure, the ECM will activate the ESP (Exhaust Back Pressure) step test. It will then command a specific back pressure and measure the EBP signal. The ECM will then compare the expected value against the commanded value to determine if the exhaust back pressure device is functioning correctly.

At the completion of the test the engine will return to normal low idle and the screen will display the number of faults found.

If there are any faults found, press the "ENTER" key to display the faults. If the "↑↓" symbol is shown, more faults are accessible. Press the "↓" key to display additional faults.

After the "ENGINE RUNNING TEST" has been completed the injector test is accessible.

INJECTOR TEST

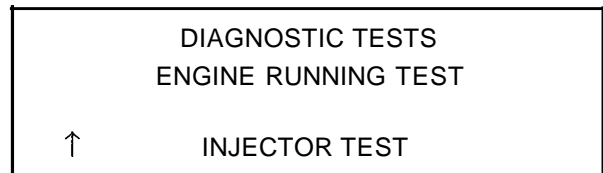
The injector test will test each cylinder's contribution. This will measure how much work is being done by each cylinder as compared to the other cylinders.

The ECM will measure this by increasing the amount of fuel delivery to the injector being tested and monitoring the reduction in the other cylinders to maintain engine speed. If there is no reduction in fuel delivery to the other cylinders, the ECM will set a fault code.

To access the "INJECTOR TEST" from the Diagnostic Tests menu press the "↓" key until the "INJECTOR TEST" is shown on the screen under the "ENGINE RUNNING TESTS" menu. Then press the "ENTER" key.

Note 1: "ENGINE RUNNING TEST" must be performed first to access this test.

Note 2: While performing this test the engine will run rough!



When the test is complete, the number of faults found will be displayed. If there are any faults found press the "ENTER" key to display the faults. If there is more than one fault, the "↑↓" symbol will be displayed. Press the "↓" key to display other faults.

TACH BUFFER TEST

The Tach Buffer Test checks the circuit between the ECM and VPM along with the internal buffer circuit in the VPM.

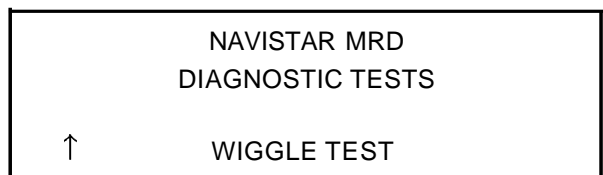
To perform this test select the "TACH BUFFER TEST" from the "ENGINE RUNNING TEST" menu.

The test must be performed with the engine speed above 1250 RPM.

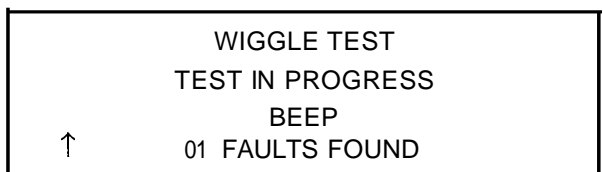
WIGGLE TEST

"WIGGLE TEST" is available under the Diagnostic Test Menu. The wiggle test is to assist the technician in finding an intermittent condition. The wiggle test will monitor both signal outputs and inputs on a continuous basis. Any interruption in the circuit will cause a fault.

To access "WIGGLE TEST" from the Diagnostic Test Menu, press the "↓" key until "WIGGLE TEST" is displayed on the screen. Press the "ENTER" key, to start the test.



At any time during the Wiggle Test if an open or short is detected, the EST will beep and the word "BEEP" will display on the screen.



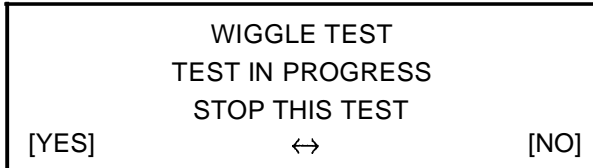
PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

DIAGNOSTIC TESTS - Continued

WIGGLE TEST - Continued

While in the Wiggle mode, the technician can move and wiggle the wiring harness and connectors to locate the problem.

To end the test press the "FUNC" key. The message will ask "STOP THIS TEST" press the "←" key to select yes. This will end the test.

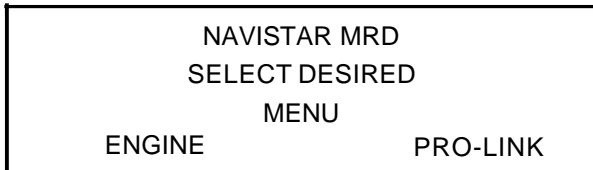


If any faults were detected, press the "ENTER" key to display the fault.

SERVICE TOOL FUNCTIONS

PRO-LINK FUNCTIONS

Several options are available in the Pro-Link tool menu. To access these functions press the "→" key to select the "PRO-LINK" options. This will cause brackets [] to be placed around "PRO-LINK". Press the "ENTER" key to make this selection.



From the tool menu press the "↓" key to display the tool functions.

CONTRAST ADJUST

From the "CONTRAST ADJUST" display press the "ENTER" key to select this option.

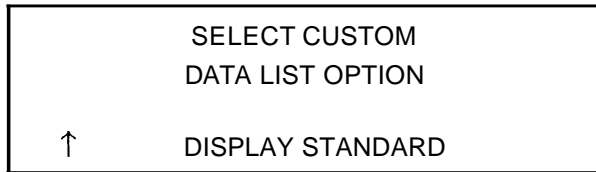
Use the "↑↓" keys on the Pro-Link keypad to adjust the contrast of the characters on the Pro-Link display.

ENGLISH/METRIC

The Pro-Link displays in either English or Metric units. To select the feature, press the "← →" keys to select either English or Metric. Press the "ENTER" key to enter the selection.

CUSTOM DATA LIST

This selection enables the technician to design a custom data list, placing data items in the list in the order that the technician chooses to view them. When the Custom Data List is selected from the Function Menu, the following screen is displayed.



Display Standard

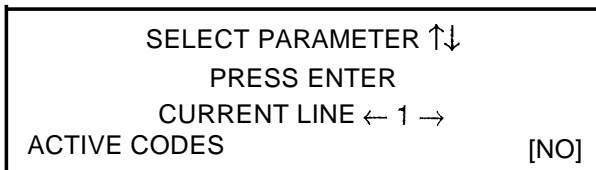
The Pro-Link stores in memory both the Standard Data List and one Custom Data List created by the technician. Selecting Display Standard selects the default list configuration for viewing and printing data lists. Pressing the "ENTER" key presents Diagnostic Data on the display in the Standard format for viewing.

Display Custom

Selecting Display Custom, selects the list configuration created with the Edit Custom menu selection. The Pro-Link displays Diagnostic data on the Pro-Link screen in the chosen custom format. If no custom list exists, the Standard List is displayed.

Edit Custom

Selecting Edit Custom enables the technician to configure how he wants to view Diagnostic Data on the Pro-Link screen and/or from a printer. The editing screen is shown below.



PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

SERVICE TOOL FUNCTIONS - Continued

CUSTOM DATA LIST - Continued

The table below shows the keys used for creating the Custom Data List and the result of the key.

FUNC	Exits Edit Custom Mode
→	Scrolls up Current Line number and Parameter
←	Scrolls down Current Line
↑	Scrolls up the Parameter only, Current Line Number unchanged
↓	Scrolls down the Parameter only, Current line number unchanged
ENTER	Accepts the Current Line number and Parameter combination

To create a custom Data List:

- Select the desired data line as the Current Line number.
- Select the desired parameter to be displayed on the line.
- Press the ENTER key. No change to the data list occurs unless ENTER is pressed.
- Repeat for each Data Line.

Reset Custom

This selection resets the Custom Data list back to the Standard List form. When selected, the following screen is displayed.

RESET CUSTOM LIST BACK TO STANDARD ARE YOU SURE? ← →	
YES	[NO]

No is the default action. Reset the Custom Data List to the Standard List by pressing the ← key to Select YES, then press the "ENTER" key.

NOTE: If the Custom Data List is reset to the Standard List form, the Custom List is lost and must be recreated.

RESTART

Restart resets the Pro-Link to the beginning of the program. The contrast adjustment is not affected by Restart.

RS-232 SERIAL PORT

This selection allows the technician to configure the Pro-Link RS-232 serial port for either printer or terminal (personal computer) output. The screen below appears when this item is selected.

RS-232 SERIAL PORT FUNCTION MENU	
↑	PRINTER OUTPUT

This selection is used to print out diagnostic information.

The Pro-Link is set up to print to the Pro-Link Printer and no Port Setup is necessary for that printer. In order to print to a different printer, follow the instructions under Port Setup, in the Electronic Service Tool manual.

The following screen will be displayed if the "PRINTER OUTPUT" function is selected.

SELECT DATA TO PRINT	
↑	DATA LIST

There are five types of data which can be printed out:

DATA LIST
DIAGNOSTIC CODES
CALIBRATION DATA
SNAPSHOT DATA
REPROG PARMS

Press the "↓" key to select other options. Press "ENTER" and the selection will be printed.

PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

SERVICE TOOL FUNCTIONS - Continued

Snapshot

Selecting the Snapshot option will display the following screen.

```
DO YOU WISH TO PRINT
THE COMPLETE LIST
OR A CUSTOM LIST?
[COMPLETE]  ← →  CUSTOM
```

Complete

Choosing "COMPLETE" produces a screen as shown below.

```
SNAPSHOT PRINTOUT
SELECT FRAMES
TRIG = ###          FRAMES =###
START=###
```

TRIG = Frame number that contains the trigger.

FRAME = Total number of frames in Snapshot memory (a frame is one complete Data List)

START = The first frame desired to print

Selecting "COMPLETE" will print all lines of the data list. Enter the first frame desired to print at "START" and press "ENTER". Now line four will display END = # # #. Enter the last frame desired to print and press "ENTER". The tool will now print the complete data list for each of the frames that are selected.

Custom

Selecting Custom produces the following screen.

```
SELECT UP TO 6 DATA
PARAMETERS TO PRINT
USE FUNC TO QUIT
ENTER TO CONTINUE
```

Press the "ENTER" key and the following screen appears.

```
SELECT DATA TO PRINT
PRESS ENTER
COLUMN # = 1
ACTIVE CODES
```

Use the "↑↓" keys to scroll the list on line four. Choose the item desired for column 1 of the custom list, press the "ENTER" key. Line three, "COLUMN #", advances to 2. Repeat this procedure for all six columns of data to be printed. Press the "FUNC" key when finished! The Select Frames screen appears. Select the desired frames to print and the Custom printout will begin.

SNAPSHOT

Snapshot allows the technician to record data from the Data List, for review. This can be helpful for correcting data while driving the truck or for searching for an intermittent problem.

The following functions are available for Snapshot:

- Quick Trigger
- Trigger Setup
- Data Update Rate
- Review Snapshot

Quick Trigger

The Quick Trigger function enables the technician to take a second Snapshot quickly, using the previous setting established during Trigger Setup for the first Snapshot. It is not necessary to reset the setup values for each Snapshot. Press the "ENTER" key and the data is displayed on the Pro-Link screen.

The Quick Trigger default trigger is Any Numeric Key. Press any numeric key on the Pro-Link keypad to start recording data. Press any numeric key again to stop recording data.

PRO-LINK 9000 ELECTRONIC SERVICE TOOL OPERATION

SERVICE TOOL FUNCTIONS - Continued

Trigger Setup

Trigger Setup allows the technician to configure how and when Snapshot triggers. Selecting this option displays the screen shown below.

SELECT SNAPSHOT TRIGGER SOURCE	
↑	ANY NUMERIC KEY

Four choices are available for Snapshot triggering.

- Any Numeric Key
- Any Code
- Specific PID
- Specific SID

Any Numeric Key

Choosing this option requires the technician to press any numeric key on the Pro-Link keypad to activate the trigger.

Specific Code, PID and SID

When selecting a Specific Code, PIO or SID a screen is displayed which enables the technician to choose the Code, PID or SID to trigger on from a list of those choices.

Setting Memory Trigger Point

Selecting any of the Trigger Setup options presents the display below.

DO YOU WISH TO ADJUST THE MEMORY TRIGGER POINT		
YES	← →	[NO]

NO is the default. To adjust the trigger point, use the "←" key to select YES, then press "ENTER". Selecting YES present the following screen.

T INDICATES LOCATION OR TRIGGER IN MEMORY		
BEG	MID	END
.....oT.....		

Use the ← → keys on the Pro-Link keypad to adjust the location of "T" along the line, then press "ENTER" to accept this position. When the trigger occurs, all data to the right of "T" was received after the trigger occurred or towards the end of the Snapshot, Data to the left of "T" was received before the trigger occurred or towards the beginning of the Snapshot.

Processing the Trigger

After defining all the setup functions, pressing the "ENTER" key presents the prompt on the screen, "WAITING FOR TRIGGER".

The Pro-Link is now storing data from the ECM and waiting for the trigger condition to occur. When the trigger occurs, the prompt is displayed "PROCESSING TRIGGER". The Pro-Link will record data in its memory buffer until full. When complete refer to "Review Snapshot".

Review Snapshot

This function will only be displayed when there is Snapshot data in memory to view. The Snapshot should have been triggered previously and the data stored in memory. The following screen is displayed.

DATA
DATA
DATA
T =# # # C =# # # GOTO

PRO-LINK 9000

ELECTRONIC SERVICE TOOL OPERATION

SERVICE TOOL FUNCTIONS - Continued

Review Snapshot - Continued

The "↑↓" keys are active and scroll the data up and down. The "← →" keys scroll the current frame number (C). Pressing any numeric key followed by pressing the "ENTER" key reverts to that frame number. Entering a GOTO frame number greater than the number of frames in memory, reverts to the highest frame in memory. Pressing the "ENTER" key without having pressed any other key presents the codes for that frame. Arrows appear on line four if there is more than one code. Pressing "ENTER" again reverts back to the Review Snapshot Data List mode. Data Update Rate

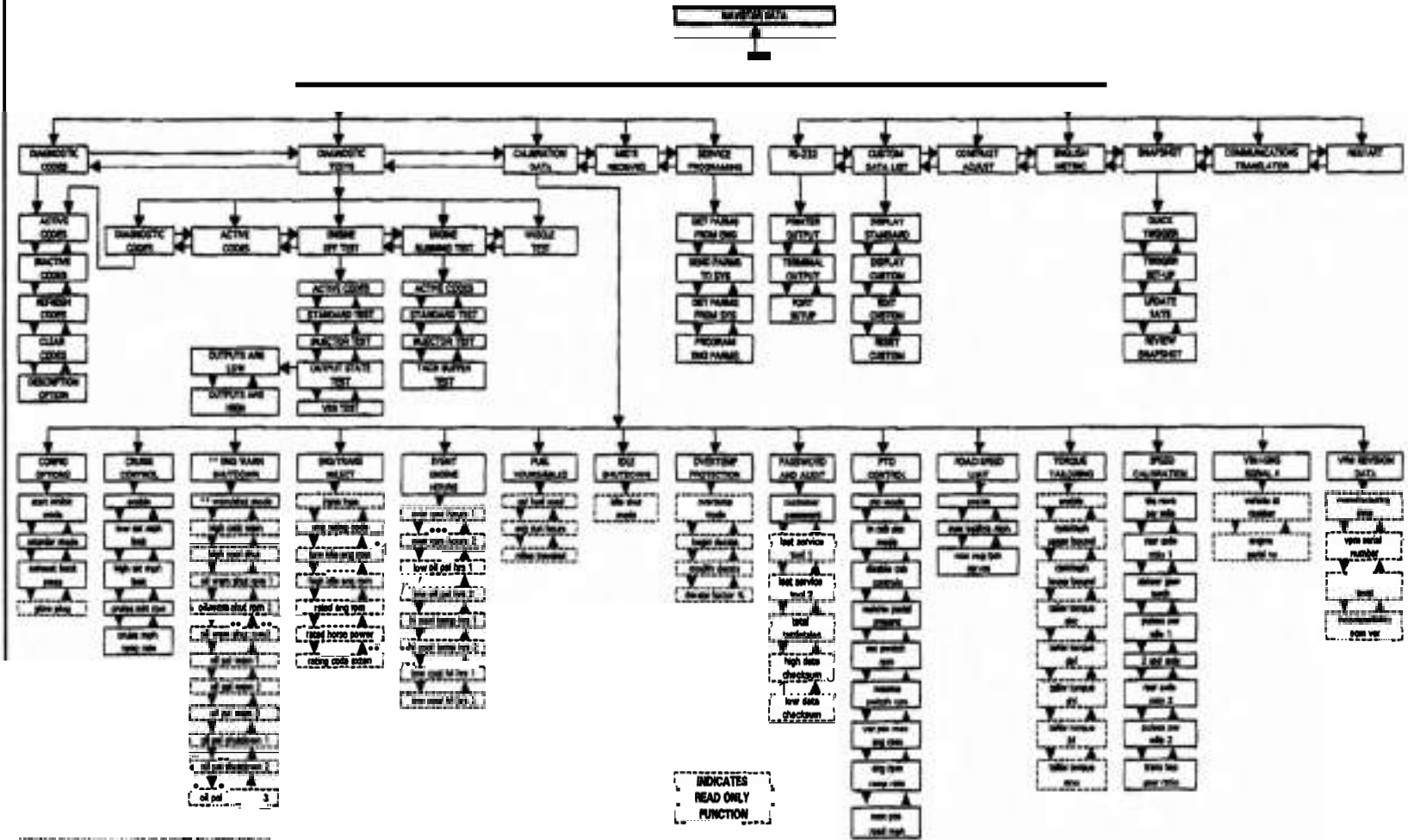
This selection gives the technician the ability to determine how often Snapshot data is updated in

memory. As the time is increased, the delay between sampling frames is increased. The following screen is displayed when this option is selected.

DATA UPDATE RATE
SELECT DELAY
THEN PRESS ENTER
CURRENT =0.1 NEW =0.1

On the numeric keypad of the Pro-link, type in the desired delay time from within the range of 0.1 to 9.9 seconds, then press "ENTER". The screen automatically returns to the Snapshot Function Menu screen.

ELECTRONIC SERVICE TOOL
MPSI PRO-LINK MAP
WITH 1678129C3 VPM



**TROUBLE SHOOT GUIDE CAN NOT BE TURNED ON WHEN PROGRAM.

PRESS "ENTER" TO PREPARE SELECTED COMMAND
 PRESS "FUNCT" TO RETURN TO LAST SCREEN OR TO SWITCH FROM DATA TO MAIN MENU
 PRESS "▲" TO GO TO OPTIONS
 PRESS "◀ ▶" TO SELECT OPTION

VOLTAGE

Voltage is an electrical pressure or force that pushes the current through a circuit. The pressure is measured in Volts and the symbol V (as in 12V) is used in the circuit diagrams. The letter "E" is also used for voltage and stands for Electromotive Force. Voltage can be compared to the pressure necessary to push water through a metering valve.

Low voltage to a lamp will cause the lamp to glow dimly. This can be caused by low source voltage (battery discharged or low alternator output), or by high circuit resistance in the circuit due to a poor connection. The resistance of the poor connection or poor ground acts as an additional load in the circuit, causing less voltage to be available to push current through the load device. Before making any meter measurements, it is important to briefly review the relationship between voltage, current, and resistance (Ohms Law).

OHMS LAW REVIEW

Ohms Law describes the relationship of voltage, current and resistance, and provides us with a formula to make calculations as is shown in (Figure 5.3-1).

If any two of the values are known for a given circuit, the missing one can be found by substituting the values in amperes, volts, or ohms and solving for the missing value.

In a typical circuit, battery voltage is applied to a bulb through a 1a-amp fuse and a switch (Figure 5.3-2). Closing the switch turns on the bulb.

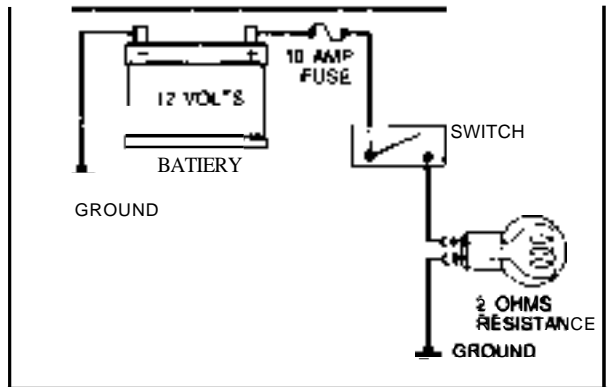




Figure 5.3-2 - Simple Electrical Circuit

OHMS LAW



WHERE: I = CURRENT (AMPERES)
E = VOLTAGE (VOLTS)
R = RESISTANCE (OHMS)

1. $I = E/R$ THIS FORMULA STATES THAT CURRENT FLOW (I) = VOLTAGE (E) APPLIED TO A CIRCUIT DIVIDED BY TOTAL RESISTANCE (R) IN THE CIRCUIT. THIS SHOWS THAT AN INCREASE IN VOLTAGE OR A DECREASE IN RESISTANCE INCREASES THE CURRENT FLOW.
2. $R = E/I$ THIS FORMULA STATES THAT RESISTANCE (R) = VOLTAGE (E) APPLIED TO A CIRCUIT DIVIDED BY CURRENT FLOW (I) IN THE CIRCUIT. THIS ALLOWS US TO CALCULATE RESISTANCE NEEDED FOR A SPECIFIC CURRENT FLOW WITH A SPECIFIC VOLTAGE APPLIED (LIKE 12V).
3. $E = IR$ (I MULTIPLIED BY R) THIS GIVES THE VOLTAGE DROP ACROSS A PARTICULAR LOAD DEVICE (RESISTANCE) THAT IS PART OF A SERIES OF LOAD DEVICES.



MEMORIZE THE FORMULA IN THE CIRCLE, THEN YOU ONLY HAVE TO COVER THE LETTER THAT YOU WISH TO CALCULATE, WITH YOUR FINGER, AND YOU HAVE THE FORMULA. FOR EXAMPLE: IF YOU COVER THE LETTER "I", THE FORMULA IS $I = E/R$.

Figure 5.3-1 - Ohms Law

To find the current flow use the formula:

$$I = E / R$$

Filling in the numbers for the circuit in Figure 5.3-2, we have:

$$I = 12V/2 \text{ ohms or } I = 12 \text{ divided by } 2 = 6 \text{ amperes of current flow.}$$

The bulb in this circuit operates at 6 amps and is rated to operate at this level. With 12 volts applied, the bulb will glow at the rated output level (candle-power rating). However:

- If the voltage applied is low (low battery), then (the value of E is lower) and current flow will be less and the bulb will glow less brightly.
- Or if the connections are loose, or the switch corroded, the circuit resistance will be greater (value of R will be larger) and the current flow will be reduced and the bulb will glow less brightly.

MULTIMETER USE

OHMS LAW REVIEW (Continued)

Being able to determine voltage drops is important because it provides the following information:

- Too high a voltage drop indicates excessive resistance. If, for instance, a blower motor runs too slowly or a light glows too dimly, one can be sure that there is excessive resistance in the circuit. By taking voltage drop readings in various parts of the circuit, the problem can be isolated (corroded or loose terminals for example).
- Too low of a voltage drop, likewise, indicates low resistance. If for instance, a blower motor ran too fast, the problem could be isolated to a low resistance in a resistor pack by taking voltage drop readings.
- Maximum allowable voltage drop under load is critical, especially if there is more than one high resistance problem in a circuit. It is important because all voltage drops in a circuit are cumulative. Corroded terminals, loose connections, damaged wires or other similar conditions create undesirable voltage drops that decrease the voltage available across the key circuit components. Remember our earlier discussion, the increased resistance from the undesirable conditions will also decrease the current flow in the circuit and all the affected components will operate at less than peak efficiency. A small drop across wires (conductors), connectors, switches, etc. is normal. This is because all conductors have some resistance, but the total should be less than 10 percent of the total voltage drop in the circuit.

USING THE VOLTMETER

In electrical diagnosis, the voltmeter is used to answer:

- Is voltage present?
- What is the voltage reading?
- What is the voltage drop across a load device?

When using a voltmeter to determine if voltage is present to power a device, connect the positive meter lead to input connection of the device (positive side) and connect the negative meter lead to good vehicle ground (Figure 5.3-3). This shows how much of the source voltage is available to the device. Note that the meter is connected in parallel to the device.

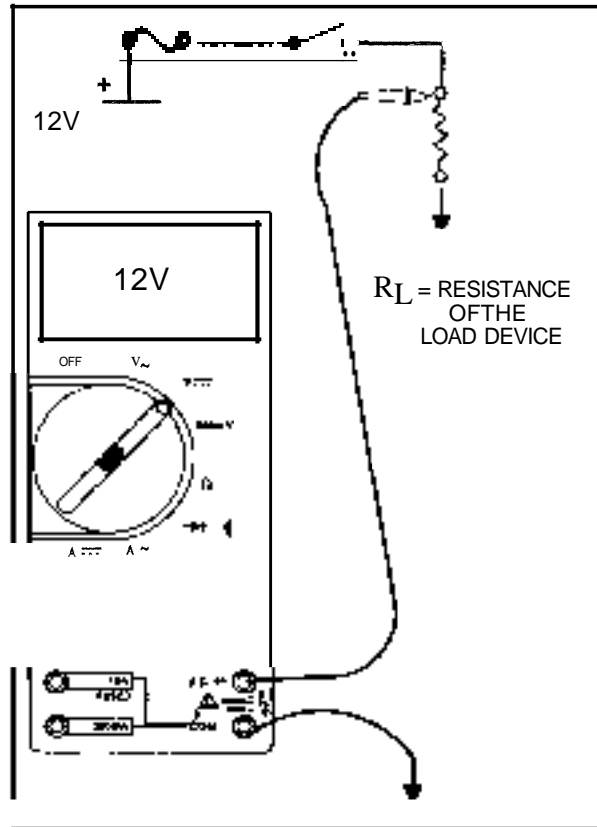


Figure 5.3-3 - Checking Power To A Load Device

Should we need to determine if voltage is available at a connector where we can't readily connect to the device, we can connect the meter in parallel as shown in (Figure 5.3-4). The meter internal resistance is very high so little current will flow in the circuit, and the voltage can be read accurately.

To check the voltage drop across a load device (Figure 5.3-5), connect the positive lead of the voltmeter to the positive side of the device and the negative meter lead to the negative side of the device.

USING THE VOLTMETER (Continued)

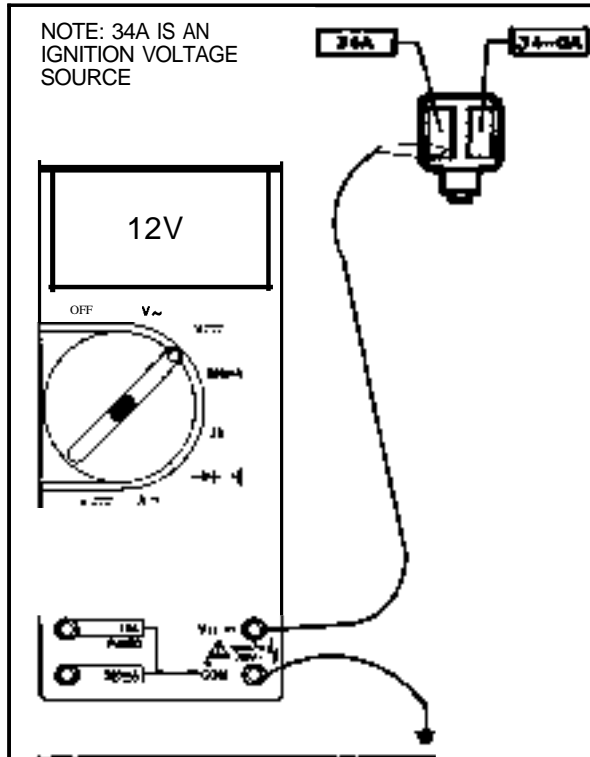


Figure 5.3-4 - Checking Power To A Connector

With the device operating, this will measure the voltage drop across the device. Notice in (Figure 5.3-5) that since we only have one device, all of the voltage should be dropped at the device. In any circuit, the voltage applied will equal the voltage dropped in the circuit. If in this circuit we only dropped 9V across the load, that would indicate that our wires, connections, etc. were dropping the other 3V, which would indicate excessive circuit resistance.

AMMETER

An ammeter is used to measure current flow (amperage) in a circuit. Amperes are units of electron flow, which indicate how many electrons are passing through the circuit. Ohms Law indicates that current flow in a circuit is equal to the circuit voltage divided by total circuit resistance. Since amps (I) is the current in the circuit, increasing voltage also increases the current level (amps). Also, any decrease in resistance (ohms) will increase current flow (amps).

At normal operating voltage, most circuits have a characteristic amount of current flow, referred to as current draw. Current draw can be measured with an ammeter. Referring to a specified current draw rating for a component (electrical device), measuring the current flow in the circuit, and comparing the two (the rating versus the actual measured) can provide valuable diagnostic information.

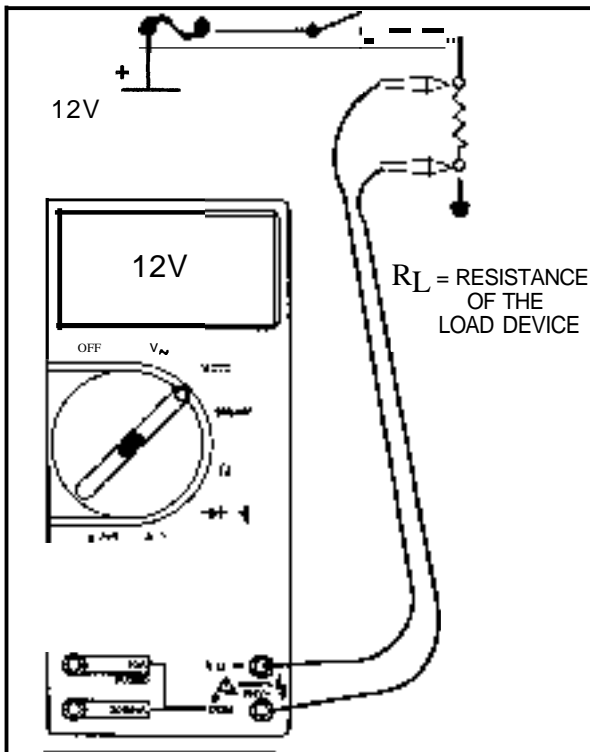


Figure 5.3-5 - Checking Voltage Loss

An ammeter is connected in series with the load, switches, resistors, etc. (Figure 5.3-6) so that all of the current flows through the meter. The meter will measure current flow only when the circuit is powered and operating. Before measuring current flow, we need to know approximately how much current will be present to properly connect the meter. The DMM is fused to measure up to 10 amps using the 10A connection point.

The estimate of current flow can easily be calculated. In (Figure 5.3-6), the resistance of the light bulb is 2 ohms. Applying ohms law, we can calculate that current flow will be 6 amps ($6A = 12V/2 \text{ ohms}$). If we remove the fuse, and install the ammeter as shown, with the switch closed we will measure 6 amperes of current flowing in the circuit. Notice that the ammeter is installed so that all the current in the circuit flows through it. The ammeter is installed in series.

MULTIMETER USE

USING THE AMMETER (Continued)

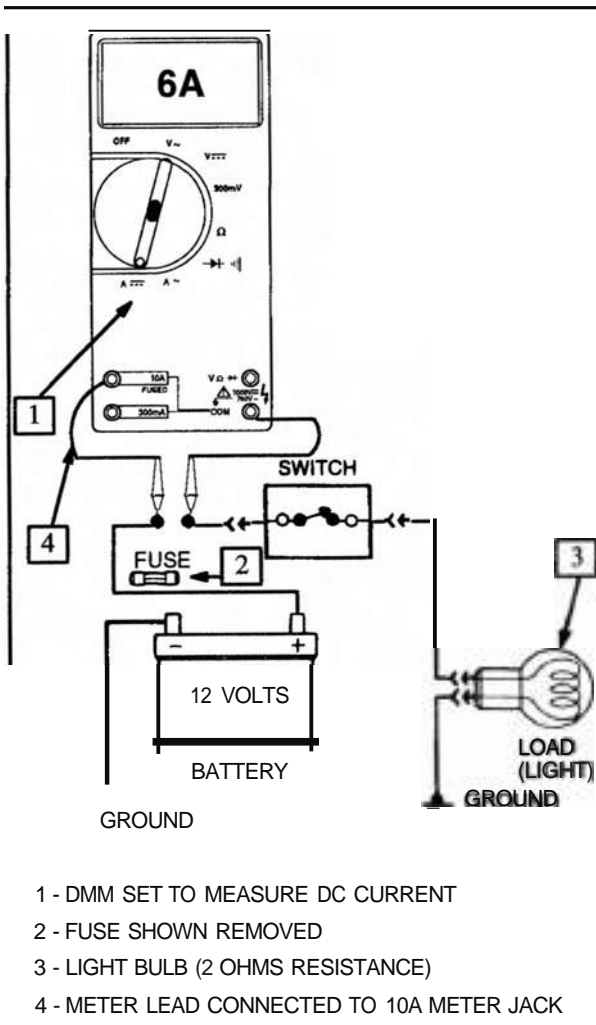


Figure 5.3-6 - Installing The Ammeter

WARNING— Always make sure the power is off before cutting, soldering or removing circuit component before inserting the DMM for current measurements. Even small amounts of current can be dangerous.

Excessive current draw means that more current is flowing in a circuit than the fuse and circuit were designed for. Excessive current will open fuses and circuit breakers. Excessive current draw can also quickly discharge batteries. An ammeter is useful to help diagnose these conditions. On the other hand, there are times reduced current draw will cause a device (electric window motor for example) to operate poorly. Remember increased circuit resistance causes lower current to be available to the

device. Loose or corroded connections can frequently cause this problem.

OHMMETER

The ohmmeter is used to measure resistance (ohms) in a circuit. Like the ammeter and voltmeter, there are both analog and digital meters available. It is recommended that the digital meter (Fluke 88 DVOM) be used. See ELECTRONIC CIRCUIT TESTING in this section.

CAUTION -The ohmmeter can only be used on circuits where power has been removed. The meter contains its own low voltage power supply and the power from 12-volt systems may damage the meter.

Ohmmeters use a small battery to supply the voltage and current which flow through the circuit being tested. The voltage of the meter battery and the amount of current flow in the circuit are used with Ohms Law and the meter calculates the circuit resistance which is displayed by the meter. With the Fluke 88 DVOM, range selection and meter adjustment are not necessary.

MEASURING RESISTANCE

Resistance measurements determine:

- Resistance of a load
- Resistance of conductors
- Value of resistors
- Operation of variable resistors

To measure the resistance of a component or a circuit, power must first be removed from the circuit.

The component or circuit that is to be measured must be isolated from all other components or circuits so that meter current (from probe to probe) only flows through the desired circuit or component or the reading will not be accurate. Notice in (Figure 5.3-7) that if we wanted to measure the resistance of the load, most of the current flow from the meter would flow through the indicator lamp because it has less resistance. To measure the load, one connector to the load should be removed. It is not always apparent when a component must be isolated in such a manner, so it is usually a good practice to isolate the circuit or component by physically disconnecting one circuit.

USING THE OHMMETER (Continued)

The ohmmeter leads are then placed across the component or circuit and the resistance will be displayed in ohms (Figure 5.3-8). When checking a sensor or variable resistor such as fuel level gauge, heating the element or moving the arm should move the meter through a range of resistance that can be compared to a specification.

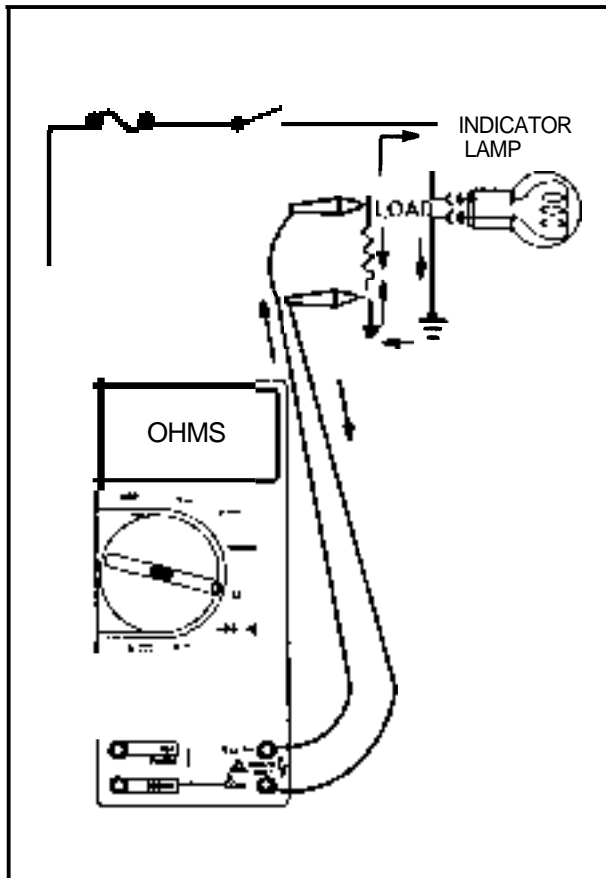


Figure 5.3-7- Improperly Isolating Component For Resistance Check

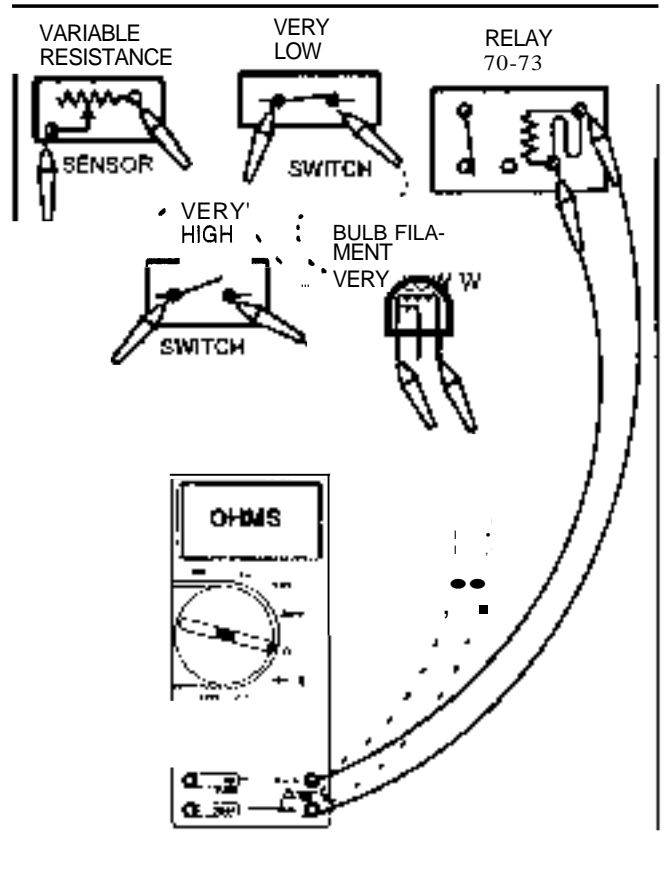


Figure 5.3- 8- Measuring Resistance

MULTIMETER USE

USING THE OHMMETER (Continued)

CHECKING FOR OPEN CIRCUITS

Electrical circuits can be checked for opens using an ohmmeter. The circuit must first be disconnected from the power supply. The circuit to be checked must also be isolated from other circuits. Connect the meter to the open ends of the circuit as shown in (Figure 5.3-9). A high reading (infinity) indicates there is an open in the circuit. A near zero reading is an indication of a continuous circuit. Notice also in (Figure 5.3-9) that we disconnected the circuit between the light and the ground. This precaution prevents reading a circuit as complete that may be shorted to ground ahead of the load device.

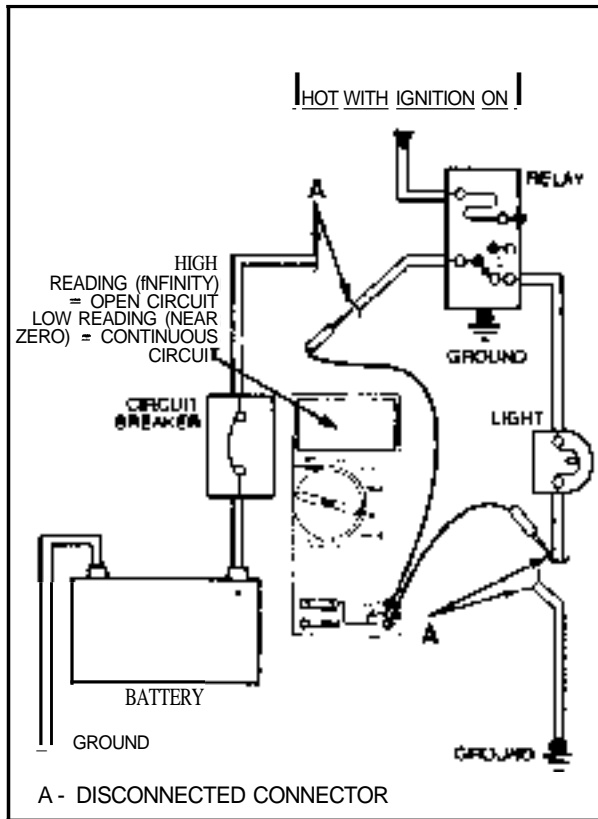


Figure 5.3-9 - Open Circuit Check Using An Ohmmeter

CHECKING FOR SHORT CIRCUITS

Checks for short circuits are made in a similar manner to that used to check for open circuits, except that the circuit to be checked must be isolated from both the power source and the ground point.

Connecting the ohmmeter as shown in (Figure 5.3-10) between an isolated circuit and a good ground point will allow checking the circuit for a short to ground. A short to ground will be indicated by a near zero reading, while a circuit not shorted to ground will cause the meter to read very high (near infinity). With the Fluke 88 DVOM, an open circuit will read "OL" on the meter display.

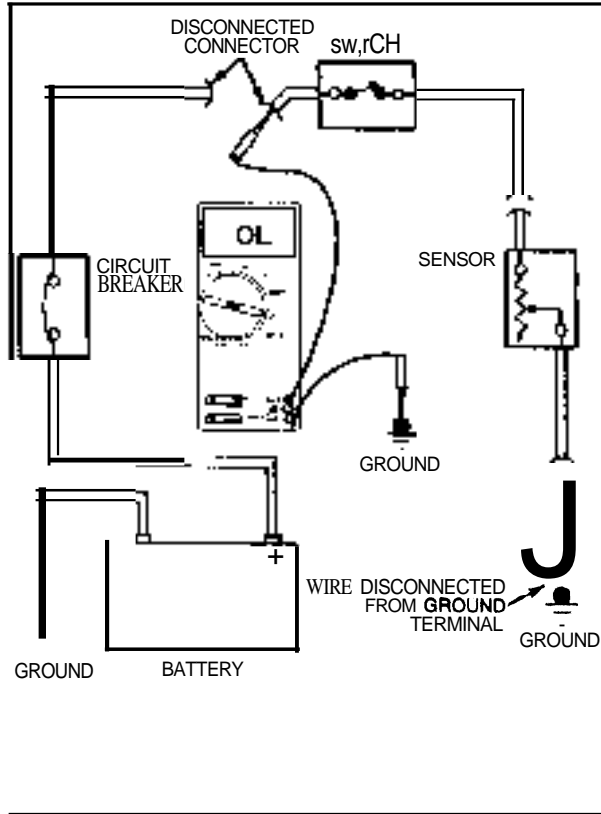


Figure 5.3-10 - Short Circuit Check Using An Ohmmeter

TROUBLESHOOTING

Before beginning any troubleshooting, there are several important steps to be taken:

VERIFY THE PROBLEM

Operate the complete system and list all symptoms in order to:

- Check the accuracy and completeness of the complaint.
- Learn more that might give a clue to the nature and location of the problem.
- Analyze what parts of the system are working.

READ "ELECTRICAL OPERATION"

Read the electrical operation for the problem circuit (while referring to the circuit diagram). By studying the circuit diagram and the electrical operation, enough information about circuit operation should be learned to narrow the cause of the problem to one component or portion of the circuit.

CHECK THE CIRCUIT DIAGRAM

Refer to the circuit diagram for possible clues to the problem. Location and identification of the components in the circuit may give some idea of where the problem is.

The circuit diagrams are designed to make it easy to identify common points in circuits. This knowledge can help narrow the problem to a specific area. For example, if several circuits fail at the same time, check for a common power source or common ground connection (see POWER DISTRIBUTION AND GROUNDS). If part of a circuit fails, check the connections between the part that works and the part that doesn't work.

For example, if the low-beam headlights work, but both high-beam lights and the high-beam indicator do not work, then the power and ground paths must be good. Since the dimmer switch is the component that switches the power to the high-beam headlights, it is the most likely cause of failure.

CHECK FOR CAUSE OF THE PROBLEM

Diagnosis charts are provided for many of the common faults that may occur. Refer to these charts in each section. Follow the procedures in the chart until the cause of the problem is located.

If the particular symptom found in the problem circuit is not covered by a diagnosis chart, refer to the

general electrical troubleshooting information provided under "Electrical Test Equipment" in this section.

MAKE THE REPAIR

Repair the problem circuit as directed in the diagnostic charts.

VERIFY THAT THE REPAIR IS COMPLETE

Operate the system and check that the repair has removed all symptoms, and also that the repair has not caused any new symptoms.

ELECTRICAL TEST EQUIPMENT

Various electrical testers have been developed over the years. A few of these are basic but necessary to perform an electrical diagnosis. These include:

- Jumper Wires
- Test Lights
- Voltmeter
- Ohmmeter
- Ammeter

All of these testers come in a variety of models and any working model will be adequate for simple tests. However, when the value of a reading obtained using a meter is critical to the diagnostic procedure, accuracy becomes important. Make sure any electrical test meter used is of sufficient quality and accuracy to make the measurements required in the electrical testing. The "Fluke 88 Digital Multimeter" (DMM) is the Navistar recommended meter and discussions of meter use in this manual will refer to that meter.

The Fluke 22 Multimeter, a digital meter, is recommended because it uses very little current to do its measuring. The digital meter has high impedance (resistance): 10 megohms.

ELECTRONIC CIRCUIT TESTING

Some of the devices in an electronic control system are not capable of carrying any appreciable amount of current. Therefore the test equipment used to troubleshoot an electronic system must be especially designed not to damage any part of it. Because most analog meters (Figure 5.3-11) use too much current to test an electronic control system, it is recommended that they not be used, unless specified.

MULTIMETER USE

ELECTRONIC CIRCUIT TESTING (Continued)

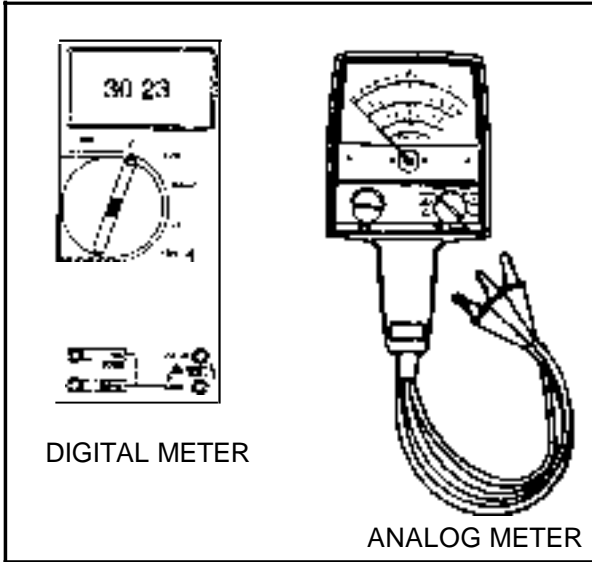


Figure 5.3-11 - Typical Meters, Digital And Analog

The use of any kind of battery-powered test light is not recommended when troubleshooting an electronic circuit, since it, too, could damage an electronic control circuit.

JUMPER WIRES

Jumper wires (Figure 5.3-12) allow "jumping" across a suspected open or break in a circuit.

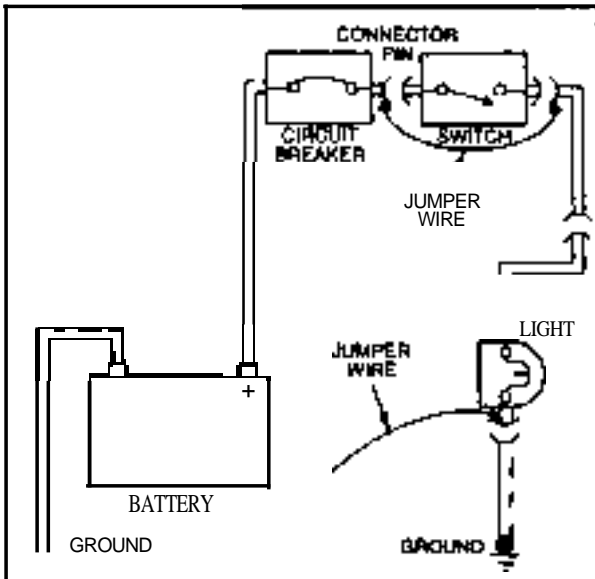


Figure 5.3-12 - Troubleshooting Using Jumper Wires

- If the circuit (Figure 5.3-12) works properly with the jumper wire in place, but does not

work when the jumper wire is removed, the circuit has an open spot.

- A circuit without any opens or breaks has continuity (which means continuous) and needs no further testing.

Jumper wires are fitted with several types of wire tips. It will be helpful to have several jumper wires available with different tips (Figure 5.3-13).

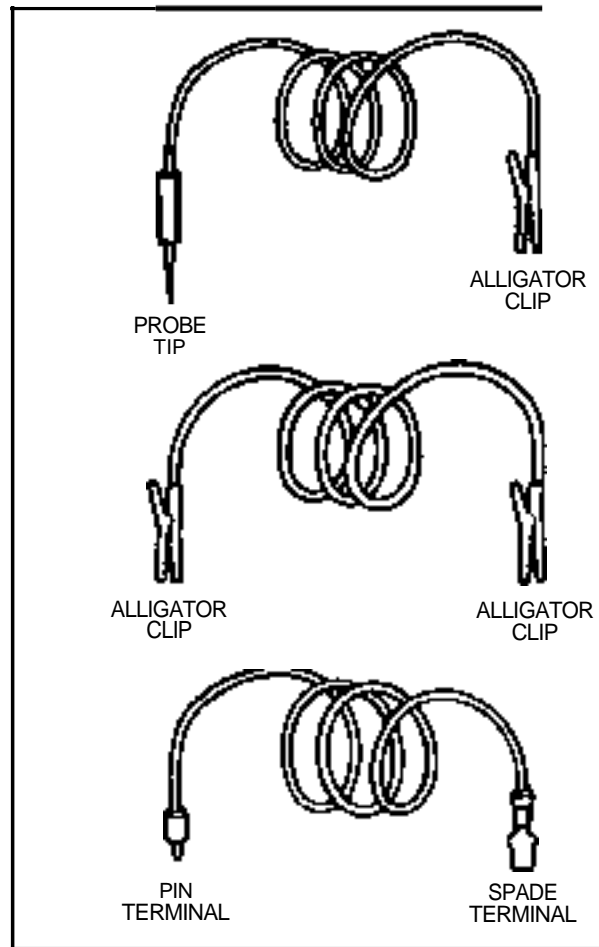


Figure 5.3-13 - Jumper Wires

In (Figure 5.3-12), if bypassing the switch with a jumper wire causes the light to illuminate, but closing the switch does not, it indicates the switch has failed. If, with the switch closed, the light does not illuminate, and "jumping" the switch doesn't cause the light to operate, but "jumping" the light to ground causes the light to operate, then there is an open in the ground circuit.

JUMPER WIRES (Continued)

The jumper wire can be used to check for open relay contacts, wire breaks, poor ground connections, etc.

12-VOLT TEST LIGHTS

The 12-volt test light tests for voltage in a circuit between the point being tested and ground (Figure 5.3-14). If there is no glow in the bulb, the circuit is open and no current is flowing.

Once a technician becomes familiar with the test light and the brilliance of the bulb in a normal circuit, high-resistance circuits can be recognized by the dimming effect that they have on the test light bulb. As the current drops in a high-resistance circuit, the bulb will glow less brightly. Although using a 12-volt test light cannot be used as a fool-proof test for high resistance, a less than normal brilliance of the test light is an indication of circuit high resistance. Further testing will verify the condition and locate the cause.

The 12-volt test light continuity tester depends on the vehicle battery to power the circuit under test. Twelve-volt testers are available with a variety of tips to permit touching them to connectors, bare wires, insulated wires or even wires within wiring harnesses (Figure 5.3-15). To check the tester before use, briefly touch the clip to one post of the battery and the other to the opposite post. Twelve-volt testers are not sensitive to polarity and can be connected either way.

The 12-volt test light generally has a sharp probe tip so it can be inserted into connector terminals or through wire insulation for testing. It is important to

keep the probe tip sharp to minimize damage to wire insulation. When the test is complete at a particular point, make sure to tape any holes made in wire insulation.

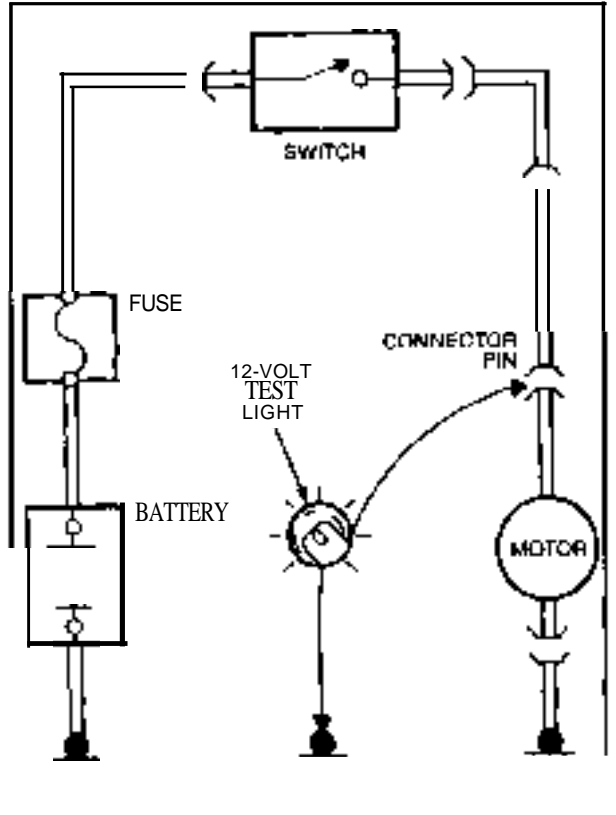


Figure 5.3-14 - Troubleshooting Using 12-Volt Test Light

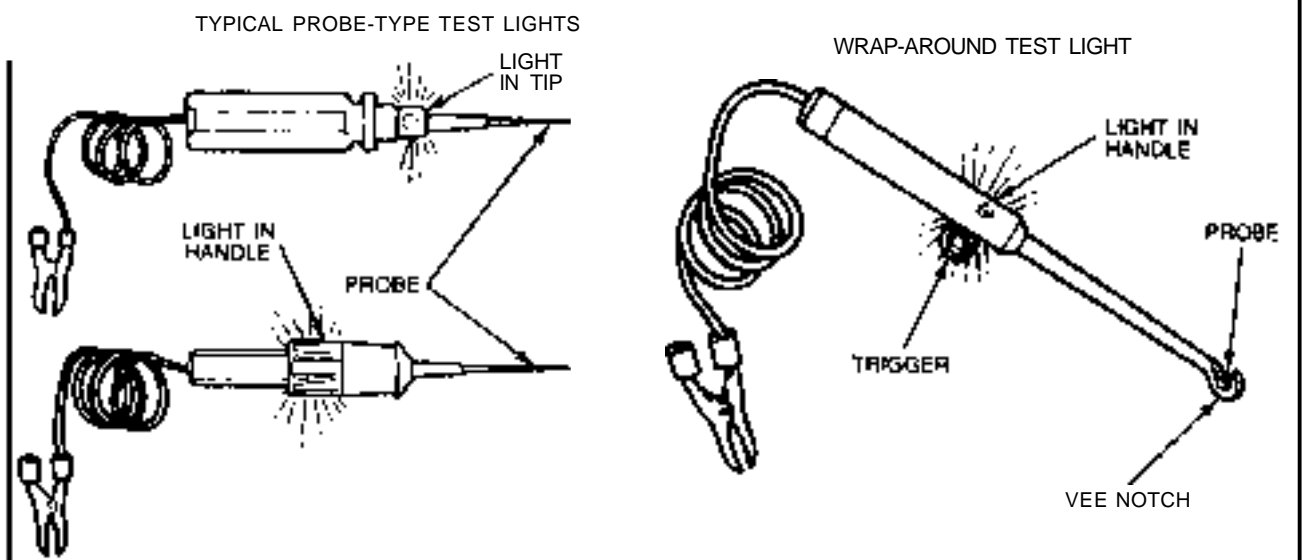


Figure 5.3-15 - Typical 12-Volt Test Lights

SECTION 6 CONNECTOR AND HARNESS REPAIR

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CONNECTOR REPAIR

Several different types of connectors are used on the subject vehicle. The Deutsch heavy-duty connector is used for the engine harness to instrument harness connection and others to be discussed later are used in other applications.

Each type can be repaired by following these procedures.

DEUTSCH HEAVY-DUTY CONNECTORS

The Deutsch heavy-duty connectors used are designed to seal against moisture and contaminants. They also protect against damage from shock and vibration. The Deutsch part numbering system provides a complete description of the connector. The part number takes the form of HD 34-18-8 P N - XXX. A complete explanation is provided in (Figure 6-1).

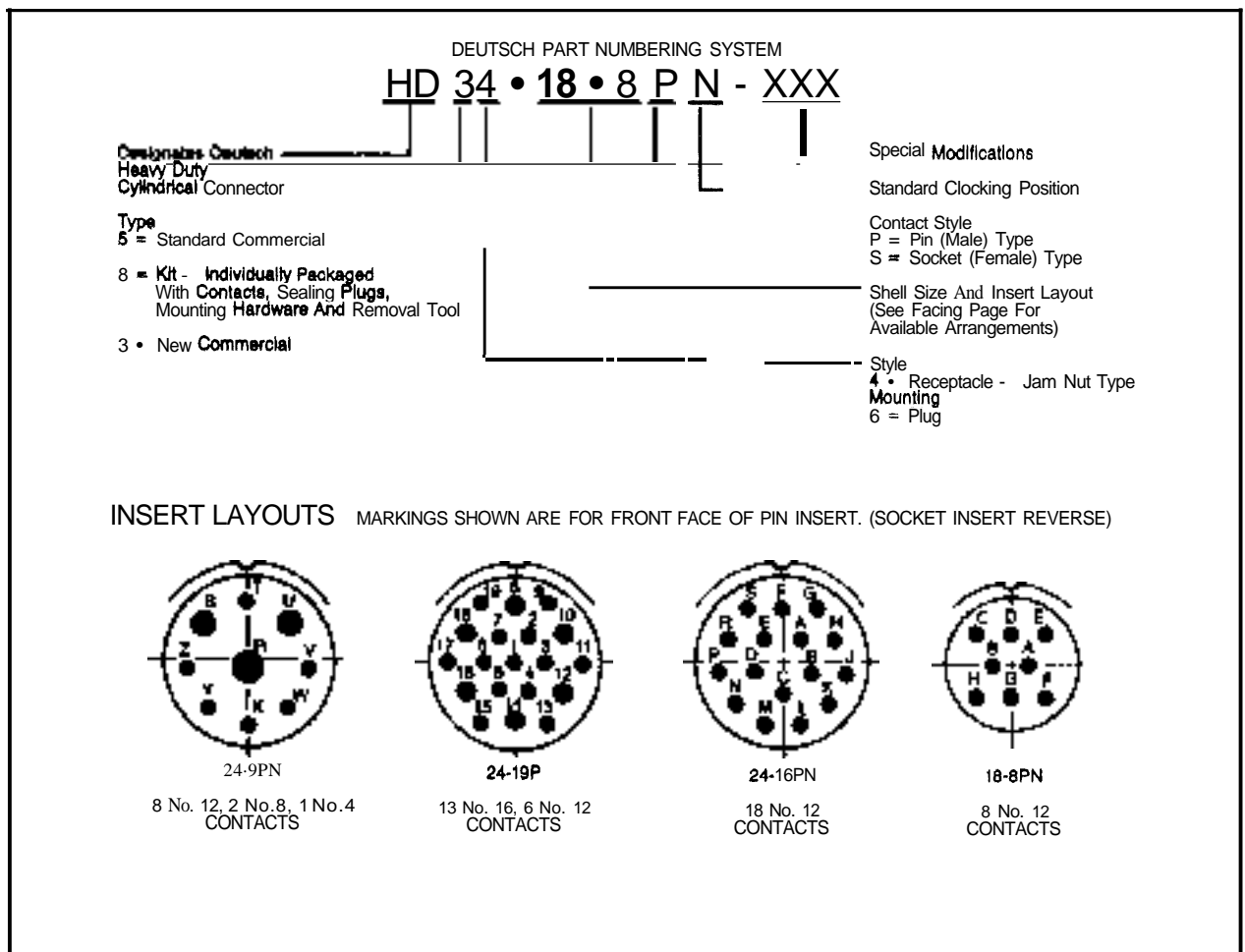


Figure 6-1 - Deutsch Connectors

CONNECTOR AND HARNESS REPAIR

CONNECTOR REPAIR (Continued)

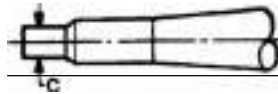
CONTACT REMOVAL

- To remove the damaged contact, snap an appropriate size plastic contact repair tool over the wire of the contact to be removed (Figure 6-2).

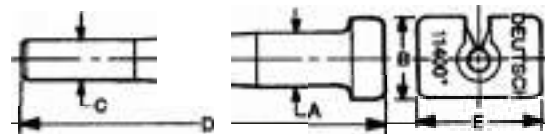
If the wire to the contact is broken off, insert the tool into the applicable cavity over the contact. Use a Deutsch tool or equivalent.

CONTACT REMOVAL TOOL

PART NO.	SIZE	$\pm .015$ A	$\pm .031$ B	REF C	MAX D	$\pm .031$ E
114008	8	.555	.875	.314	2.250	1.500
114009	4	.740	.875	.435	2.250	1.500
114010	12	.350	.825	.202	2.300	1.250
111-254-1005	18	.286	.500	.180	2.300	1.000



SIZE . CONFIGURATION



SIZE 4, 12 & 18 CONFIGURATION
(USE THIS DEUTSCH TOOL, OR EQUIVALENT,
FOR CONTACT REMOVAL)

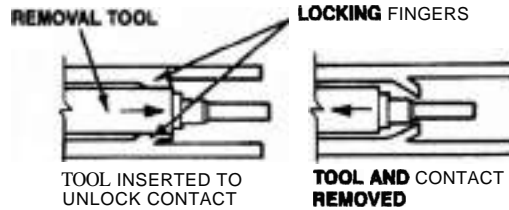
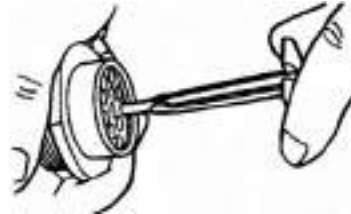


Figure 6-2 - Deutsch Connector Contact Removal

- Slide the tool into the cavity over the contact until resistance is felt (locking fingers released) as shown in (Figures 6-3 and 6-4.).
- Pull the contact/wire/tool assembly out of the connector (Figure 6-5.).

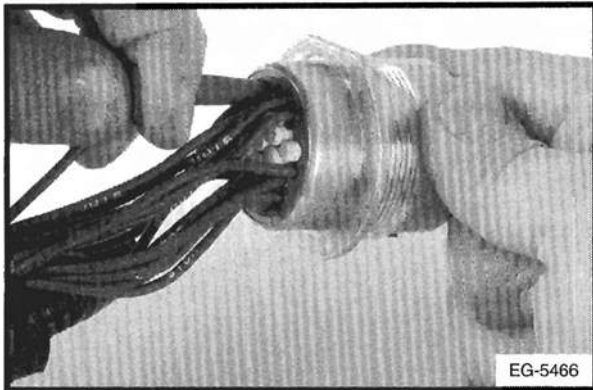


Figure 6-3 - Sliding Tool Into Cavity



Figure 6-4. - Contact Locking Finger Released

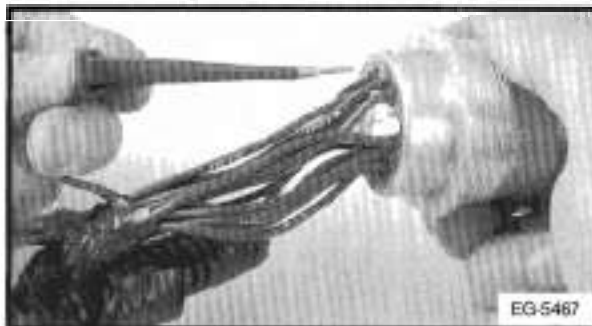


Figure 6-5. - Contact Removal From Connector

CONTACT AND WIRE ASSEMBLY

1. Strip 0.253 +/- 0.031 inch (approximately 1/4 inch) of insulation from end of wire using suitable stripping tool.



Figure 6-6. - Insert Contact Into Tool

2. Position contact into Deutsch HDT-4800 hand crimping tool (or equivalent) so that the crimp barrel is 1/32 inch above the tool indenters (Figure 6-6.). Hold contact in place by hand or by lightly squeezing the tool.



Figure 6-7. - Insert Wire Into Contact

3. Place the stripped end of the wire into the crimp barrel of the contact. Insert wire into contact. (Figure 6-7.) Fully depress the tool handles. Release and remove wire/contact assembly. (Figure 6-8.)
4. Inspect the wire/contact terminal to make sure that all wire strands are in the crimp barrel and that the crimp is secure.



Figure 6-8.- Contact Crimping

CONTACT INSERTION

1. Grasp the contact/wire assembly, between the thumb and forefinger, on the wire approximately one inch behind the contact crimp barrel.
2. Hold the connector with the grommet facing the contact.

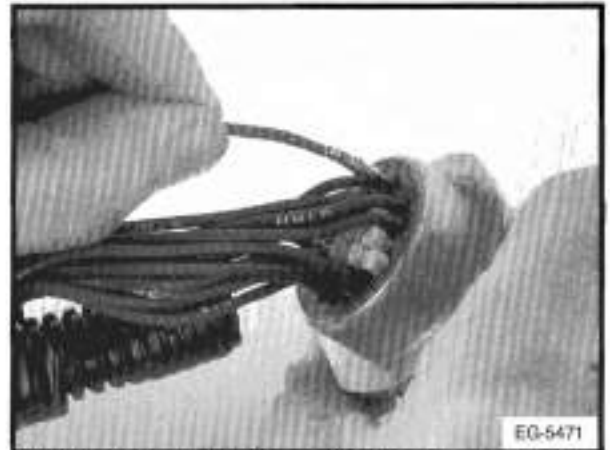


Figure 6-9. - Connector/Contact **For Insertion**

3. Push the contact straight into the appropriate cavity in the connector grommet, until a positive stop is felt. The retaining fingers in the connector will snap behind the shoulder of the contact and lock it in place. (Figure 6-9.). A slight tug backward on the wire will verify that the contact is properly seated. (Figure 6-10)

CONNECTOR AND HARNESS REPAIR

CONNECTOR REPAIR (Continued)

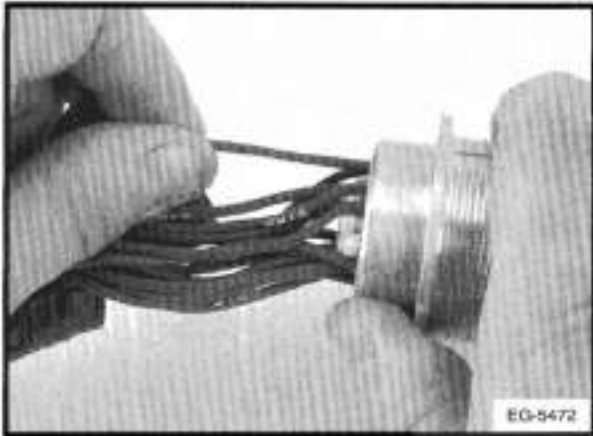


Figure 6-10. - Verification of Contact Seating

Several different types of electrical connectors are used on the subject vehicles. Refer to Figures 6-11. through 6-14. for additional connector illustrations.

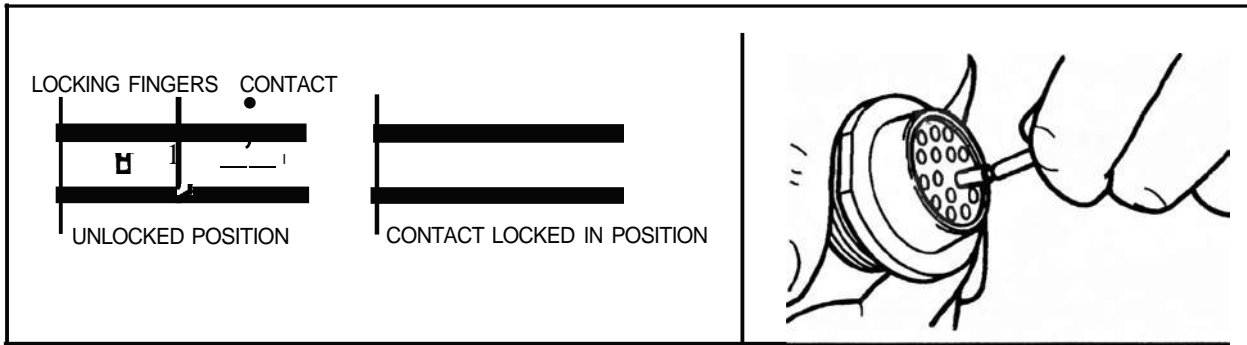


Figure 6-11. - Contact (Left) and Insertion (Right)

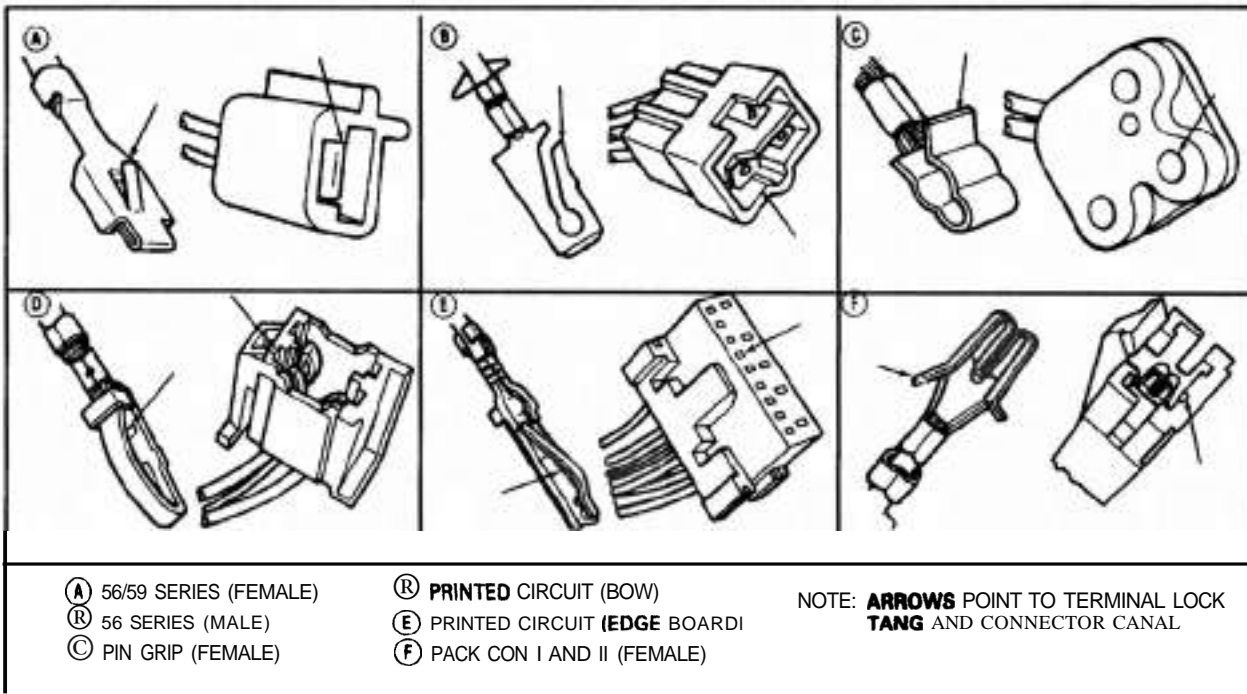
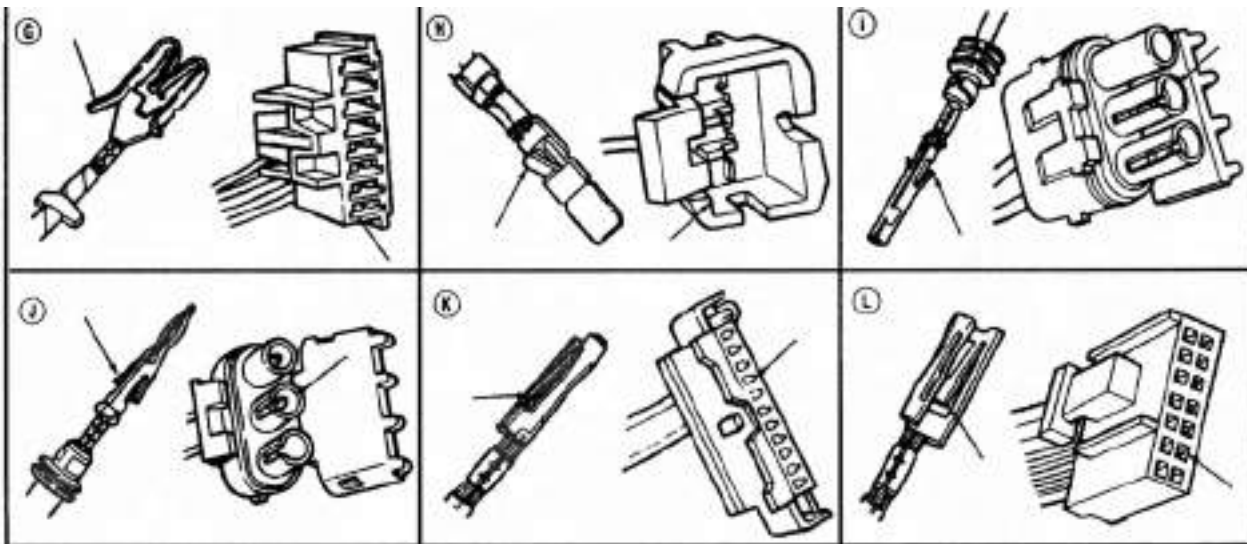


Figure 6-12. - Connector Details

CONNECTOR REPAIR (Continued)



ⓐ PACK CON (FEMALE)
HEAVY DUTY III SERIES

ⓐ PACK CON "HEAVY DUTY"

ⓐ WEATHER PACK (FEMALE) SLEEVE

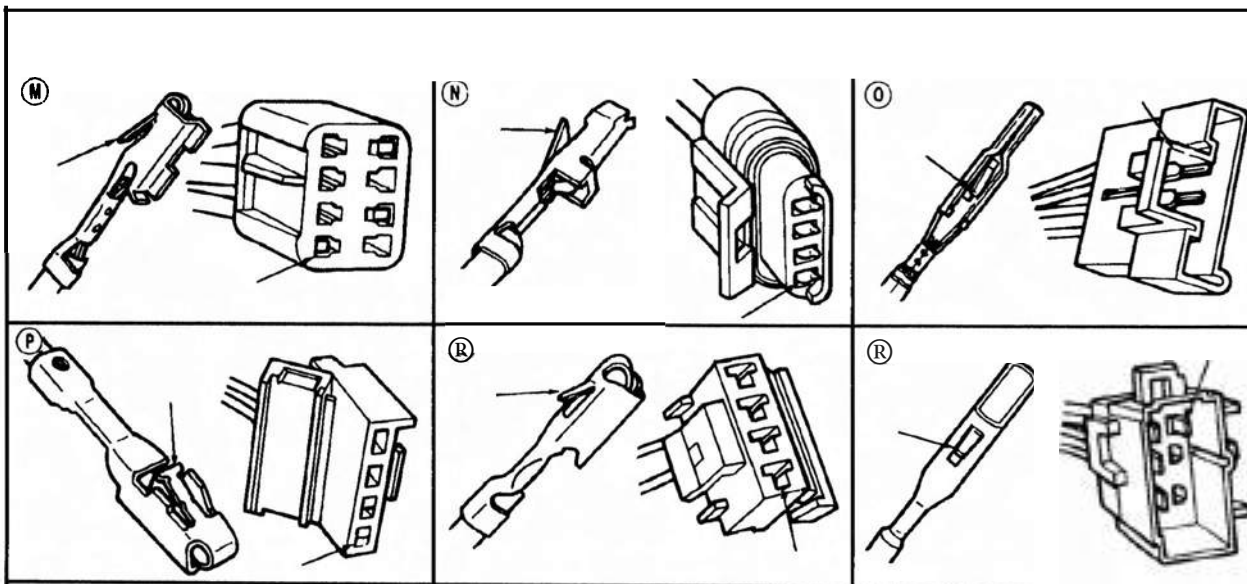
ⓐ WEATHER PACK (MALE) PIN

ⓐ MICRO-PACK (FEMALE)

ⓐ MICRO-PACK (FEMALE)

NOTE: ARROWS POINT TO TERMINAL LOCK
TANG AND CONNECTOR CANAL

Figure 6-13. - Connector Details



ⓐ METAI-PACK (FEMALE)
150 SERIES

ⓐ METAI-PACK (FEMALE)
150 SERIES - PULL TO
SEAT

ⓐ METRI-PACK (MALE)
160-280 SERIES
150-280 SERIES SEALED

ⓐ METRI-PACK (FEMALE)
280 SERIES
280 SERIES SEALED

ⓐ METRI-PACK (FEMALE)
480-630 SERIES
480 SERIES SEALED

ⓐ METRI-PACK (MALE)
480-630 SERIES

Figure 6-14. - Connector Details

CONNECTOR AND HARNESS REPAIR

INSPECTION

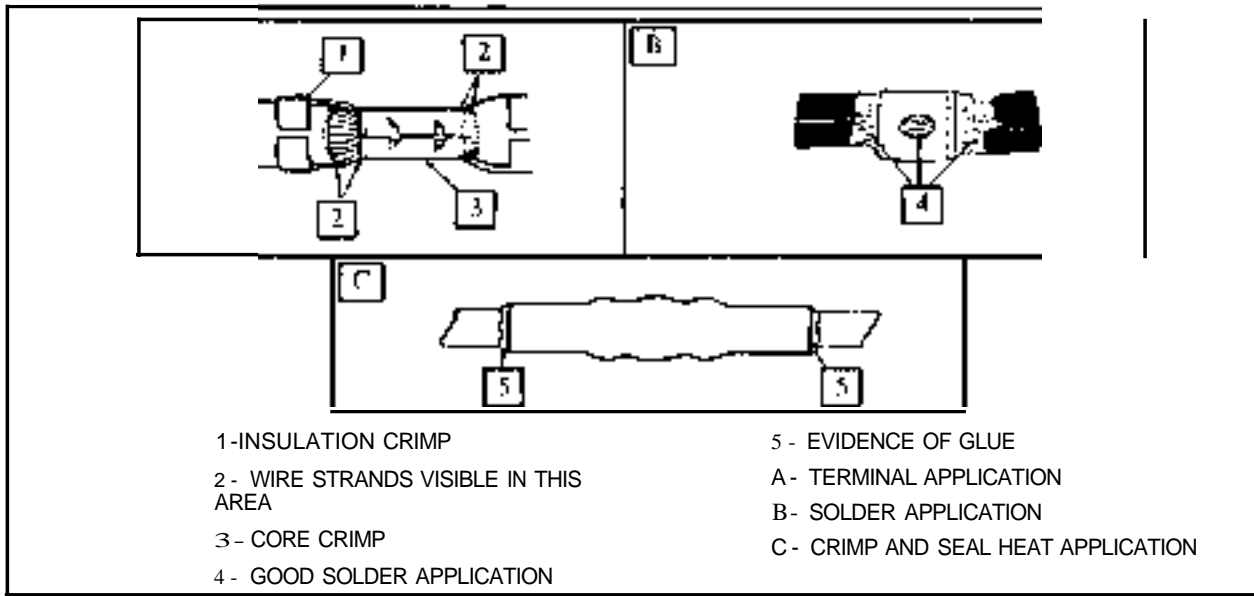


Figure 6-15. -Inspecting Terminal, Solder, Crimp and Seal Heat Applications

STANDARD TERMINAL REPLACEMENT

Refer to Figure 6-16

1. Cut the cable just before the insulation wings on the terminal.
2. Remove the insulation being careful not to cut any of the wire strands.
3. Position cable in the new terminal.

4. Hand crimp the core wings first, then the insulation wings.

NOTE: Always use the recommended crimp tool for each terminal. A detailed crimp chart is included in the repair kit.

5. Solder all hand crimped terminals and electrically check for continuity.

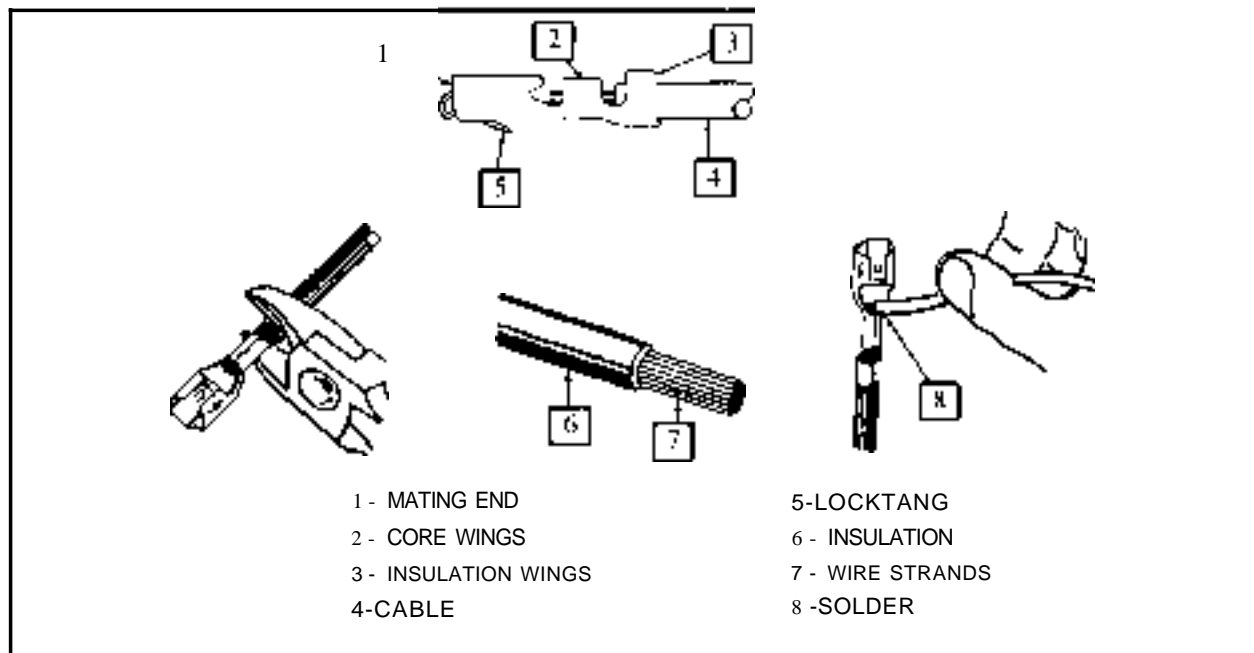


Figure 6-16. - Standard Terminal Replacement

TERMINAL REPLACEMENT - SEALED WEATHER PACK AND METRI-PACK

Refer to Figure 6-17.

1. Cut the cable just before the insulation wings on the terminal.
2. Replace the seal and remove the insulation being careful not to cut any of the wire strands.
3. Align the seal with the cable insulation.
4. Position the cable in the new terminal.
5. Hand crimp the core wings first, then the insulation wings.
6. Solder all hand crimped terminals and electrically check for continuity.
7. Replace the terminal in correct connector cavity.

NOTE: Always use the recommended crimp tool for each terminal. A detailed crimp chart is included in the repair kit.

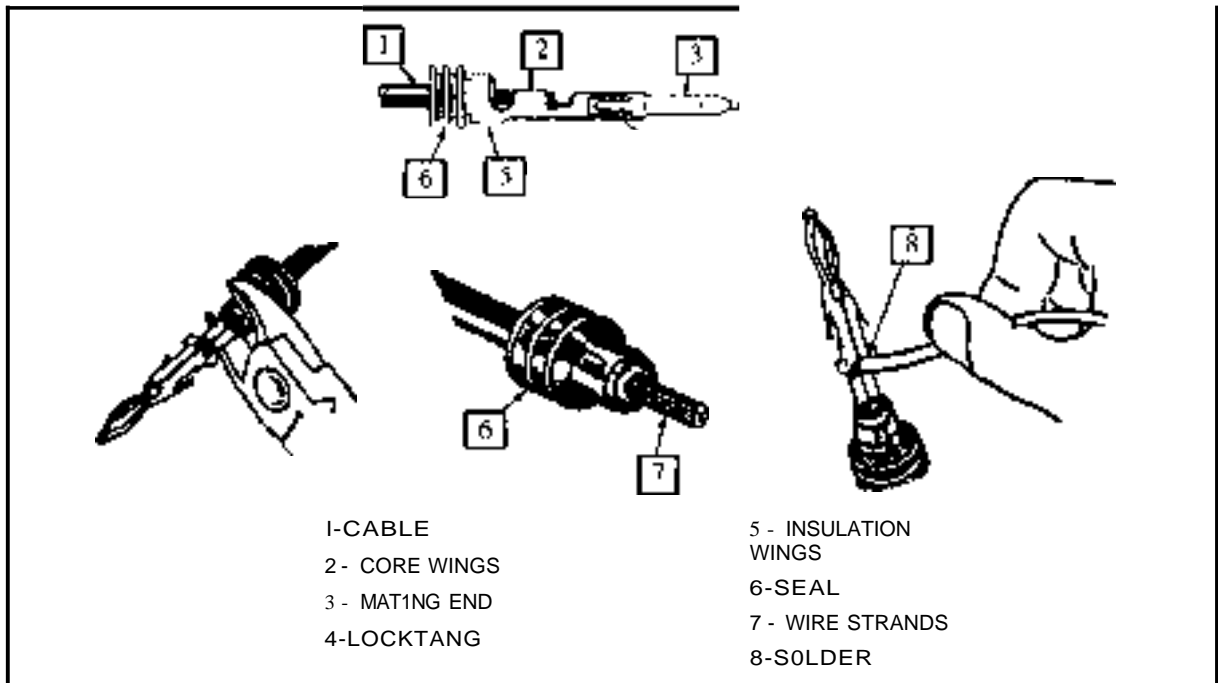


Figure 6-17. - Sealed Weather Pack and Metri-Pack Terminal Replacement

SPLICE CLIP INSTALLATION

Refer to Figure 6-18.

NOTE: A new clip must be located a minimum of 1.5 inches (40 mm) from a connector, sleeve or another clip.

1. Cut off the old clip or bad section of wire.
2. Remove the insulation being careful not to cut any of the wire strands.
3. Install the proper clip on the wire strands.
4. Hand crimp the clip until securely fastened.
5. Solder the clip and electrically check for continuity.
6. Cover the entire splice with splice tape. Extend the tape onto the insulation on both sides of the splice(s).

CONNECTOR AND HARNESS REPAIR

SPLICE CLIP INSTALLATION (Continued)

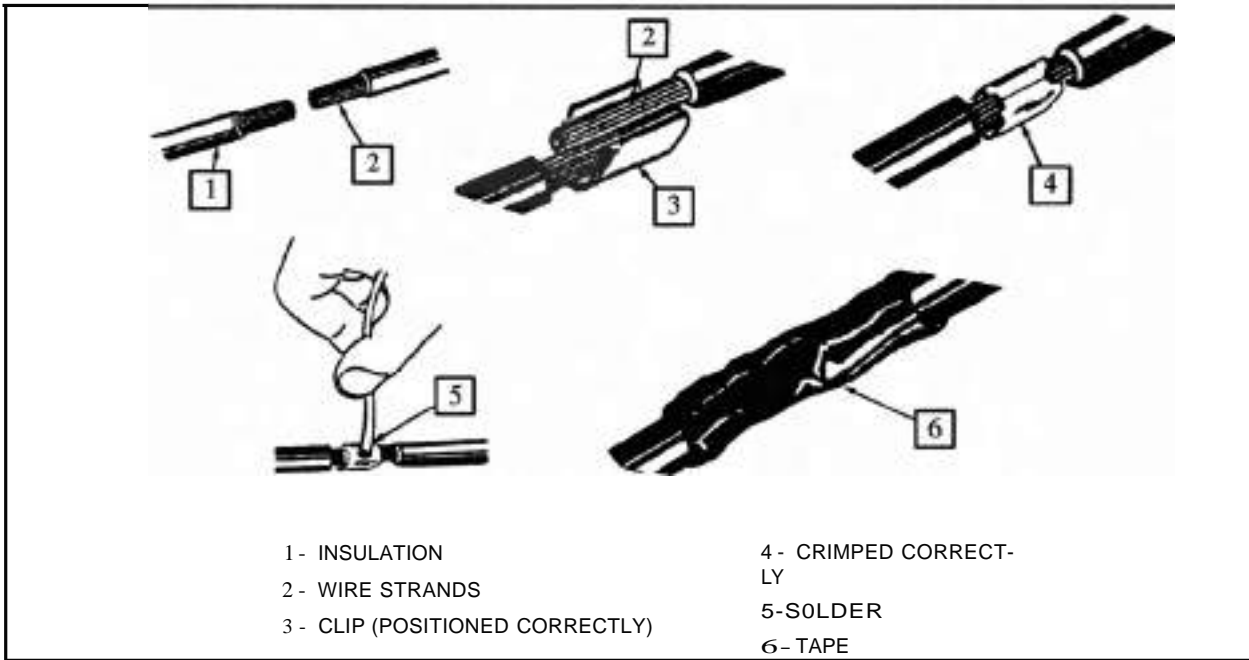


Figure 6-18. - Splice Clip Replacement

CRIMP AND SEAL SPLICE SLEEVE INSTALLATION

Refer to Figure 6-19.

NOTE: A new sleeve must be located a minimum of 1.5 inches (40 mm) from a connector, clip or another sleeve.

1. Cut off the old sleeve or bad section of the wire.
2. Remove insulation being careful not to cut any of the wire strands.
3. Install the proper sleeve on the wire strands making sure the ends of the wire, hit the stop.

4. Hand crimp to the sleeve. Gently tug on the wire to make sure that they are secure.

NOTE: Always use the recommended crimp tool for each sleeve. A detailed crimp chart is included in the Repair Kit.

CAUTION - Do not use a match or open flame to heat the sleeve seal.

5. Electrically check the sleeve and wire cable for continuity.

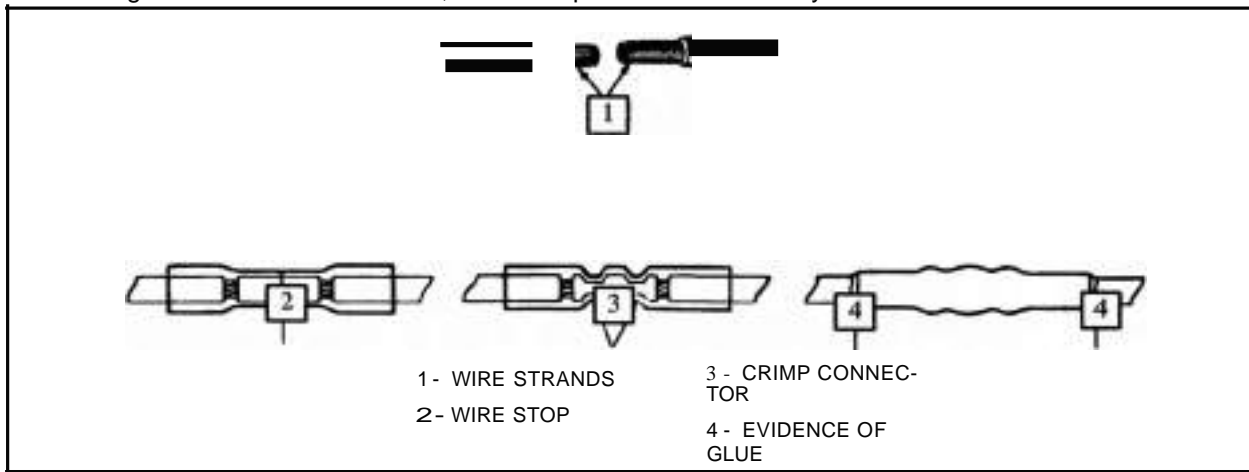


Figure 6-19. - Seal Splice Sleeve Replacement

LOCKING WEDGE CONNECTORS

Procedure for removal of wire terminals from EeT, EOT, IAT and MAP.

The terminals are held in place by plastic retaining fingers which are part of the connector. The fingers snap into the shoulder of the terminal and are held in place by the locking wedge.

TO REMOVE THE TERMINAL FROM THE CONNECTOR:

1. Using the appropriate tool, pry the connector lock out of the connector body from the mating end and remove the lock from the connector (Figure 6-20).



Figure 6-20. - Remove Lock Wedge

2. Insert a narrow blade into the connector to lift the retaining finger away from the terminal (Figure 6-21.).

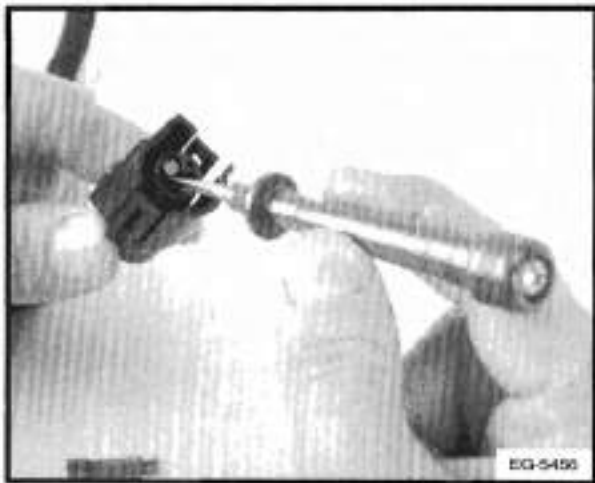


Figure 6-21. - Release Retaining Finger

3. Pull the wire and terminal out of the connector body (Figure 6-22.).

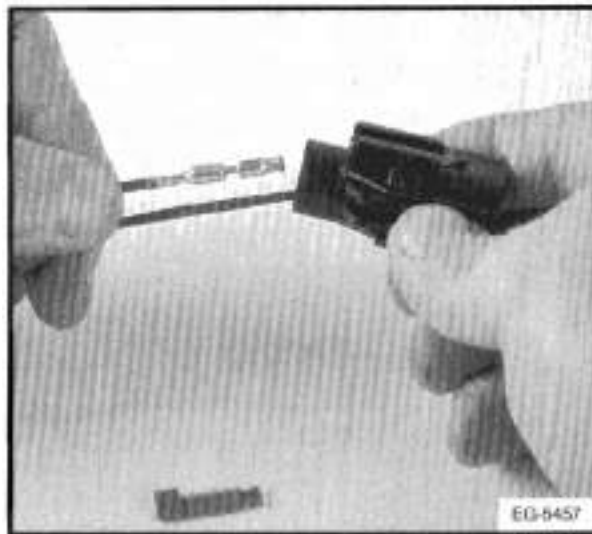


Figure 6-22. - Remove Terminal From Connector

TO REPLACE THE TERMINAL:

1. Remove the insulation, being careful not to cut any of the wire strands.
2. Position the wire in the new terminal (Figure 6-23.).

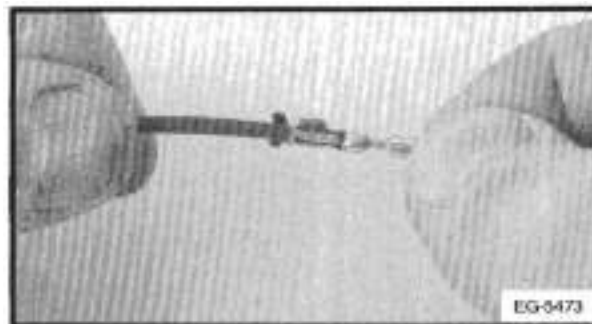


Figure 6-23. - Place Terminal Over Wire

3. Hand crimp the core wings first and then the insulation wings (Figure 6-24.).

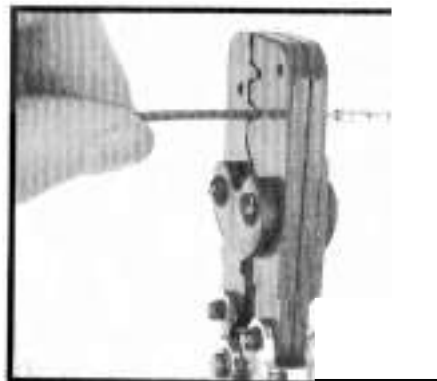


Figure 6-24. - Terminal Over Wire

CONNECTOR AND HARNESS REPAIR

TO REPLACE THE TERMINAL: - Continued

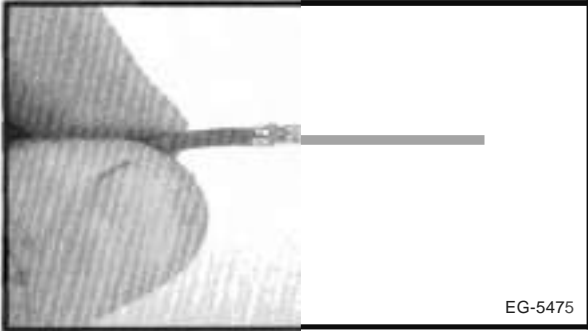


Figure 6-25. - Contact Crimping Complete

TO INSTALL THE TERMINAL IN THE CONNECTOR:

1. Push the terminal into the connector body, deep enough so that the retaining finger snaps over the terminal shoulder (Figure 6-26.).

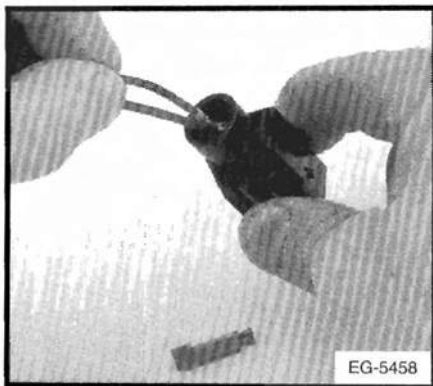


Figure 6-26. - Insert Terminal

2. Push the insulator over the wires into the connector body (if equipped) (Figure 6-27.).



Figure 6-27. - Insert Insulation

3. Insert the locking wedge and push in until flush with the face of the connector body (Figure 6-28.).

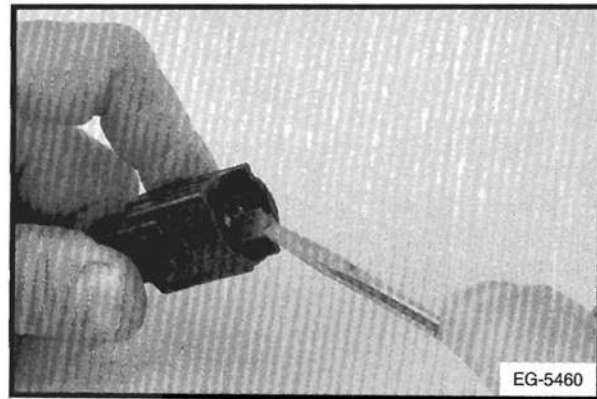


Figure 6-28. - Insert Terminal Lock

PACKARD CONNECTORS

Procedure for removal of wire terminals from CMP, ICP, IPR, EOP and injector connectors.

The terminals are held in place by locking tabs that are part of the terminal. To remove the terminal the locking tab must be released from the wire side of the connector body and the terminal is removed toward the mating end of the connector body.

TO REMOVE THE TERMINAL FROM THE CONNECTOR:

1. Pry the insulator from the rear of the connector body (Figure 6-29.).

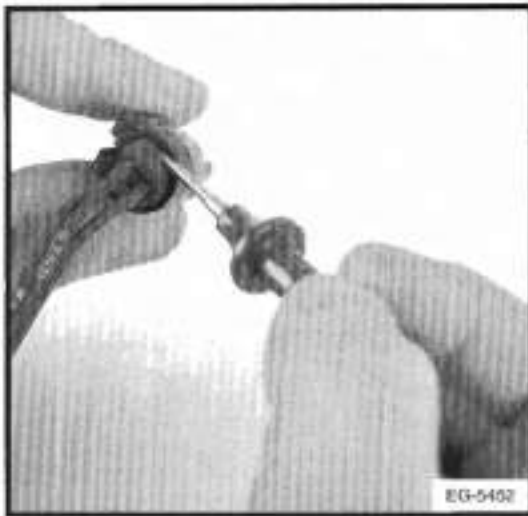


Figure 6-29. - Move The Insulation Back

2. Slide the insulator down the wires away from the connector body (Figure 6-30.).



Figure 6-30. - Slide The Insulator Back

3. Insert the narrow blade tool into the rear of the connector body on the locking tab side of the wire terminal (Figure 6-31.).



Figure 6-31. - Release Terminal Lock Tab

CONNECTOR AND HARNESS REPAIR

PACKARD CONNECTORS (Continued)

TO REPLACE THE TERMINAL: - Continued

4. Push the blade forward until the lock tab is depressed (Figure 6-32.).



Figure 6-32. - Release Terminal

5. Additional pressure will force the wire terminal out the end of the connector body.

If the terminal is to be replaced, use the standard repair procedure (instructions above). Make certain that the wire is through the insulator and wire before the terminal is crimped onto the wire. Figure 6-33.

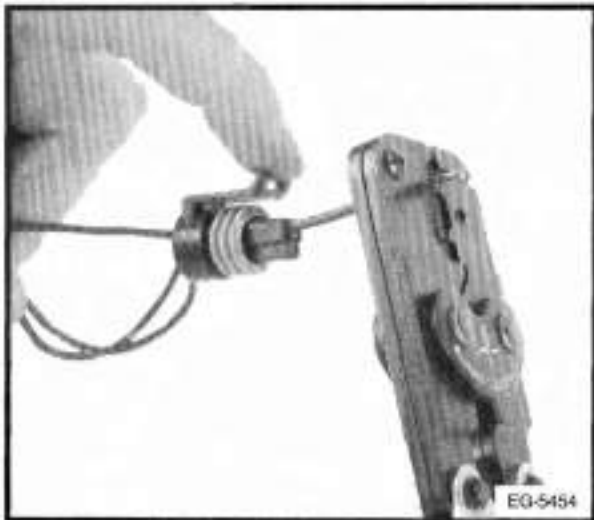


Figure 6-33.- Contact Crimping

TO INSTALL THE TERMINAL IN THE CONNECTOR:

1. Align the wing on the terminal with the slot in the connector body. Pull the wire into the connector body until the locking tab snaps into the connector.
2. Push the wire insulator into place at the rear of the connector body. (Figure 6-34.)
3. Make certain the connector insulator is in place to reinstall the connector.



Figure 6-34. - Reinstall Insulator

SECTION 7

VEHICLE AND COMPONENT ILLUSTRATIONS

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SECTION 7

VEHICLE AND COMPONENT ILLUSTRATIONS

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TRUCK LH CAB WIRING

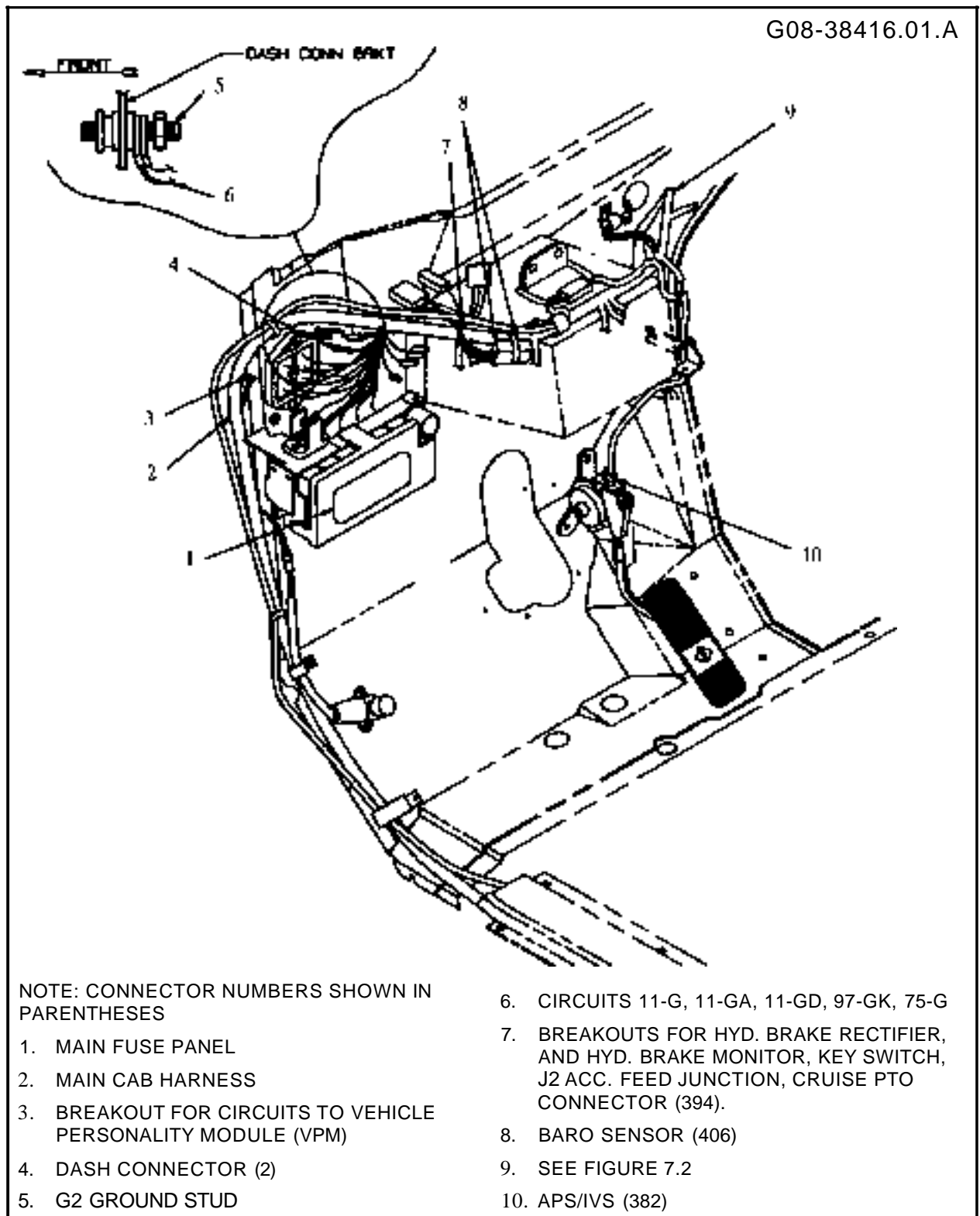


Figure 7.1 - Truck LH Cab Wiring

RH TRUCK CAB WIRING

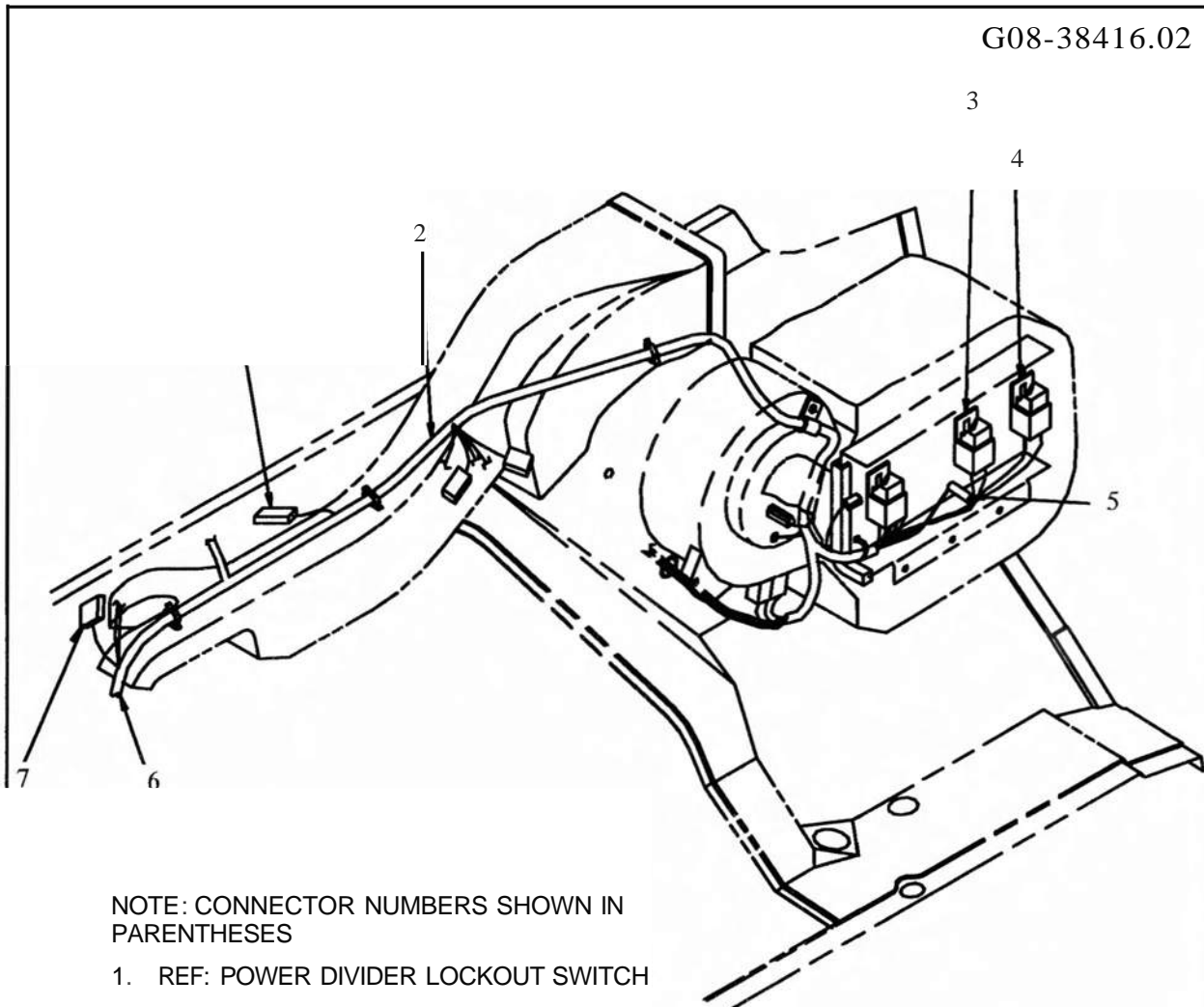
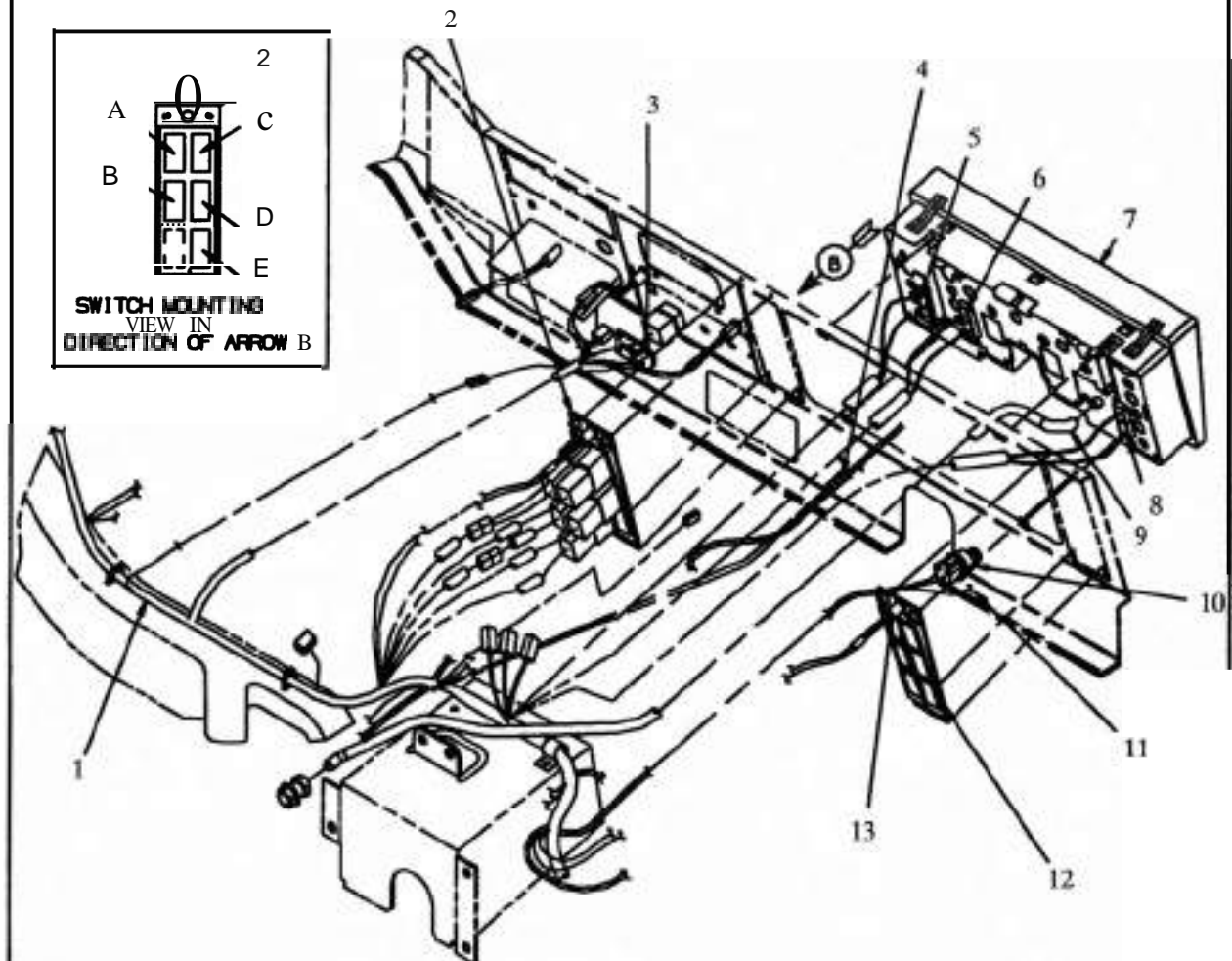


Figure 7.2 - RH Truck Cab Wiring

CENTER TRUCK CAB WIRING

G08-38416.03.A



NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

- | | |
|--|---|
| <ol style="list-style-type: none"> 1. MAIN CAB HARNESS 2. RH SWITCH PANEL (VIEW B) <ul style="list-style-type: none"> A. WINDSHIELD WIPER (31) B. HEADLIGHT (35) C. WINDSHIELD WASHER (34) D. PANEL LIGHT (33) E. INTERRUPT (36) 3. CIRCUIT 43 TO POL SWITCH 4. DIAGNOSTIC SWITCH (CIRCUITS 98/98A & 98-G) | <ol style="list-style-type: none"> 5. YELLOW CLUSTER CONNECTOR (26) 6. GREEN CLUSTER CONNECTOR (27) 7. INSTRUMENT CLUSTER 8. NATURAL CLUSTER CONNECTOR (28) 9. REF: OIL PRESSURE LINE TO GAUGE 10. KEY SWITCH (24) 11. CIRCUIT 17 TO KEY SWITCH "S" TERMINAL W/O PUSH BUTTON 12. LH SWITCH CLUSTER <ul style="list-style-type: none"> LEFT CENTER - CRUISE ON/OFF (391) RIGHT CENTER - SET/RESUME (392) 13. REF: DASH LIGHT |
|--|---|

Figure 7.3 - Center Truck Cab Wiring

TRUCK FUSE PANEL AND EST CONNECTOR (384) INSTALLATION

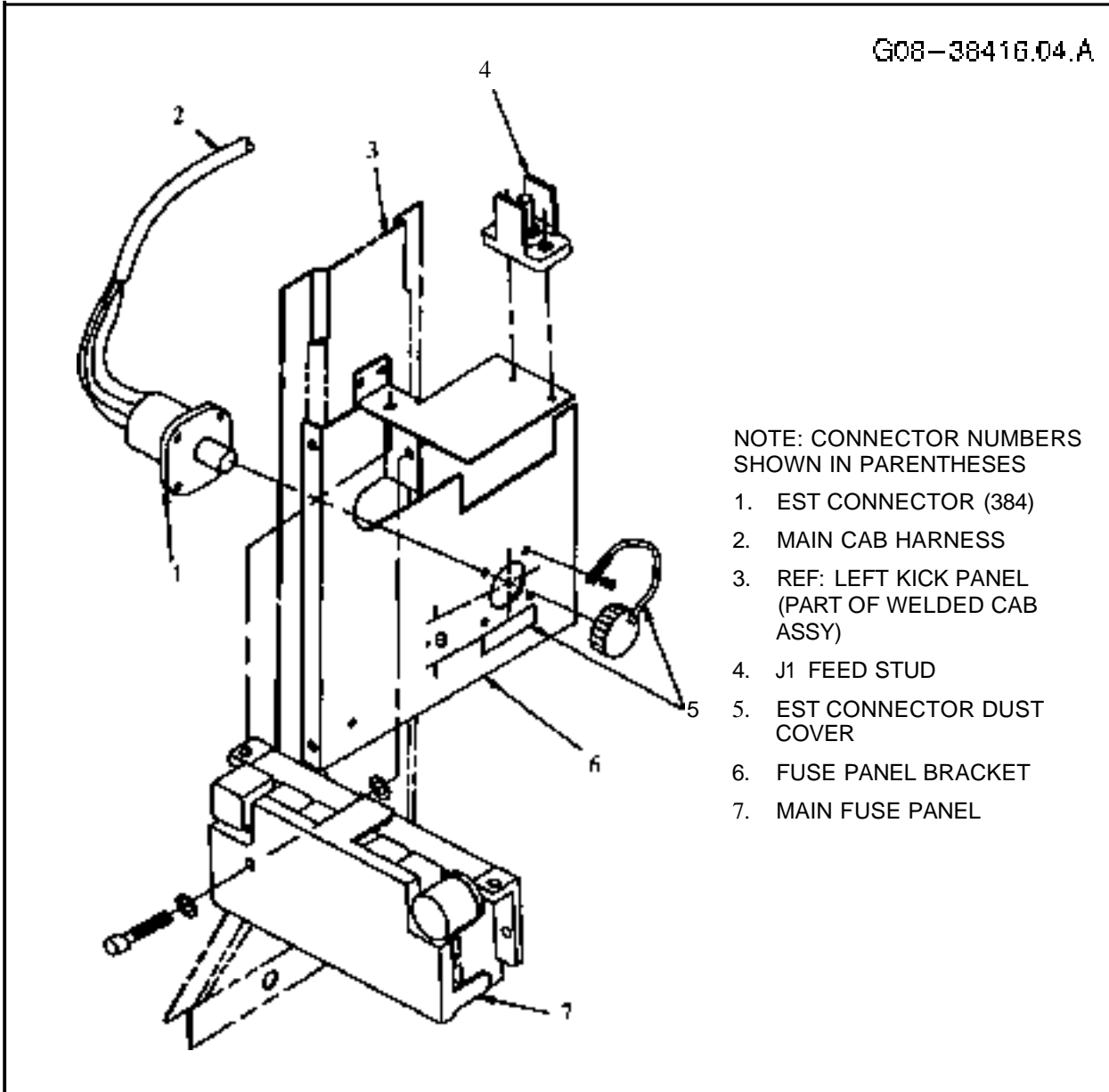


Figure 7.4 - Truck Fuse Panel And EST Connector (384) Installation

TRUCK BNO/BNC AIR BRAKE PRESSURE SWITCHES

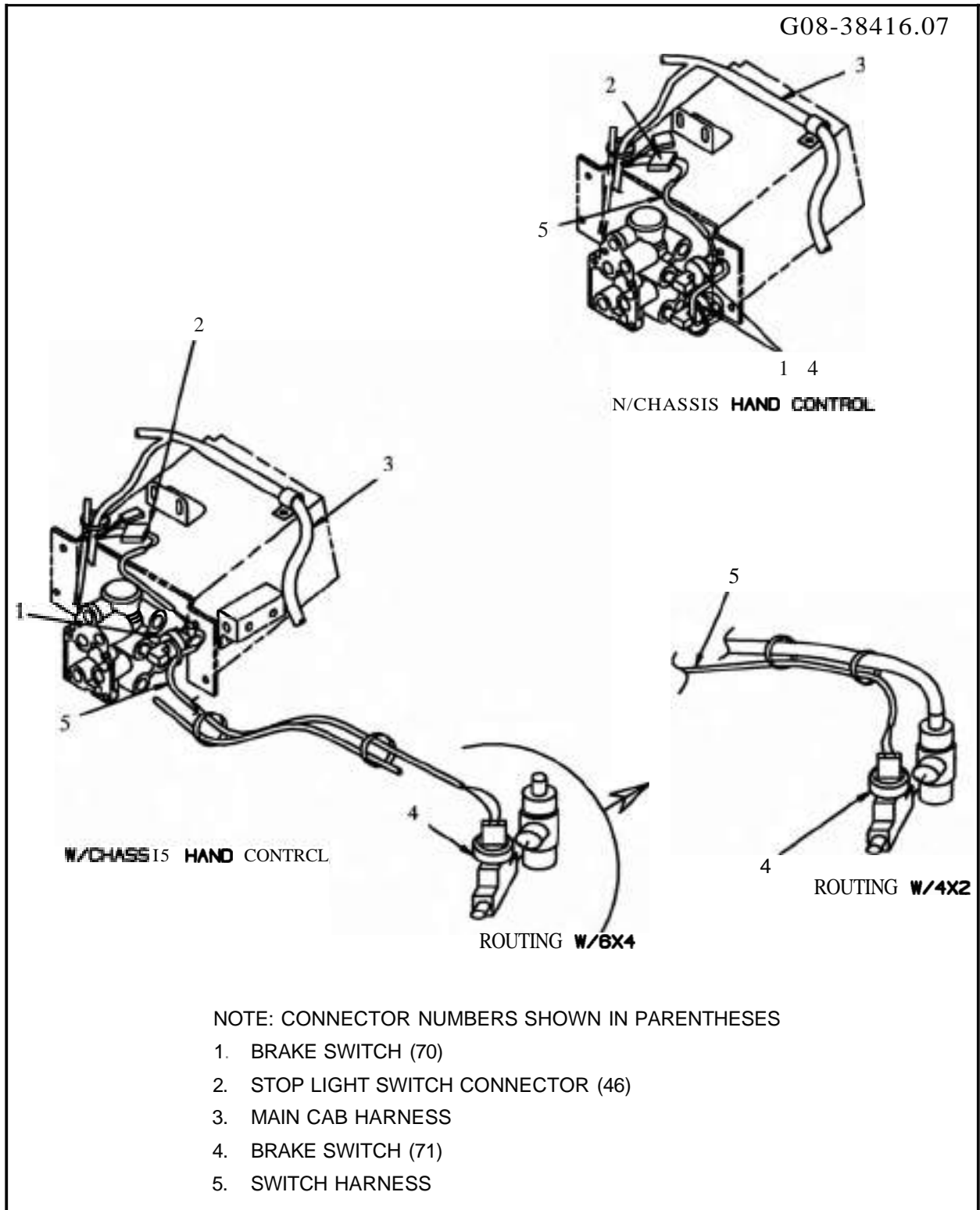


Figure 7.5 - Truck BNO/BNC Air Brake Pressure Switches

VEHICLE AND COMPONENT ILLUSTRATIONS

TRUCK BNO/BNC HYDRAULIC BRAKE SWITCHES

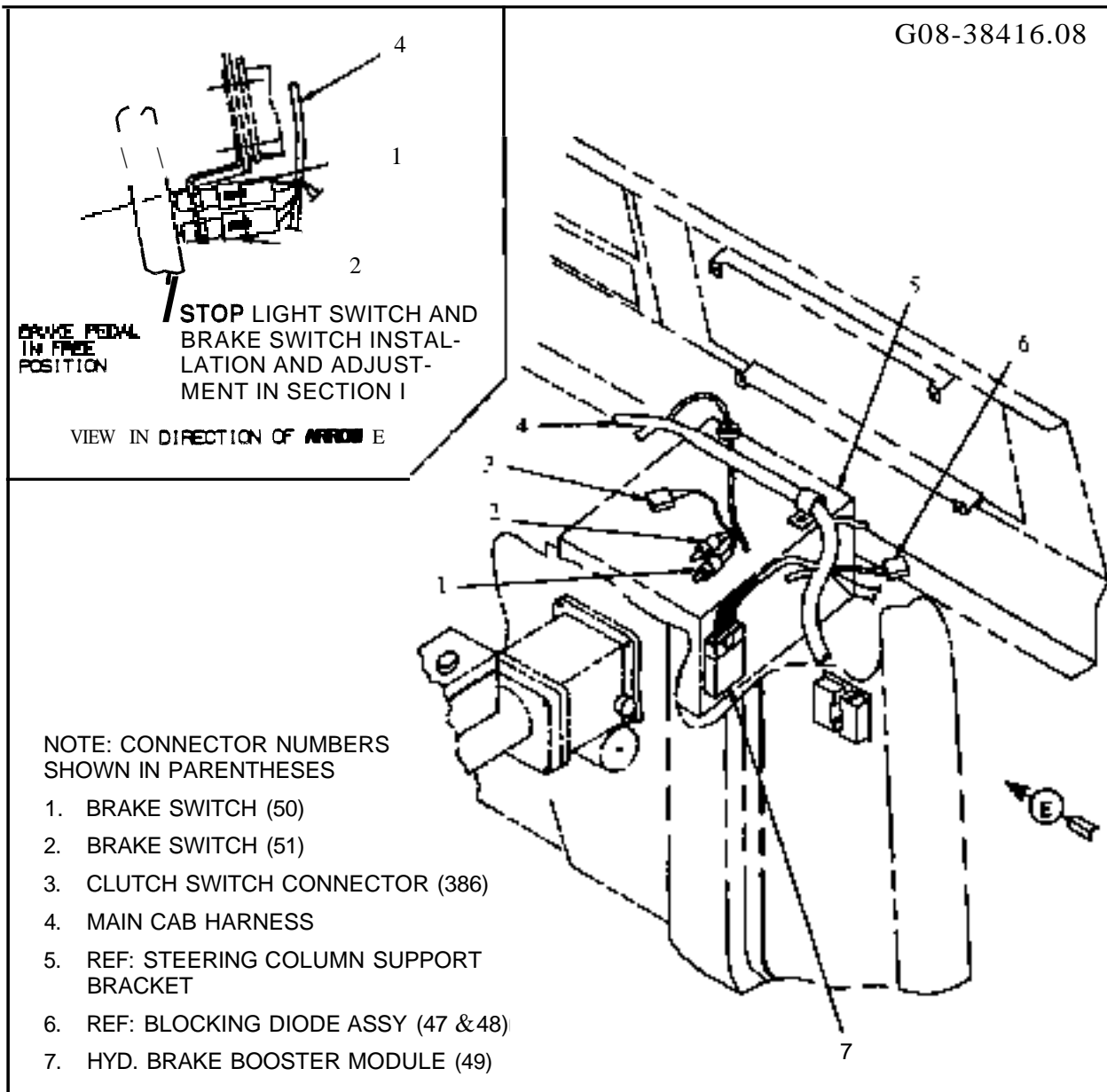


Figure 7.6 - Truck BNO/BNC Hydraulic Brake Switches

ECMNPM MODULE LOCATION

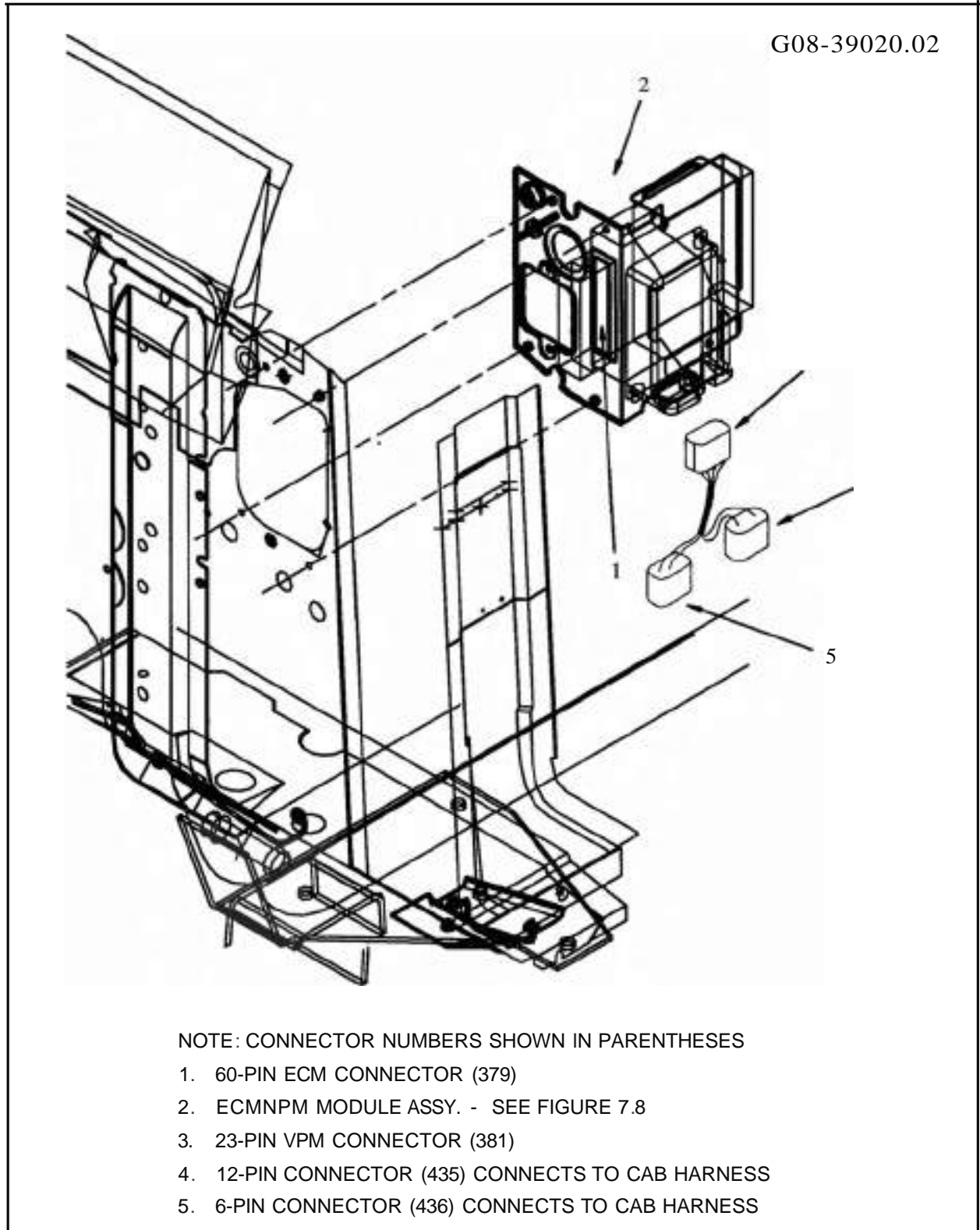
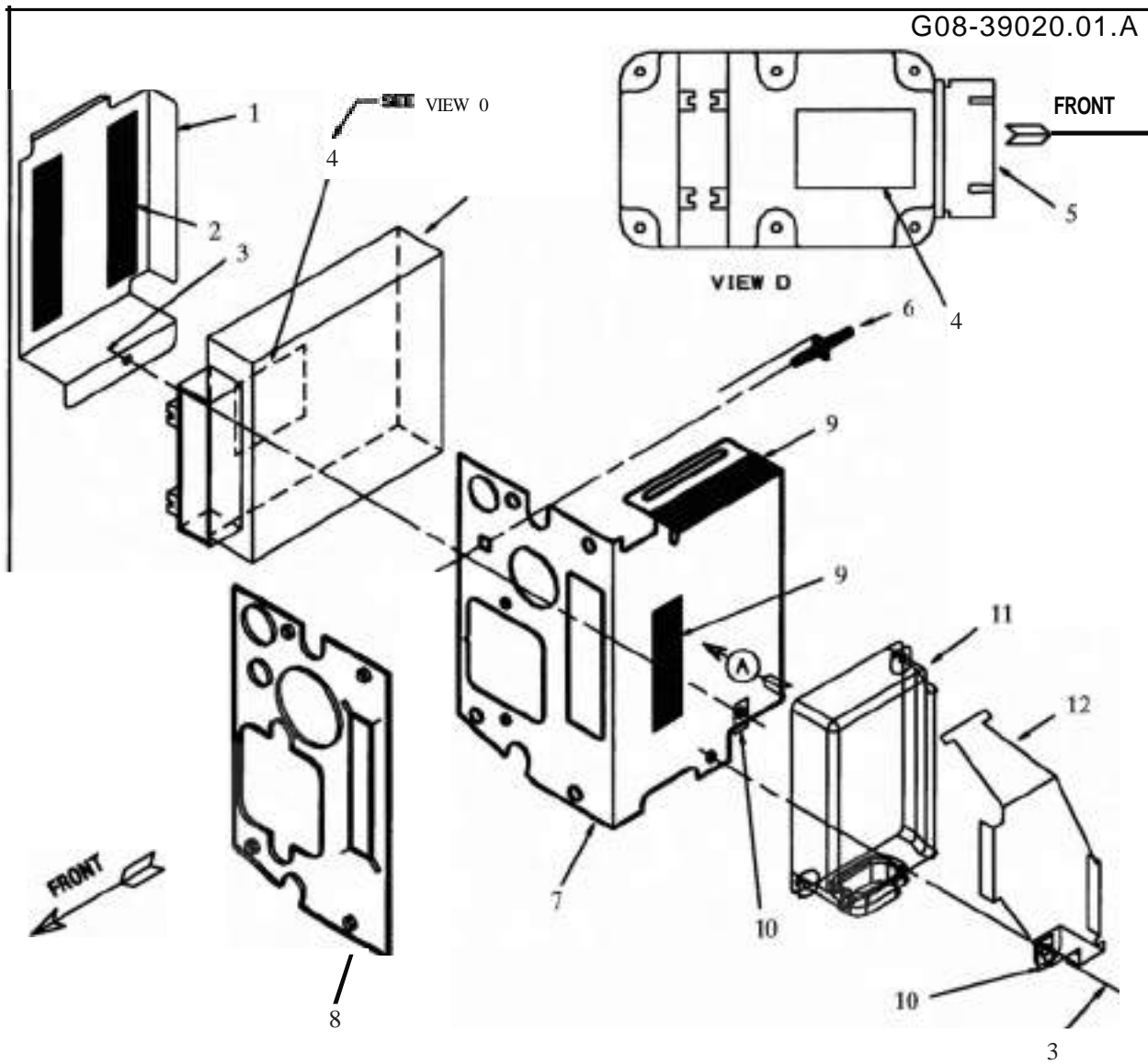


Figure 7.7 - ECMNPM Module Location

ECMNPM MODULE ASSEMBLY



NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

- | | |
|--|--|
| 1. DETACHABLE ECM BRACKET | 7. CONTROL MODULE BRACKET ASSY. |
| 2. SEALING TAPE (1/4" THICK X 1" WIDE X 5.5" LONG) | 8. SEAL APPLIED TO FRONT OF ITEM 7 |
| 3. PAN HEAD SCREW (1/4-14 X 1/2) | 9. SEALING TAPE (1/4 THICK X 1" WIDE X 3.5" LONG) |
| 4. ECM INFORMATION LABEL (SEE VIEW D) | 10. J-SPRING NUT -1/4-14.060 TO .087 PNL THICKNESS |
| 5. ECM | 11. VPM |
| 6. GROUND STUD | 12. DETACHABLE VPM BRACKET |

Figure 7.8 - ECMNPM Module Assembly

TRUCK CRUISE/PTO WIRING

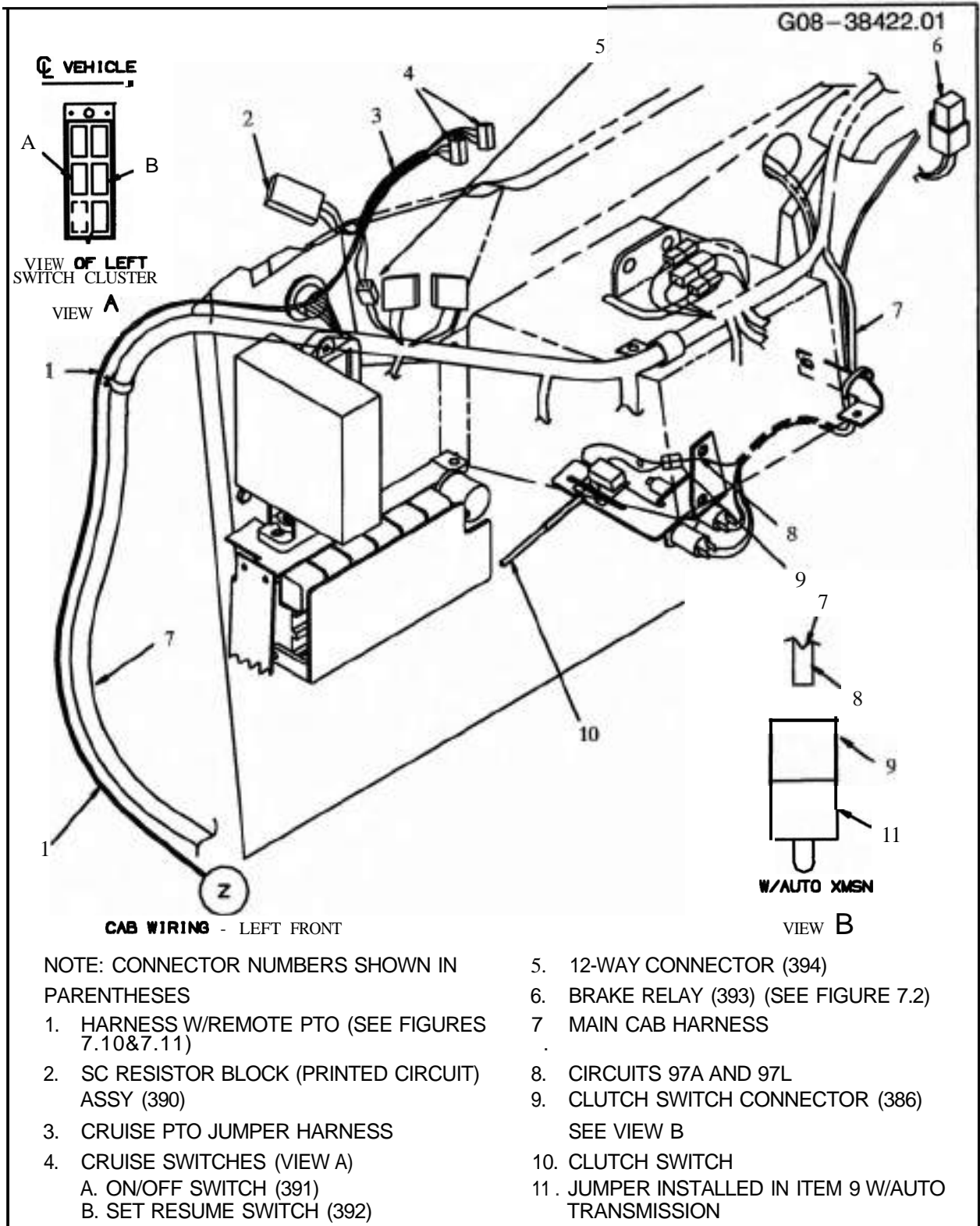


Figure 7.9 - Truck Cruise/PTO Wiring

VEHICLE AND COMPONENT ILLUSTRATIONS

REAR CAB PTO WIRING (NITRAVELCREW CAB)

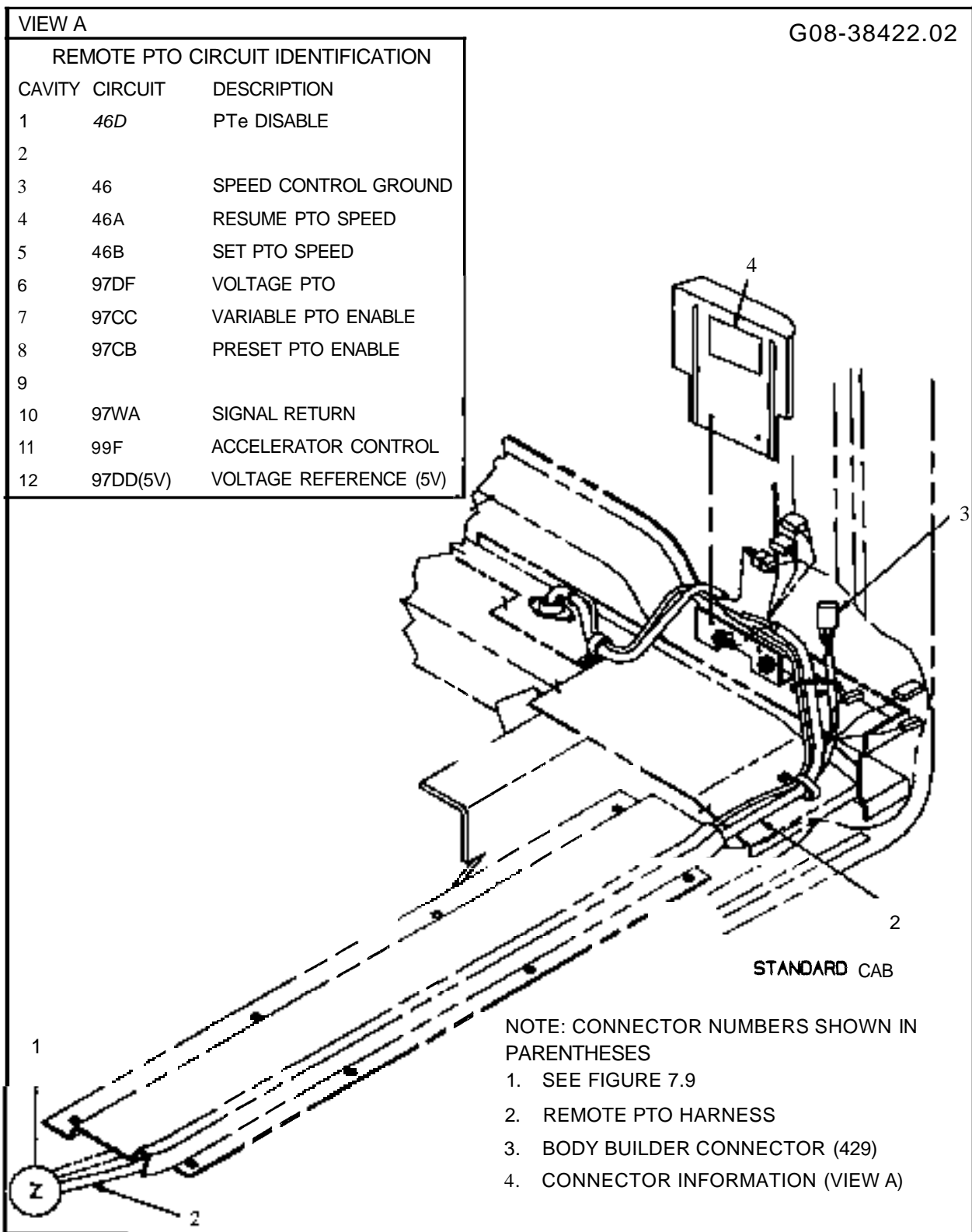


Figure 7.10 - Rear Cab PTO Wiring (NITRAVELCREW Cab)

REAR TRAVEL CREW CAB PTO WIRING

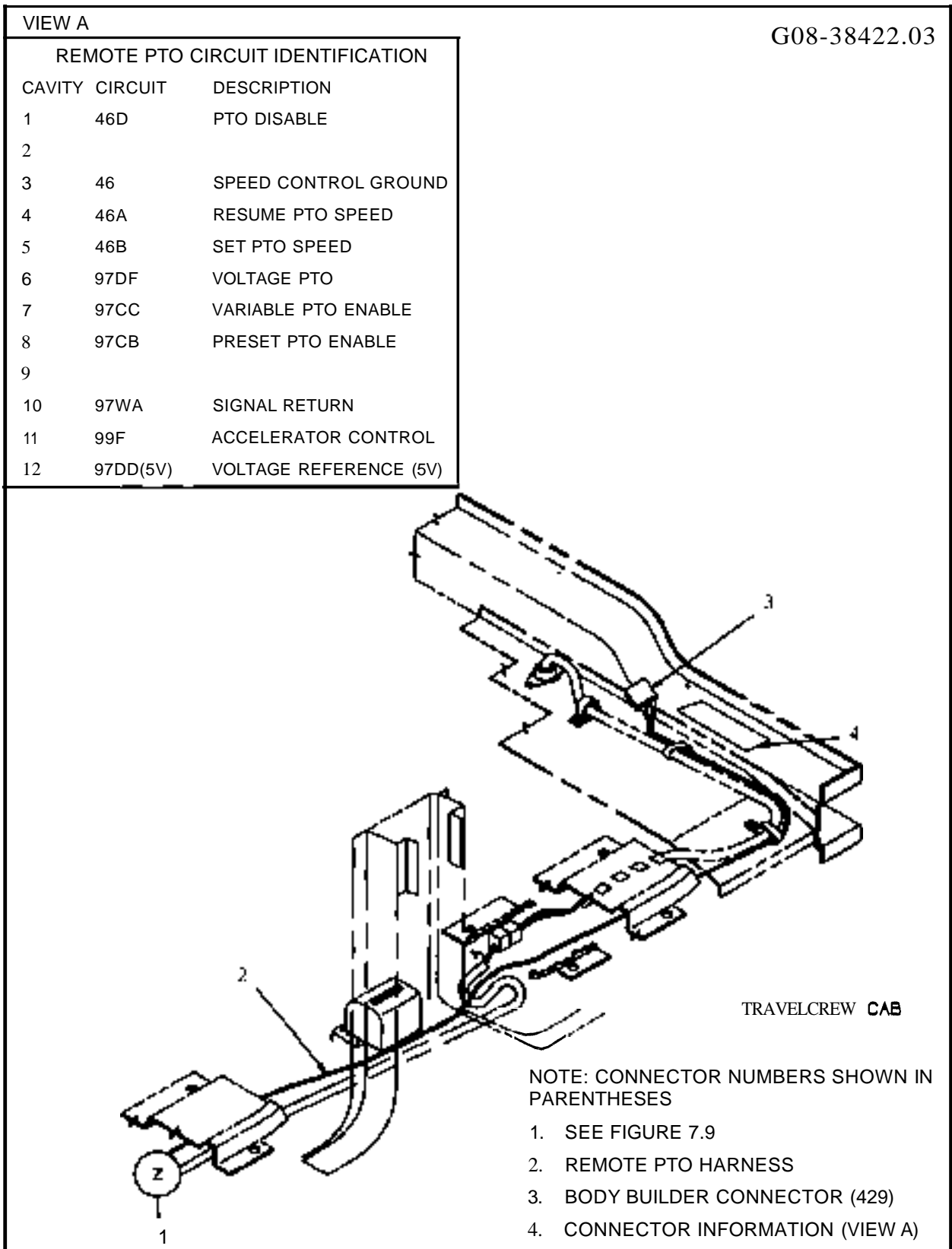
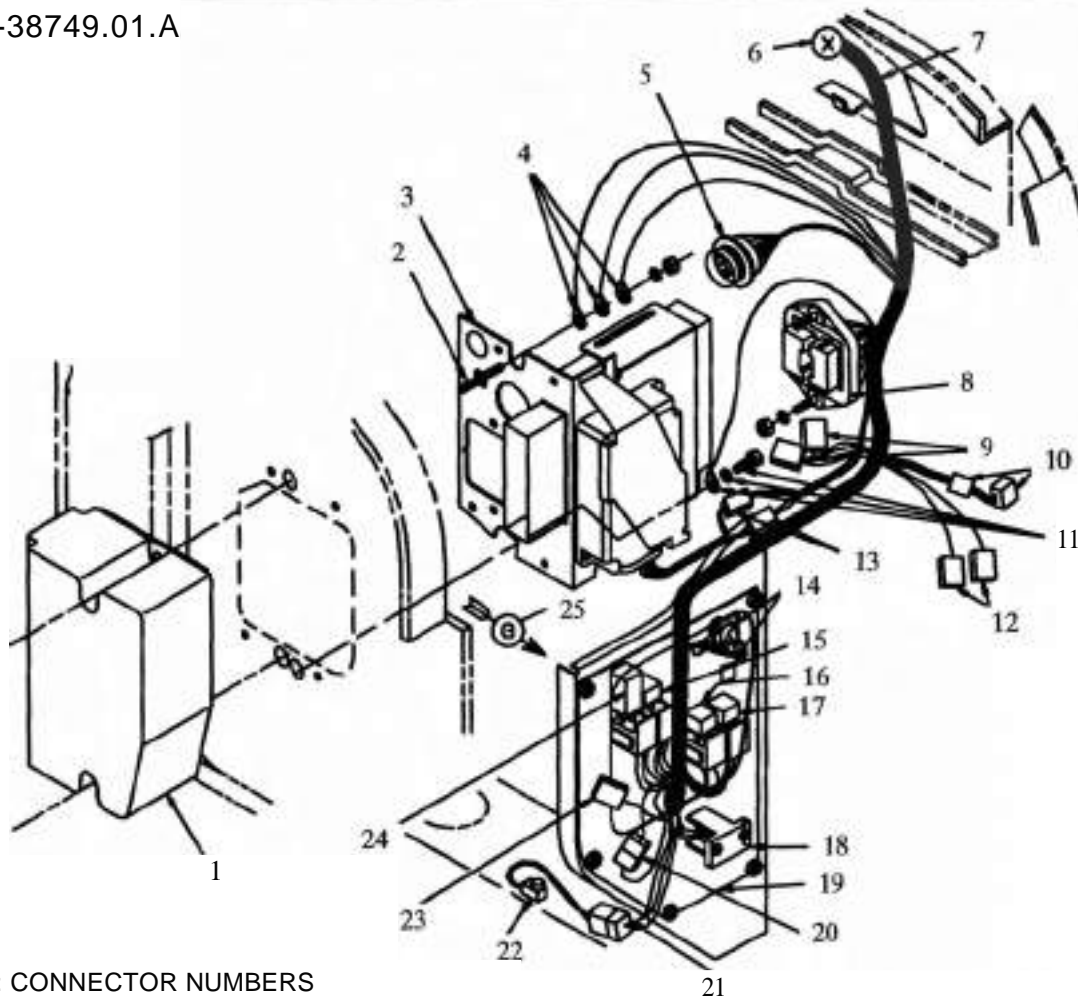


Figure 7.11 - Rear Travel Crew Cab PTO Wiring

FBC LH CAB WIRING

G08-38749.01.A

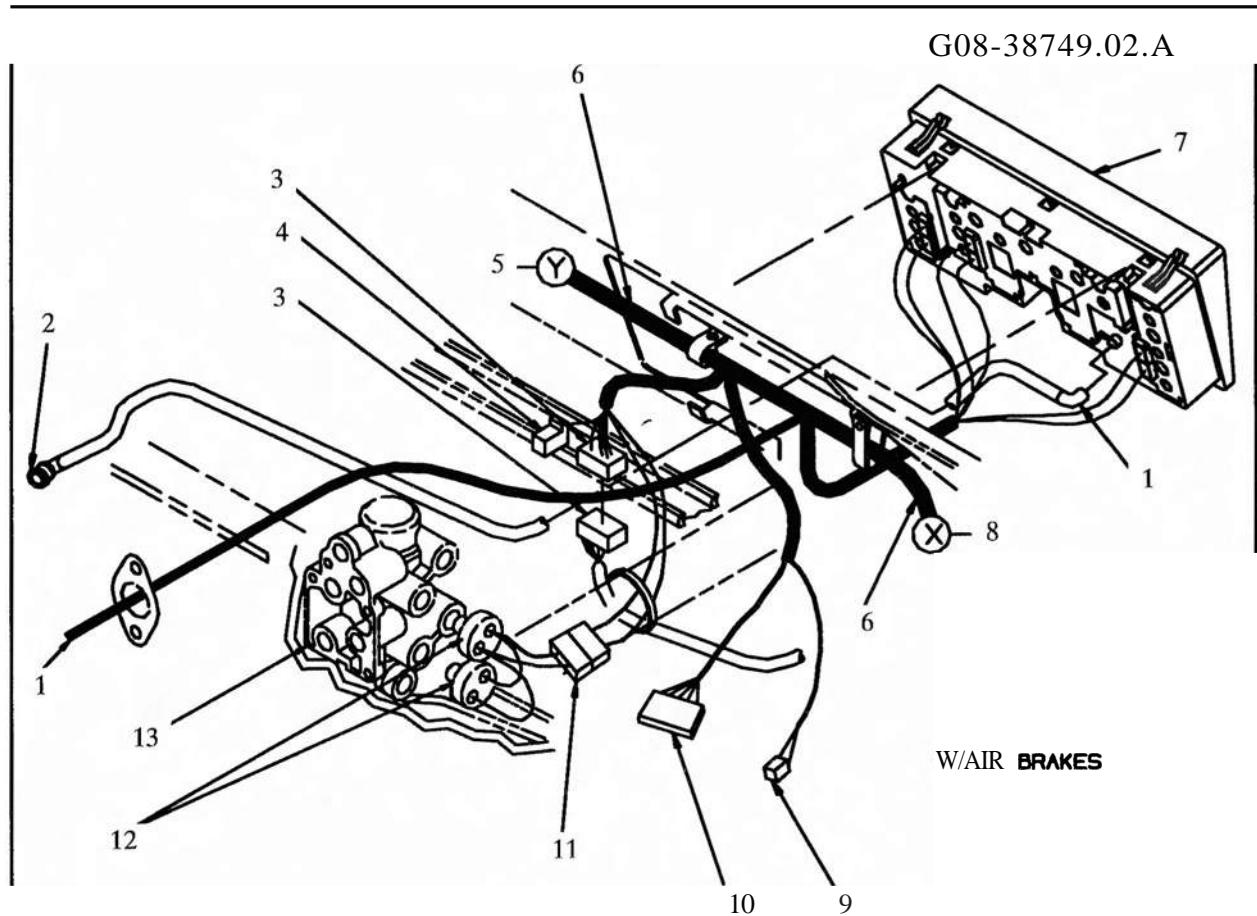


NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

- | | |
|---|---|
| <ul style="list-style-type: none"> 1. JUNCTION BOX COVER 2. G2 GROUND STUD 3. ECMNPM MODULE SUB-ASSY. (FIGURES 7.7 AND 7.8) 4. CIRCUITS 11-G, 36-G, 11-GD, 97-GK, 97-GQ 5. 31-PIN DEUTSCH CONNECTOR (3) 6. SEE FIGURES 7.13 AND 7.14 7. MAIN CAB HARNESS 8. DASH CONNECTOR (2) 9. RED POSITIVE (427) & BLUE NEGATIVE (428) BUS CONNECTORS 10. BODY BUILDER CONNECTOR (194) & LABEL 11. CIRCUIT 11-GD GROUNDS AT MTG BOLT 12. 2-SPEED AXLE ONE WAY CONNECTORS | <ul style="list-style-type: none"> 13. VPM CONNECTORS (435) AND (436) 14. EST CONNECTOR (384) 15. HORN RELAY (61) 16. BRAKE SWITCH RELAY (300) 17. CRANK RELAY (385) 18. J1 BODY BUILDER FEED STUD 19. REF: LEFT COWL INNER PANEL 20. STARTER INTERRUPT CONNECTION (CIRCUIT 17 TO 17C) 21. DIMMER SWITCH CONNECTOR (17) 22. DIMMER SWITCH 23. FOG LIGHT CONNECTOR (115) 24. ALARM (20) 25. SEE FIGURE 7.18 |
|---|---|

Figure 7.12 - FBC LH Cab Wiring

FBC CAB WIRING WITH AIR BRAKES



NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

- | | |
|--|--------------------------------------|
| 1. CIRCUIT 140 TO J30 FEED STUD ON 10M BRACKET | 7. INSTRUMENT CLUSTER |
| 2. REF: OIL PRESSURE GAUGE HOSE | 8. SEE FIGURE 7.12 |
| 3. TURN SIGNAL CONNECTOR (58) | 9. CLUTCH SWITCH CONNECTOR (386) |
| 4. HORN SWITCH ONE WAY CONNECTOR | 10. APS/IVS CONNECTOR (382) |
| 5. SEE FIGURE 7.15 | 11. STOP LIGHT SWITCH CONNECTOR (46) |
| 6. MAIN CAB HARNESS | 12. AIR BRAKE SWITCHES (70 & 71) |
| | 13. REF: AIR BRAKE VALVE |

Figure 7.13 - FBC Cab Wiring With Air Brakes

VEHICLE AND COMPONENT ILLUSTRATIONS

FBC CAB WIRING WITH HYDRAULIC BRAKES

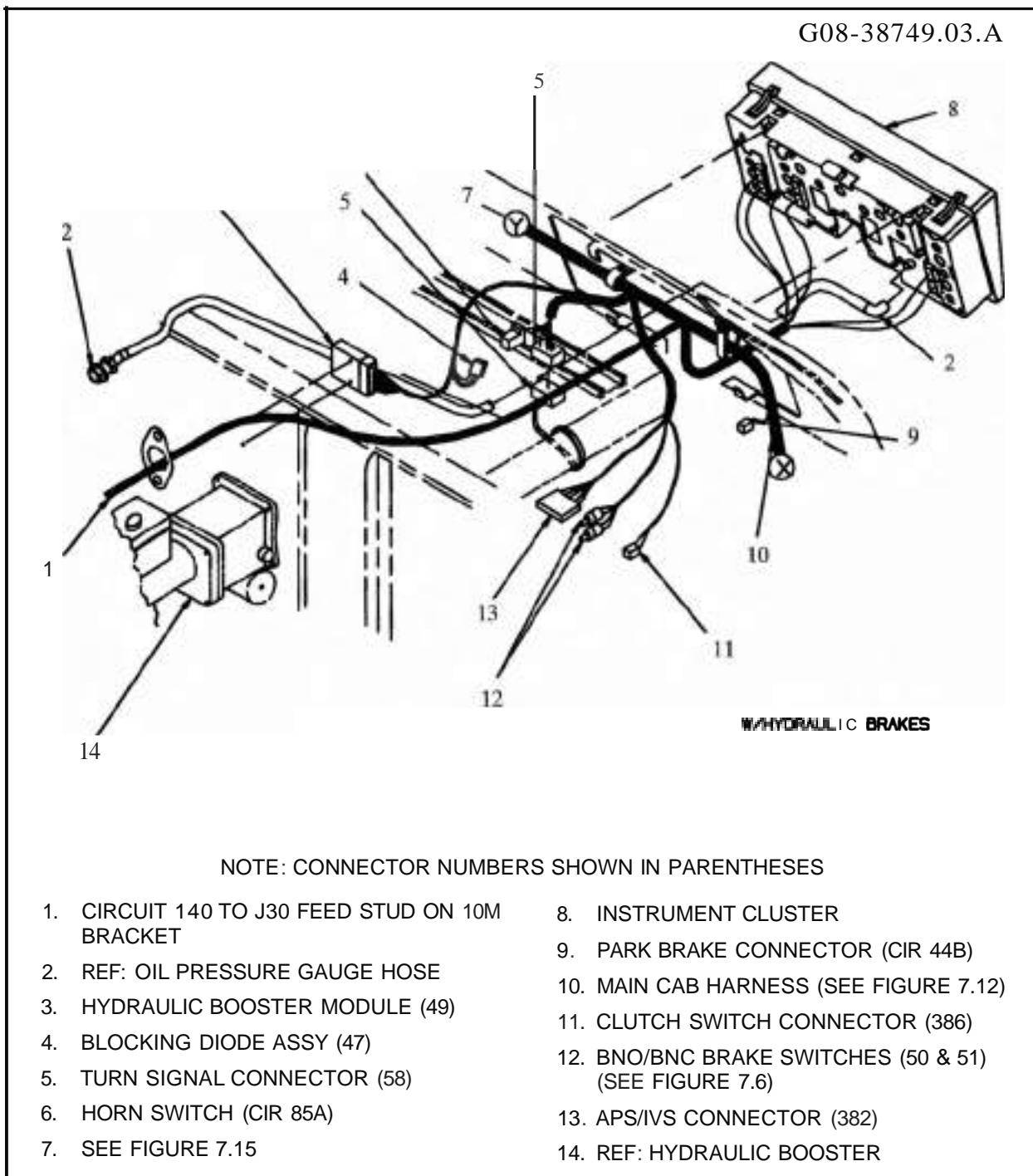


Figure 7.14 - FBC Cab Wiring With Air Brakes

FBC RH CAB WIRING

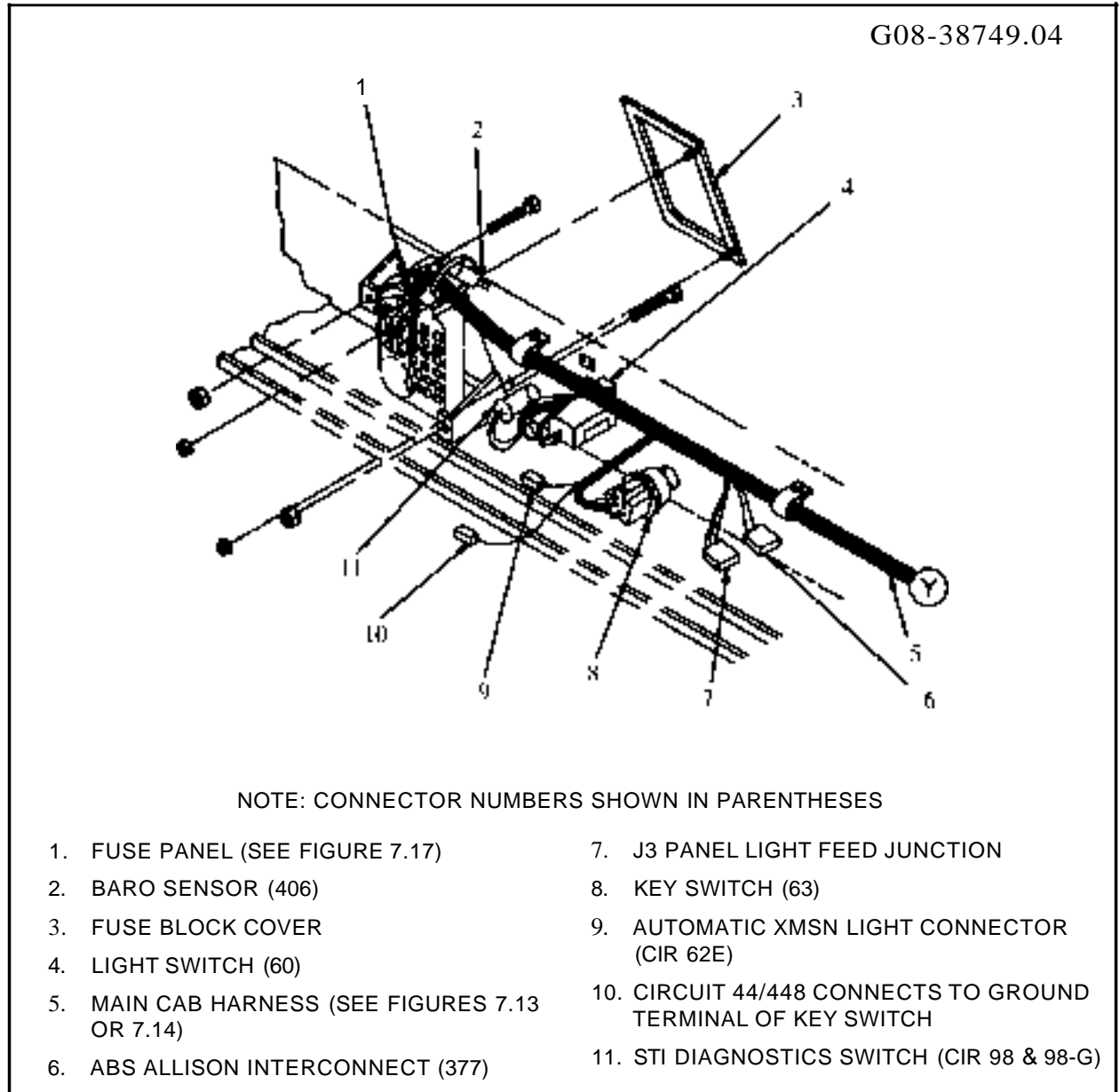


Figure 7.15 - FBe RH Cab Wiring

FBC PARK BRAKE SWITCH

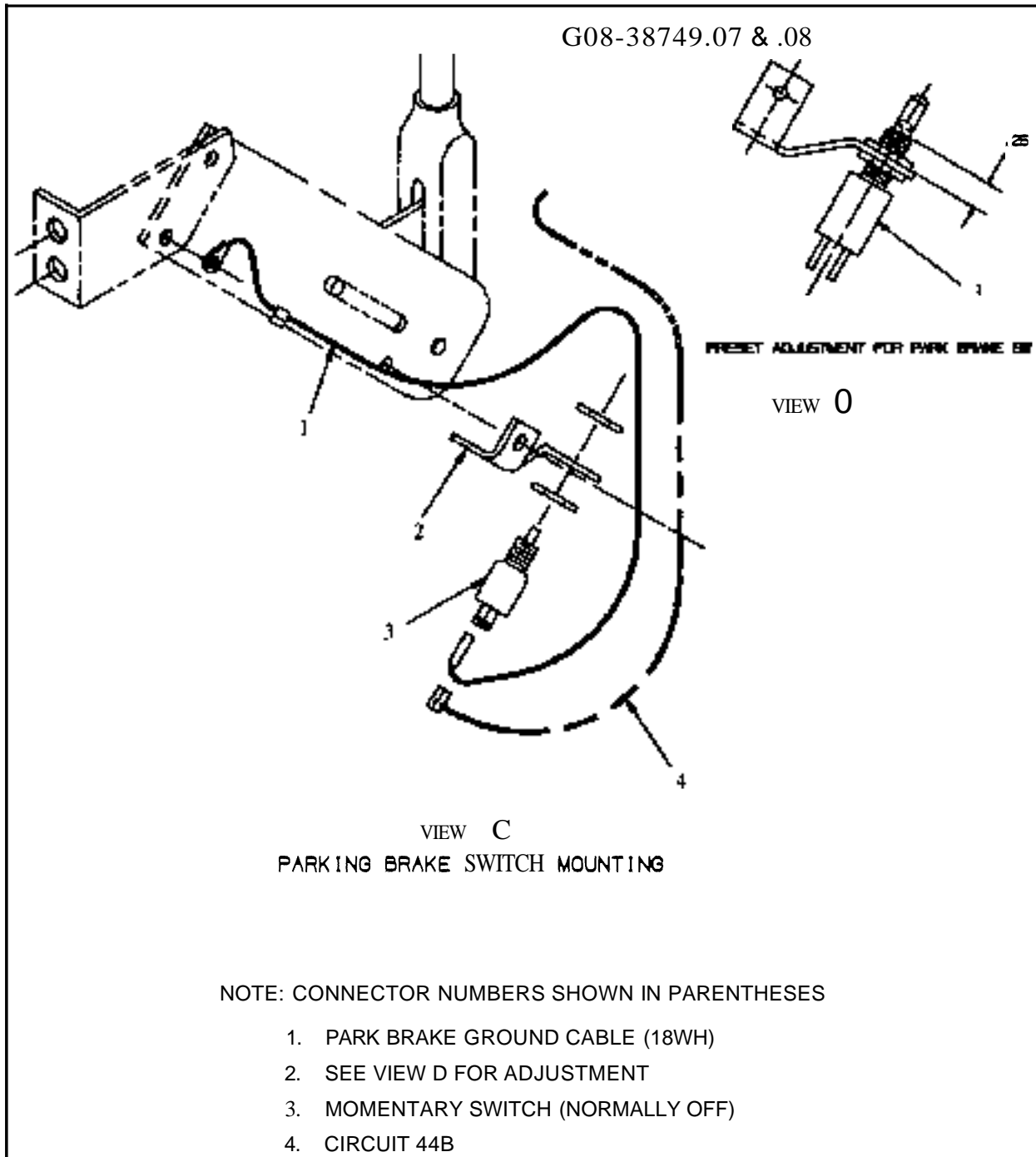


Figure 7.16 - FBC Park Brake Switch

FBC FUSE PANEL

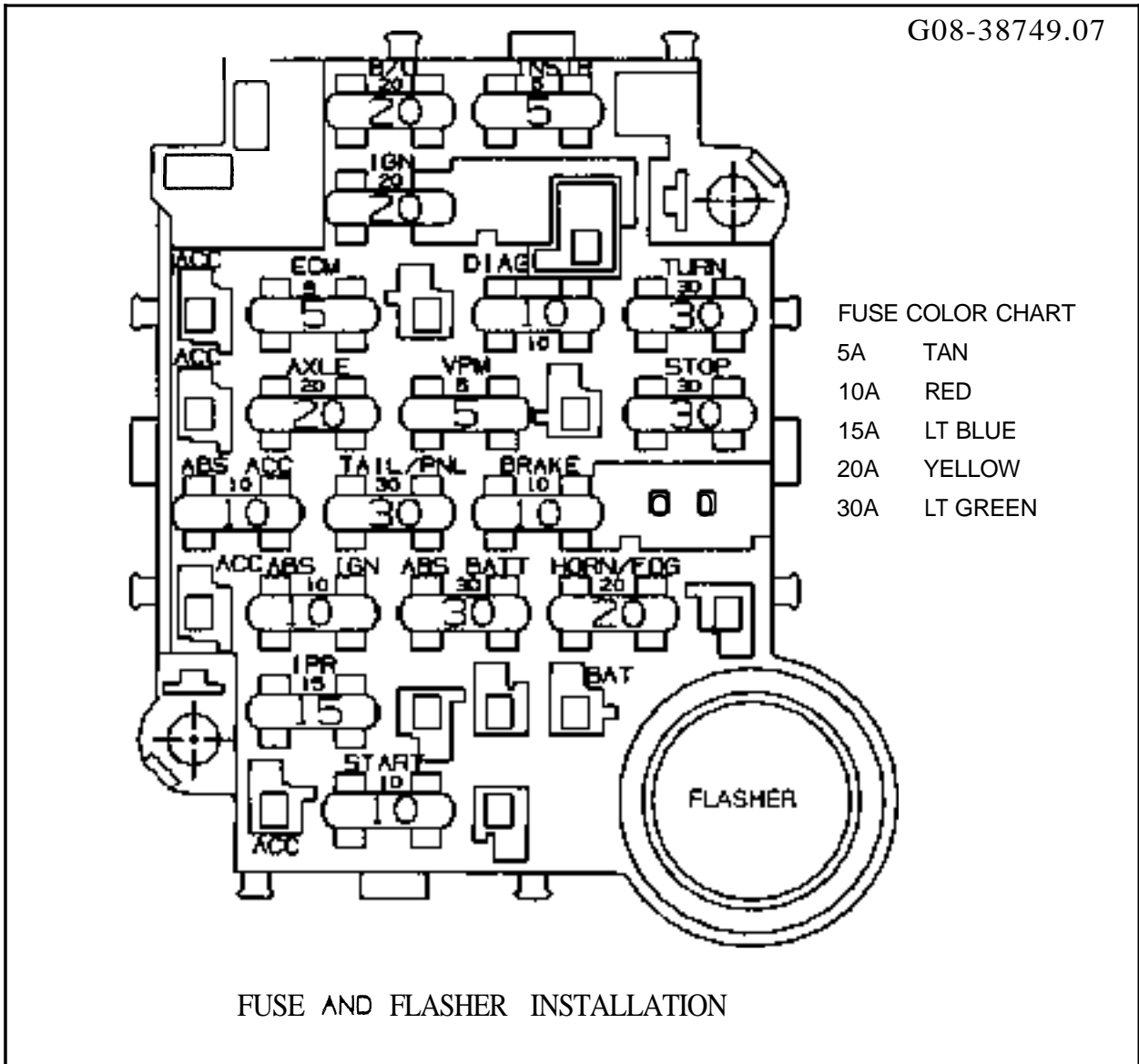


Figure 7.17 - FBC Fuse Panel

FBC LEFT KICK PANEL

G08-38749.09

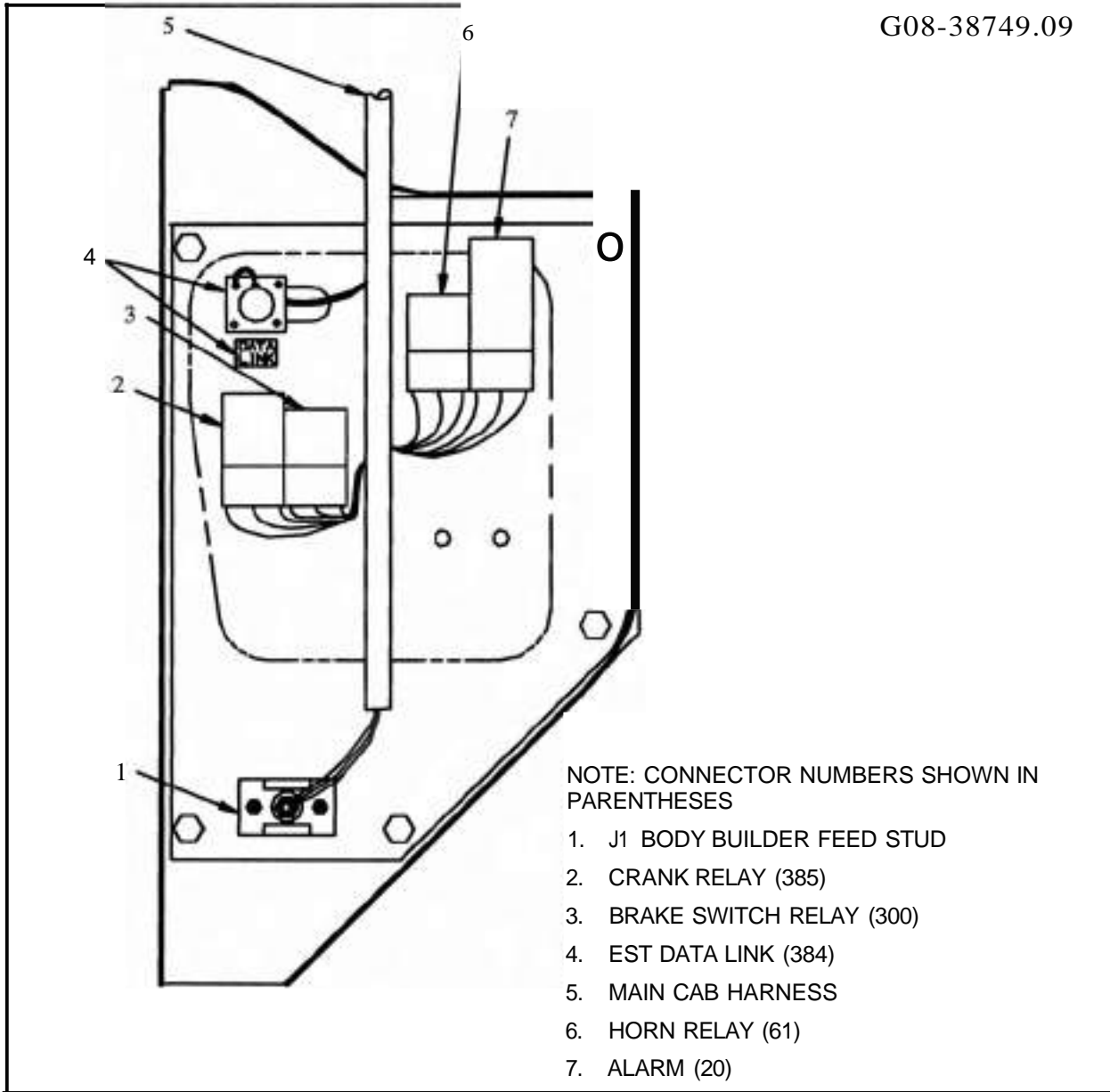


Figure 7.18 - FBC Left Kick Panel

DASH HARNESS WIRING TRUCK AND FBC (LEFT SIDE)

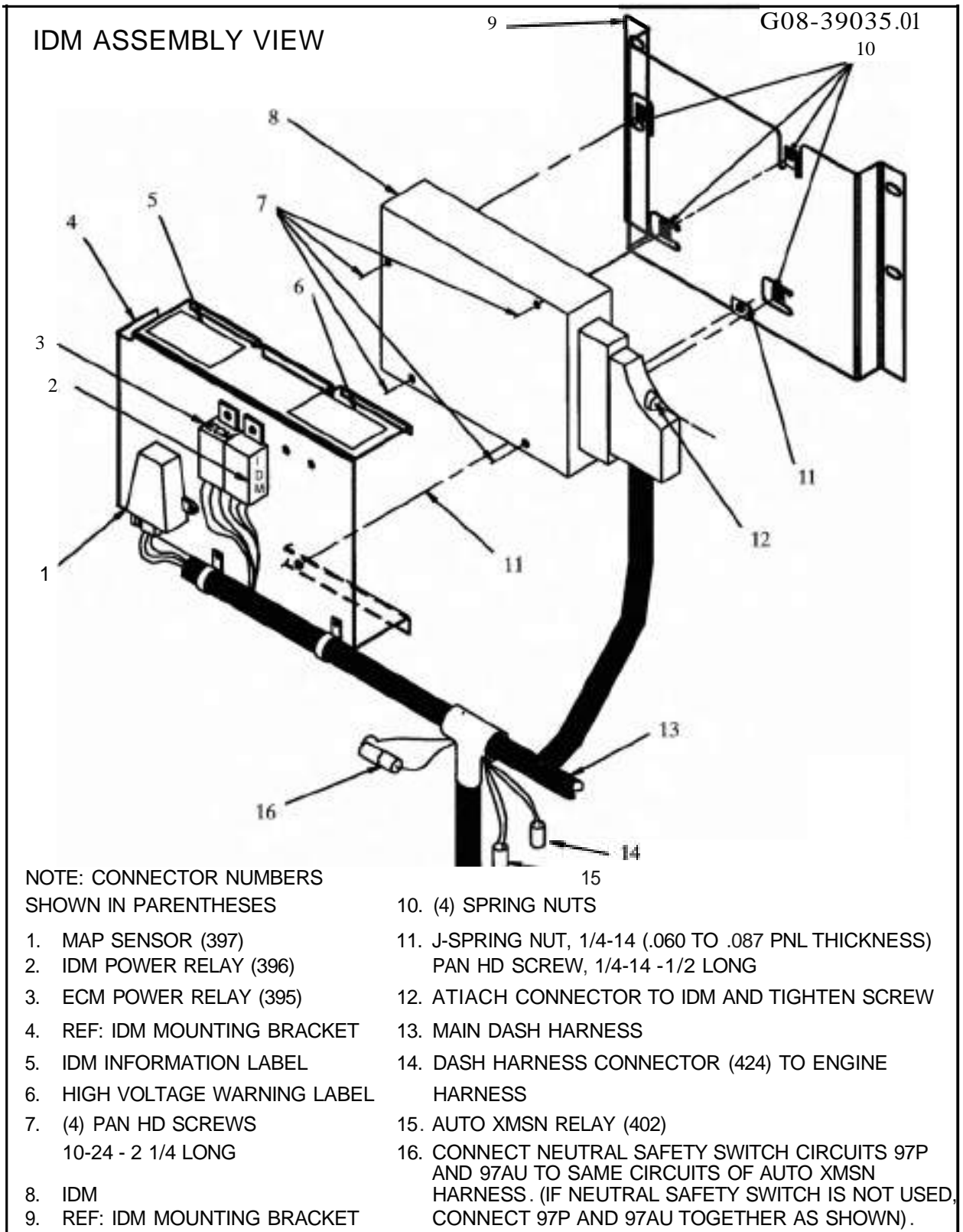
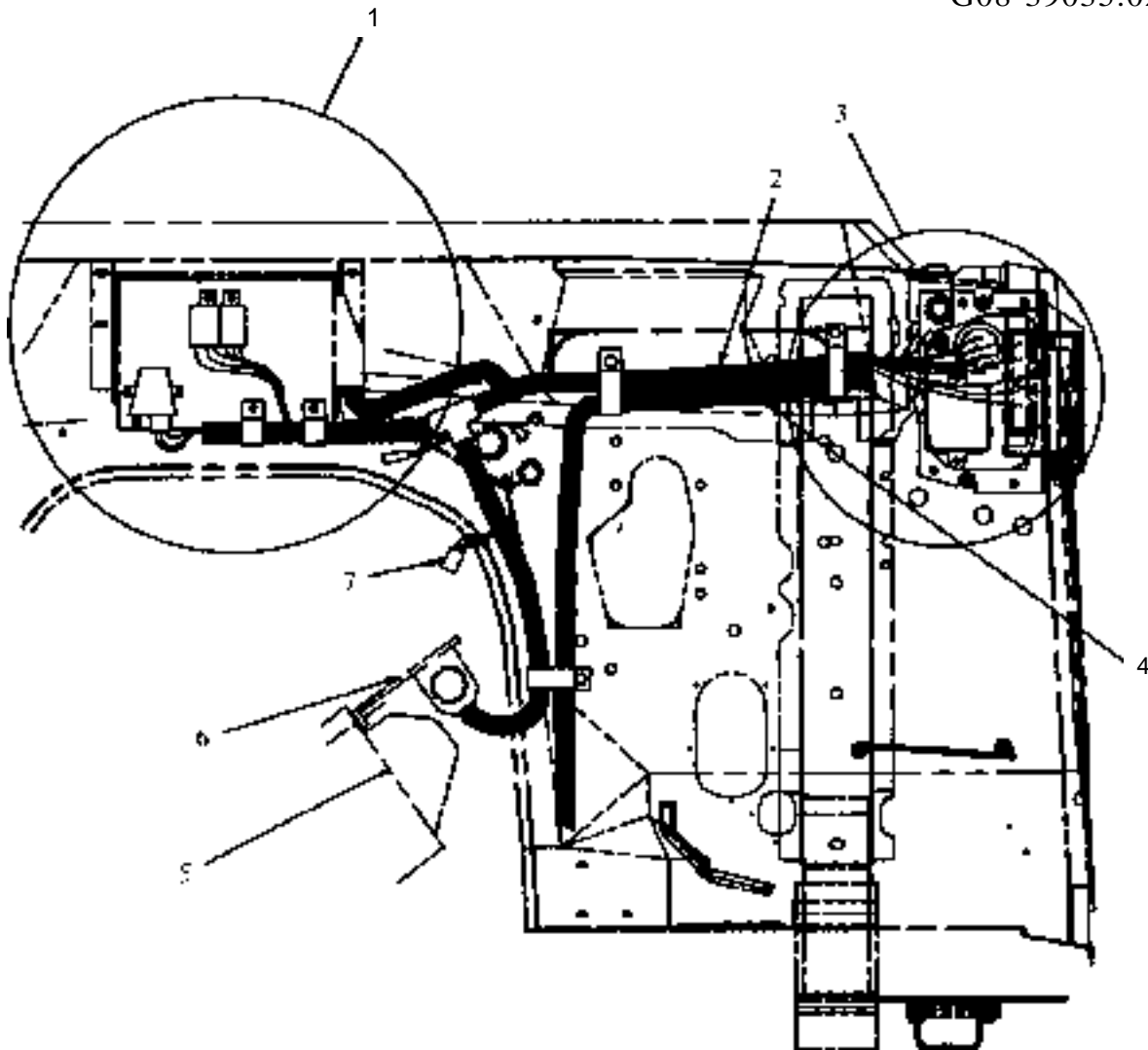


Figure 7.19 - Dash Harness Wiring Truck And FBC (Left Side)

DASH HARNESS WIRING TRUCK AND FBC (CENTER)

G08-39035.02



NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

1. SEE FIGURE 7.19 FOR 10M ASSY CONNECTIONS
2. MAIN DASH WIRING HARNESS
3. SEE FIGURE 7.21
4. MAIN ENGINE HARNESS
5. REF: LEFT VALVE COVER
6. DASH HARNESS 31-WAY CONNECTOR (405) CONNECTS TO ENGINE HARNESS
7. EXHAUST BACK PRESSURE CONNECTOR (410)

Figure 7.20 - Dash Harness Wiring Truck and FBC (Center)

EGES-125-1

DASH HARNESS WIRING TRUCK AND FBe (LEFT SIDE)

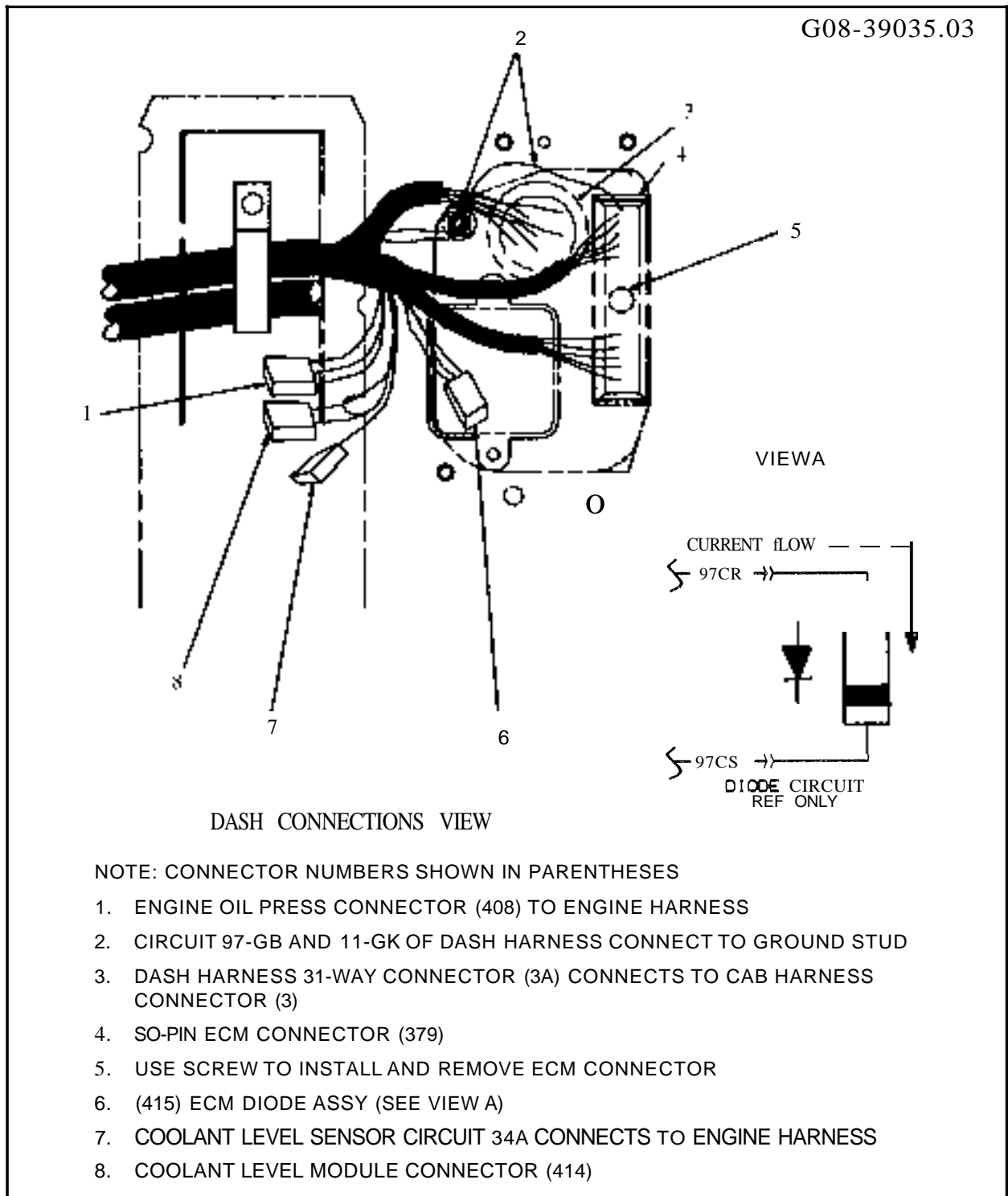
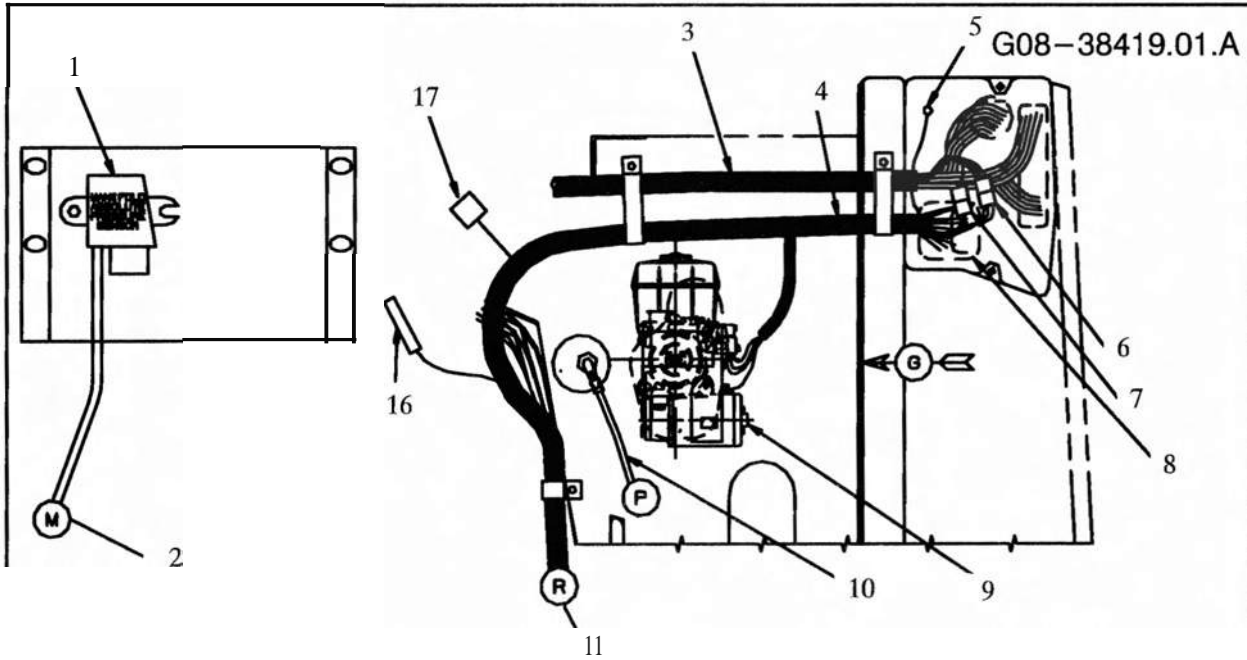


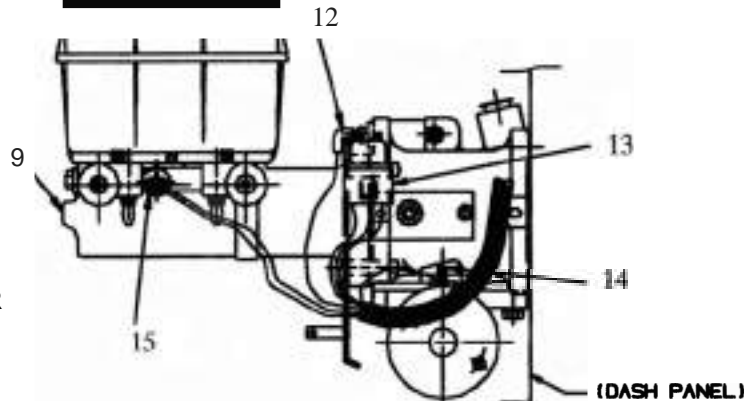
Figure 7.21 - Dash Harness Wiring Truck And FBe (left Side)

ENGINE WIRING - TRUCK AND FBC



NOTE: CONNECTOR NUMBERS ARE SHOWN IN PARENTHESES

1. MAP SENSOR (PART OF DASH HARNESS) MTD ON 10M MOUNTING BRACKET
2. HOSE CONNECTS MAP SENSOR TO ENGINE (FIGURE 7.23)
3. DASH HARNESS
4. ENGINE HARNESS
5. CIRCUIT 11-GH OF ENGINE HARNESS TO GROUND STUD
6. ENGINE Oil PRESS SENSOR CONNECTOR (408)
7. LOW COOLANT SENSOR CIRCUIT 34A OF ENGINE HARNESS TO CIRCUIT 34A OF DASH HARNESS
8. CONNECTORS (2A & 2B) CONNECT TO CAB HARNESS CONNECTOR (2)
9. REF: HYDRAULIC BRAKE POWER CYLINDER
10. Oil PRESS GAUGE HOSE (SEE FIGURE 7.23)



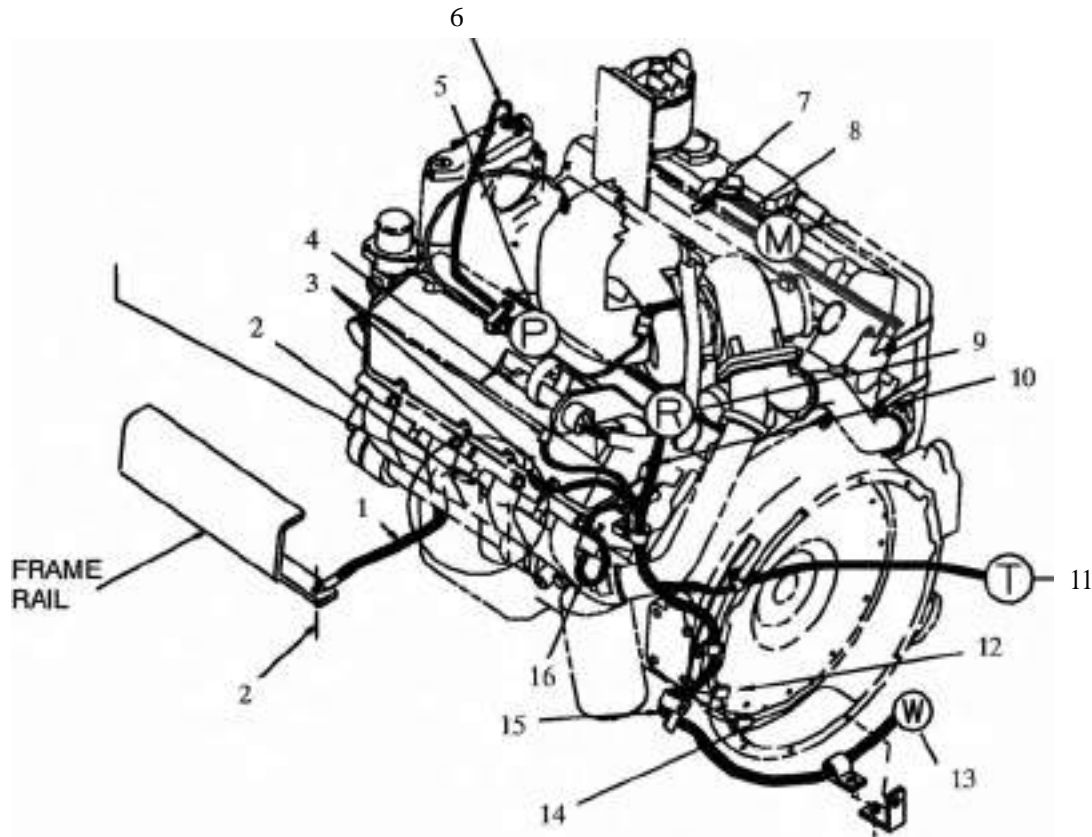
VIEW IN DIRECTION OF ARROW G
HYDRAULIC BRAKE WIRING

11. SEE FIGURE 7.23
12. CIRCUIT 90I TO FLOW SWITCH
13. BRAKE RELAY (300)
14. CIRCUITS 90P & 90N CONNECT TO HYDROMAX POWER STUD
15. DIFFERENTIAL PRESSURE SWITCH (301)
16. CIRCUIT 14 CONNECTS TO CAB HARNESS CIRCUIT 14
17. CONNECTOR (424) CONNECTS TO DASH HARNESS

Figure 7.22 - WITruck V_a Electronic Engine Wiring (See Figure 7.29 For FBC)

ENGINE WIRING - TRUCK AND FBe (Continued)

G08-38419.02.A



NOTE: CONNECTOR NUMBERS ARE SHOWN IN PARENTHESES

1. GROUND CABLE
2. APPLY GRAPHO GREASE TO COMPLETED CONNECTION
3. REF: HOOD HARNESS CONNECTORS (413 & 425)
4. DASH/ENGINE HARNESS CONNECTOR (405)
5. SEE OIL PRESSURE HOSE FIGURE 7.22
6. OIL PRESSURE HOSE
7. MAP SENSOR HOSE CONNECTOR BARB (SEE FIGURE 7.27 VIEW D AND E)

8. MAP SENSOR HOSE - HOSE MUST FLOW IN CONTINUOUS INCLINE TO MAP SENSOR AS LOW SPOTS IN ROUTING MAY CAUSE WATER POCKETS. (SEE FIGURE 7.22)
9. SEE FIGURE 7.22
10. START MOTOR CRANK RELAY (387)
11. SEE FIGURE 7.25
12. CONNECTOR (426F) TO NEG BATTERY CABLE (SEE FIGURE 7.28 VIEW B)
13. SEE FIGURE 7.24
14. FUEL SENDER W/BUS & FBC COWL ONLY- CIRCUITS 36 & 36-G
15. ENGINE HARNESS
16. ENGINE COOLANT CIRCUITS 29A & 29-G

Figure 7.23 - Electronic Engine Wiring (Truck & FBe)

VEHICLE AND COMPONENT ILLUSTRATIONS

ENGINE WIRING - TRUCK AND FBC (Continued)

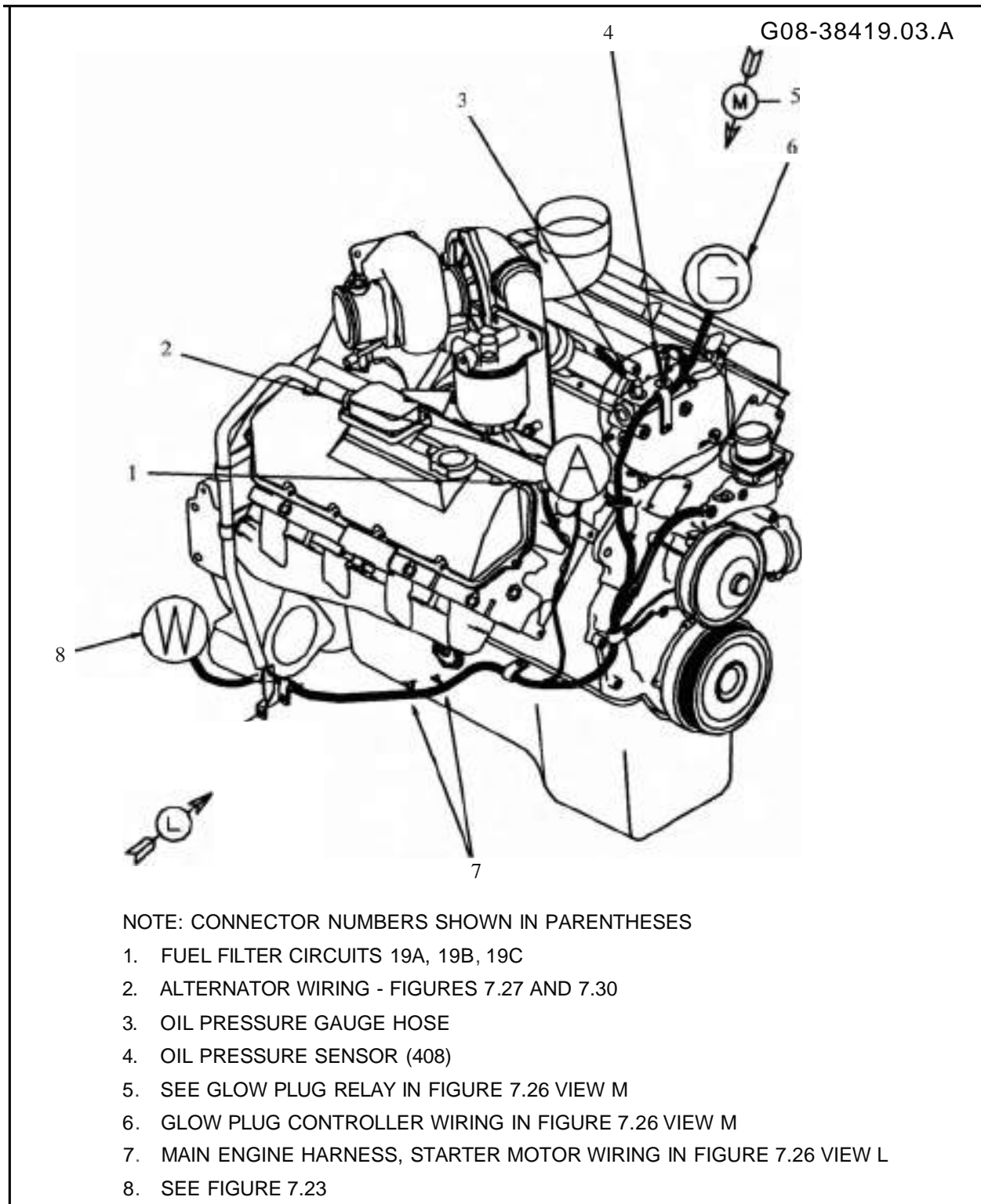


Figure 7.24 - Electronic Engine Wiring (Truck & FBC)

ENGINE WIRING AT TRANSMISSION - TRUCK AND FBC

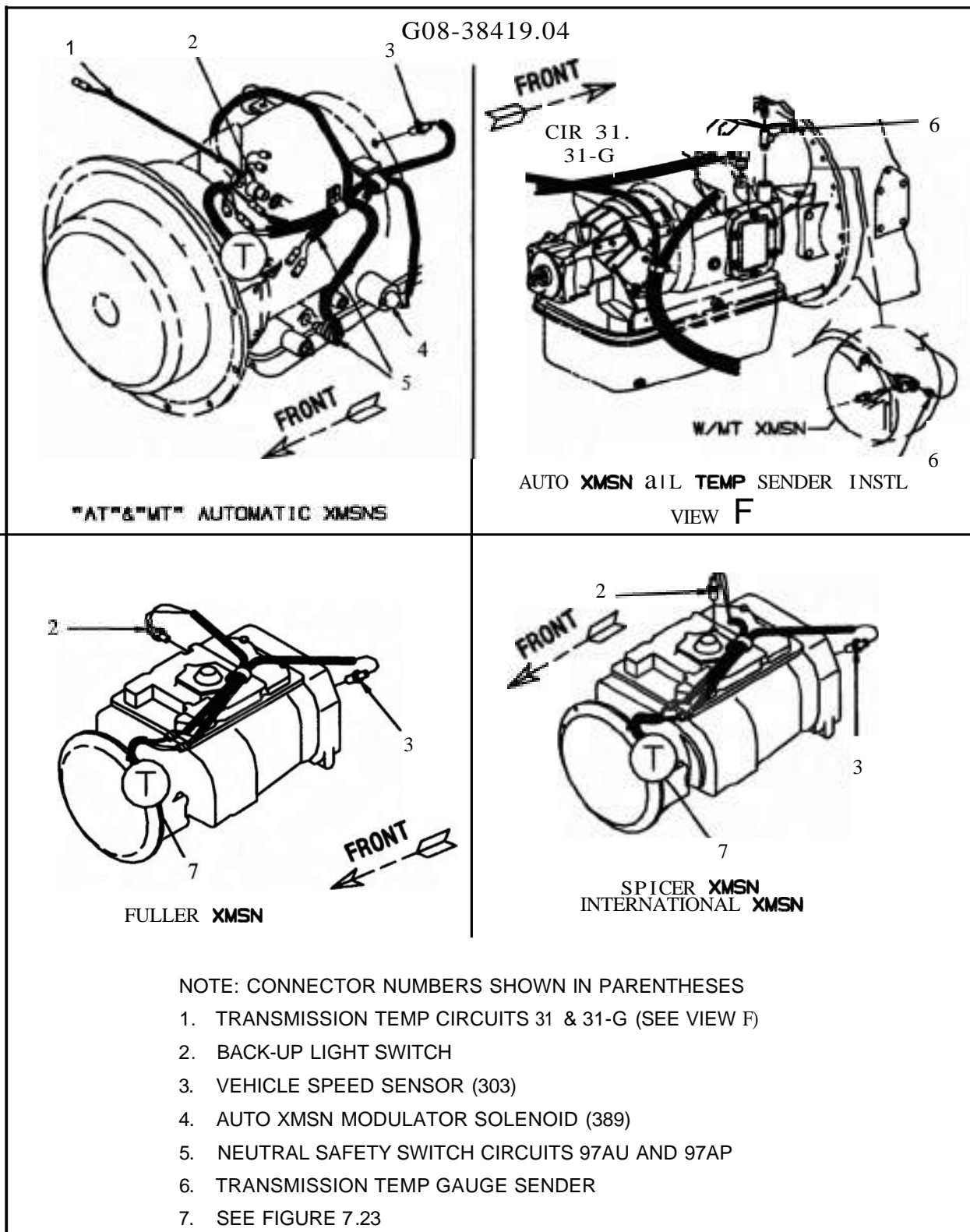


Figure 7.25 - Vå Electronic Engine Wiring At Transmission (Truck & FBC)

ENGINE WIRING AT STARTER MOTOR - TRUCK AND FBC

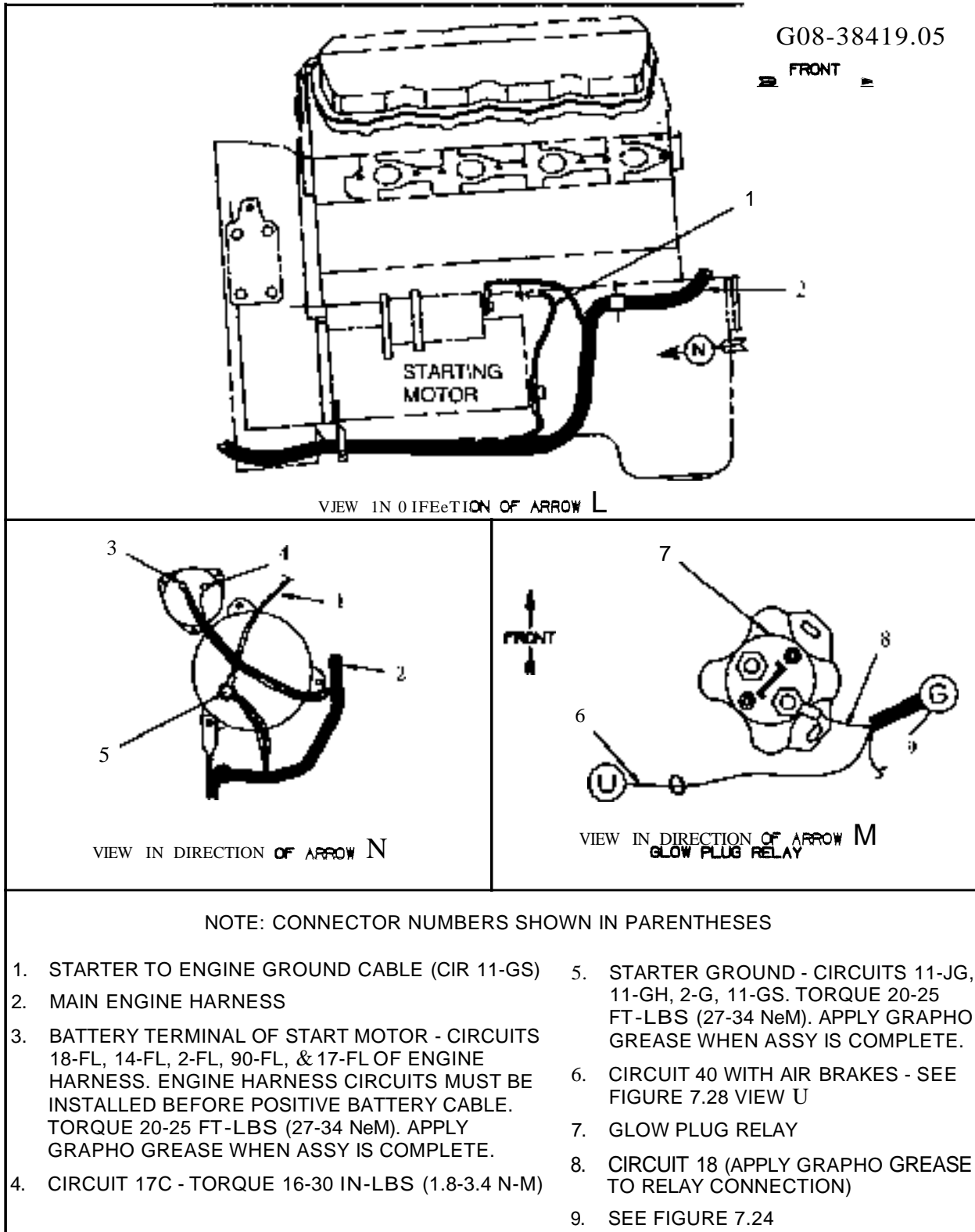


Figure 7.26 - va Electronic Engine Wiring (Truck & FBe)

ENGINE WIRING ALTERNATORS - TRUCK AND FBC

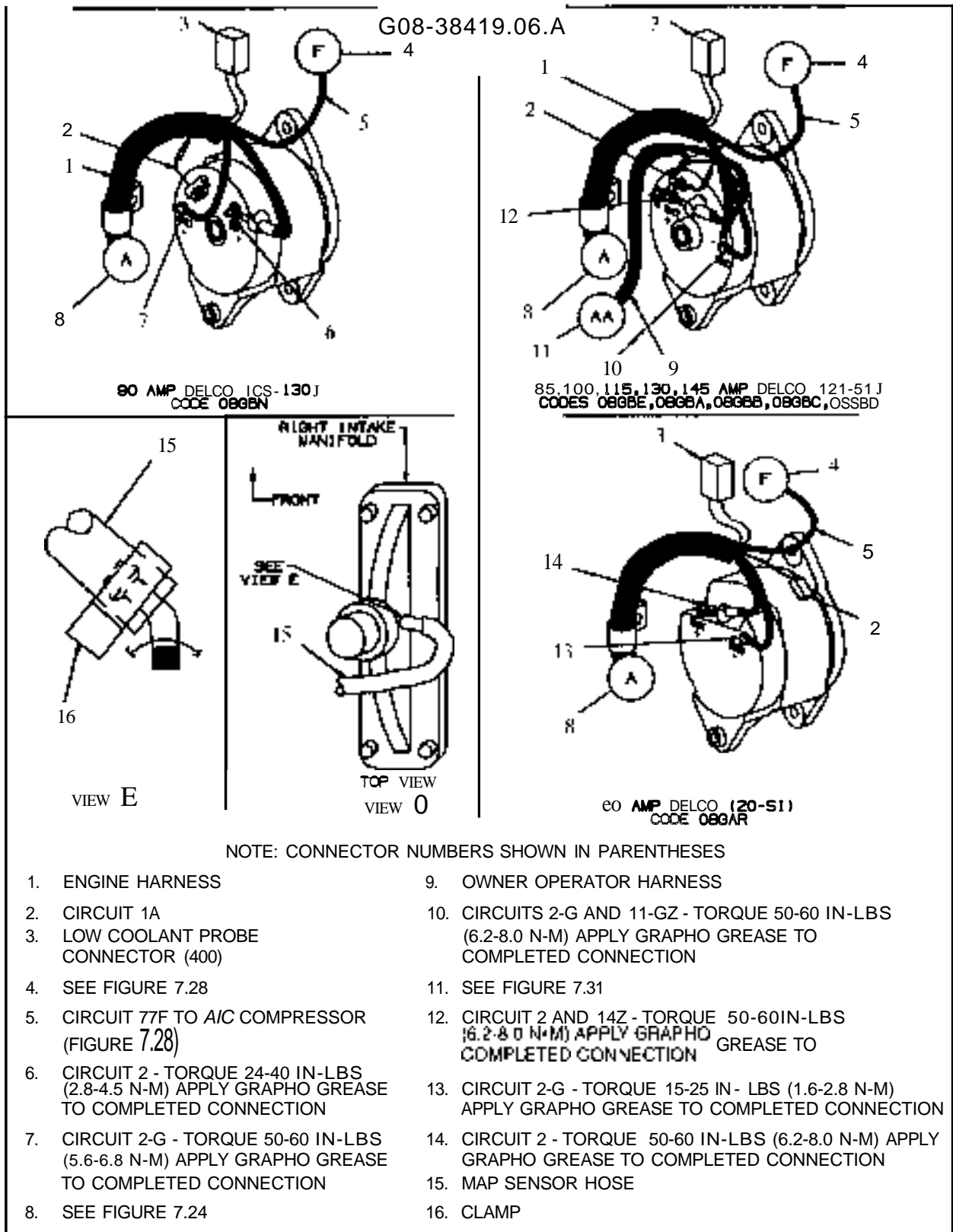


Figure 7.27 - VB Electronic Engine Wiring (Truck & FBe)

ENGINE WIRING AT AIRIFREON COMPRESSOR - TRUCK AND FBe

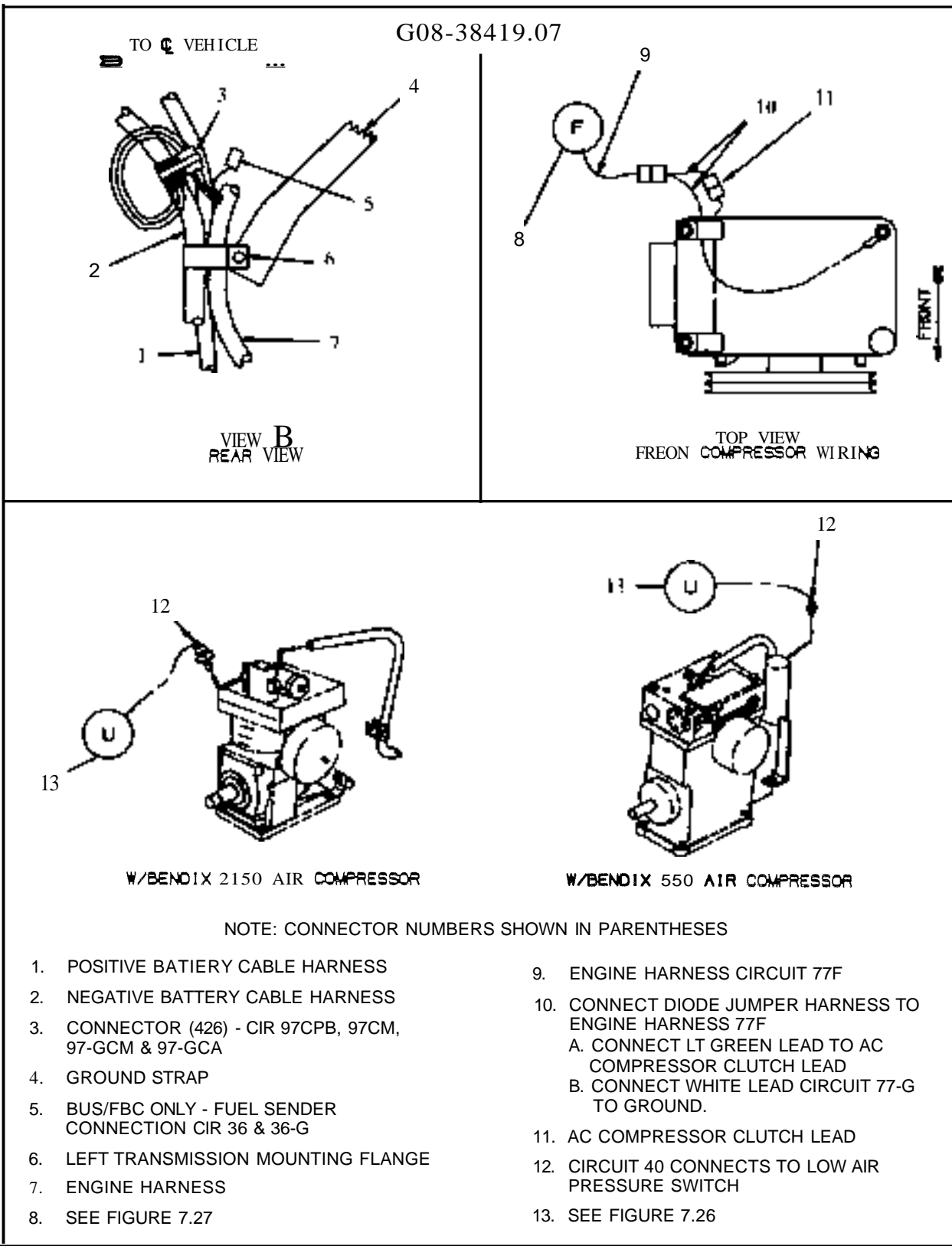


Figure 7.28 - V8 Electronic Engine Wiring (Truck & FBe)

ENGINE WIRING HYDRAULIC BRAKE/DASH/ENGINE HARNESS - TRUCK AND FBC

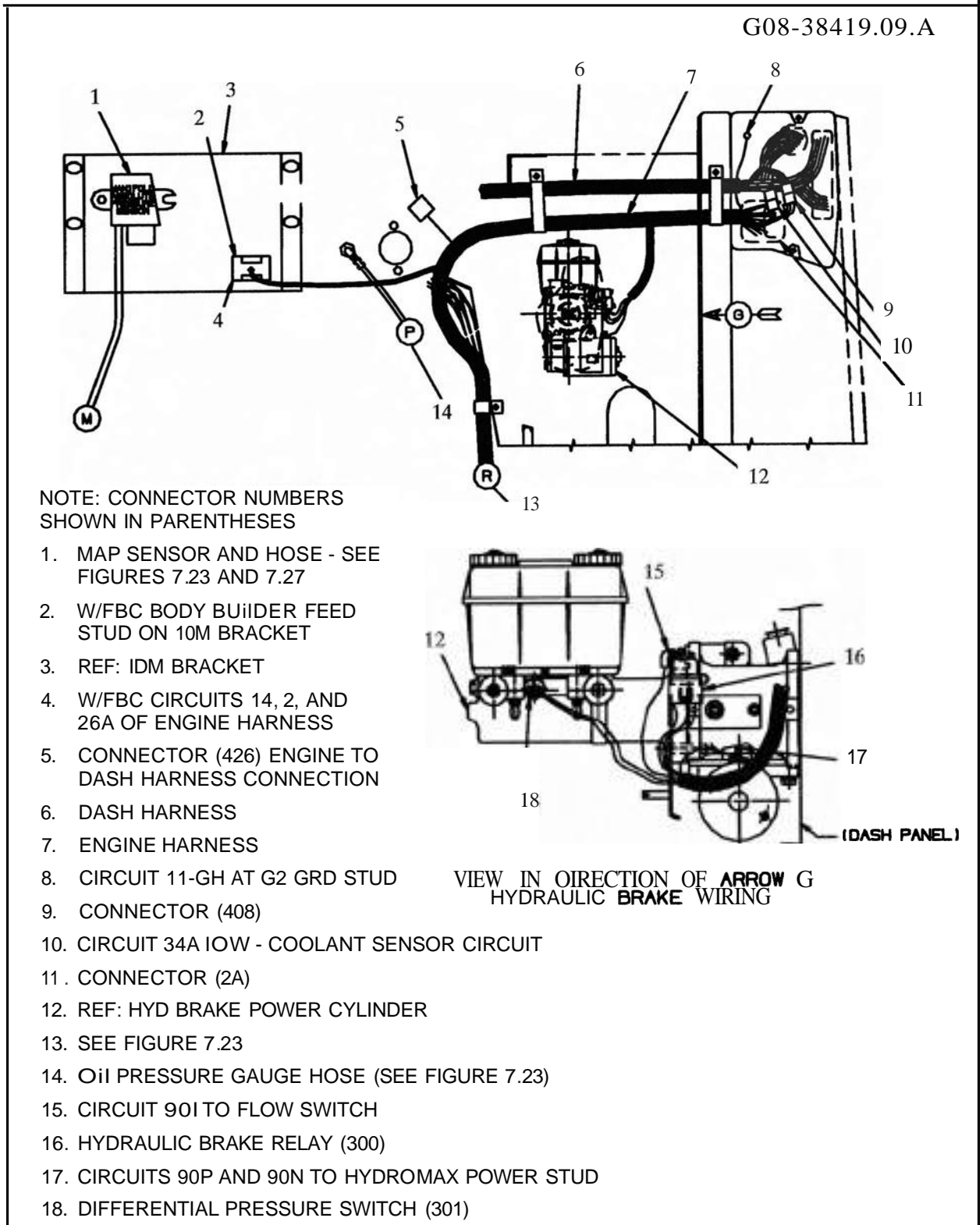


Figure 7.29 - Va Electronic Engine Wiring (With FBC - For Truck See Figure 7.22)

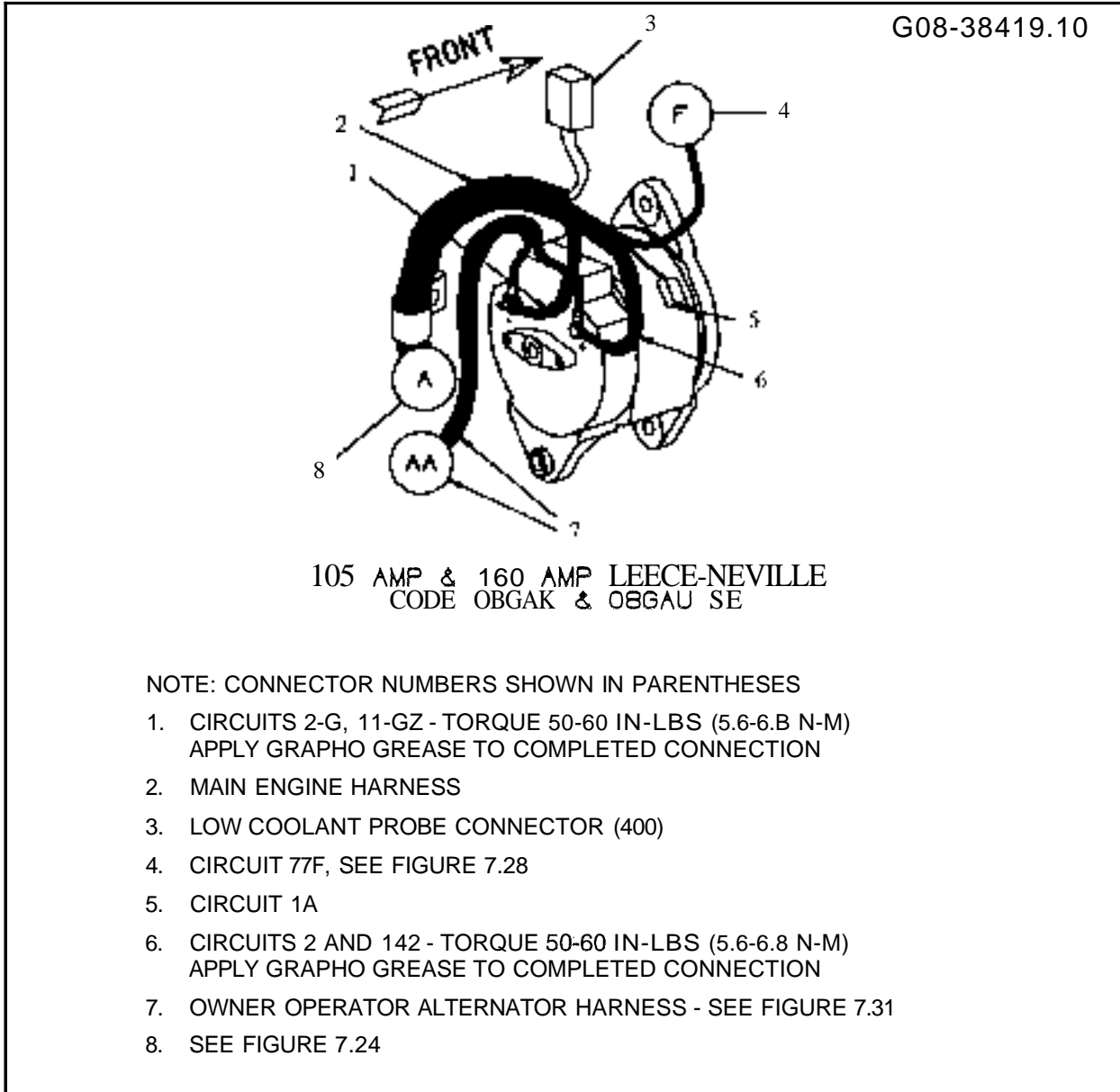
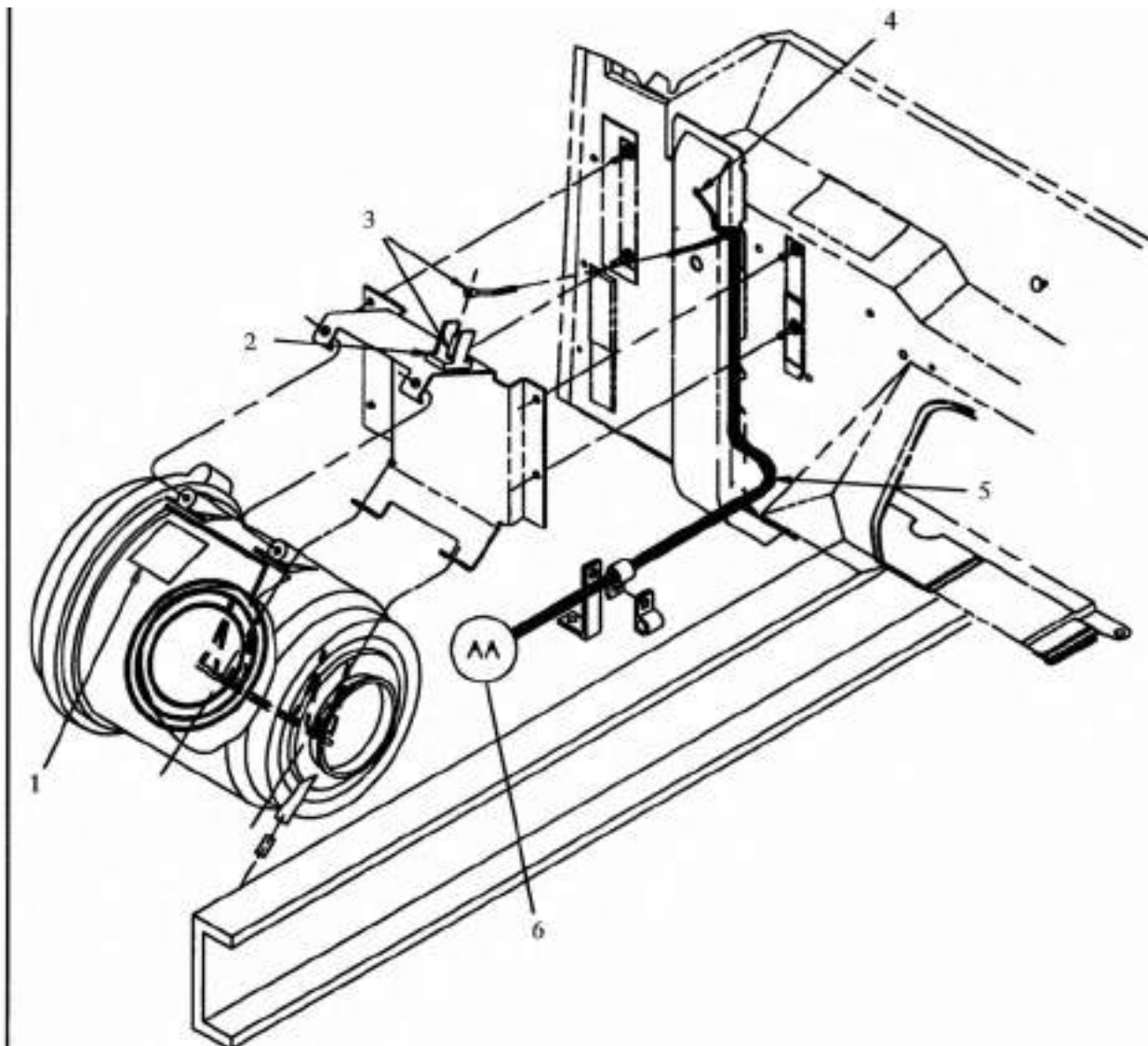


Figure 7.30 - Va Electronic Engine Wiring (Truck)

ENGINE WIRING - (Truck W/ Leece-Neville 2600JA 12V/160A Alternator W/4 Gauge Protection)

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NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

1. LABEL - INFORMATION ON OWNER OPERATOR CONNECTIONS
2. FEED STUD
3. CIRCUIT 14Z CONNECTED
4. CIRCUIT 11-GZ GROUNDED TO DASH
5. OWNER OPERATOR ALTERNATOR HARNESS
6. SEE FIGURE 7.27 OR 7.30

Figure 7.31 - VB Electronic Engine Wiring (Truck W/ Leece-Neville 2600JA 12V/160A Alternator W/4 Gauge Protection)

ENGINE WIRING BATTERY CABLE/STARTING HARNESS - TRUCK AND FBC

G08-38414.01

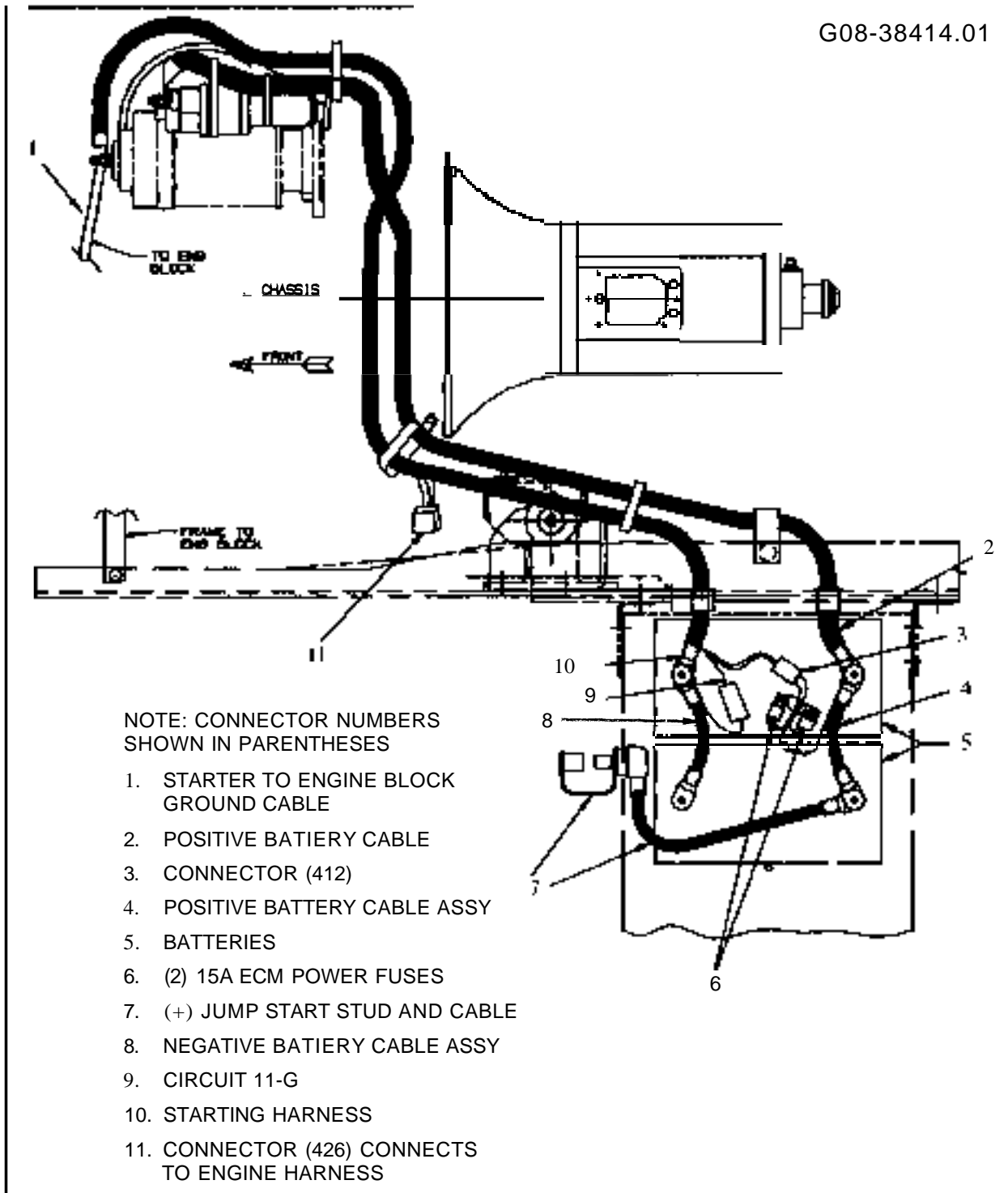
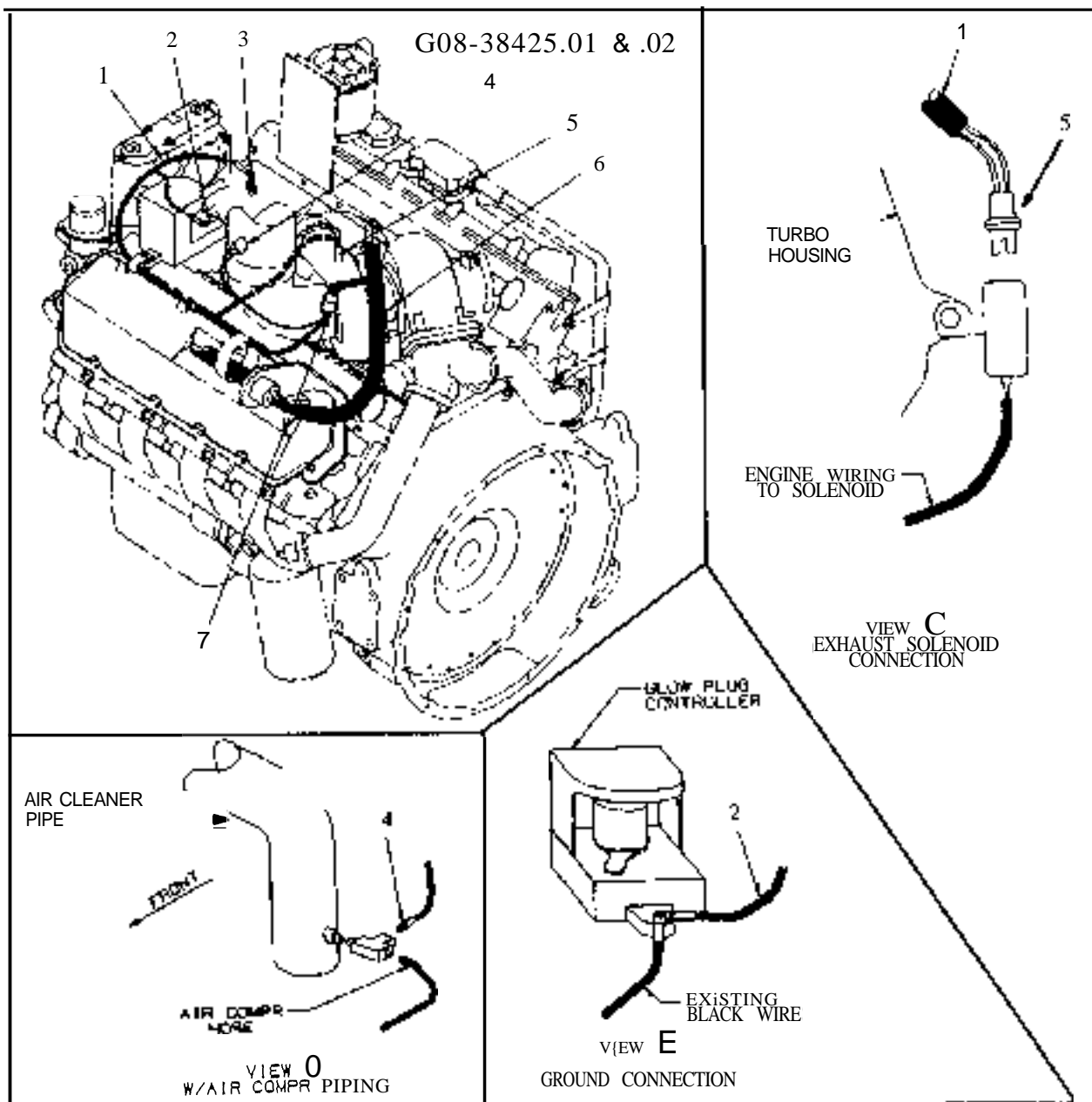


Figure 7.32 - Battery Cable Wiring (Truck And FBC)

ENGINE WIRING EXHAUST BACKPRESSURE/GLOW PLUG RELAY - TRUCK AND FBC



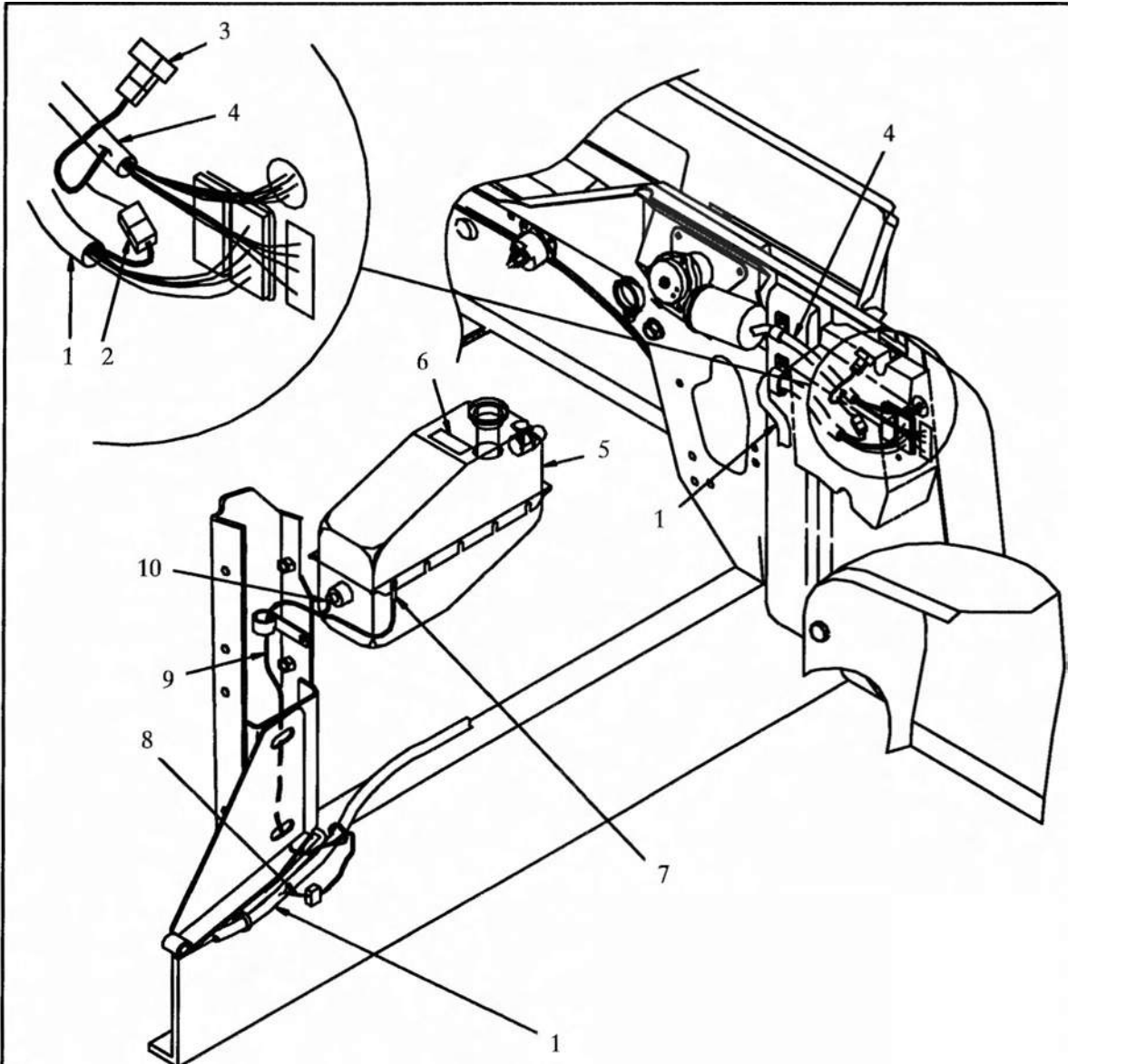
NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

1. EXHAUST BACK PRESSURE HARNESS
2. SEE VIEW E - CIRCUIT 2 OF ITEM 1 CONNECTS TO GLOW PLUG CONTROLLER GROUND STUD
3. CIRCUITS 97CA(5V), 97BC AND 9780 CONNECT TO EXHAUST BACK PRESSURE SENSOR
4. CIRCUITS 978U AND 97AX CONNECT TO AMBIENT AIR TEMP SENDER (VIEW D)
5. VIEW C - CIRCUITS 97BC AND 97-GP CONNECT TO EXHAUST SOLENOID CONNECTION
6. DASH HARNESS
7. 6-WAY CONNECTOR - 97BD, 9782, 97BC, 97BU, 97AX, AND 97CA(5V) BETWEEN ITEMS 1 AND 6

Figure 7.33 - Exhaust Back Pressure Device

VEHICLE AND COMPONENT ILLUSTRATIONS

ENGINE WIRING COOLANT LEVEL SENSOR - TRUCK AND FBC



NOTE: CONNECTOR NUMBERS SHOWN IN PARENTHESES

- | | |
|---|-----------------------------------|
| 1. ENGINE HARNESS | 6. CAUTION LABEL |
| 2. CIRCUIT 34A ENGINE TO DASH HARNESS ONE WAY CONNECTOR | 7. CIRCUIT 34-G |
| 3. CLS MODULE CONNECTOR (414) | 8. CONNECTOR (400) |
| 4. DASH HARNESS | 9. CLS HARNESS |
| 5. SURGE TANK | 10. CIRCUIT 34A CONNECTS TO PROBE |

Figure 7.34 - Coolant Level Sensor (CLS) Wiring (Truck & FBC)

ENGINE WIRING ALLISON AT TRANSMISSION WIRING - TRUCK AND FBC

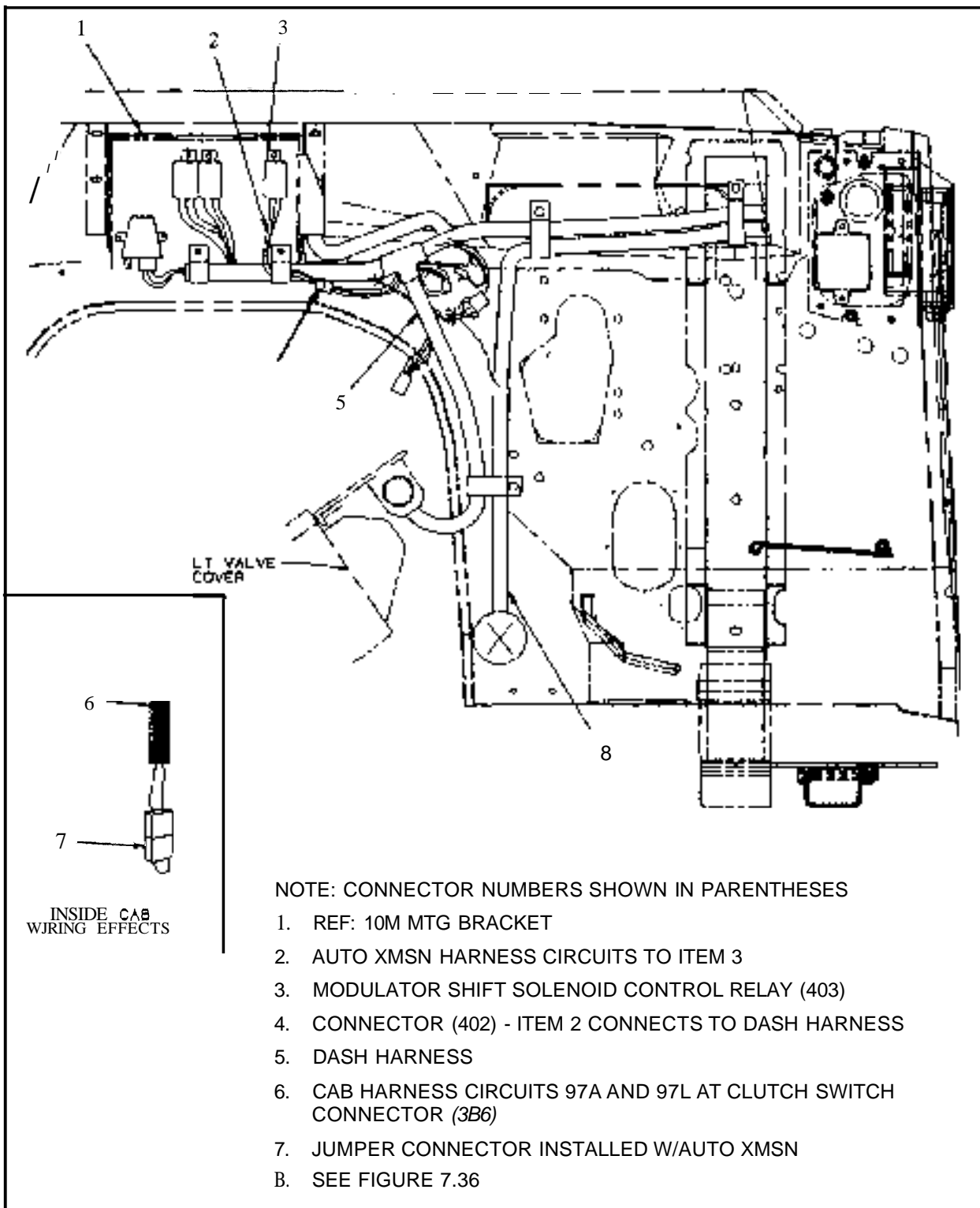


Figure 7.35 - Allison AT Transmission Wiring (Truck & FBe)

ENGINE WIRING - TRUCK AND FBC

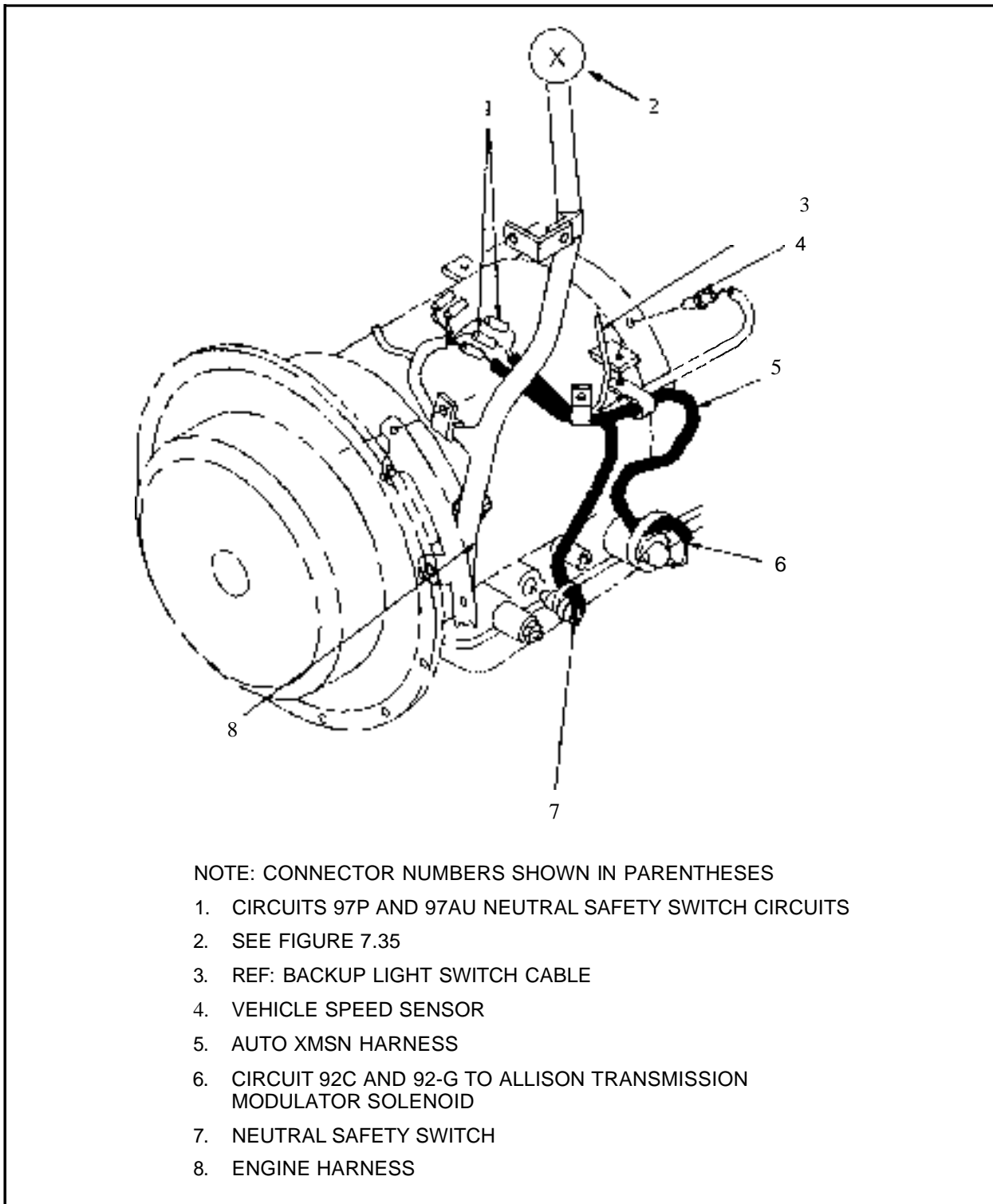


Figure 7.36 - Allison AT Transmission Wiring (Truck & FBC)

1652SC WIRING - PLATFORM WIRE HARNESS

With the 1652SC, wiring is divided into three areas: Platform Harness Wiring, Dash Harness Wiring, and Engine Harness wiring. The location of many platform components is approximate as they are installed by the various body builders.

PLATFORM HARNESS WIRING

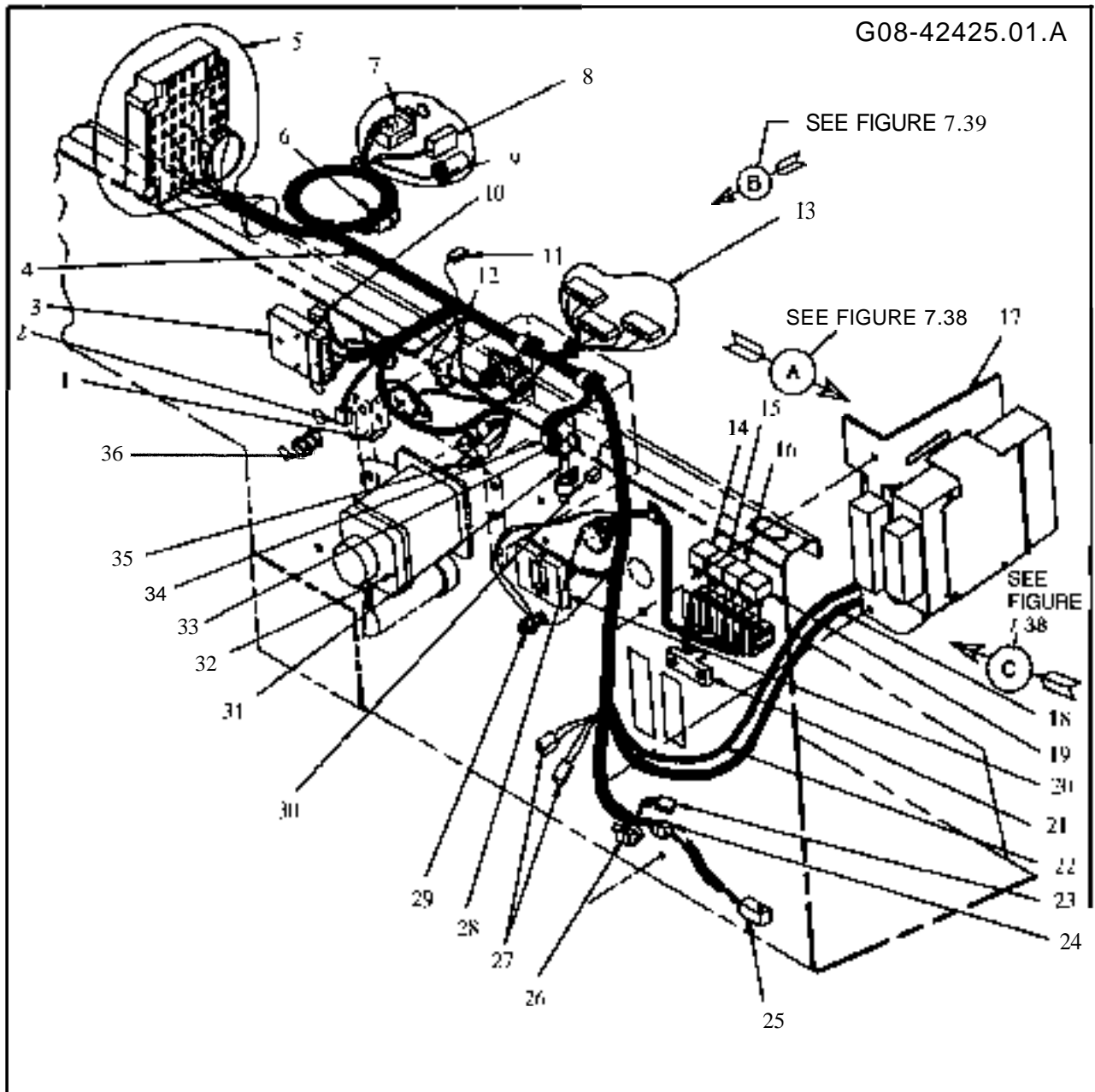


Figure 7.37 - Platform Wire Harness (See next page for callouts)

VEHICLE AND COMPONENT ILLUSTRATIONS

PLATFORM HARNESS WIRING (Continued)

Platform Wire Harness (Callouts)

- | | |
|---|---|
| 1. CIR 14, BATTERY FEED TO J1 FEED STUD, CONNECTS TO THE ENGINE HARNESS | 17. ECM/IDMNP ASSY - SEE FIGURES 7.38, 7.44 AND 7.45 |
| 2. (382) ACCELERATOR PEDAL SENSOR (APS/IVS) CONNECTS TO CAB HARNESS | 18. (384) EST (DATA) LINK CONNECTOR IS ATTACHED TO MODULE BRACKET - FIGURE 7.38 |
| 3. (49) HYDRAULIC BRAKE MONITOR | 19. (393) BRAKE RELAY |
| 4. MAIN WIRING HARNESS | 20. (2) DASH CONNECTOR |
| 5. FUSE BLOCK - SEE FIGURE 7.42 (NOT SHOWN IN MOUNTED POSITION) | 21. J1 FEED STUD - CIR 14A, 14C, 15, 50 |
| 6. (406) BAROMETRIC AIR PRESSURE SENSOR (BARO) | 22. (381) CONNECTS PLATFORM HARNESS TO VPM - FIGURE 7.38 |
| 7. (60) LIGHT SWITCH (NOT SHOWN IN MOUNTED POSITION) | 23. (194) BODY BUILDER CONNECTOR |
| 8. (394) CRUISE CONTROL CONNECTOR (NOT SHOWN IN MOUNTED POSITION) - SEE FIGURE 7.43 | 24. (17) DIMMER SWITCH CONNECTOR |
| 9. (375) STI DIAGNOSTIC SWITCH (NOT SHOWN IN MOUNTED POSITION) | 25. DIMMER SWITCH |
| 10. (47) HYD BRAKE BLOCKING DIODE ASSY. | 26. STARTER INTERRUPT CONNECTOR (W/O AUTO TRANS CIR 17 CONNECTS TO 17A) |
| 11. CIR 62E TO AUTOMATIC TRANSMISSION LIGHT | 27. (427) RED AND (428) BLUE ATA CONNECTORS |
| 12. CIR 44/44A CONNECTS TO GROUND TERMINAL OF KEY SWITCH | 28. (3 & 3A) DASH CONNECTOR (DEUTSCH) |
| 13. INSTRUMENT CLUSTER CONNECTORS (26) YELLOW, (27) GREEN, (28) NATURAL | 29. G2 GRD STUD - CIR 11-GD, 11-G, 36-G, 97-GK, 97-GQ |
| 14. (20) ALARM WARNING BUZZER | 30. CIR 44 TO PARK BRAKE SWITCH - FIGURE 7.40 |
| 15. (385) TIME DELAY CRANK RELAY | 31. CABLE TO TURN SIGNAL SWITCH |
| 16. (61) HORN RELAY | 32. HYDRAULIC BRAKE BOOSTER |
| | 33. HORN CIR 85A |
| | 34. (58) TURN SIGNAL CONNECTOR |
| | 35. STOP LIGHT SWITCHES - FIGURE 7.40 |
| | 36. REF: MECHANICAL OIL PRESSURE GAUGE HOSE CONNECTION |

EST (DATA LINK)NPM CONNECTIONS/ACCELERATOR PEDAUSTOP LIGHT SWITCH WIRING

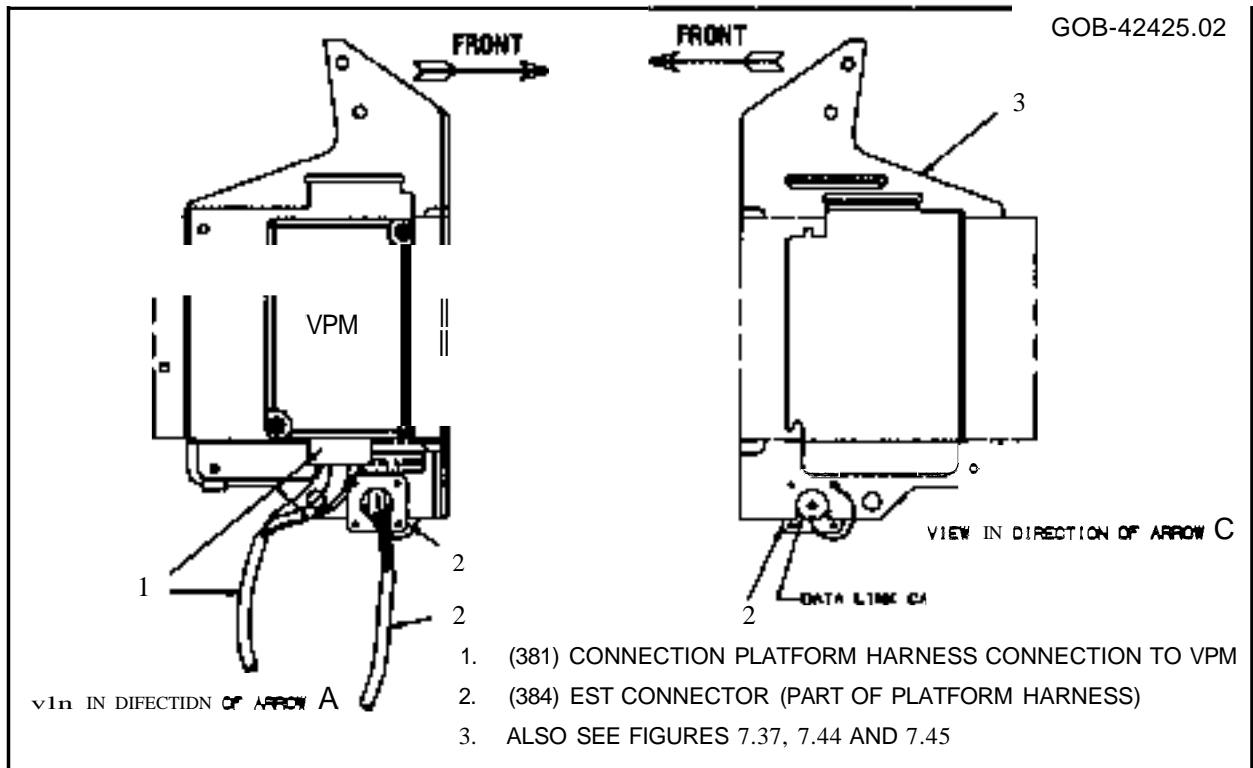


Figure 7.38 - EST (Data Link) and VPM Connections

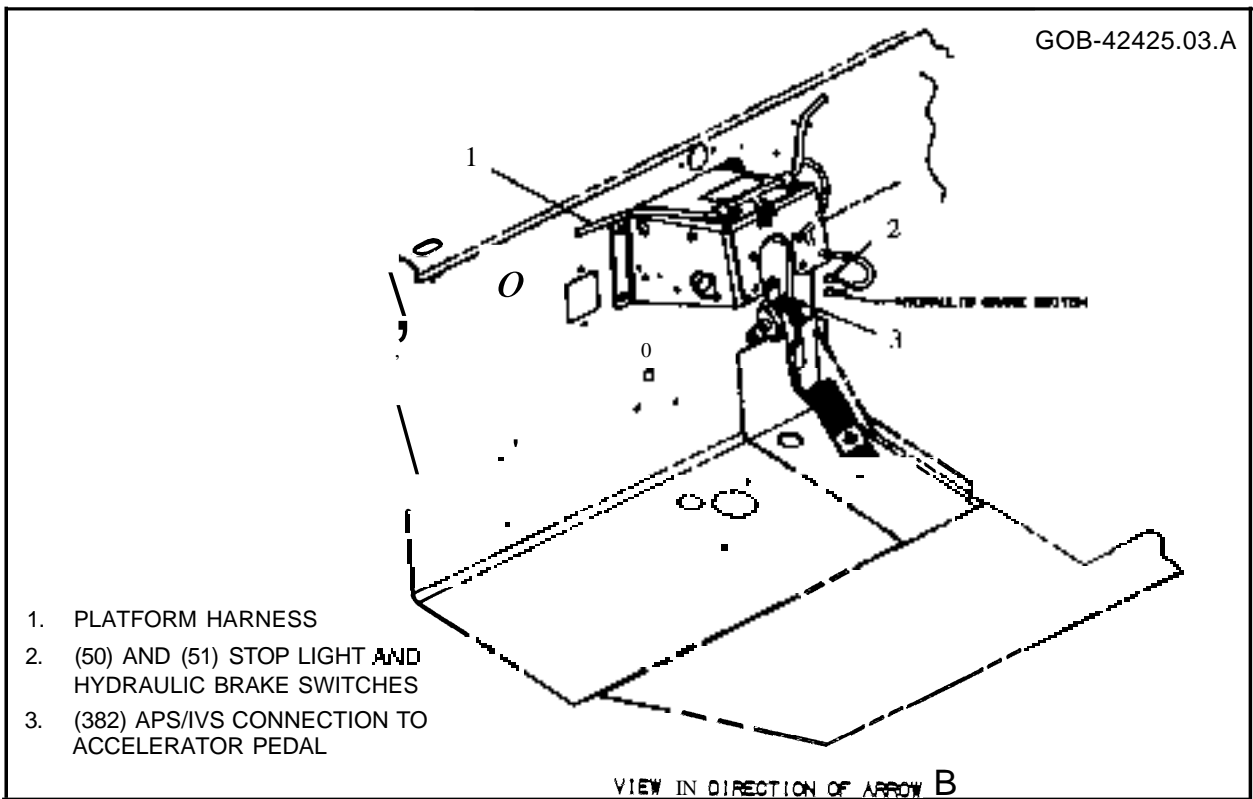


Figure 7.39 - Accelerator Pedal/Stop Light Switches

VEHICLE AND COMPONENT ILLUSTRATIONS

PARK BRAKE SWITCH INSTALLATION & ADJUSTMENT

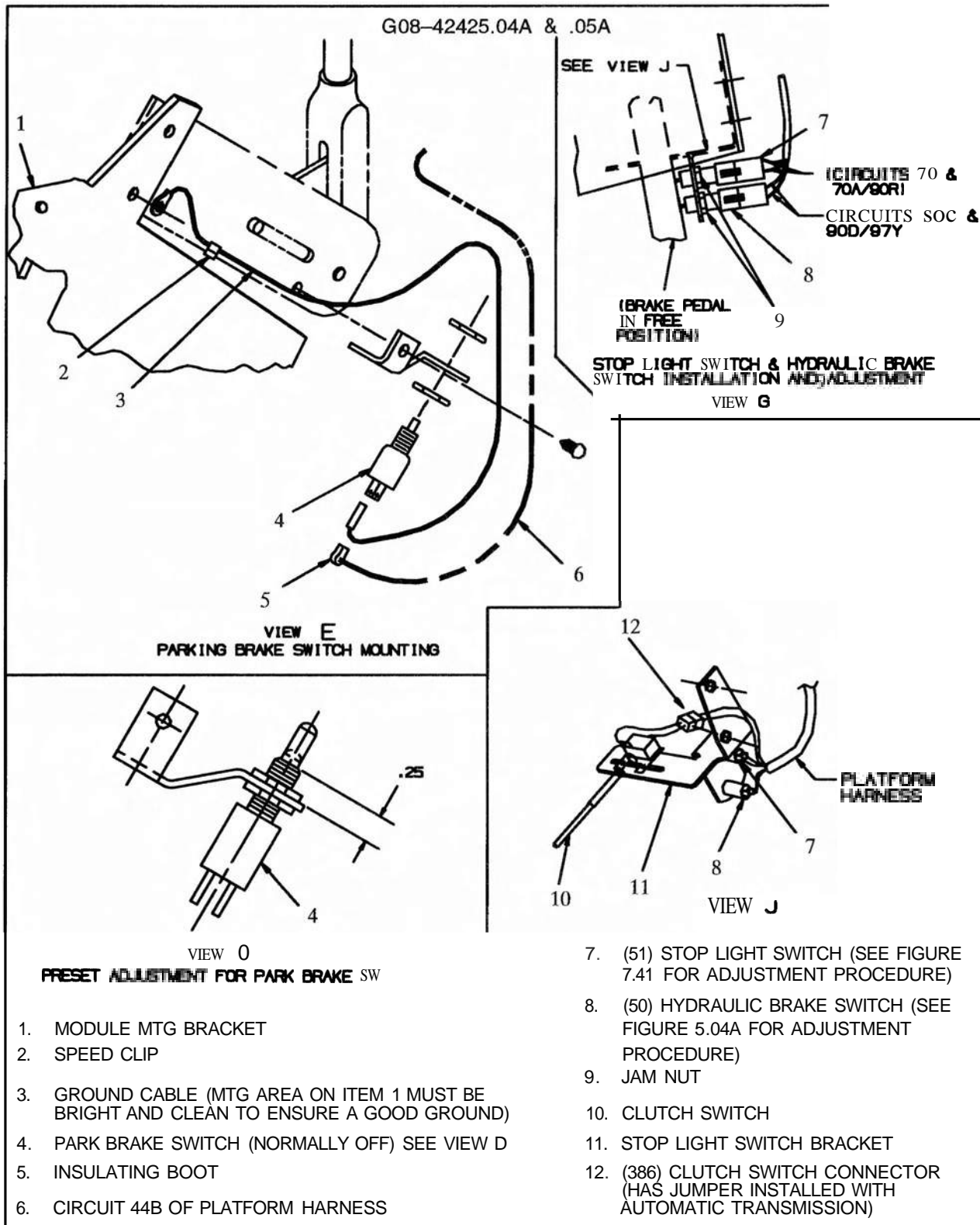
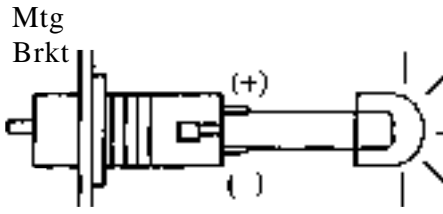


Figure 7.40 - Park Brake Switch Installation & Adjustment

PLATFORM HARNESS WIRING - FUSE PANEL/ BRAKE SWITCH INSTALLATION & ADJUSTMENT



Mtg Brkt

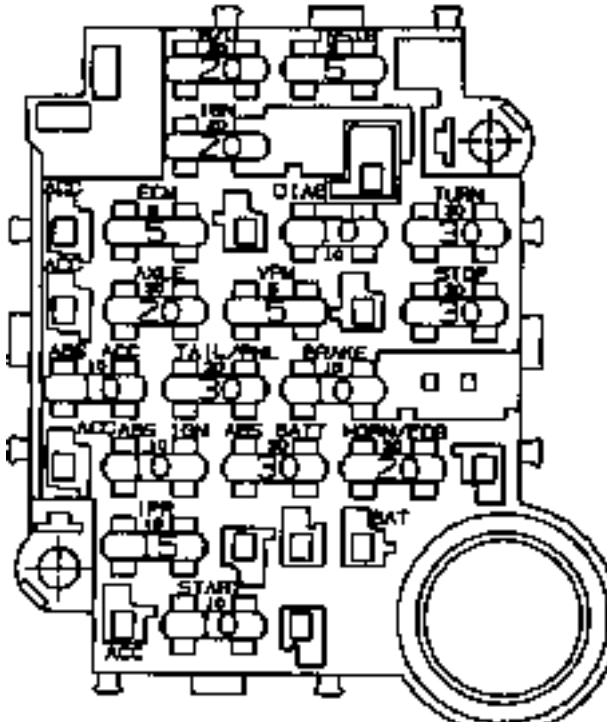
Normally Closed Hydraulic Brake Switch

Battery Powered Test Light

Brake Switch Adjustment Procedure

1. The PAL nut on upper switch (backside of bracket) should be finger tight.
2. Connect leads for test light #1 to upper switch, adjust the switch until the light just comes on or goes off. Note the position of the key tab on the switch body.
3. Hold PAL nut and rotate switch clockwise ONE full turn. The key tab should be in the same position as in step 2.
4. Tighten PAL nut and watch that the key tab so the switch is not turned.
5. With PAL nut on lower switch finger tight, install Test light #2 to lower switch. Adjust the lower switch so that when pedal is depressed, both test lights come on at the same time.
 - IF Test Light #2 (lower switch) comes on first, mover lower switch closer to the pedal.
 - IF Test Light #1 (upper switch) comes on first, move lower switch away from pedal.
6. Tighten PAL nut on lower switch and test one more time to verify the adjustment.
7. Remove test lights, then connector (51) with circuits 70 & 70A/90R to upper switch and (50) with circuits 90C & 90D/97Y to lower switch.

Figure 7.41 - Brake Switch Installation & Adjustment



VIEW H

FUSE/CIRCUIT BREAKER AND FLASHER INSTALLATION

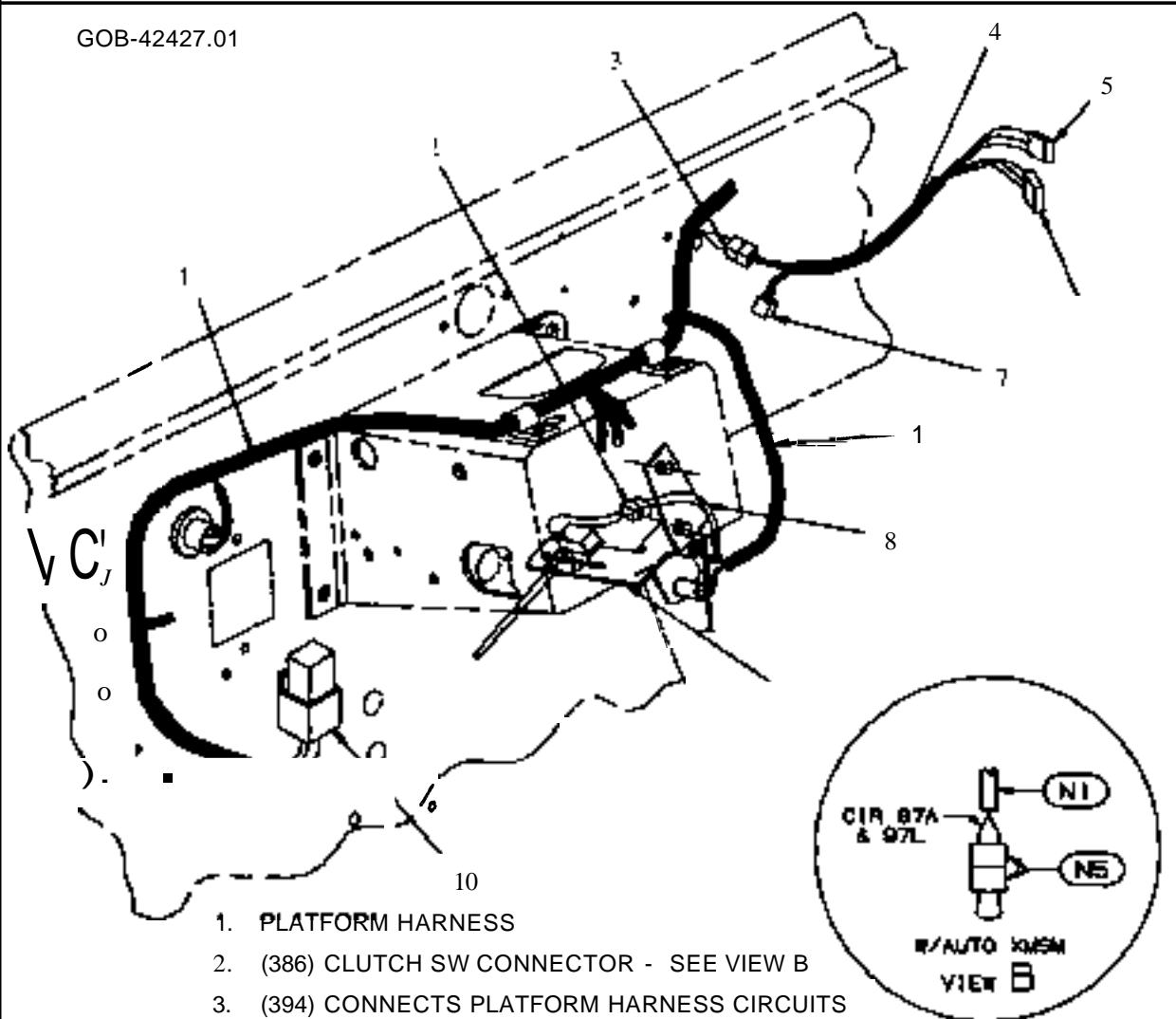
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Figure 7.42 - Fuse Panel

VEHICLE AND COMPONENT ILLUSTRATIONS

PLATFORM HARNESS - CRUISE CONTROL WIRING

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1. PLATFORM HARNESS
2. (386) CLUTCH SW CONNECTOR - SEE VIEW B
3. (394) CONNECTS PLATFORM HARNESS CIRCUITS 97AC & 97CF TO THE CRUISE CONTROL HARNESS
4. CRUISE CONTROL HARNESS
5. (392) SET/RESUME SW
6. (391) CRUISE ON/OFF SW
7. (390) SC RESISTOR BLOCK
8. CIRCUITS 97A & 97L
9. CLUTCH SW ASSY
 - A. TO ADJUST CLUTCH SW - With clutch pedal depressed to bottom of Free Travel position, the actuator arm should touch the clutch pedal. The pedal should activate with an audible click, when the clutch pedal returns to the stop.
10. (393) BRAKE SWITCH RELAY MUST BE INSTALLED IN VEHICLES WITH CRUISE CONTROL.

Figure 7.43 - Cruise Control Wiring

DASH HARNESS WIRING - ECMNPM/IDM Module With 1652SC

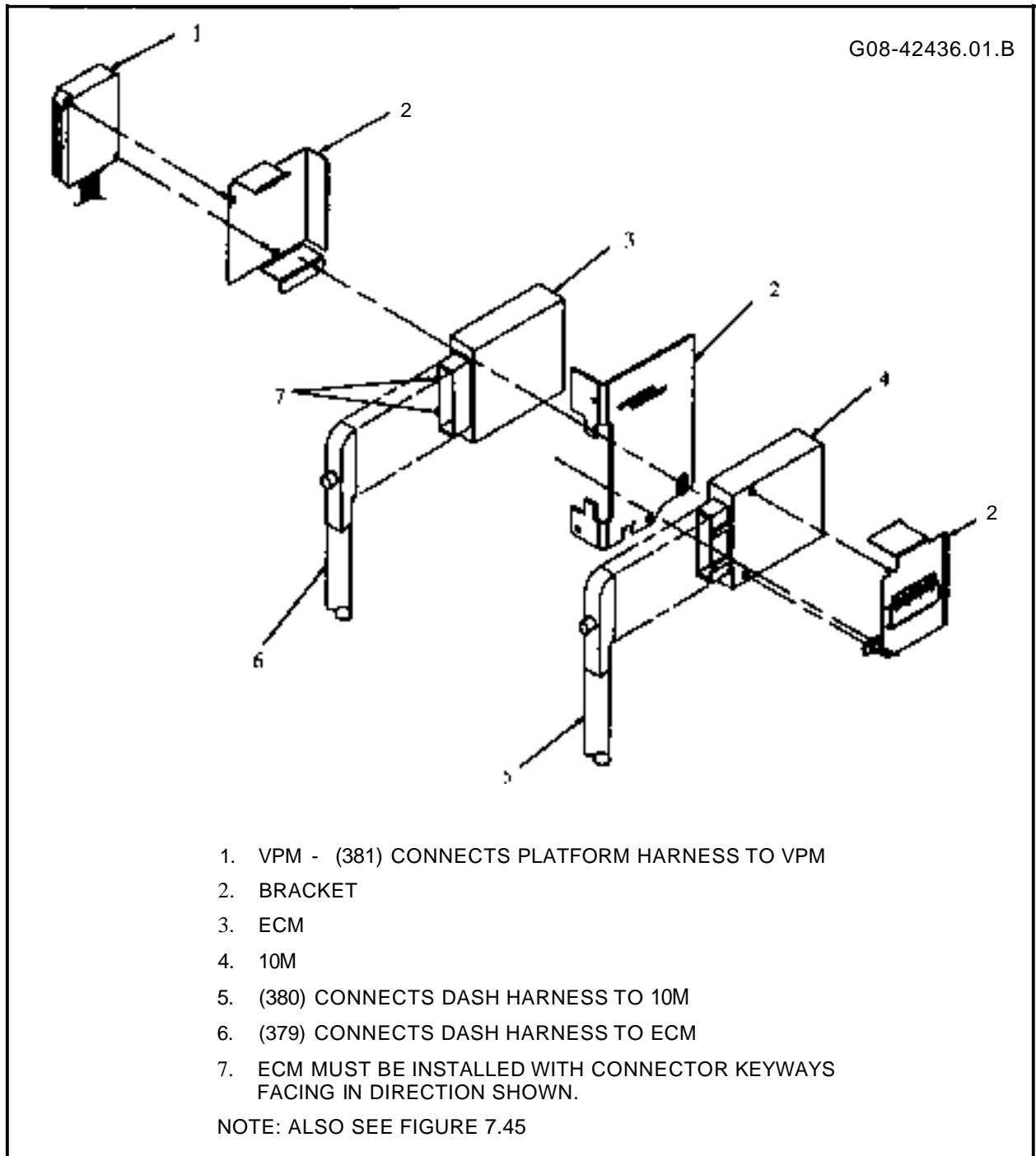


Figure 7.44 - ECMNPM/IDM Module With 1652SC

DASH HARNESS WIRING - VPMIECMIIDM MODULE INSTALLATION WITH 1652SC

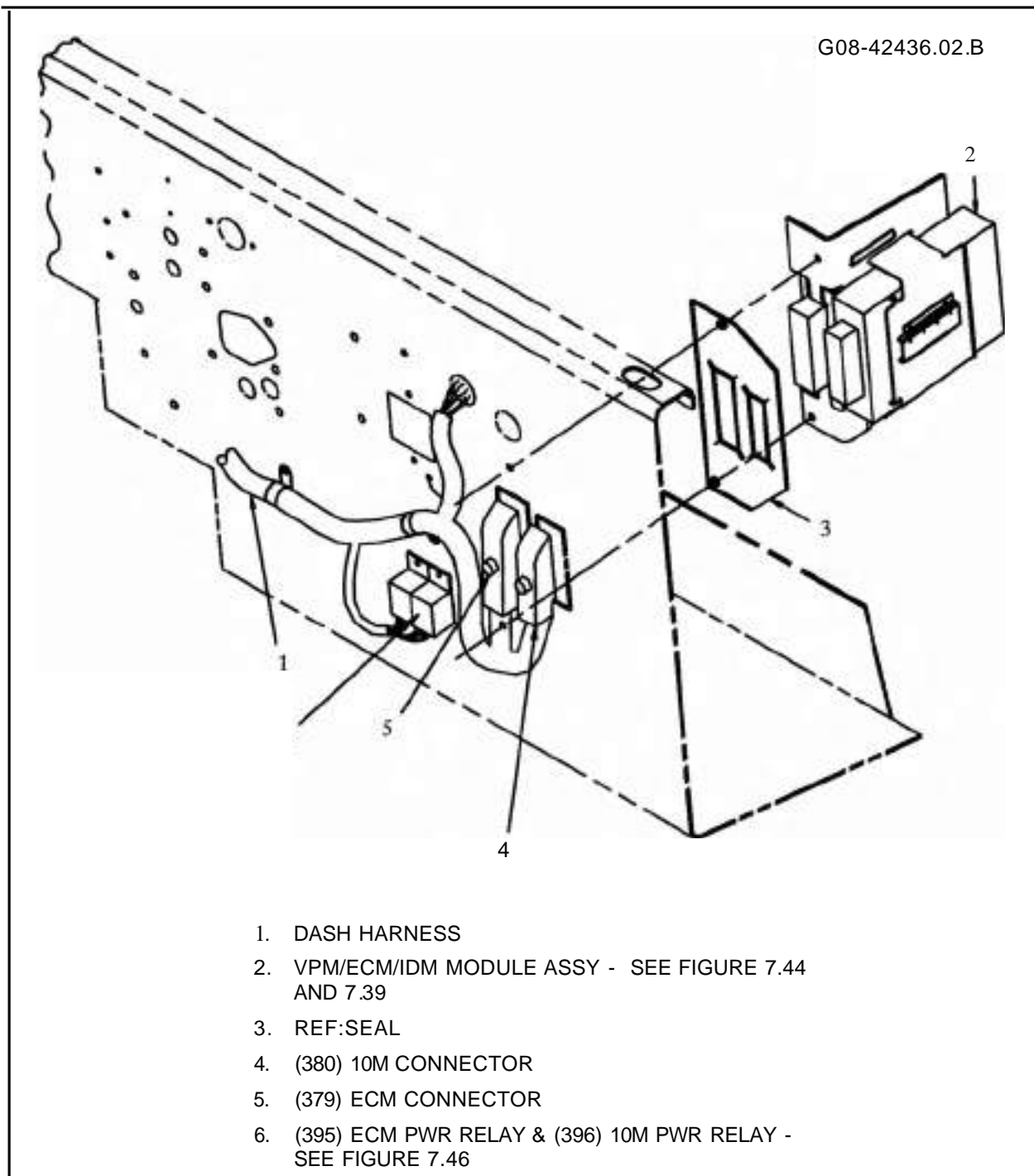


Figure 7.45 - VPM/ECMIIDM Module Installation With 1652SC

DASH HARNESS WIRING - LEFT SIDE WITH 1652SC PLATFORM

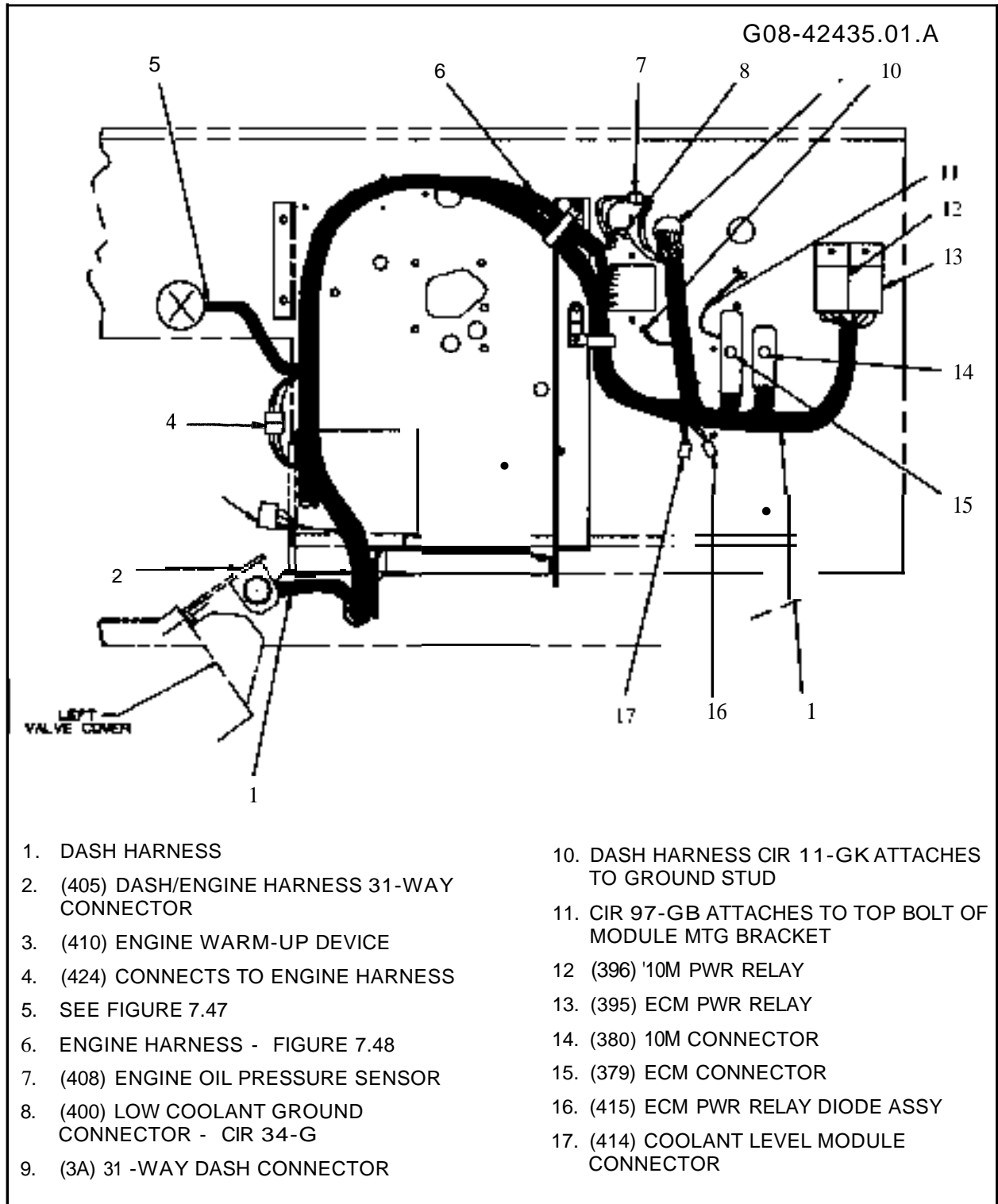


Figure 7.46 - Dash Harness Wiring - Left Side With 1652SC Platform

VEHICLE AND COMPONENT ILLUSTRATIONS

DASH HARNESS WIRING - RIGHT SIDE WITH 1652SC

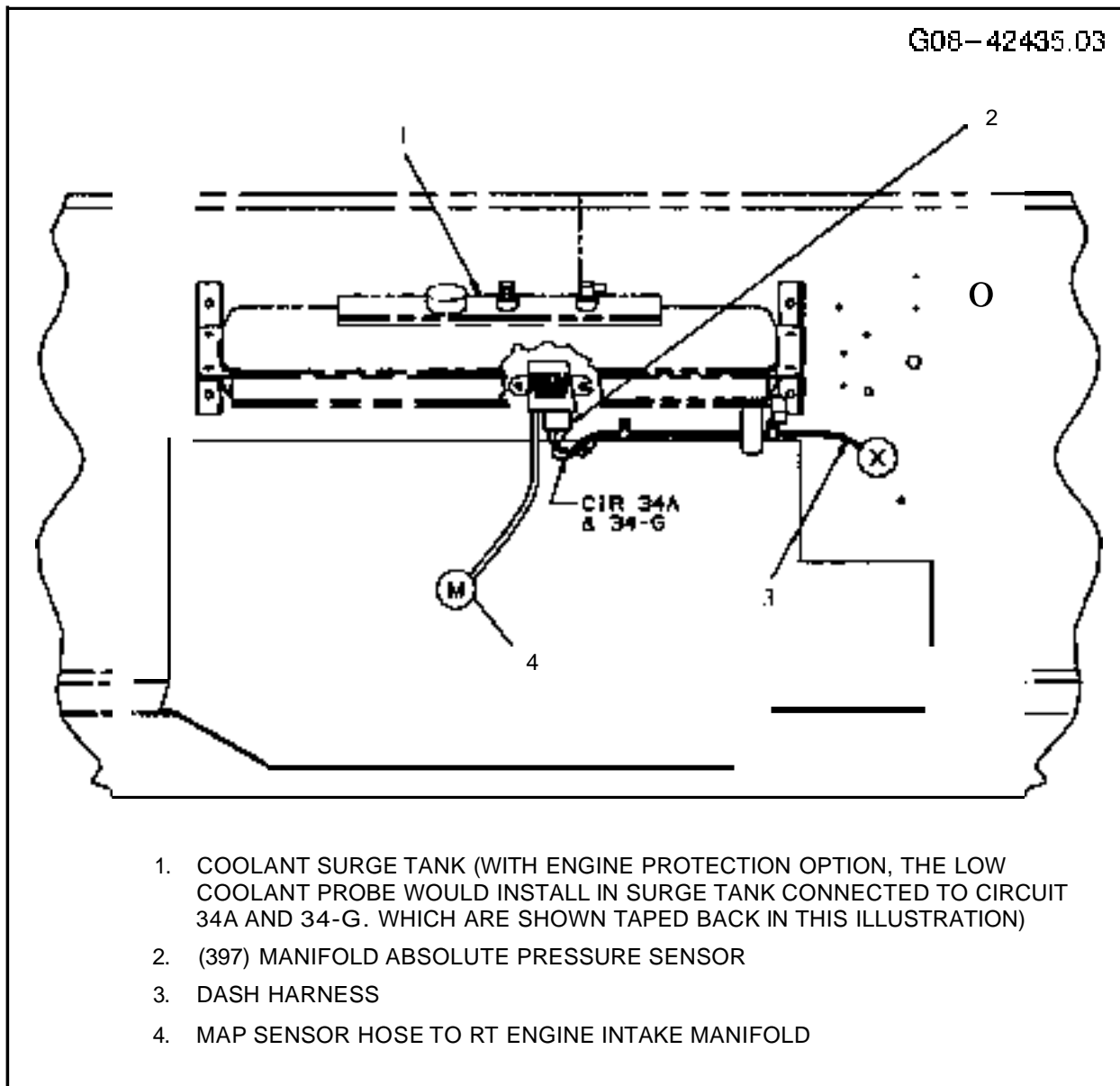


Figure 7.47 - Dash Harness Wiring - Right Side With 1652SC

ENGINE HARNESS WIRING AT DASH PANEL WITH 1652SC

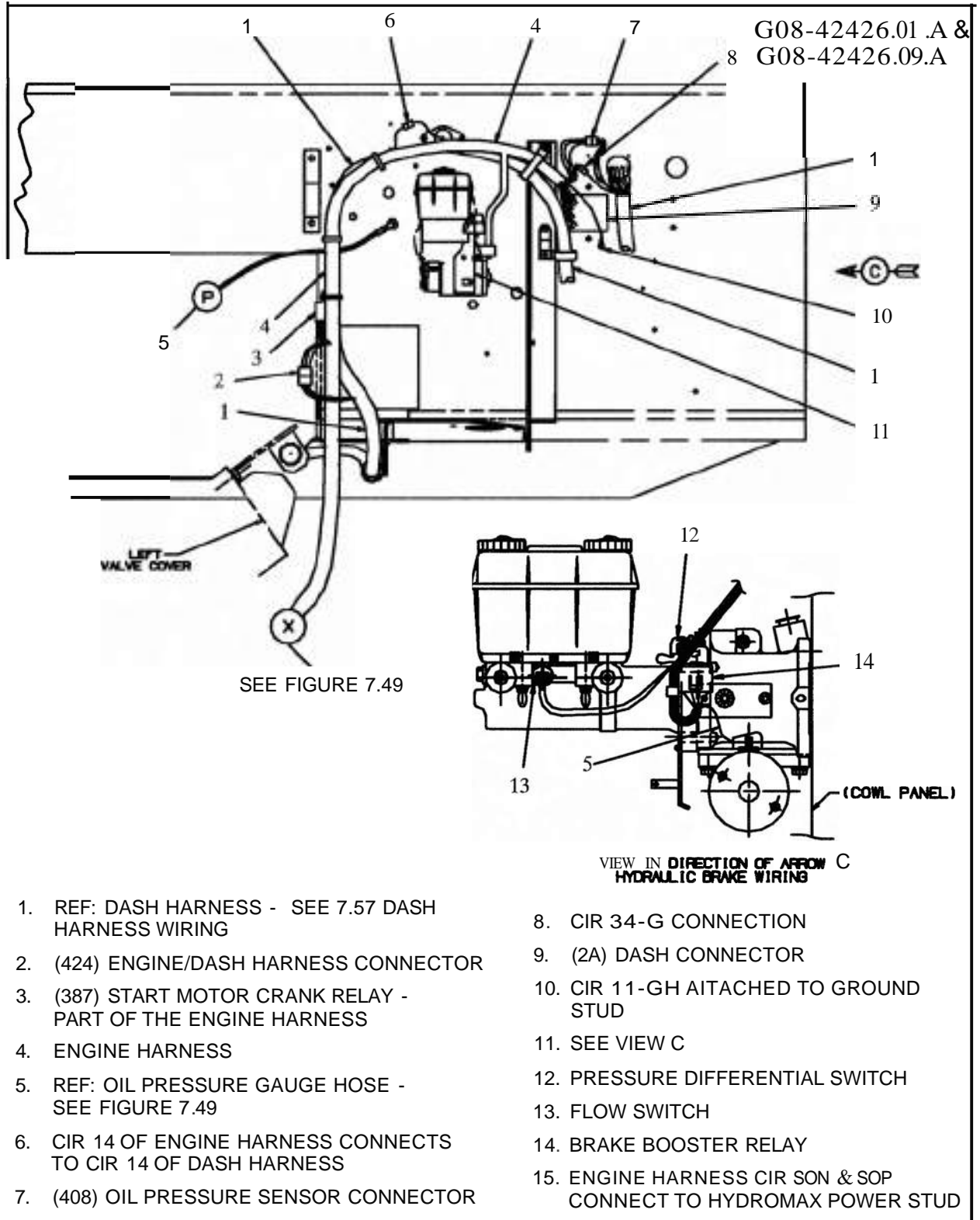
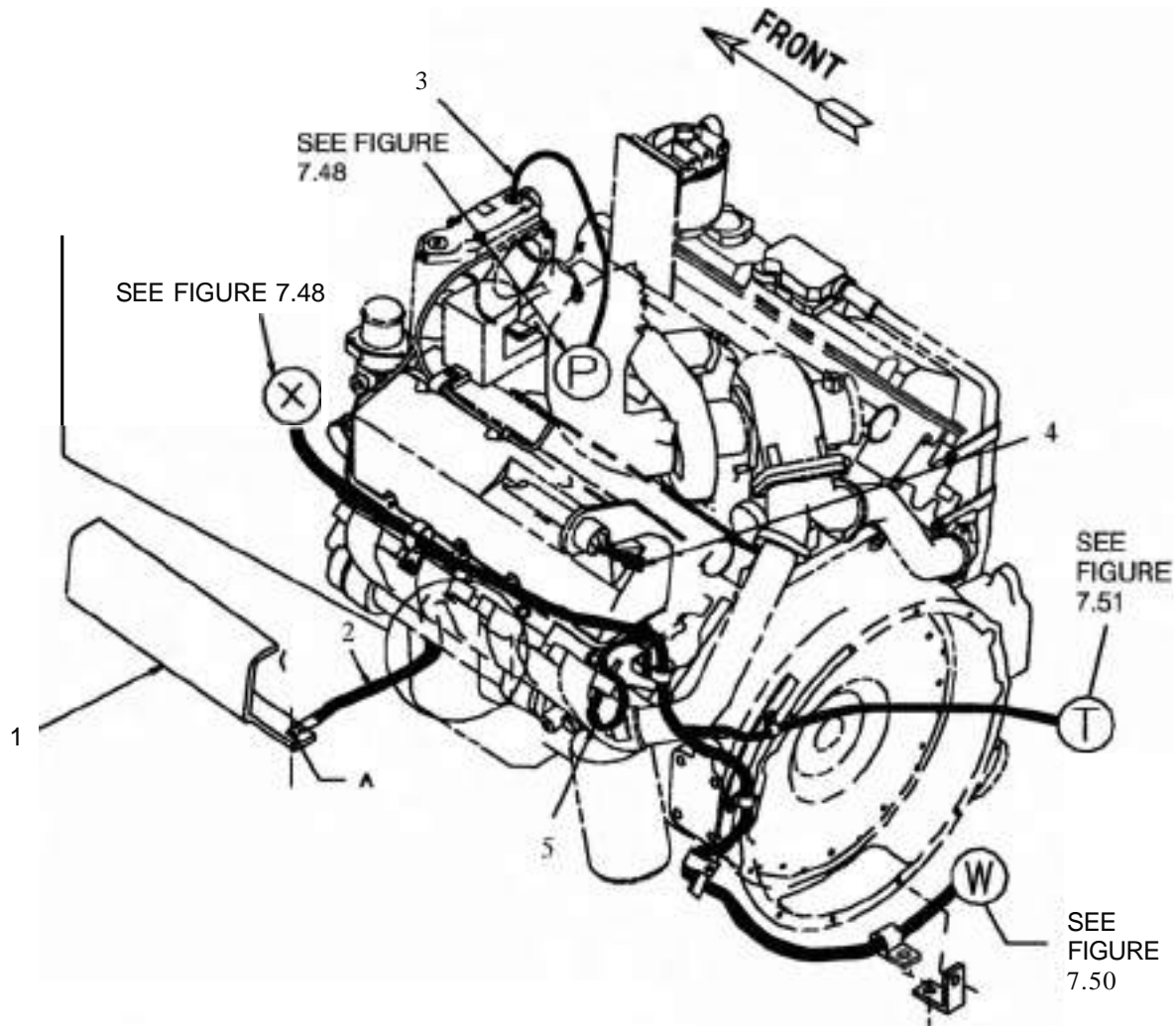


Figure 7.48 - Engine Harness Wiring At Dash Panel With 1652SC

LEFT SIDE ENGINE WIRE HARNESS

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1. LEFT FRAME RAIL
2. GROUND CABLE
3. OIL PRESSURE GAUGE HOSE
4. (405) DASH/ENGINE HARNESS CONNECTOR
5. CIR 29 & 29-G TO ENGINE TEMP GAUGE SENDER

Figure 7.49 - Left Side Engine Wire Harness

VEHICLE AND COMPONENT ILLUSTRATIONS

ENGINE HARNESS WIRING AT TRANSMISSION

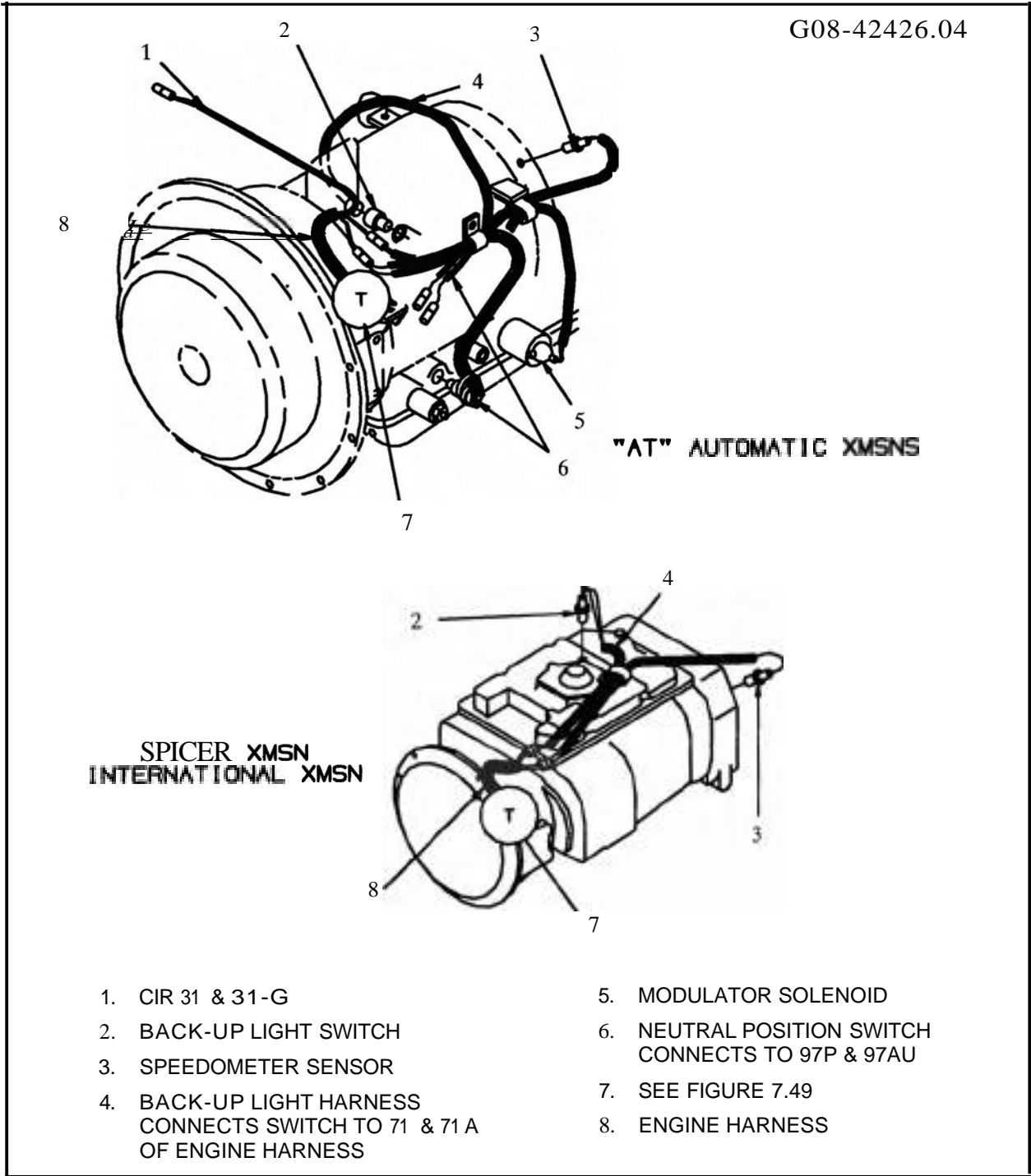


Figure 7.51 - Engine Harness Wiring At Transmission

RIGHT SIDE ENGINE WIRING WITH 1652SC

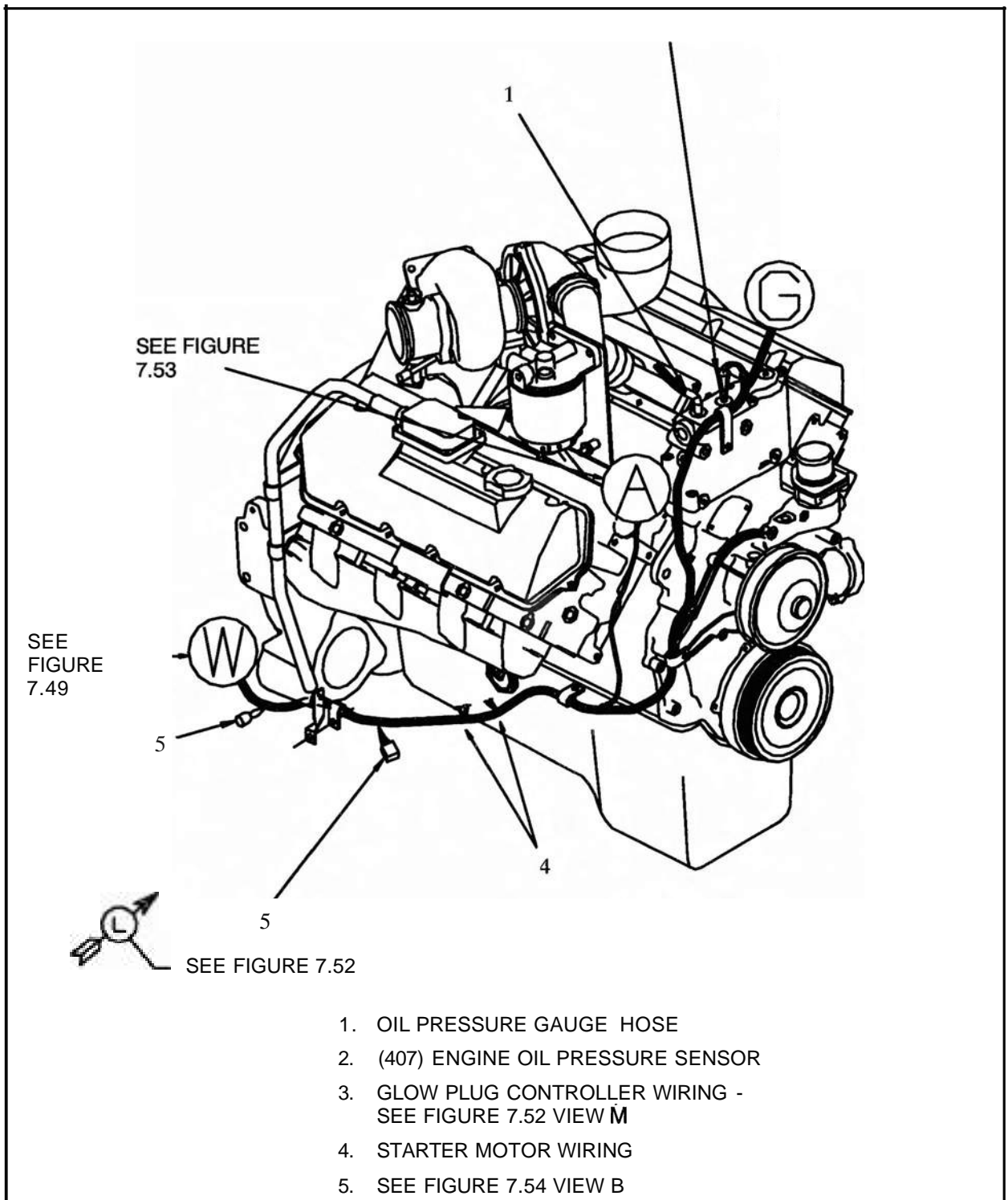


Figure 7.50 - Right Side Engine Wiring With 1652SC

ENGINE HARNESS WIRING

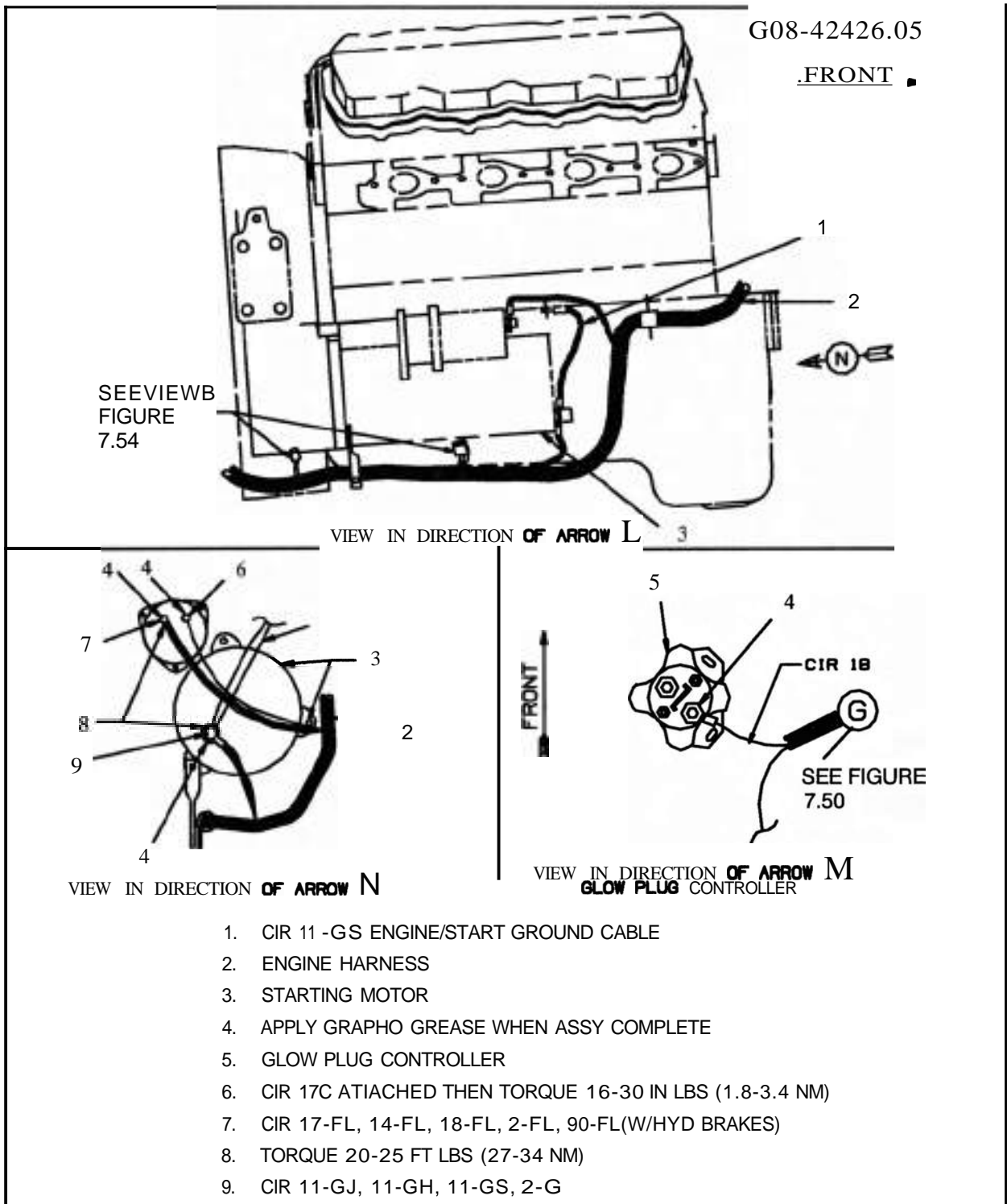


Figure 7.52 - Engine Harness Wiring

ENGINE WIRING AT ALTERNATOR

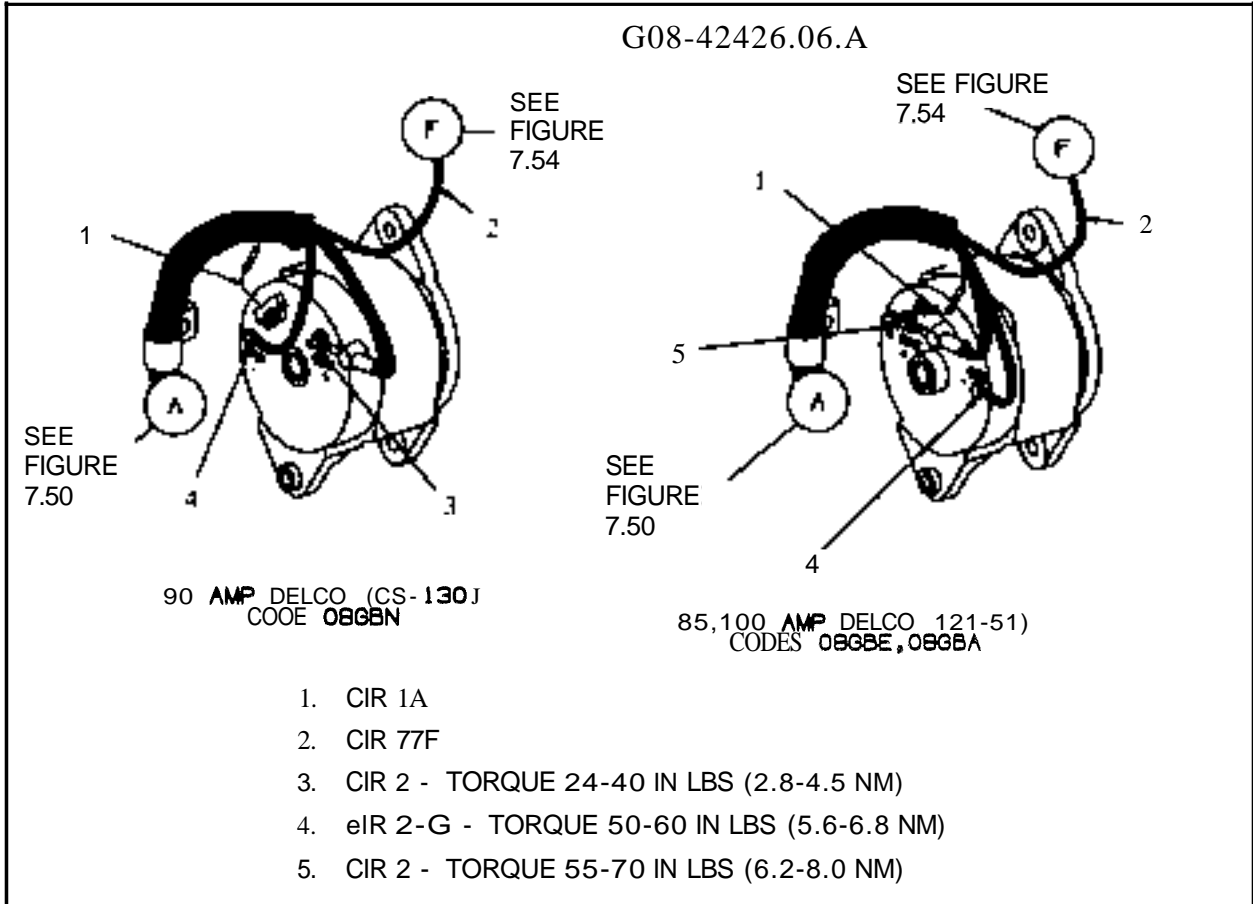


Figure 7.53 - Engine Wiring at Alternator

BATTERY CONNECTOR (426) AND TOP VIEW OF AC COMPRESSOR

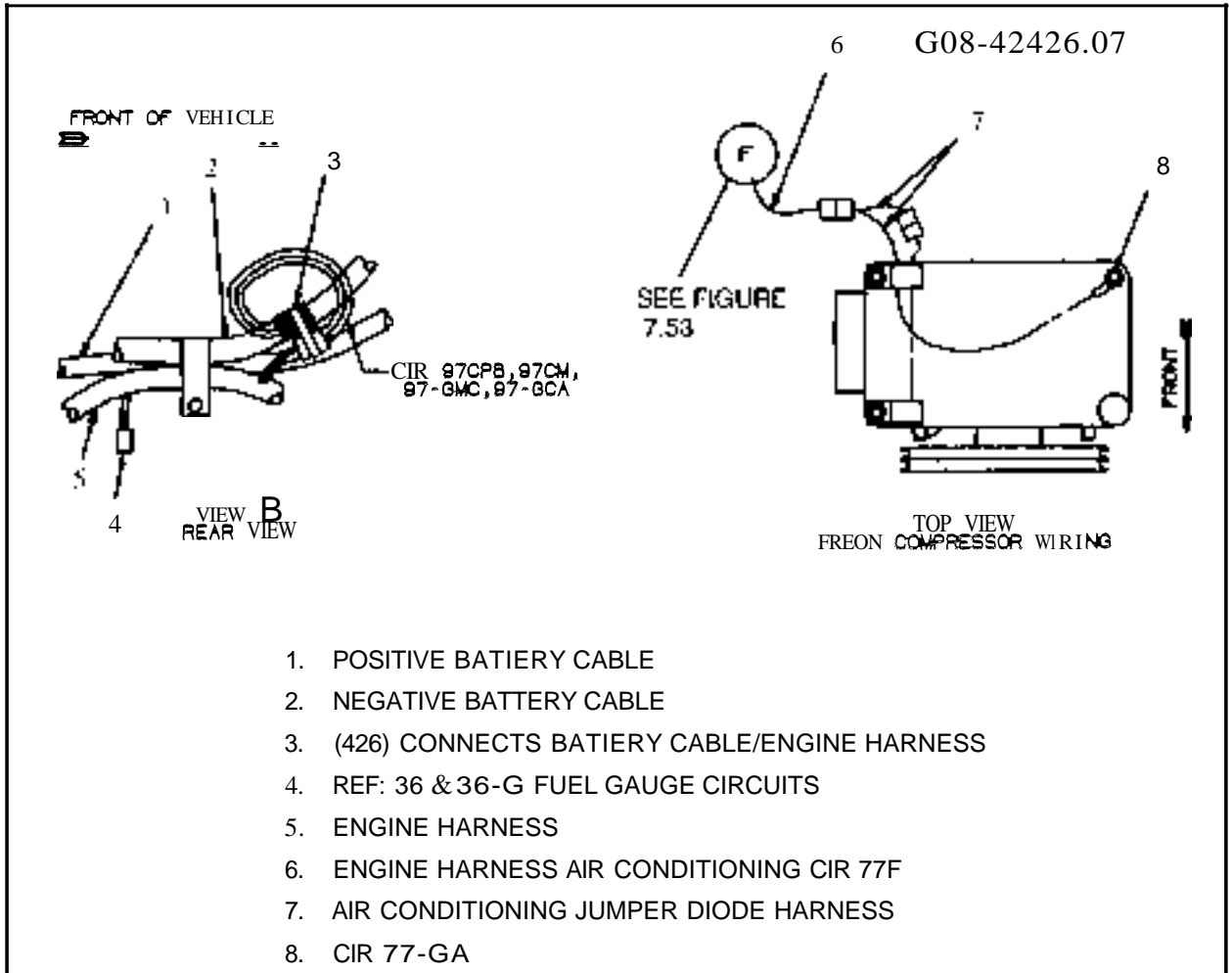


Figure 7.54 - Battery Connector (426) and Top View of AC Compressor

VEHICLE AND COMPONENT ILLUSTRATIONS

ALLISON "AT" TRANSMISSION WIRING

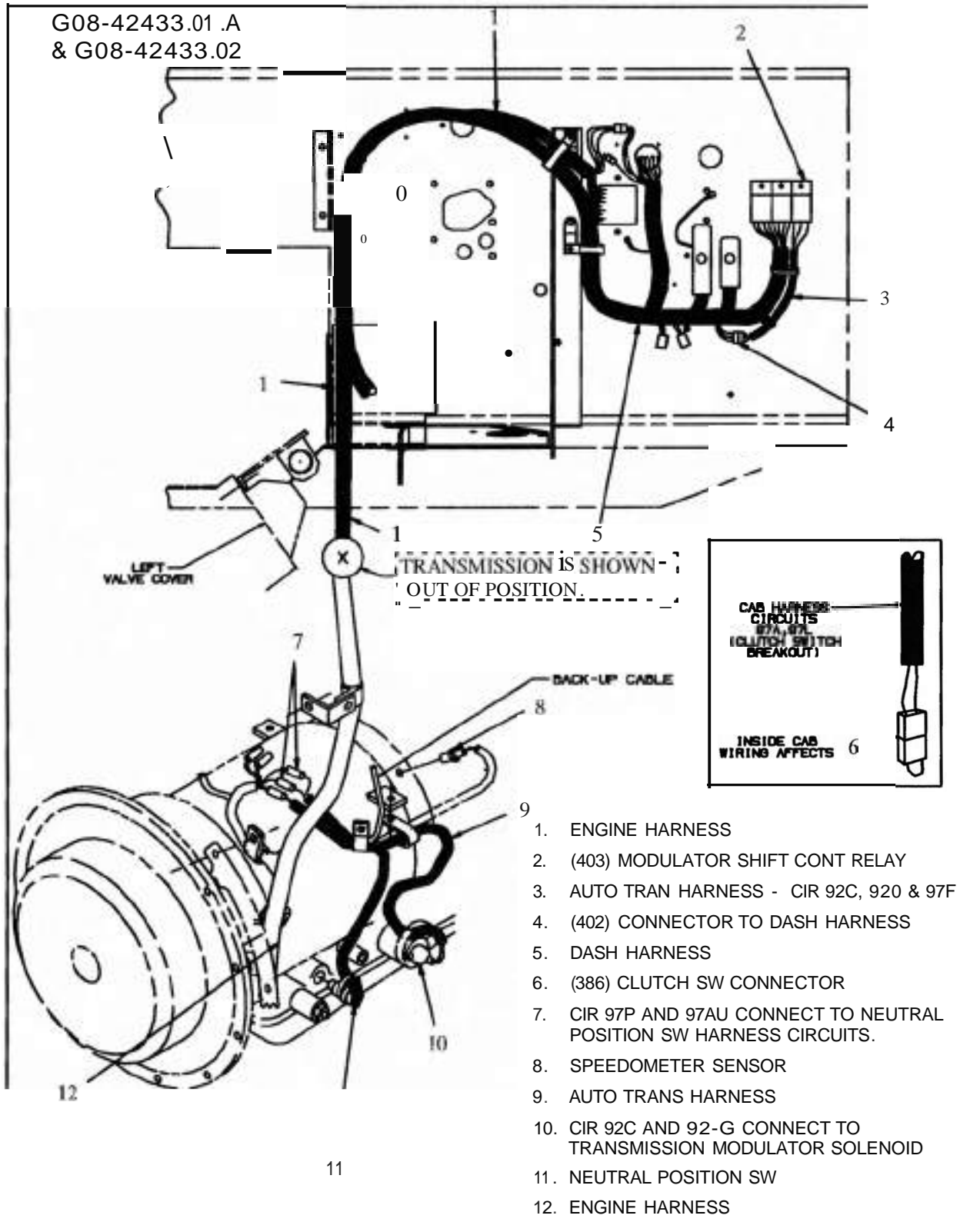


Figure 7.55 – Allison "AT" Transmission Wiring

ENGINE WARM-UP DEVICE

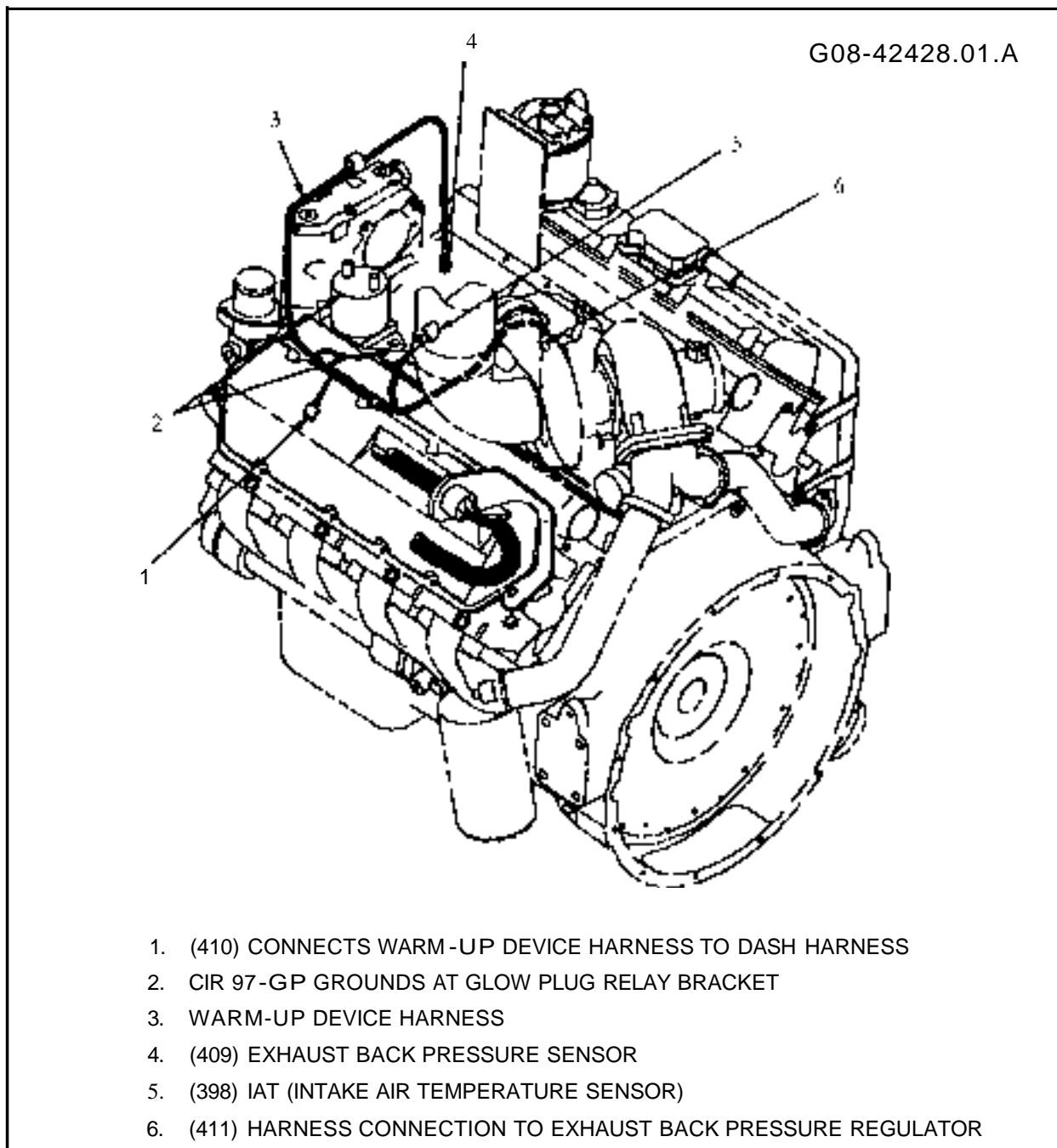


Figure 7.56 – Engine Warm-Up Device

ENGINE SHUTDOWN WIRING AT DASH PANEL

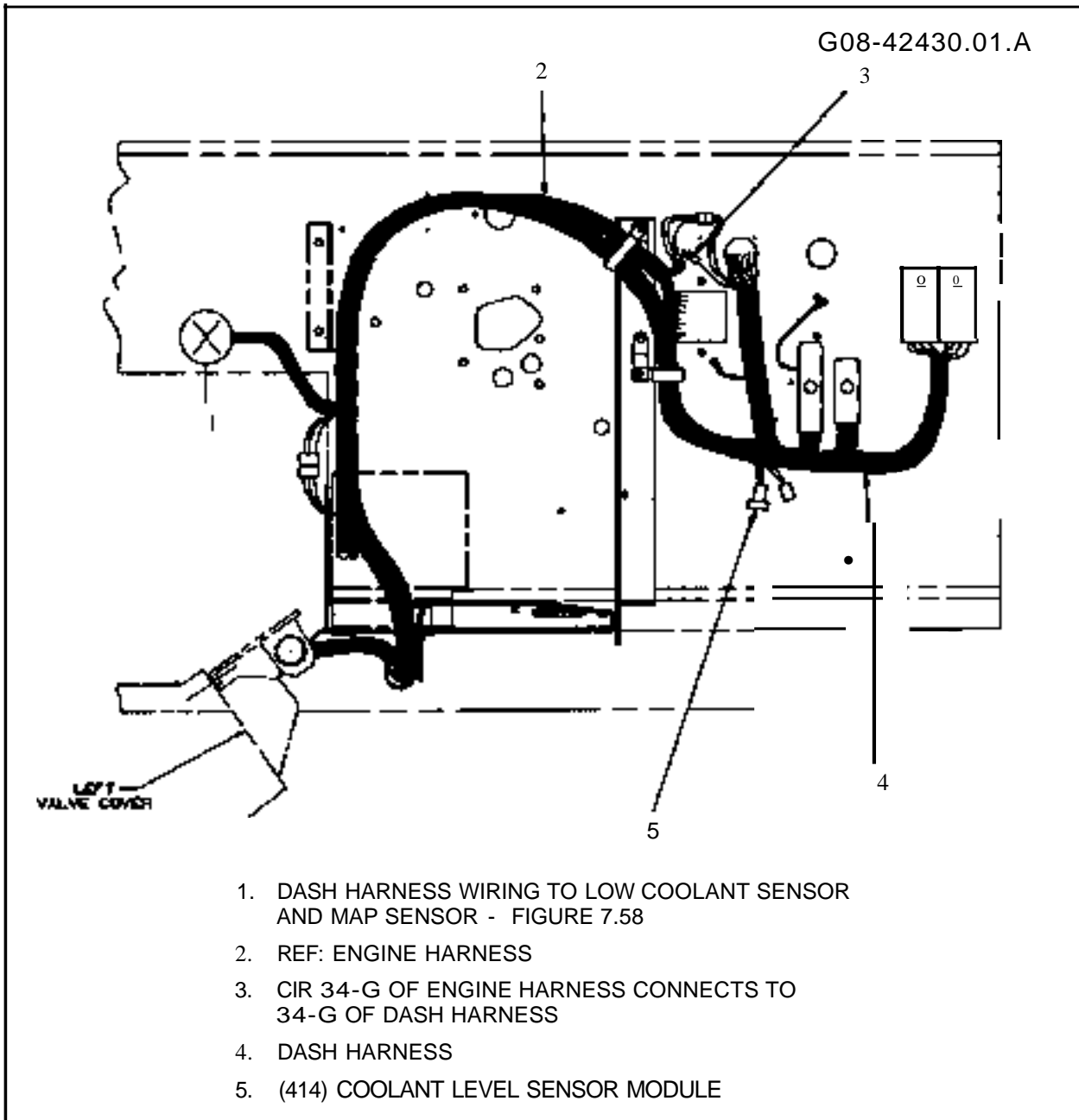


Figure 7.57 - Engine Shutdown Wiring At Dash Panel

ENGINE SHUTDOWN WIRING AT DASH PANEL (Continued)

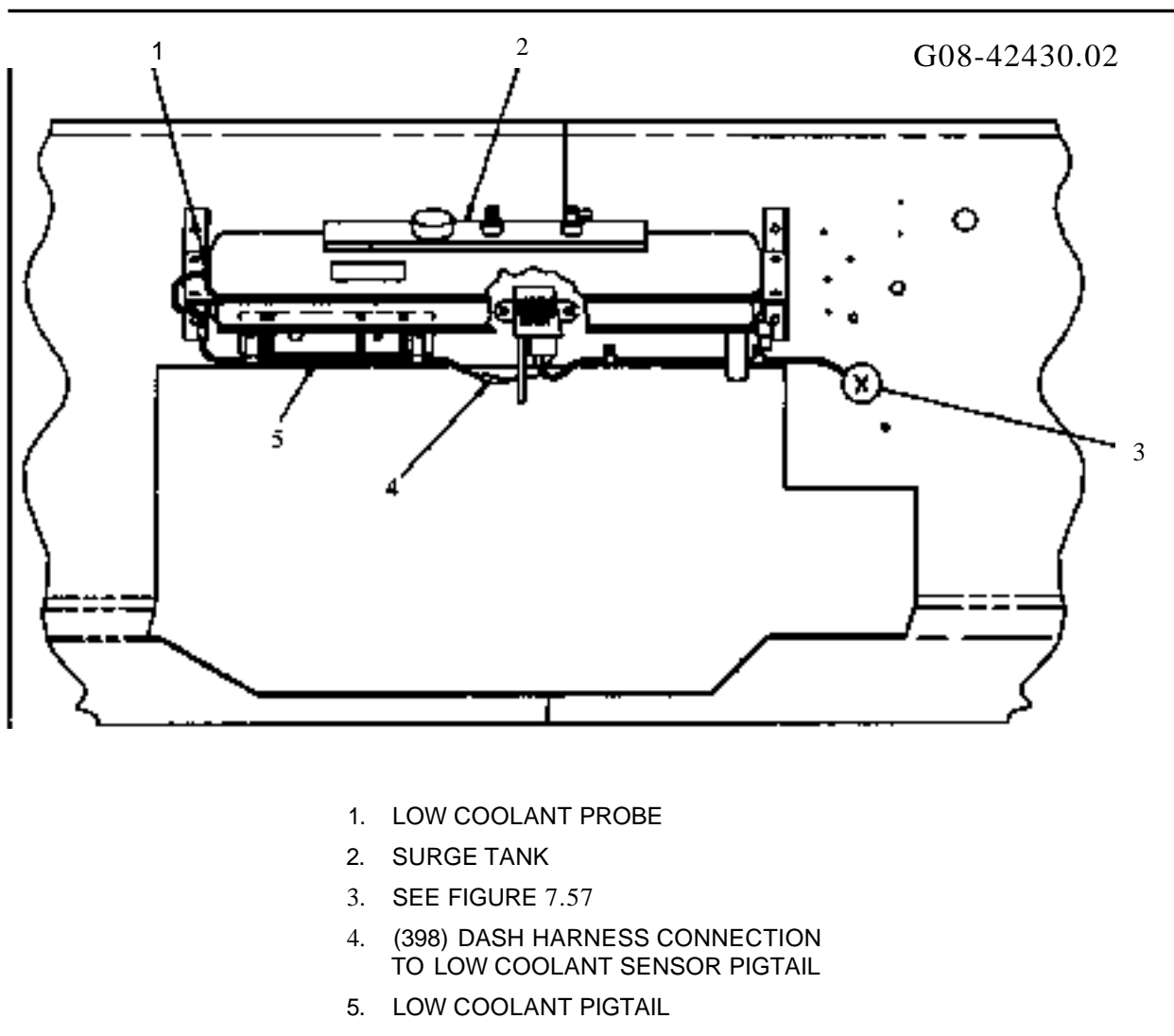


Figure 7.58 - Engine Shutdown Wiring At Dash Panel

Actuator - A device which performs work in response to an electrical signal.

Address - A specific memory location in the RAM, ROM, or KAM of the ECM. The ECM can either read information from an address or send information (write) to an address (RAM or KAM only).

Analog - A continuously variable voltage.

Analog to Digital Converter (AID) - A circuit within the processing section of the ECM that takes an analog signal (either DC or AC) and converts it into a usable digital signal for the microprocessor.

Analog Multimedia - A meter that uses a needle to point to a number on a scale of numbers to indicate a measured value (volts, ohms, amperes). Not recommended for use on microprocessor systems because of the possibility of excessive current due to the low impedance of the meter.

APS, Accelerator Position Sensor - A potentiometer style sensor that indicates the operator's pedal position.

ATA Data link - A serial data link specified by the American Trucking Association and the SAE.

Background Manager - The portion of the computer that performs "housekeeping duties". Typically the Background Manager controls low priority items or items that occur at a slower rate.

BARO Barometric Pressure Sensor - A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating pressure.

BNC, Brake Normally Closed - An on/off switch style sensor used to indicate if the brake is applied. Normal primary function is to disengage cruise control. (normally closed).

BNO, Brake Normally Open - An on/off switch style sensor used to indicate if the brake is applied. Normal primary function is to disengage cruise control. (normally open).

Calibration - The data values used by the strategy to solve equations and make decisions. Calibration values are stored in the ROM as scalars, functions and tables. Calibration values are input into the processor during programming to allow for the engine to operate within certain parameters.

CI, Cylinder Identification - A signal from the ECM to the IDM that identifies the position of the cylinders of the engine.

CIS, Coolant level Switch - A switch style sensor used to indicate low coolant level.

CMP, Camshaft Position Sensor - A Hall effect sensor used to indicate engine speed and camshaft position. Speed is indicated by the number of vanes counted per revolution. Camshaft position is indicated by a single narrow vane which indicates #1 cylinder position or a wide vane in dual sync application that indicates #4 cylinder.

Continuous Test - A function of the ECM in which the inputs and outputs of the ECM are continuously monitored to assure that the readings are within set limits.

DCI, Data Communication Link - A serial communication link between the ECM and the VPM.

DDS, Driveline Disengagement Switch - A switch indicating when the transmission is going out of gear.

Disable - A type of computer decision which results in a system being deactivated and not allowed to operate.

Driver - A transistor in the output section of the ECM that is used to turn on or off various actuators in the system.

Duty Cycle Signal - A type of wave signal that has a controlled on/off time measure from 0% to 100%. Normally used to control solenoids.

DVOM Digital Volt Ohm Meter - A meter that uses a digital display to indicate a measured value. Preferred for use on microprocessor systems, because a DVOM has a very high internal impedance and will not load down the circuit being measured.

EBP, Exhaust Back Pressure Sensor - A variable capacitance type sensor used to indicate exhaust back pressure.

ECl, Engine Crank Inhibit - An output on the ECM that controls the ECl relay and controls when the starter motor is allowed to operate and crank the engine over.

ECM, Electronic Control Module - The housing which contains the micro computer, Vref regulator, input conditioners and output drivers.

GLOSSARY OF TECHNICAL TERMS

ECM Power Relay - Relay which supplies or removes power to the ECM.

ECT, Engine Coolant Temperature Sensor - A thermistor type sensor which indicates engine temperature.

EF 10M Feedback - A communication line from the IDM to the ECM. In run mode, the signal on EF mirrors the FDCS signal received by the ECM from the 10M. EF extensions will be used to identify detected problems with individual injectors.

EFRC, Engine Family Rating Code - A code readable in the calibration list of the VPM with the EST service tool that identifies the horsepower and emission calibration of the engine.

Engine Off Test - A self test operation that is performed with the ignition switch in the "ON" position with the engine off.

Engine Running Test - Self test operation that is performed with the engine running.

EOP, Engine Oil Pressure sensor - A variable capacitance type sensor used to indicate oil pressure.

EOT, Engine Oil Temperature sensor - A thermistor type sensor which senses engine oil temperature. This sensor is used to provide engine temperature signal to the ECM which uses the information for fuel rate and timing adjustment.

EPR, Exhaust Back Pressure Regulator - A pulse width modulated solenoid valve which allows pressurized lube oil to act upon a piston to open the butterfly valve mounted on the exhaust side of the turbocharger. The regulator valve is controlled by the ECM which determines how much the butterfly valve is closed to control the exhaust back pressure.

EST Electronic Service Tool- The scan tool used for accessing diagnostics and programming the T 444E electronic control system.

EWL - Engine Warning Light Circuit

FOCS, Fuel Demand Command Signal - Command signal generated by the ECM and sent to the 10M which controls when an injector is energized (opened) and how long the injector remains energized (open). This signal determines when and how much fuel the injector delivers to the combustion chamber.

FMEM, Failure Modes Effects Management - An alternate control strategy devised to reduce the adverse effects that can be caused by a system failure. Should a sensor fail, the ECM substitutes a good sensor signal or assumed sensor value in its place. The WARN ENGINE LAMP is then lit to alert the driver to take the vehicle in for service.

Foreground Manager - That portion of the computer that controls the primary engine control functions. The foreground manager responds to external events quickly to maintain correct engine performance under a variety of conditions. Typically the foreground manager controls high priority items.

Function - An input value to a computer which the computer solves for an output.

Fusible Link - A wire designed to melt if more than a specified amount of electrical current flows through it. Often used as a main fuse or backup fuse for large sections of the vehicle's wiring harness.

GPC, Glow Plug Control - Controls the current flow to the glow plugs. Glow plug relay "ON" time is controlled by the ECM and is a function of engine coolant temperature, barometric pressure and battery voltage. "ON" time normally varies between 10 to 120 seconds. The glow plug relay will only cycle on and off repeatedly when there is a voltage condition greater than 13.0 volts.

GPL - Glow Plug Wait Lamp - On time is controlled by the ECM and is a function of ECT and BARO. On time will vary from 2 to 20 seconds.

GPR, Glow Plug Relay - ECM controlled relay which supplies power to the glow plugs.

Hall Effect Sensor - A Hall Effect sensor generates a digital on/off signal that indicates speed and also engine timing. The signal is created by a switching action caused by the passing of a vane through a positive and negative voltage potential. When the vane is between this potential a signal is created. When the gap is between this potential is open, no signal is generated. The wider the vane the longer the duty cycle of the signal, the narrower the vane the shorter the duty cycle of the signal. A narrow vane is used to indicate the position of #1 cylinder and a wide vane to indicate the position of #4 cylinder. A Hall Effect sensor has three connections ground, Vref, signal.

HEUI Hydraulically Actuated, Electronically Controlled, Unit Injectors – Engine description for International T 444E Diesel Engine.

High Speed Digital Inputs-Inputs to the ECM that are from a sensor that generates varying frequencies. Examples of high speed digital input sensors are engine speed, vehicle speed and Manifold Absolute Pressure (MAP) sensors.

IAT, Intake Air Temperature sensor - A thermistor style sensor used to indicate intake air temperature.

ICP, Injector Control Pressure Sensor - A transducer style sensor used to indicate Injection Control Pressure.

10M, Injector Driver Module- Is an electronic unit which has the primary function of an electronic distributor for the injectors. It also is the power supply for the injectors. It supplies 115 volts dc @ 10 amps to the injectors.

Impedance - A form of opposition to AC current flow measured in Ohms.

Injection Control Pressure - High lube oil pressure generated by a high pressure pump/pressure regulator used to hydraulically actuate the fuel injectors.

Input Conditioner - A device or circuit that conditions or prepares an input signal for use by the microprocessor.

IPR, Injection Control Pressure Regulator - An ECM controlled pulse width modulated regulator valve which regulates injection control oil pressure.

IVS, Idle Validation Switch - An on/off switch sensor that indicates when the accelerator pedal is in the idle position.

KAM, Keep Alive Memory - Is a memory location in the microprocessor which allows the ECM to store information on input failures, identified in normal operations for use in diagnostic routines. Keep Alive Memory can also store alternate calibration parameters generated by the FMEM strategy in event of sensor failure or wear. KAM memory is volatile and will be lost if power is disconnected.

KAMPWR - The circuit that continuously supplies KAM memory with 12 volts to prevent the loss of KAM memory.

Low Speed Digital Inputs - Are switched sensor inputs that generate an on/off (high/low) signal to the ECM. The input supplied to the ECM from the sensor could be from a high input source switch (usually 12 or 5 volts) or could be from a grounding type switch which grounds the signal from a current limiting resistor internal to the ECM and creates a low signal. (0 volts)

MAP, Manifold Absolute Pressure - A MAP sensor is a sensor that generates a digital frequency that indicates manifold boost pressure or vacuum. The signal is created by switching action caused by manifold pressure on a diaphragm connected to a capacitor circuit in the sensor. The digital frequency increases as pressure increases. A MAP sensor has three connections, signal return (grd), MAP signal and Vref.

Microprocessor - An integrated circuit within a micro computer which controls information flow within the computer.

Normally Closed - Refers to a switch or a solenoid that is closed when no control force is acting on it.

Normally Open - Refers to a switch or solenoid that is open when no control force is acting on it.

On Demand Test - A self test which the technician initiates, and is run from a program in the processor.

ACC, Output Circuit Check - An "On Demand" test performed during an "Engine Off" self test that tests the continuity of selected actuators.

Output State Check - An "On Demand" test selected by the technician which forces the processor to activate actuators "High or Low" for additional diagnostics.

OWL - Oil/Water Light and Alarm

Potentiometer - Is an electro-mechanical device (variable voltage divider) which senses the position of a mechanical component. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion. The voltage on the wiper changes at each point along the resistive material and is proportional to the amount of mechanical movement. Potentiometers have three connections. Vref, Signal out (wiper) and ground.

PROM - Programmable Read Only Memory

PTO, Power Takeoff Unit- Accessory output, usually from the transmission that is used to power a hydraulic pump for garbage packing, lift equipment, etc.

GLOSSARY OF TECHNICAL TERMS

Pulse Width - The length of time an actuator, such as an injector remains energized.

RAM, Random Access Memory - A type of memory that is used to store information. Information can be written to and read from the RAM. Input information such as current engine speed or temperature would be stored here to be compared to values stored in the ROM. All memory in the RAM is lost when the ignition switch is turned off.

Read - A computer operation where information is retrieved from the memory.

RFI - Radio Frequency Interference

ROM, Read Only Memory - A type of memory that is used to store information permanently. Information can not be written to the ROM memory. Operating strategies and calibration tables are the type of information most commonly stored in the ROM.

Sampling - The act of periodically collecting information, as from a sensor. A microprocessor samples inputs from various sensors in the process of controlling a system.

Scalar - A single numerical value that is assigned a label and is used as a calibration parameter. This value can be multiplied, divided, added or subtracted to a given input.

SCES, Speed Control Command Switches - A set of switches used for cruise control, PTA and remote hand throttle system.

SIG GRD, Signal Ground - The common ground wire to the ECM in wire harness for the sensor inputs.

SII, Self Test Input "Engine Diagnostics" Switch - Diagnostic switch located on vehicle dash used to activate Self Test Input engine diagnostics.

Strategy - A plan or set of operating instructions that the microprocessor follows in order to achieve a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is always stored in the RAM and thus cannot be changed during calibration.

SLOP - Stop Engine Lamp

Switch Sensors - Switch sensors are used to indicate position, levels or pressures. The signal of a switch sensor is a digital signal created by either the opening or closing a switch. The on or off signal can indicate position as in the case of a clutch switch, level as in the case of a coolant level switch, or pressure as in the case of a low oil pressure switch. A switch sensor normally has two connectors signal return (Grd) and the signal. A switch sensor is considered a low speed digital signal input.

TAC, Tachometer Output Signal - Engine speed signal from the ECM to the VPM.

Table - Devices that a computer uses to take two different inputs and solve for an output.

Thermistor - Sensor used to determine temperature. A thermistor changes its resistance value in relation to temperature change. Increasing temperature results in decreasing resistance, decreasing temperature results in increasing resistance. The thermistor in conjunction with a current limiting resistor in the ECM forms a voltage divider that provides a voltage signal that indicates temperature. Since the top half of the voltage divider is the current limiting resistor and is internal to the ECM a thermistor sensor only has two connections, signal return and ground.

Threshold Value - A value stored in the ROM portion of the ECM. This value is compared to the value of a particular sensor provided to the ECM during the continuous self-test. If the value is not within the parameters of the threshold value, a service code is entered into the KAM.

Transducers (load cells) - Transducers are used to sense pressure. Their function is very similar to potentiometers. The 5 volt reference signal is changed by the internal circuitry of the sensor into an analog voltage that indicates pressure. A transducer sensor has three connections Vref, signal and ground.

Transition - Changing from one value or condition to another, such as from positive to negative in an electronic circuit.

TTS - Transmission Tailshaft Speed

UVC, Under Valve Cover - A combination valve cover gasket and harness containing fuel injector and glow plug wiring.

VEPS Vehicle Electronic System Programming System - The computer system used to program electronically controlled vehicles.

VIGN, Voltage Ignition - Voltage supplied by the ignition switch when the key is in the "ON" position.

VIT, Vendor Interface Tool - A vendor (engine supplier) tool used to translate programming information between Navistar's truck VEPS system format to the vehicle.

VPM, Vehicle Personality Module - A module which identifies to the ECM the individual vehicle parameters for the system being used. This module allows for resetting of road speed, PTO set points, cruise control set points, speedometer calibrations and other vehicle features.

VRE Vehicle Retarder Enable - Output from ECM to a vehicle retarder.

V Ref Reference Voltage - A five volt reference supplied by the ECM to operate the engine sensors.

VBAT - Battery voltage.

VPWR - Battery voltage.

VSS Vehicle Speed Sensor - Normally a magnetic pickup style sensor that is mounted on the tailshaft of the transmission to indicate ground speed.

WARN ENGINE Lamp - Lamp in the dash that comes on when selected fault codes are set or when the ECM is utilizing FMEM strategy. Fault codes in some vehicles can be read as flash codes through the WARN ENGINE lamp. To access the flash codes, the STI (Self Test Input "Engine Diagnostics") switch is depressed and held momentarily while the ignition switch is placed in the "ON" position. This will cause the WARN ENGINE lamp to flash any fault codes which were stored while operating the vehicle.

Write - A computer operation where information is sent to and stored in memory.