DIAGNOSTIC/TROUBLESHOOTING MANUAL

Diagnostic Manual

Engine Family: INTERNATIONAL® DT 466 and DT 530

EGES-215

February, 2001

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FOREWORD

This publication is part of a series of publications intended to assist service technicians in maintaining International® engines in accordance with the latest technical advancements.

Due to a commitment of continuous research and development, some procedures, specifications and parts may be altered to improve International products and introduce technological advances.

Periodic revisions may be made to these publications and mailed automatically to "Revision Service" subscribers. The following literature, supporting International Diesel Engines, is available from:

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4956 Wayne Road
Battle Creek, Michigan 49015

THE INTERNATIONAL® DT 466 AND DT 530 DIESEL ENGINE SERVICE LITERATURE

Form No*	Description
EGES-210	DT-466E & THE INTERNATIONAL® 530E Diesel Engine Service Manual (EGES-230 Included)
EGES-230	DT 466 & DT 530 Diesel Engine Service Manual Supplement
EGES-215	DT 466 / DT 530 Engine Diagnostic Manual for 4000 Series Trucks
EGED-220	DT 466 & DT 530 Mechanical Diagnostics Form
EGED-225	DT 466 & DT 530 Electronic Control System Diagnostics Form
CGE-309	INTERNATIONAL® Engine Diagnostic Trouble Codes
1171753R1	INTERNATIONAL® DT 466 Engine Operation and Maintenance Manual
1171755R1	INTERNATIONAL® DT 530 Engine Operation and Maintenance Manual

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

SAFETY INFORMATION

NOTES, CAUTIONS AND WARNINGS

Do not attempt to service engine without obtaining and reviewing this service manual EGES-215. See related application or chassis service manual(s) for additional notes, cautions and warnings.

Always disconnect the main negative battery cable before working on the electrical system.

After servicing, be sure all tools, parts, or servicing equipment are removed from the vehicle or engine.

Keep a “charged” fire extinguisher within reach whenever you work in an area where fire may occur. Also, be sure you have the correct type of extinguisher for the situation:

Type A: Wood, Paper, Textile and Rubbish
Type B: Flammable Liquids
Type C: Electrical Equipment

To avoid personal injury comply with the following warnings:

Keep work area organized and clean. Wipe up oil spills of any kind. Keep tools and parts off floor. Eliminate the possibility of a fall.

Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the engine.

Do not wear rings, wrist watches, loose fitting clothing or unrestrained long hair, when working on machinery, they could catch on moving parts. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine in bare feet, sandals, or sneakers.

Do not use defective portable power tools. Check for frayed cords prior to using the tool. Be sure all electric tools are grounded. Severe injury can occur if electrical equipment is defective or not used properly.

Be careful when using compressed air. Never apply compressed air to any part of the body or clothing.

Use approved air blow guns. Do not exceed recommended pressure. Wear safety glasses or goggles and use proper shielding to protect everyone in the work area.

When refueling, keep the hose and nozzle or the funnel and container in contact with the metal of the fuel tank to avoid the possibility of an electric spark igniting the fuel.

Do not over fill the fuel tank — overflow creates a fire hazard.

Do not smoke when refueling and never refuel when the engine is running.

Electric storage batteries give off highly flammable hydrogen gas when charging and continue to do so for some time after receiving a steady charge. Do not under any circumstances allow smoking, an electric spark or open flame near the battery or explosion may occur.

Group

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FUEL SUPPLY SYSTEM

FUEL SYSTEM DESCRIPTION

The fuel system consists of three major subsystems:

- **Fuel Supply System** (See Figure 1, page 6)
- **Injection Control Pressure System** (See Figure 3, page 9)
- **Fuel Injector** (See Figure 8, page 13)

These subsystems 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 (ICP) supplies the injectors with high pressure oil and the electronic control system controls the moment and duration of the injection.

All three systems converge into the Hydraulically Actuated Electronically controlled Unit Injector (HEUI).

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 tanks
- Fuel supply lines
- Fuel strainer
- Fuel filter
- Priming (hand) pump
- Fuel supply pump
- Fuel / Oil supply manifold
- Fuel passages (within fuel supply manifold and cylinder head to supply the injectors)
- Fuel pressure regulator
- Fuel return lines

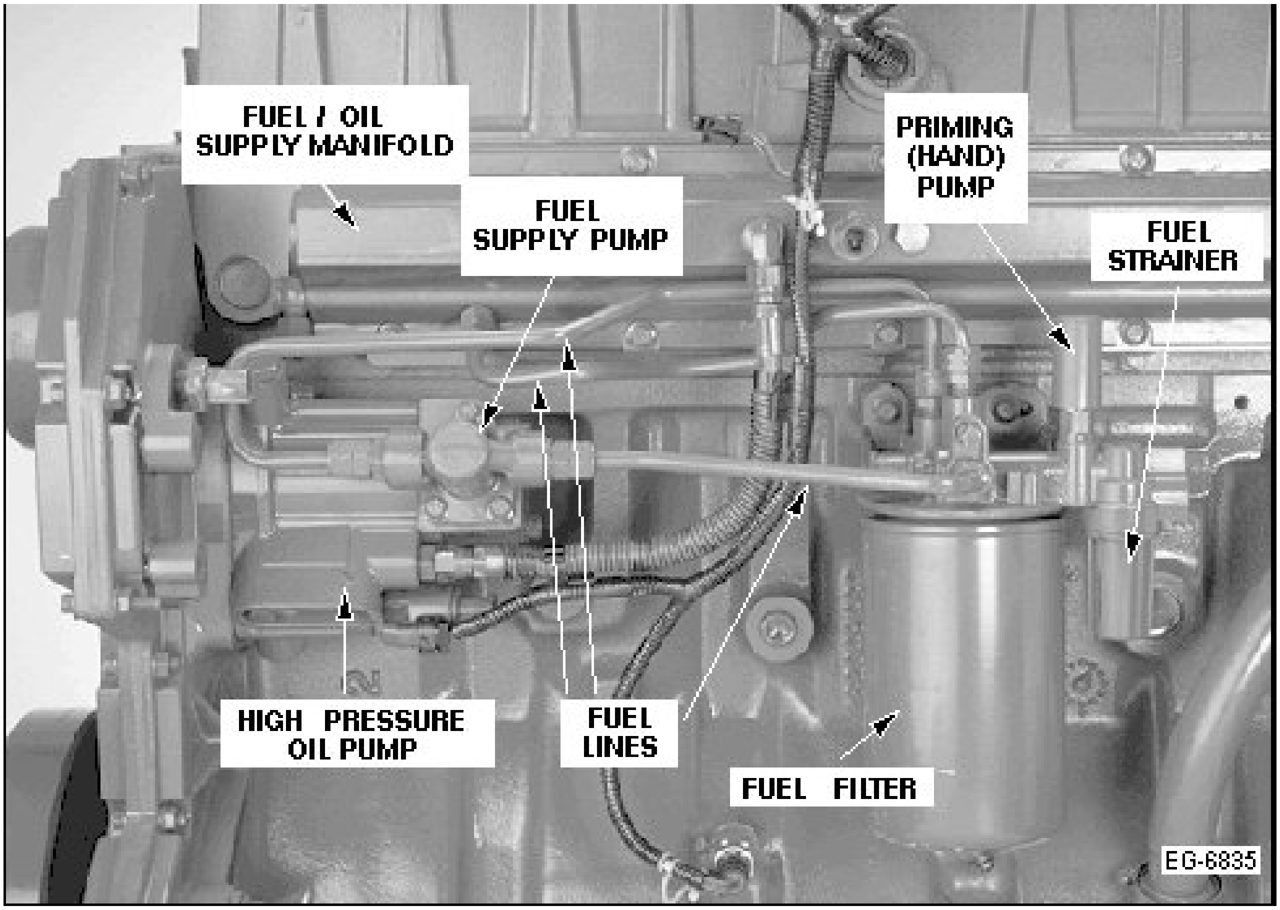


Figure 1 Fuel System Components

FUEL FLOW

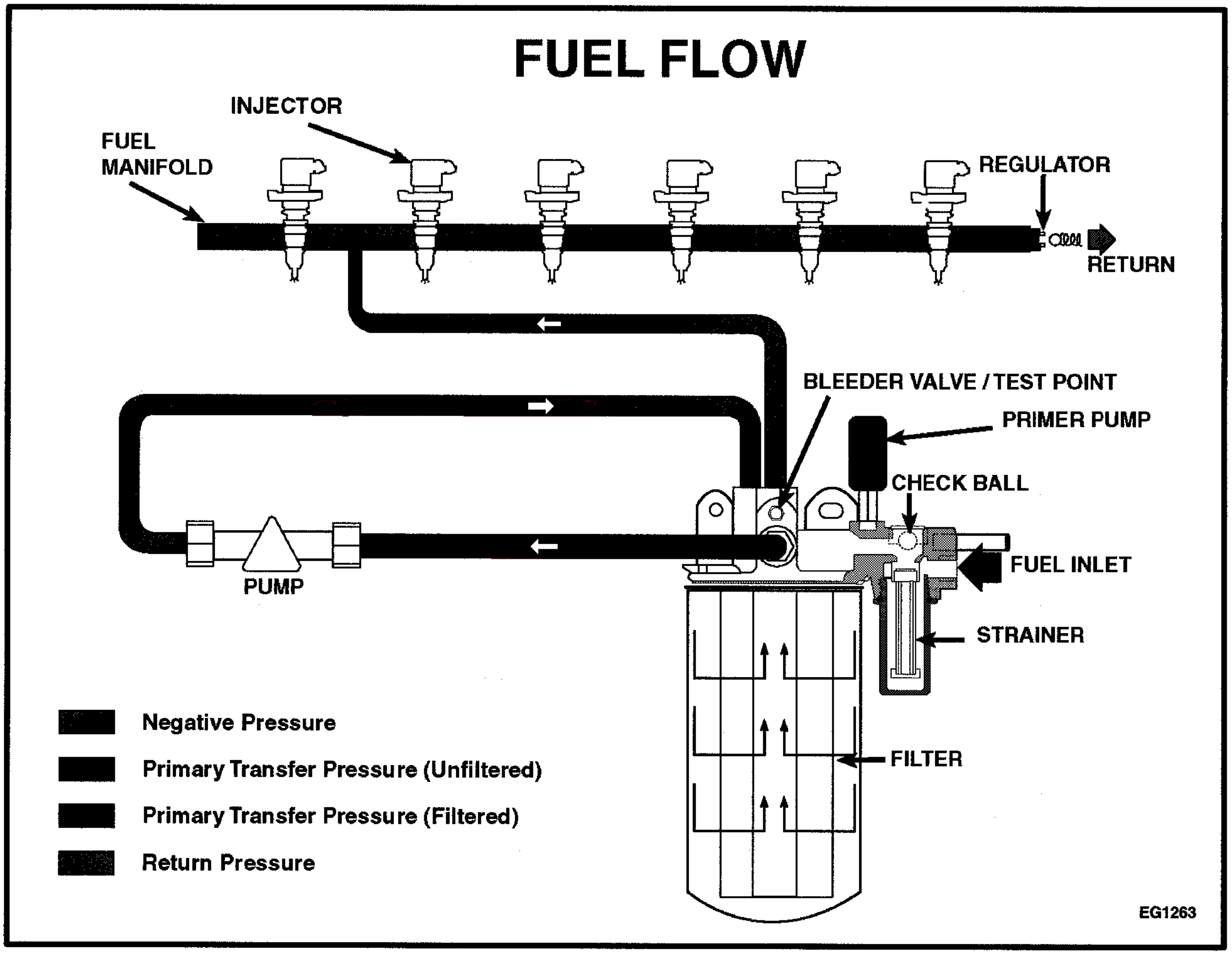


Figure 2 Fuel System Diagram

The fuel supply pump draws fuel from the fuel tanks to the fuel strainer. Fuel flows through the strainer to the supply pump. The supply pump increases fuel pressure to approximately 65 psi (448 kPa). Pressurized fuel is pumped through the fuel filter to the fuel supply manifold for distribution through passages in the head to the fuel injectors.

The fuel rail pressure is controlled to 65 psi (448 kPa) by a Fuel Pressure Regulator mounted to the rear of the fuel manifold. After the pressure regulator, excess fuel is returned to the tanks.

In the injectors the fuel pressure is increased to injection pressures of approximately 18,000 psi (124 MPa).

INJECTION CONTROL PRESSURE SYSTEM

INJECTION CONTROL PRESSURE SYSTEM OPERATION

The Injection Control Pressure system provides the necessary energy to hydraulically actuate the HEUI injectors. Engine lube oil is the hydraulic fluid used for this purpose.

Lube oil is drawn from the oil pan through the pickup tube by the engine oil lubrication pump. The lubrication pump is a gerotor type pump driven by the crankshaft. Filtered oil is fed through passages in the front cover to the oil reservoir which is an integral part of the front cover.

The reservoir makes available a constant supply of oil to a high pressure hydraulic pump mounted to the front cover. The high pressure pump is a gear driven swash plate type pump. High pressure oil is delivered by the high pressure pump to the high pressure oil supply manifold and into oil passages machined into the cylinder head.

When the solenoid of an injector is energized high pressure lube oil is utilized to pressurize and atomize the fuel into the combustion chamber. After injection is complete the solenoid is deactivated and the oil within the injector is vented through the top portion of the injector and allowed to drain back to the oil pan.

Injection control pressure is, governed by the Electronic Control Module, (ECM) depending upon operating conditions and the driver’s demand for power. The Injection Pressure Regulator (IPR) is used by the ECM for this purpose. The IPR valve is mounted on the high pressure pump and achieves injection control pressure regulation by dumping excess oil into the front cover and back to the oil pan.

The injection control pressure sensor (ICP) provides feedback pressure information to the ECM in the form of an analog voltage signal. Injection control pressure ranges from 500 to 3500 psi (3.4 to 25 MPa), depending on the engine family.

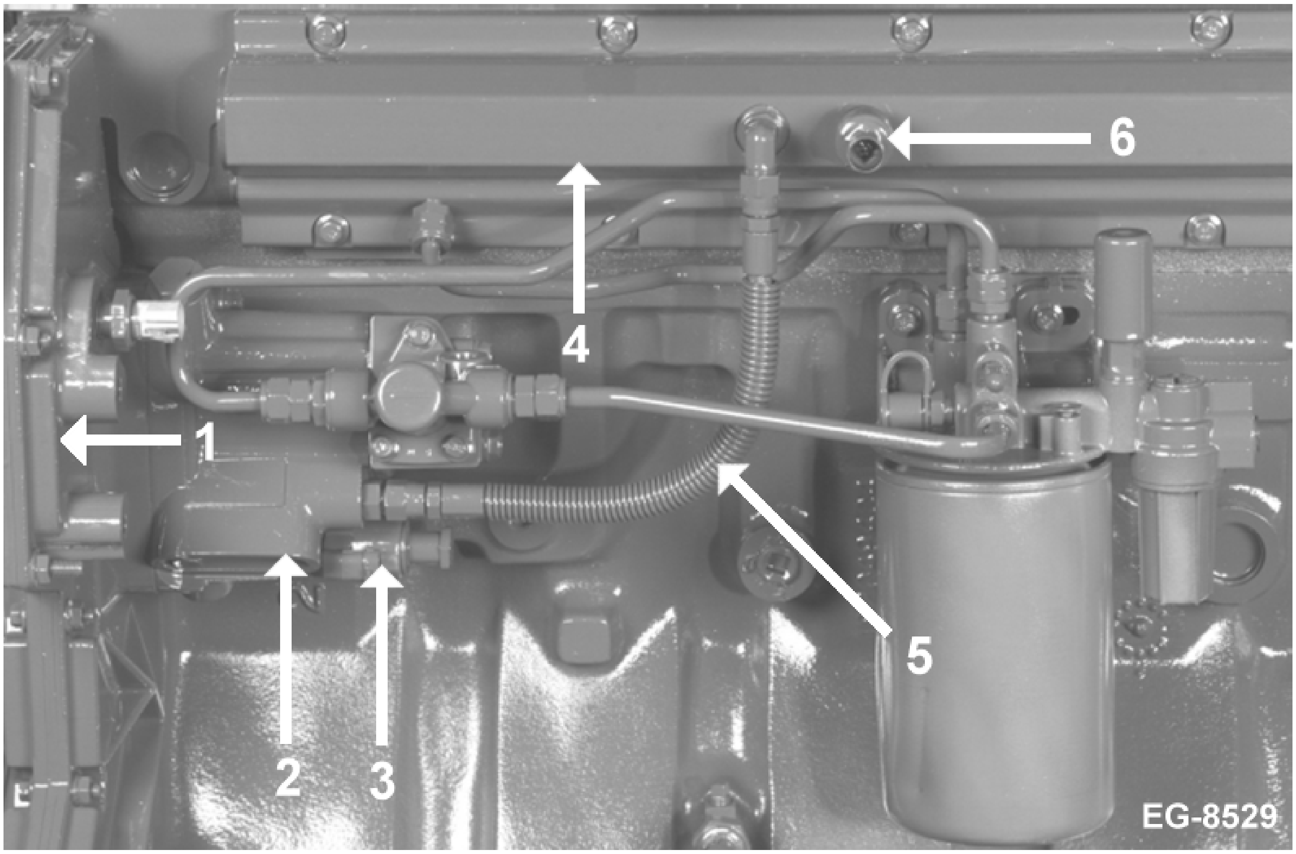


Figure 3 Injection Control Pressure System Components

1. Internal Oil Reservoir (cast into front cover)
2. High Pressure Oil Pump Assembly
3. Injection Pressure Regulator valve (IPR)
4. High Pressure Oil Supply Rail
5. High Pressure Oil Supply Hose
6. Injection Control Pressure Sensor (ICP)

INJECTION PRESSURE CONTROL

The ECM controls the injection control pressure by operating the Injection Pressure Regulator (IPR). Injection control pressure is continuously monitored by the ECM using the Injection Control Pressure sensor (ICP) (See Figure 4, page 10). The pressure signal from the ICP allows the ECM to know the actual injection control pressure. This is known as **Closed Loop Operation** (See Figure 5, page 10).

Diagnostic codes can be set by the ECM if the ICP electrical signal is out of range, or if the ICP signal received corresponds to an out of range value for the injection control pressure at a given operating condition. Should any of these conditions occur, the ECM will ignore the ICP signal and control the IPR valve operation from programmed default values. This is known as **Open Loop Operation**.

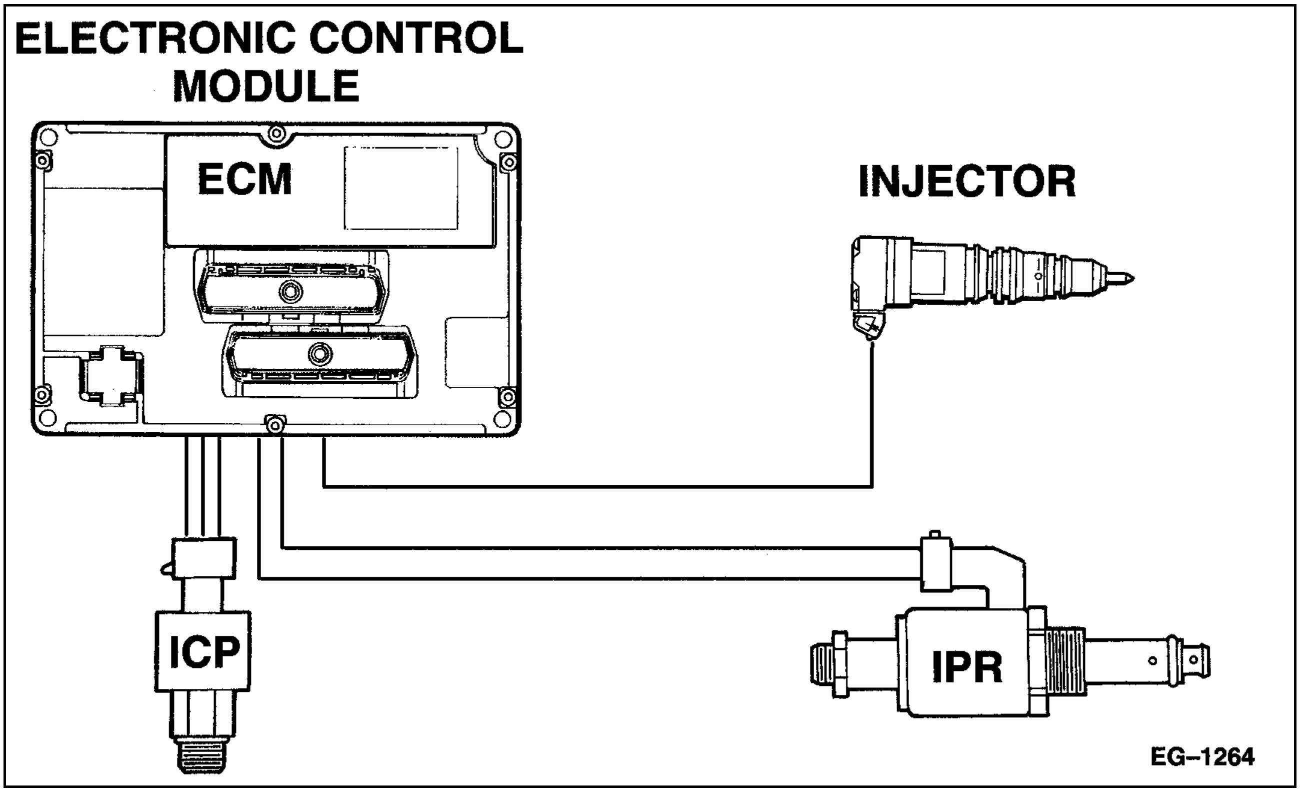


Figure 4 Injection Control System

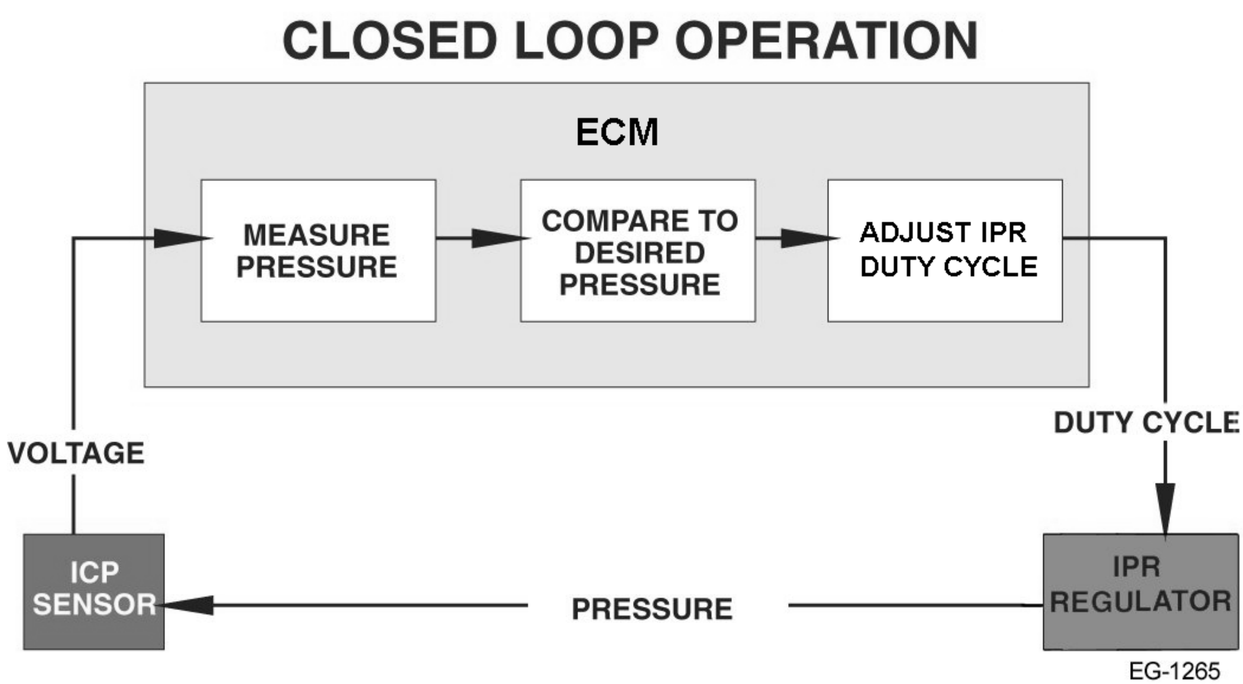


Figure 5 Closed Loop Operation

IPR VALVE OPERATION

The Injection Control Pressure Regulator valve is a pulse width (duty cycle %) controlled valve. The pulse width is modulated between 8 and 60% to control ICP pressure in the range of 3.4 to 20 MPa (500 to 3000 psi). The regulator is mounted in the high pressure oil pump and maintains desired injection control pressure by dumping excess oil through an (internal shuttle) spool valve to the front cover and back to the oil pan.

As the demand for injection control pressure increases, the ECM increases the pulse width (duty cycle %) to the IPR valve. This forces the poppet against the drain orifice increasing the pressure behind the spool valve.

As oil pressure increases behind the spool valve, it moves forward and blocks the drain ports on the sides of the IPR valve. Refer to IPR Higher Injection Pressure (See Figure 6, page 11). When the demand for injection control pressure decreases, the ECM decreases the (duty cycle %) to the IPR valve allowing oil to drain out of the drain orifice. This is accomplished by relieving the pressure behind the spool valve which allows it to partially open the relief port decreasing injection control pressure. Refer to IPR Lower Injection Pressure (See Figure 7, page 12).

The described operation allows the IPR to continuously adjust injection control pressure as commanded by the ECM.

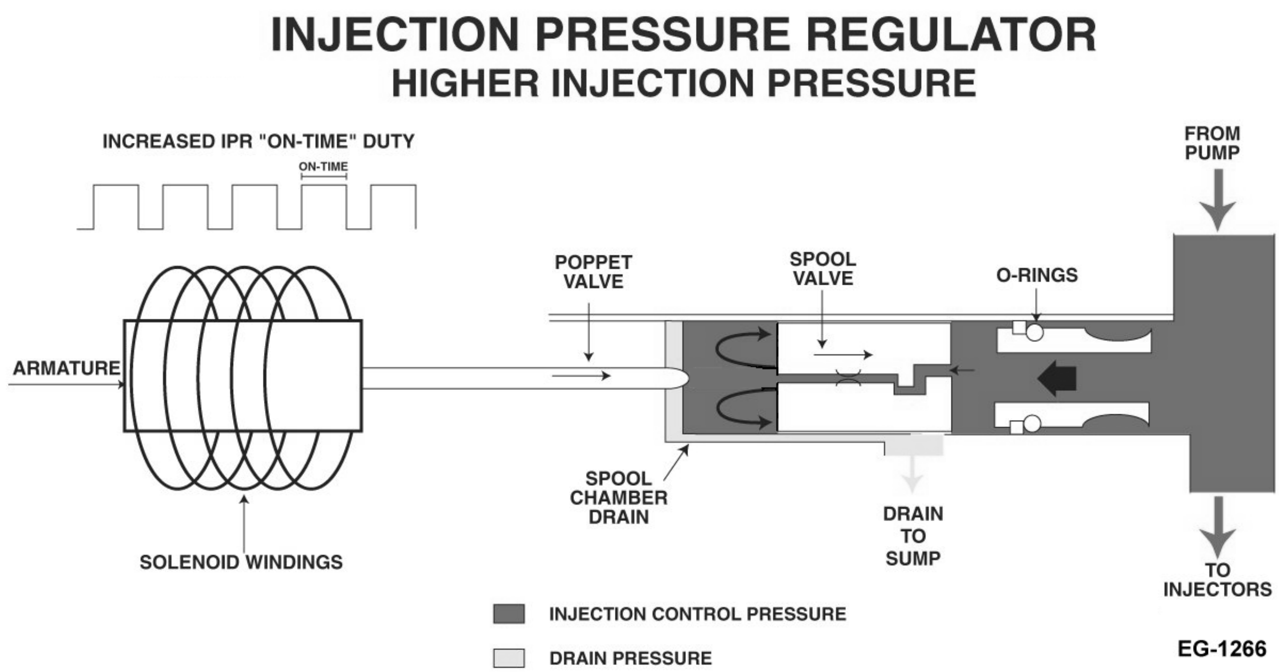


Figure 6 IPR Higher Injection Pressure

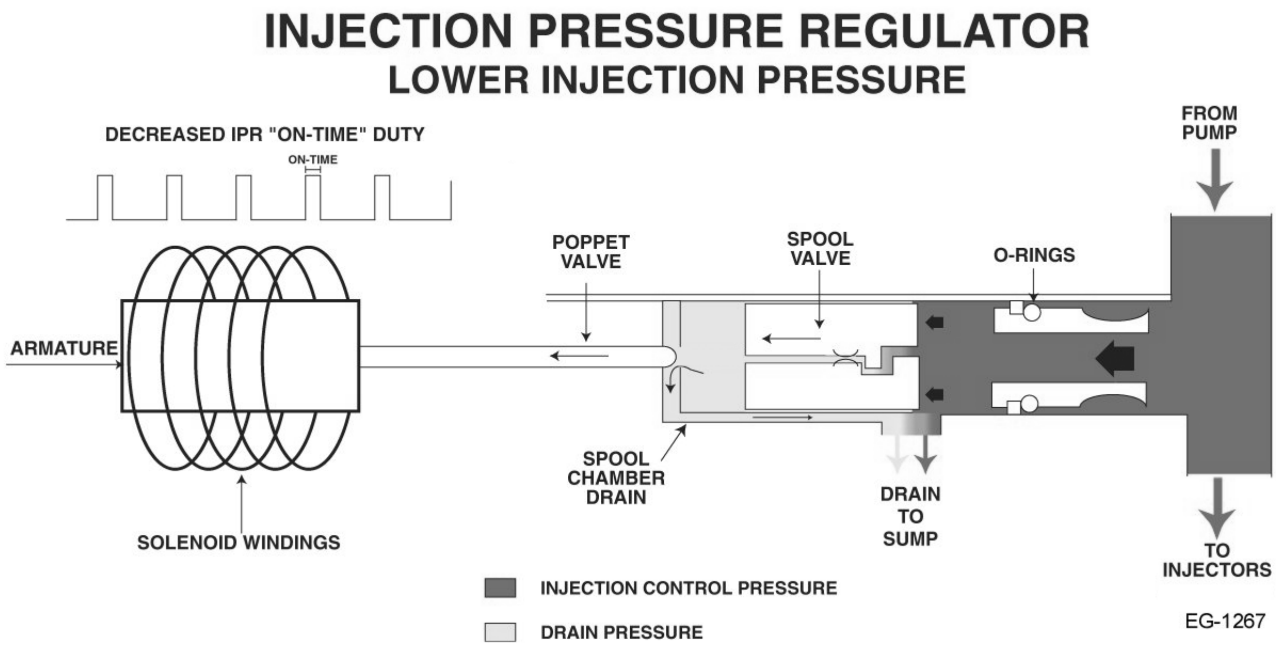


Figure 7 IPR Lower Injection Pressure

HEUI INJECTOR OPERATION

STANDARD INJECTOR OPERATION

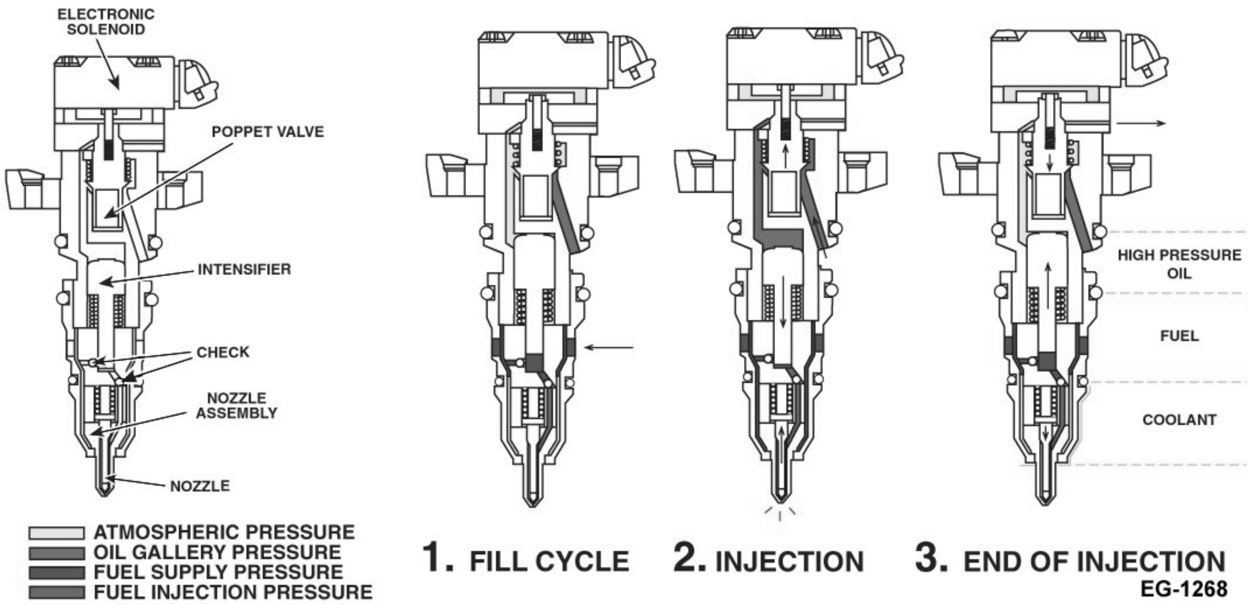


Figure 8 HEUI Injector Stages of Operation

The injection operation is divided into three stages or cycles:

1. **Fill Stage**
2. **Injection Stage**
3. **End of Injection**

Fill Stage

During the fill stage, the solenoid is deactivated and the poppet valve is closed preventing the flow of high pressure oil to the intensifier piston. At this point the intensifier piston is up allowing the fuel to enter and fill the injector nozzle.

Injection Stage

Once the ECM commands injection, the solenoid is energized and the injection stage is initiated. This action rapidly lifts the poppet valve from its seat, allowing high pressure oil to enter the injector. The intensifier piston transmits the pressure from the high pressure oil to the fuel and multiplies it 6 to 7 times creating fuel injection pressures of up to 21,000 psi.

As the fuel pressure increases, check valves prevent the fuel from flowing back to the supply manifold. Once the pressure is high enough to lift the needle valve fuel is forced into the combustion chamber.

End of Injection

Once injection is completed, the ECM deactivates the solenoid, the poppet valve and the intensifier piston return to the closed position and the injector returns to the fill stage (See Figure 8, page 13).

SPLIT-SHOT INJECTORS

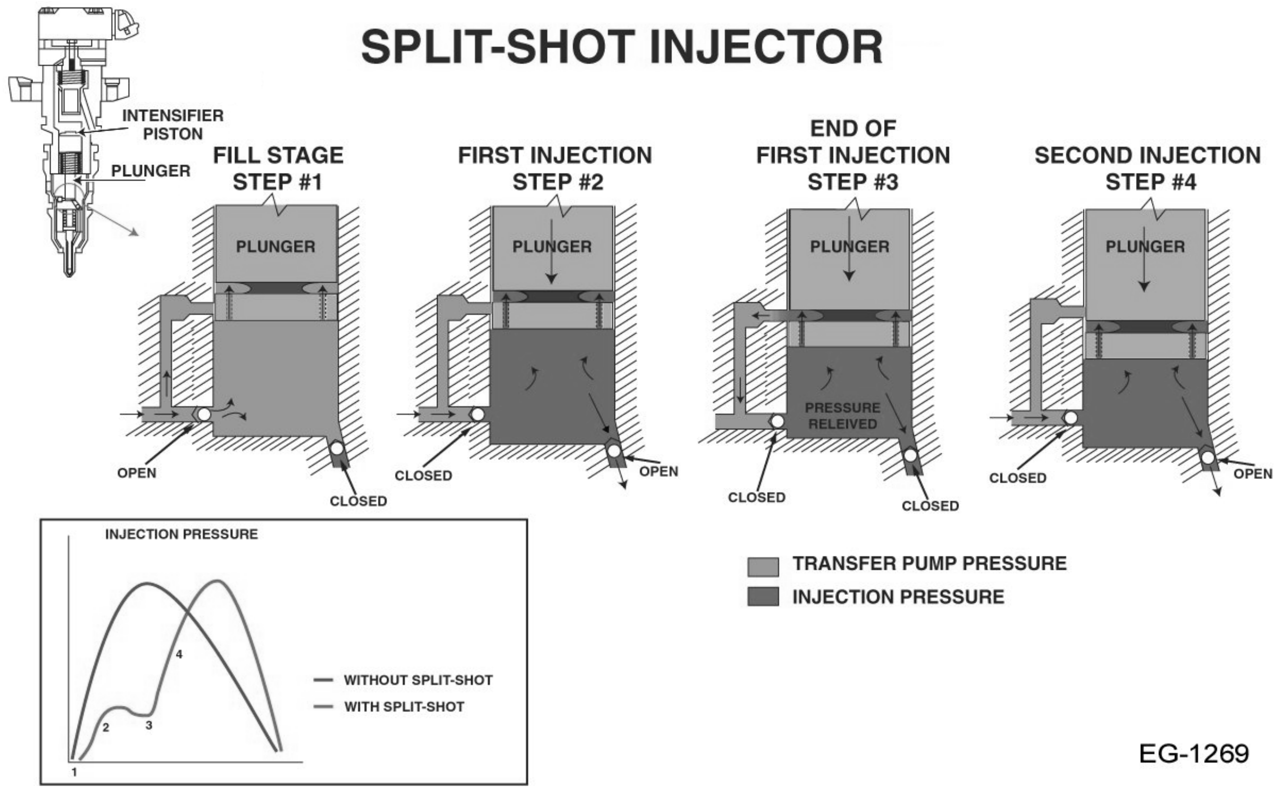


Figure 9 HEUI Split Shot-Injector Operation

Some International electronic engines are equipped with Split-Shot injectors. On these injectors the injection cycle is executed in two stages (See Figure 9, page 14). Some fuel is pre-injected into the combustion chamber to initiate combustion then the primary injection takes place. This feature reduces emission levels at light load operations. It also reduces light load engine noise.

Both the electrical and the hydraulic portions of the Split-Shot injector operate identically to the regular HEUI injector, but the fuel distribution is different.

The barrel and plunger were redesigned and a spill port was incorporated. When injection is initiated, the first shot of fuel is pre-injected into the combustion chamber until the spill port of the plunger coincides with the slot on the barrel.

At this time some fuel is allowed to return back to the fuel supply port until the spill port slot is blocked again by the plunger and the primary injection stroke takes place.

ELECTRONIC CONTROL MODULE

OPERATION AND FUNCTION

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM also monitors and regulates the vehicle cruise control, transmission, and starter engagement.

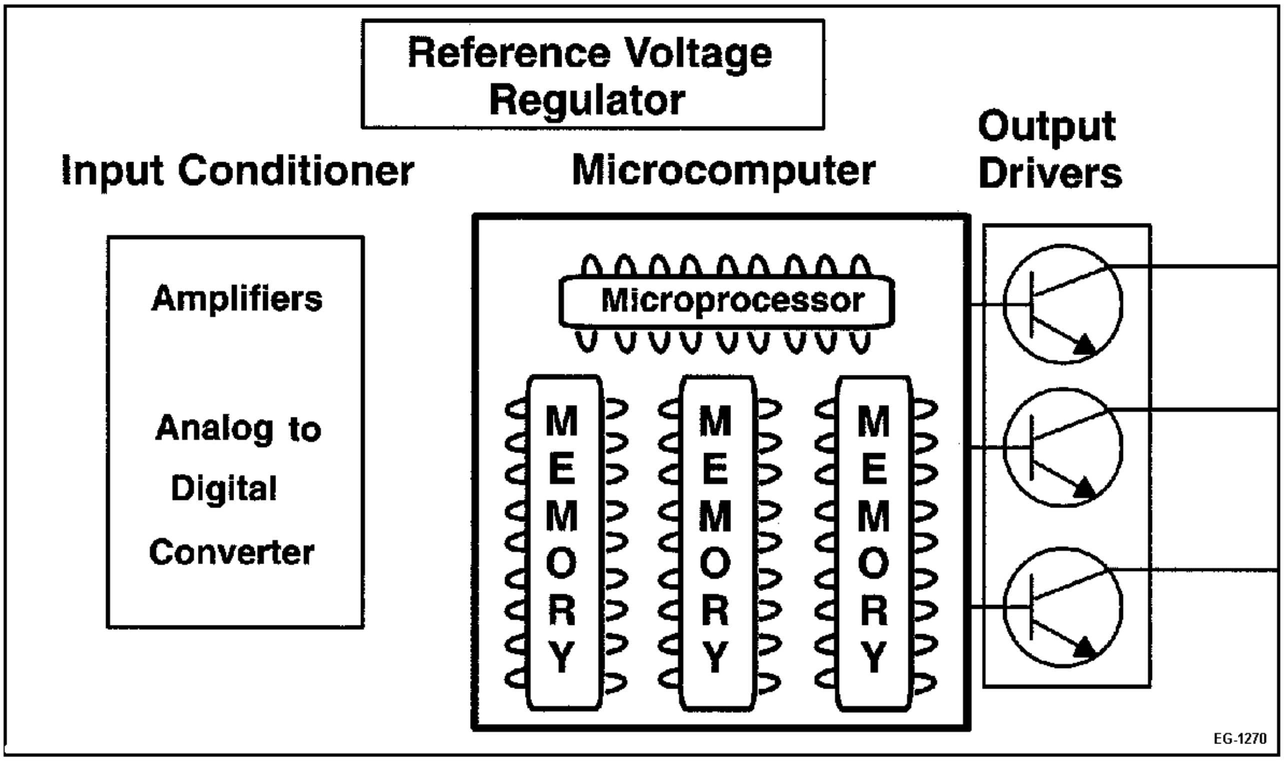


Figure 10 Electronic Control Module

The ECM controls the following:

1. Reference voltage
2. Input voltage signals
3. Microprocessor input and output
4. Actuators

REFERENCE VOLTAGE

The ECM sends a 5 volt reference signal to sensors in the control system. The ECM determines pressure, speed, position, and other variables important to engine and vehicle functions by comparing the regulated 5 volts sent to the sensors with signals from the sensors sent back to the ECM.

The ECM sends a voltage reference signal to three separate circuits.

- V_{REF}B for the cab sensors
- V_{REF}C for the body builder sensors
- V_{REF}D for the engine sensors

Individual V_{REF} circuits divides the electronic system to prevent a total V_{REF} circuit failure. A current limiting resistor protects the ECM microprocessor from an external short to ground of a V_{REF} circuit.

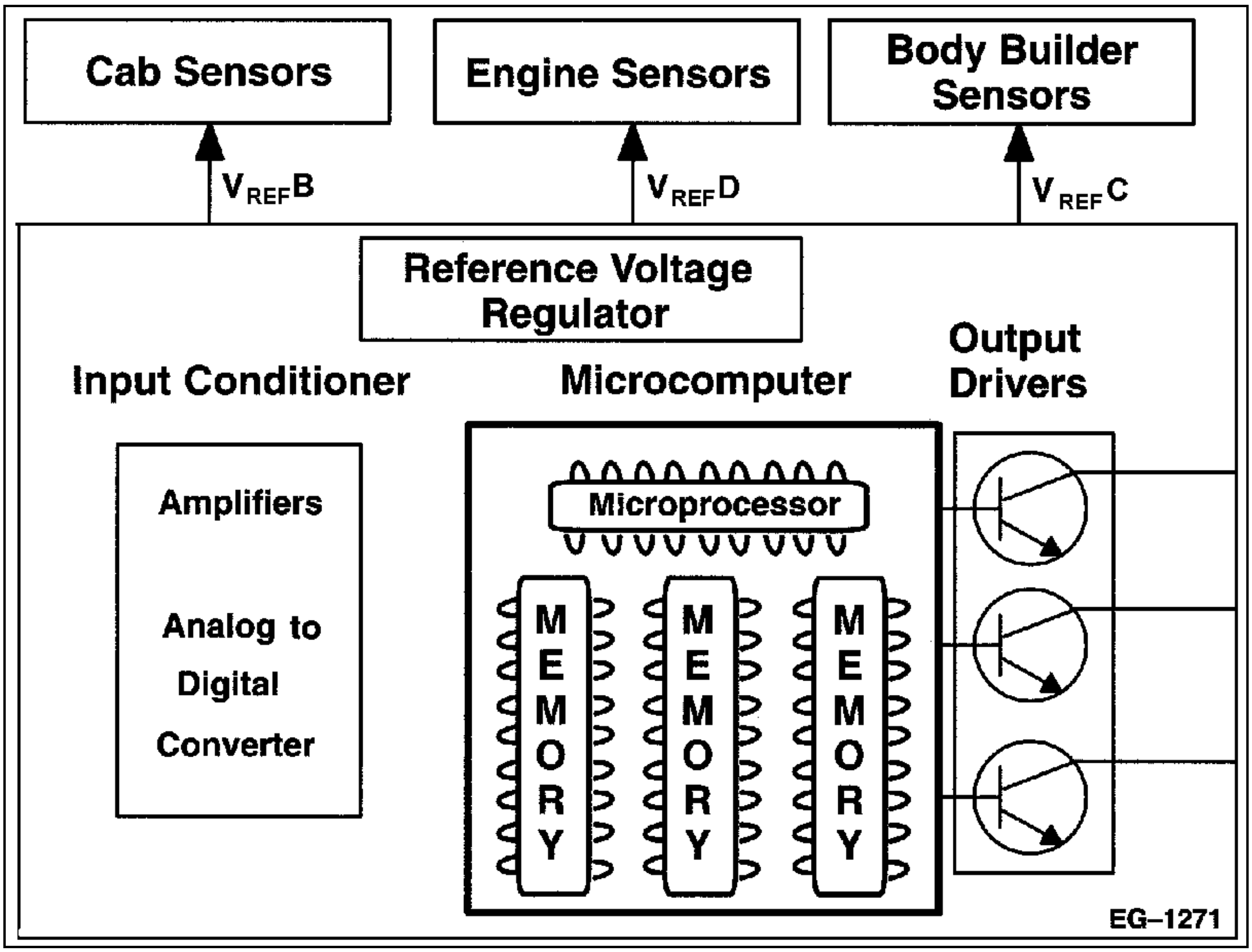


Figure 11 Reference Voltage

INPUT VOLTAGE SIGNALS

An input conditioner in the ECM:

- Converts analog signals to digital signals,
- Squares up sine wave signals, or amplifies low intensity signals

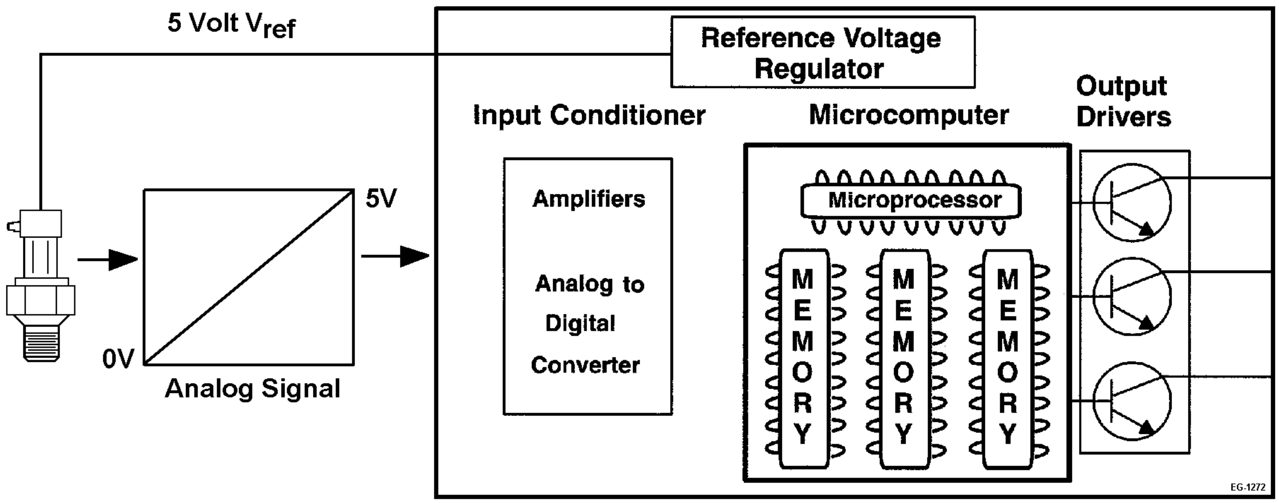


Figure 12 Input Voltage Signals

MICROPROCESSOR INPUT AND OUTPUT

The ECM internal microprocessor stores operating instructions (control strategies) and value tables (calibration parameters). The ECM compares stored instructions with input values to determine the correct operating strategy for all engine conditions.

Diagnostic codes are generated by the microprocessor if inputs or conditions do not comply with expected values. Continuous calculations in the ECM occur at two different levels or speeds: Foreground and Background.

Foreground calculations are much faster than background calculations and are normally more critical for engine operation. Engine speed control is an example.

Background calculations are normally variables that change at a slower rates. Engine temperature is an example.

Diagnostic strategies are also programmed into the ECM. Some strategies monitor inputs continuously and command the necessary outputs to achieve the correct performance of the engine. These strategies instruct the ECM to continuously perform other diagnostic tests.

Microprocessor Memory

The ECM microprocessor includes Random Access Memory (RAM) and Read Only Memory (ROM). Refer to Electronic Control Module Microprocessor Memory (See Figure 13, page 18).

ROM

Read Only Memory stores permanent information for calibration tables and operating strategies. Permanently stored Information cannot be changed or lost by turning the engine OFF or when ECM power is interrupted. ROM information includes the following:

- Vehicle configuration, modes of operation, and options
- Engine Family Ratings Code (EFRC)
- Engine warning and protection modes

RAM

Random Access Memory stores temporary information for current conditions. Temporary information in RAM is lost when the key is turned OFF or when ECM power is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

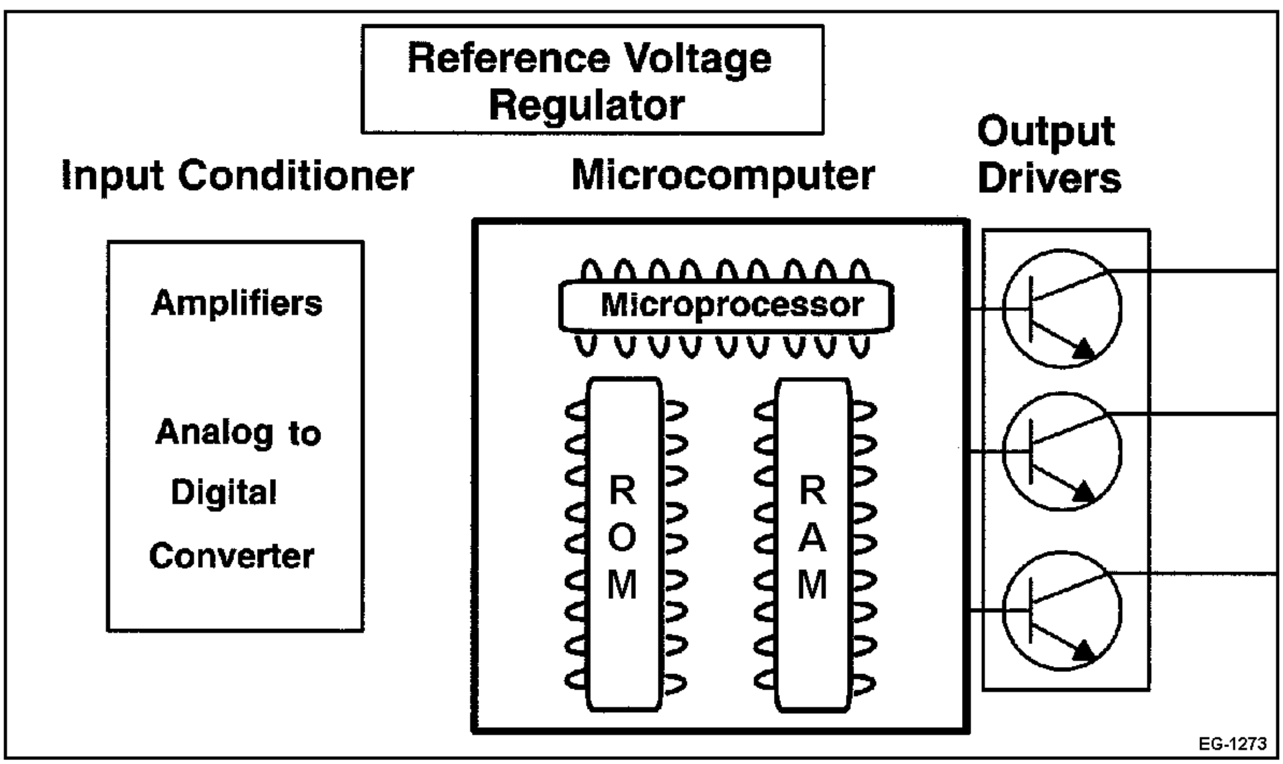


Figure 13 Electronic Control Module Microprocessor Memory

ACTUATORS

The ECM controls actuators for the following:

- Injection Pressure Regulator (IPR)
- Fuel Injectors

The ECM sends a low level signal to an output driver. When the output driver is switched on the ground circuit is completed. Actuators can be controlled with a duty cycle (% time on/off), a controlled pulse width, or switched on or off.

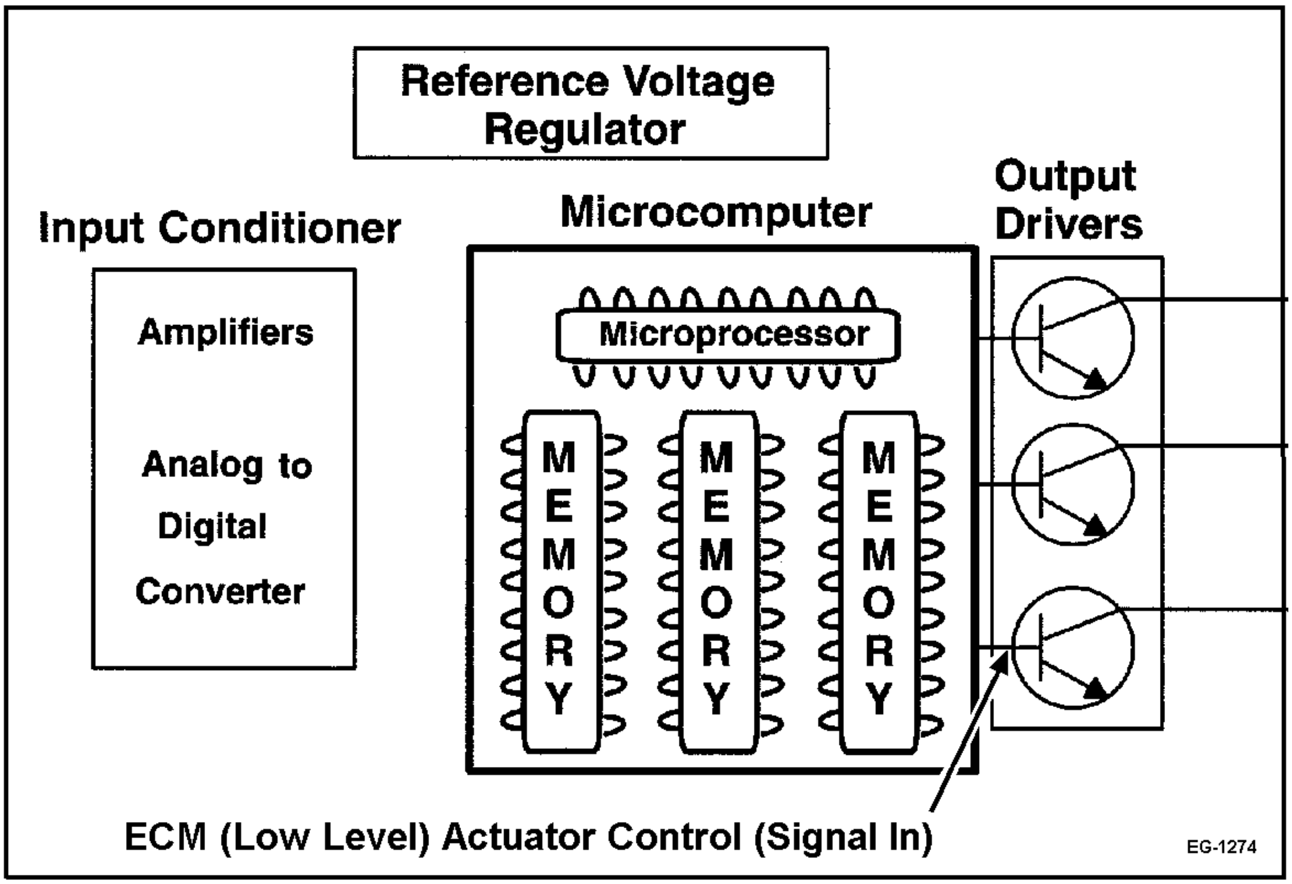


Figure 14 Output Drivers

Electronic Distribution for Fuel Injectors

The ECM monitors engine speed and cylinder positions by constantly monitoring the camshaft position signal. When the narrow vane of the timing sensor disc passes in front of the Camshaft Position sensor, the position of piston 1 is sent to the ECM; the positions of pistons 2 through 6 are based on the position of piston 1.

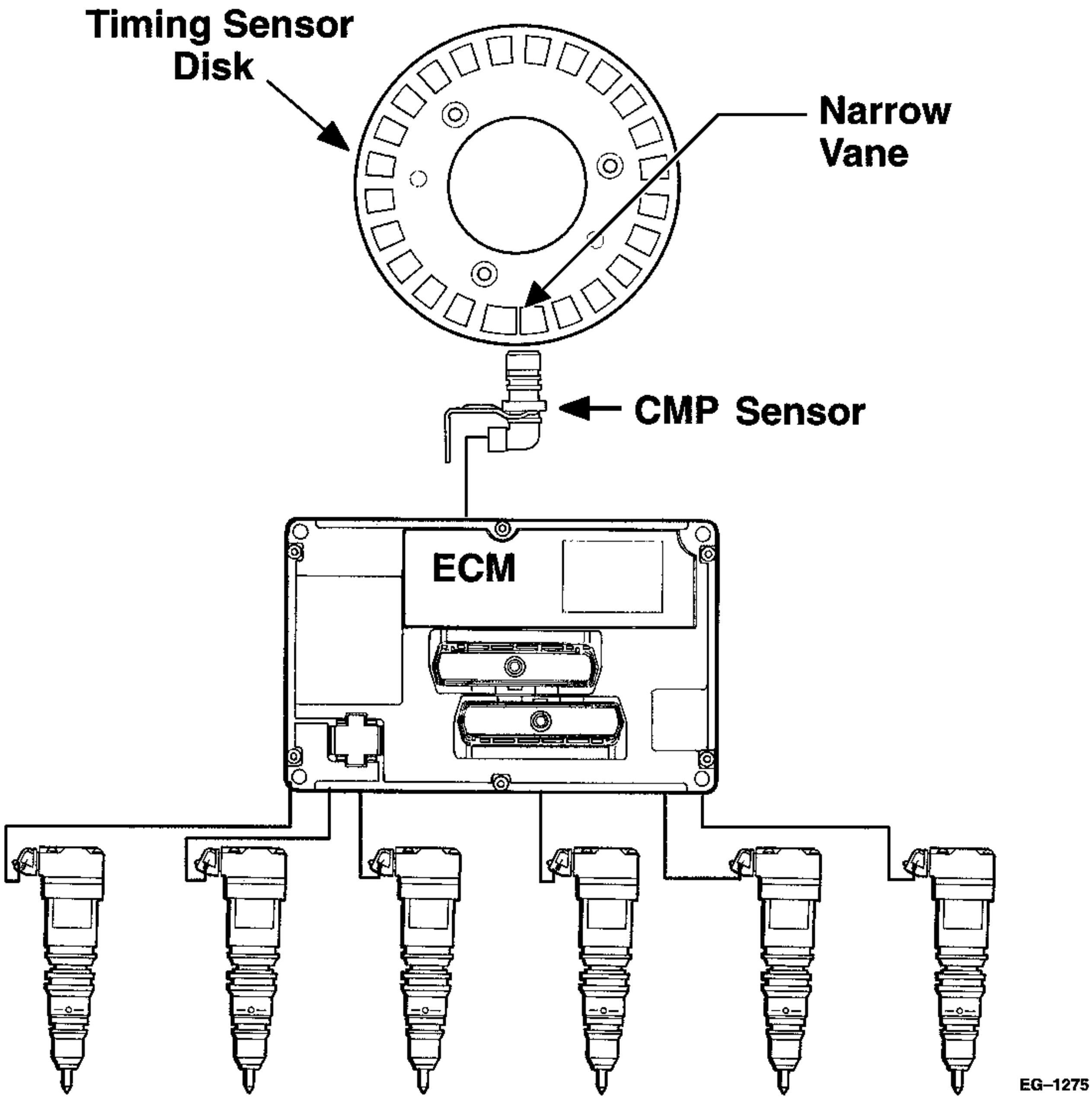


Figure 15 Electronic Distributor for Fuel Injectors

Ground Source for Fuel Injectors

The ECM provides a constant ground path to all fuel injectors.

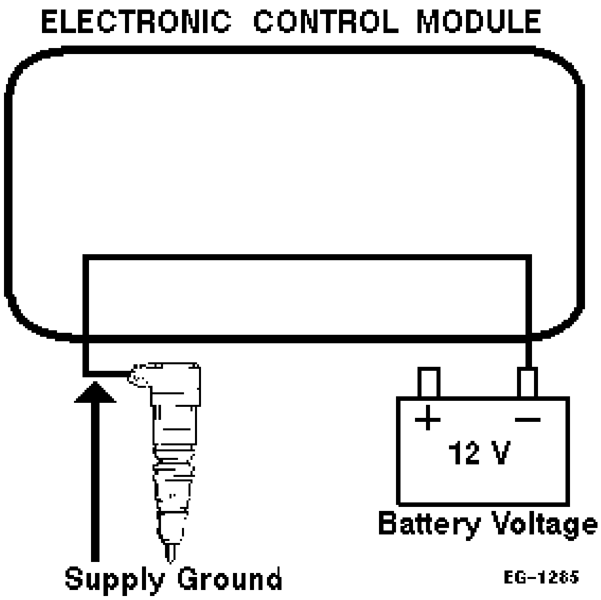


Figure 16 Ground Source for Fuel Injectors

Power Source and Output Drivers for Fuel Injectors

By using output driver transistors, the ECM supplies 115+ volts DC to each injector following the firing order (153624). The ECM contains an output driver for each fuel injector. The ECM processor controls:

- Firing sequence
- Injector timing
- Injection duration

The 115+ volt DC supply is created by the ECM by making and breaking a 12 volt source across an internal coil, based on the same principle as the automotive ignition coil.

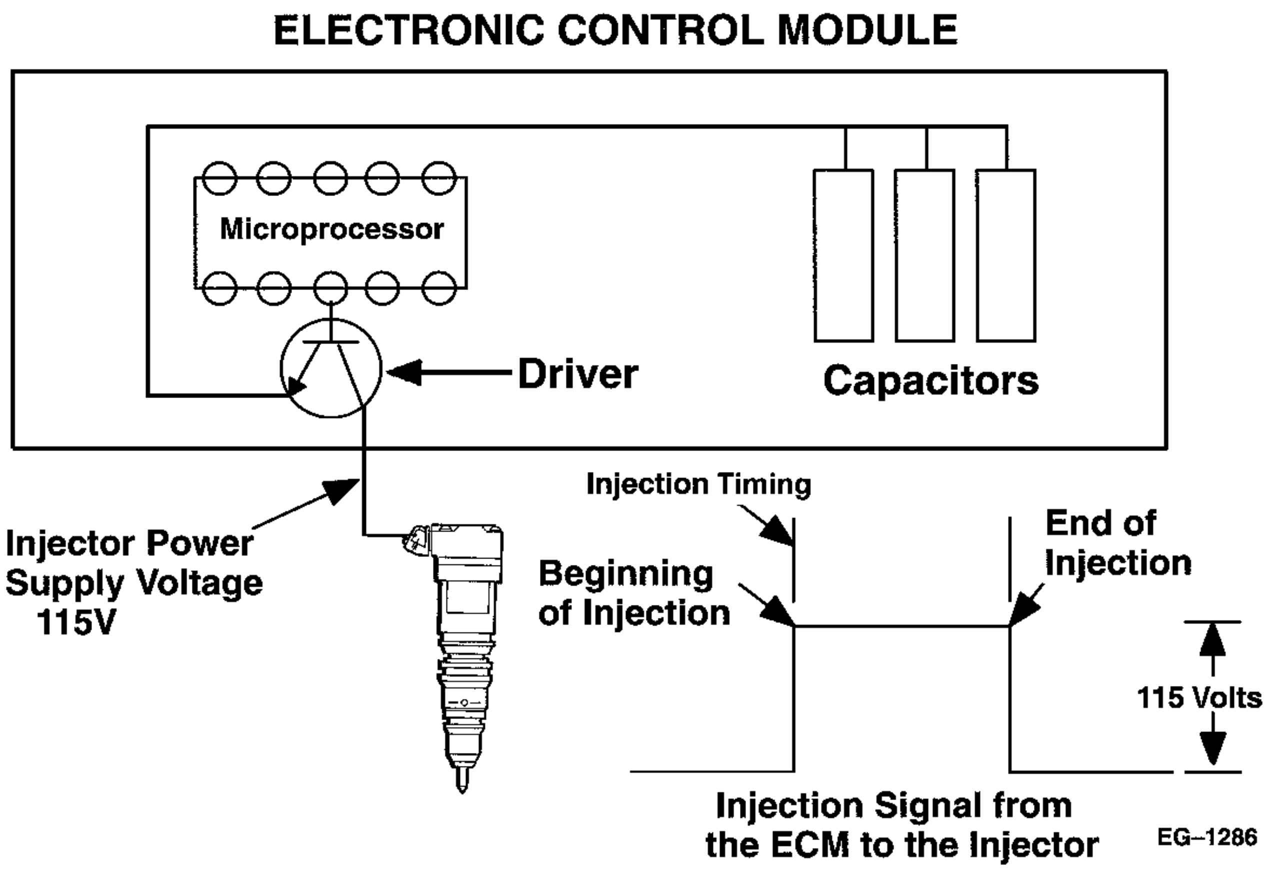


Figure 17 Power Source and Output Drivers for Fuel Injectors

ENGINE AND VEHICLE SENSORS

Sensor Operation

Engine and vehicle sensors send input signals to the Electronic Control Module (ECM) by:

- Changing reference voltage to produce an analog or digital signal
- Generating analog or digital signal voltage
- Switching an analog 12 volt signal

Input Signals

Reference voltage sensors receive a constant 5V signal from the ECM. A voltage regulator supplies the reference voltage (V_{REF}) to the sensors. V_{REF} is changed by the sensor and the resultant signal is relayed back to the ECM. The ECM compares the reference voltage to the returned signal, and determines the difference by matching the signal value with programmed tables in the ECM.

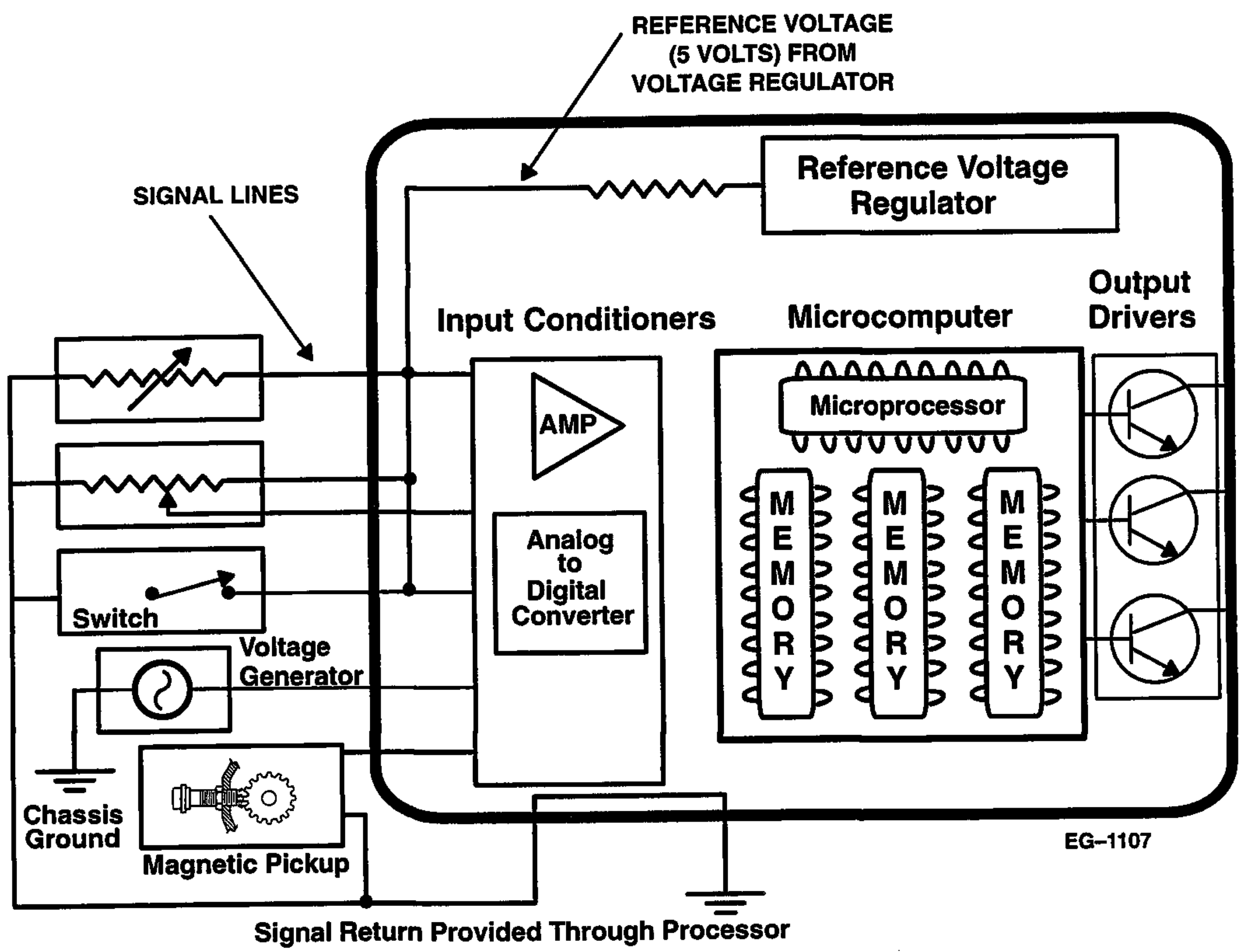


Figure 18 Input Signals

Sensors Types

The following sensor types are used with DT 466 and DT 530 engines:

- Thermistor sensor
- Potentiometer sensor
- Variable capacitance sensor
- Hall effect sensor
- Magnetic pick up sensor
- Switch sensor

THERMISTOR

A thermistor sensor is a semiconductor, a resistive circuit component that changes electrical resistance with temperature.

Thermistor Examples:

- Engine Oil Temperature sensor (EOT)
- Engine Coolant Temperature sensor (ECT)
- Intake Air Temperature sensor (IAT)

Resistance decreases as temperature increases, and increases as temperature decreases. The thermistor, with a current limiting resistor in the ECM forms a voltage divider network. The thermistor and limiting resistor provide a voltage signal to be matched with a particular temperature value.

The top half of the voltage divider is the current limiting resistor. A thermistor sensor has two electrical connections: signal return and ground. The output of a thermistor sensor is a nonlinear analog signal.

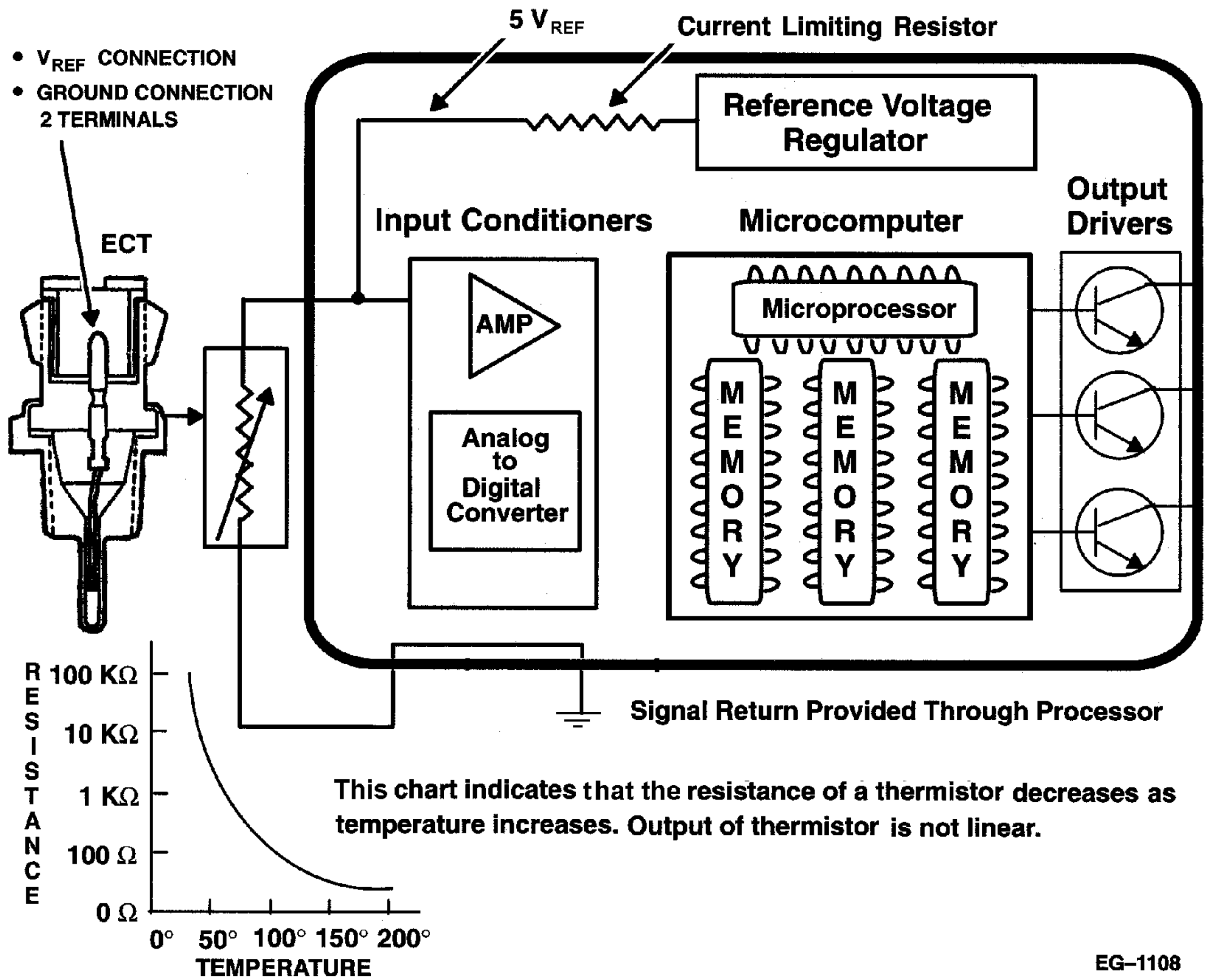


Figure 19 Engine Coolant Temperature Sensor

POTENTIOMETER

A potentiometer is a variable voltage divider used to sense the position of a mechanical component.

Example:

- Accelerator Position Sensor (APS)

A reference voltage is applied to one end of the potentiometer. A mechanical wiper moves along resistive material, changing voltage at each point along the resistive material. The voltage change is proportional to the distance the wiper moves.

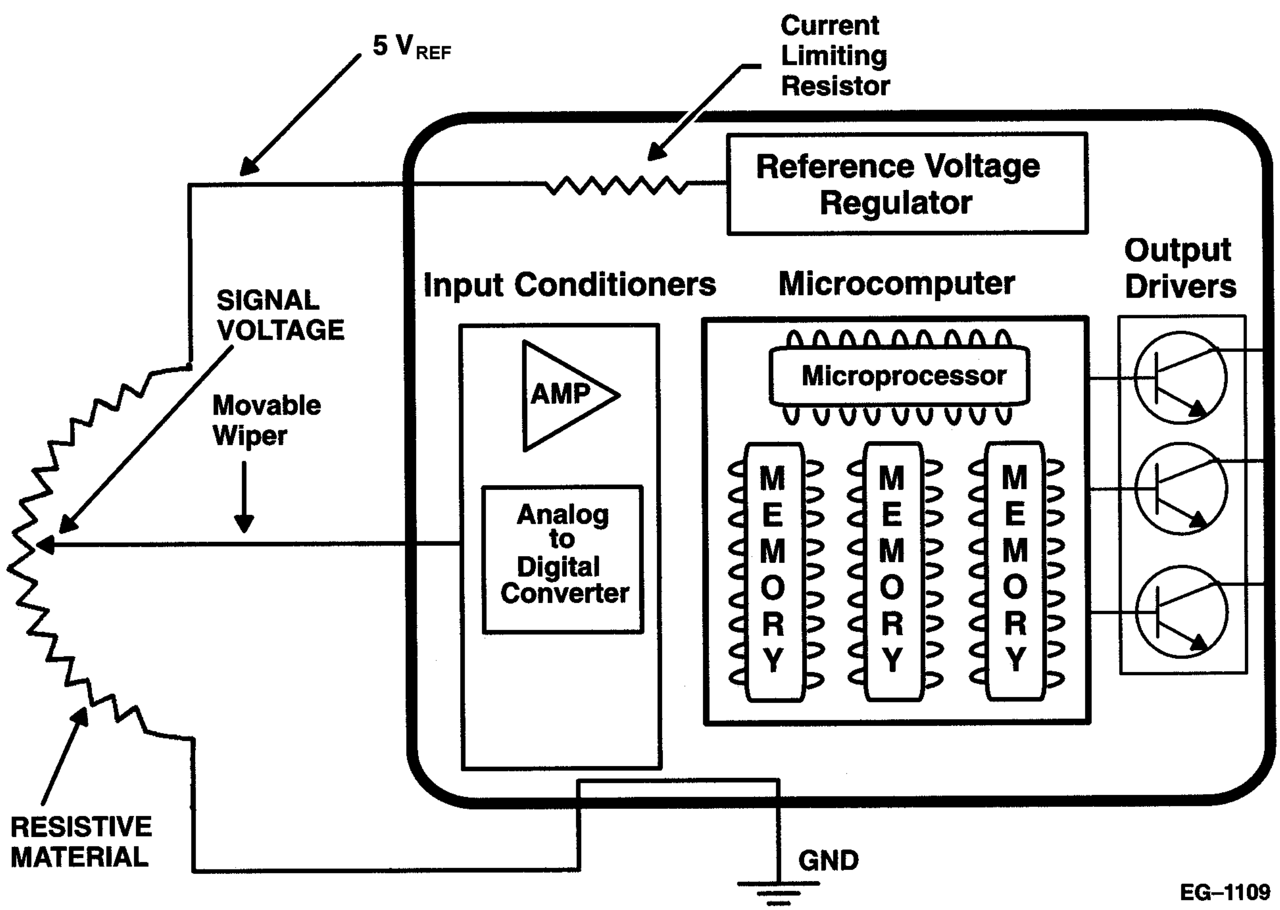


Figure 20 Potentiometer

VARIABLE CAPACITANCE SENSOR

A variable capacitance sensor measures pressure. Pressure forces a ceramic material closer to a thin metal disc, changing the capacitance of the sensor. The operational range of the sensor is linked to the thickness of the ceramic disk. The thicker the ceramic disk the more pressure the sensor can measure.

Examples:

- Engine Oil Pressure sensor (EOP)
- Injection Control Pressure sensor (ICP)
- Manifold Absolute Pressure sensor (MAP)

Variable Capacitance sensors are connected to the ECM by three wires: reference voltage, signal return and signal ground.

A variable capacitance sensor receives reference voltage from the ECM and returns an analog signal voltage back to the ECM. The ECM compares the signal voltage with programmed values to determine the pressure.

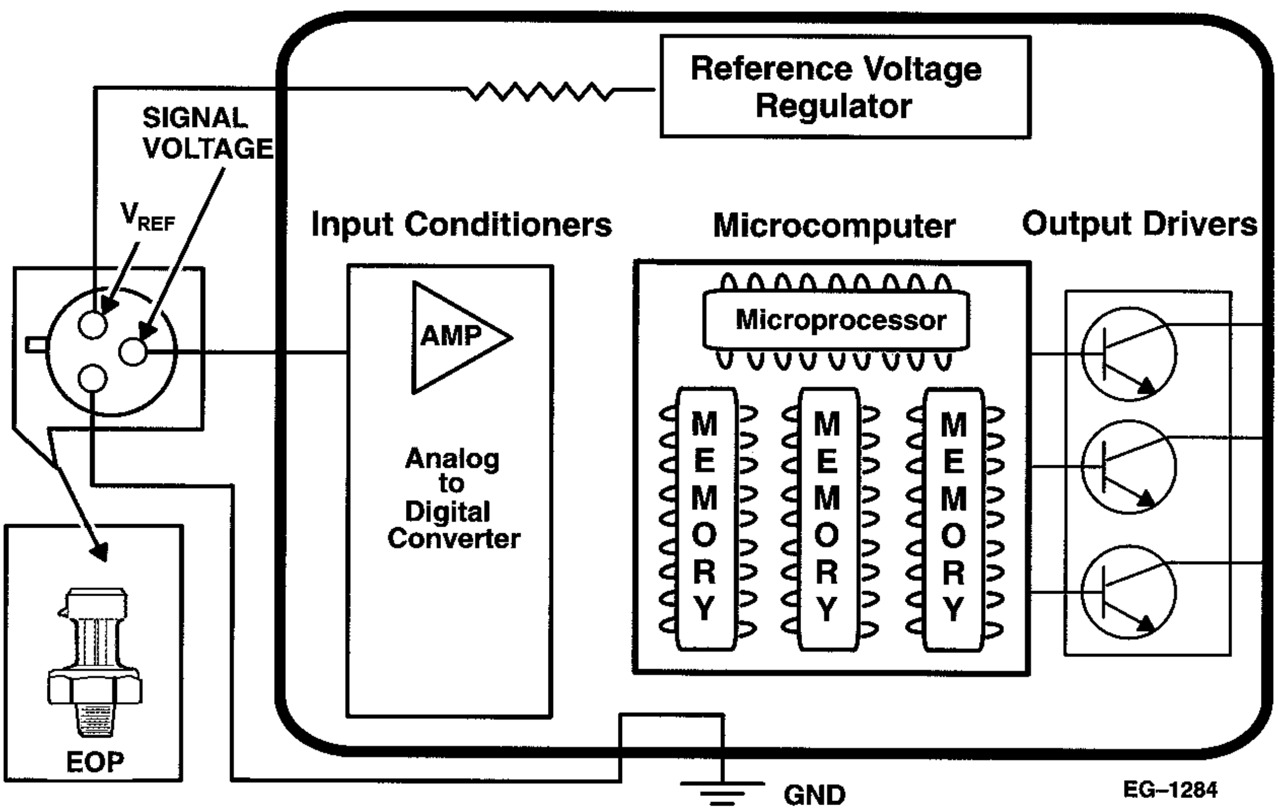


Figure 21 Engine Oil Pressure Sensor

HALL EFFECT SENSOR

The Hall Effect sensor generates voltage signals.

Example:

- Camshaft Position Sensor (CMP)

A CMP sensor contains a permanent magnet, transducer, signal conditioner, and a switching transistor. The shape and frequency of voltage signals result from disturbances in the magnetic field of the sensor. The permanent magnet generates a magnetic field around the transducer. As the timing disk (vanes and windows) rotates, the magnetic field is disturbed and the transducer generates a signal that is filtered and conditioned within the CMP.

Once conditioned, the signal is sent to the base of the switching transistor, causing the transistor to ground the 5 volt line from the ECM. At this time, the ECM will receive a 0 volt signal.

Each time a vane passes the sensor the signal is grounded by the transducer. Without a signal the transistor shuts off and the ECM receives a 5 volt signal. This allows the ECM to determine engine speed and position. The shorter duration of the narrow vane on the trigger wheel allows the ECM to determine the position of the crankshaft.

The CMP sensor is connected to the ECM by three wires: a 5 volt signal, a 5 volt V_{REF}, and a signal ground.

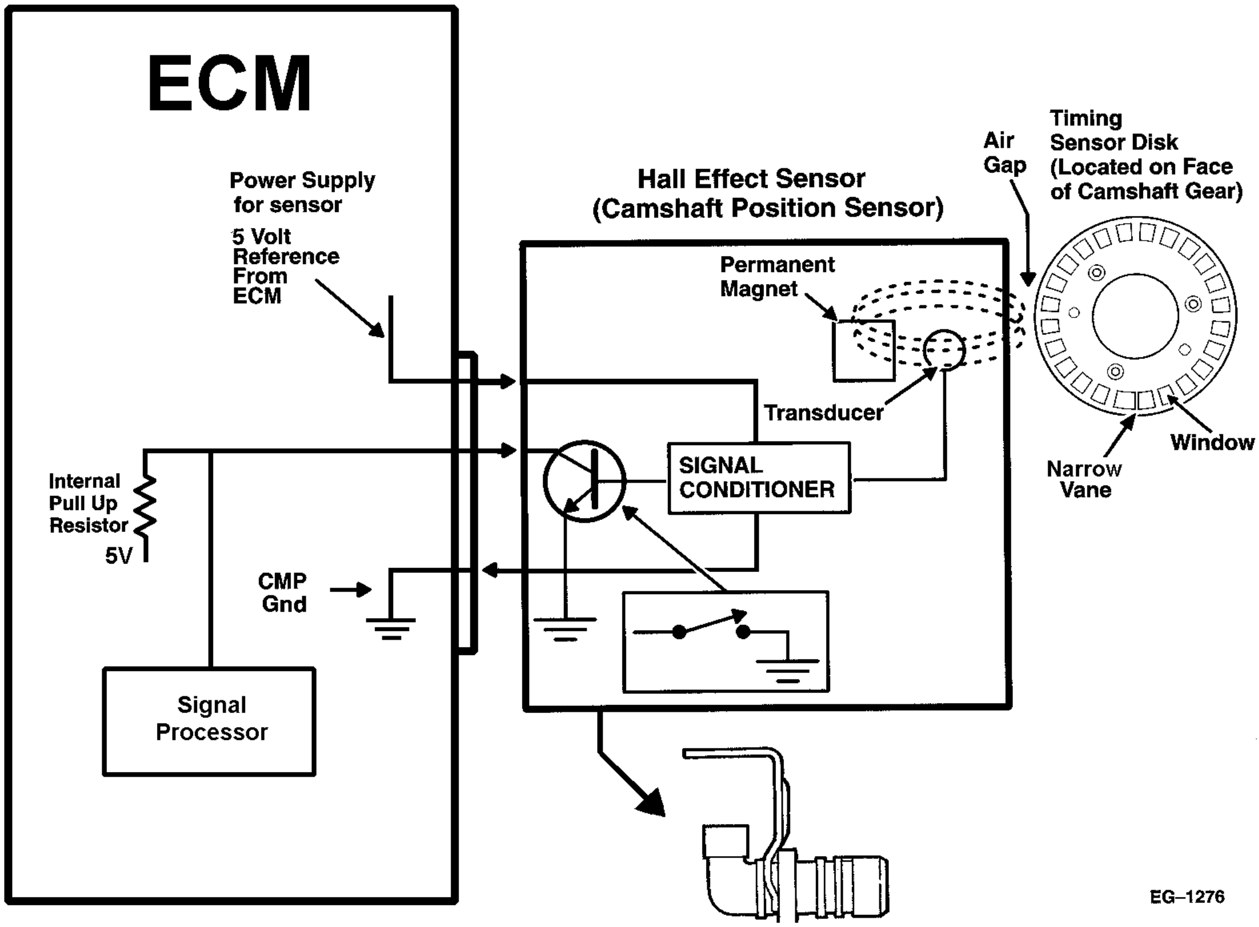


Figure 22 Camshaft Position Sensor

MAGNETIC PICKUP

A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickup sensors normally have two wire connections for signal and ground. The magnetic pickup sensor has a permanent magnetic core surrounded by a wire coil. The signal is generated by the rotation of gear teeth which disturbs the magnetic field of the magnet. Refer to Vehicle Speed Sensor (Magnetic Pickup) (See Figure 23, page 30).

Example:

- Vehicle Speed Sensor (VSS)

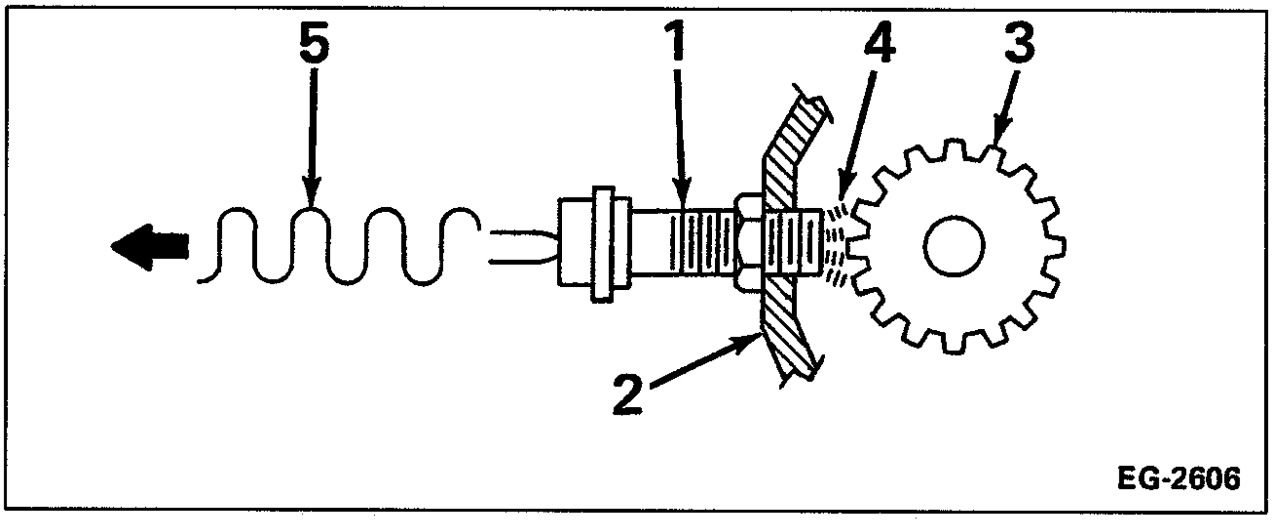


Figure 23 Vehicle Speed Sensor

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

SWITCH SENSORS

Switch sensors indicate positions and operate either open or closed to allow or prevent current flow. A switch sensor can be a voltage input switch or a grounding switch.

Examples:

- Idle Validation Switch (IVS)
- Brake Switch Normally Open (BNO)
- Coolant Level Switch (CLS)
- Driveline Disengagement Switch (DDS)

Switch sensors are connected to the ECM by one wire: either a voltage source or a ground. These sensors are considered to be a low speed digital input.

When closed, a voltage input switch sends the ECM voltage. A grounding switch will ground the circuit, causing a zero voltage signal at the ECM. Grounding switches, with a current limiting resistor, are usually installed in series.

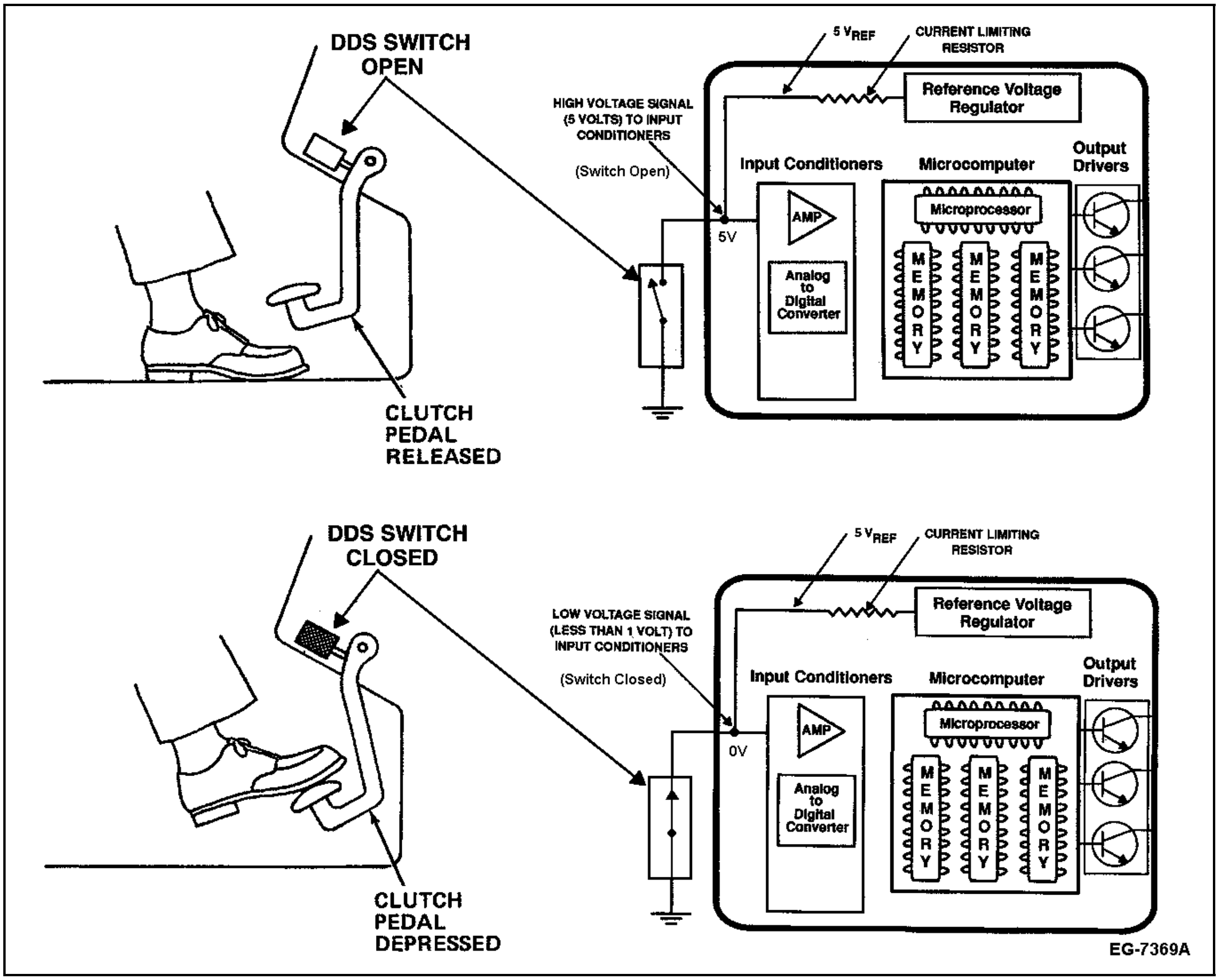


Figure 24 Driveline Disengagement Switch

VEHICLE FEATURES

STANDARD FEATURES

Electronic Governor Control

INTERNATIONAL DT 466 and DT 530 engines are electronically controlled for all operating ranges.

American Trucking Association Datalink Provisions

Vehicles are equipped with the American Trucking Association (ATA) datalink connector for communication between the ECM and the Electronic Service Tool (EST).

The datalink provides communication capabilities for the following:

- Transmission of engine parameter data
- Diagnostics and troubleshooting
- Customer programming
- Production line programming of vehicle features
- Field programming

Service Diagnostics

The electronic service tool provides diagnostic information for the Master Diagnostics (MD) Software.

Diagnostic Trouble Codes (DTC's)

DTC's for sensors, actuators, electronic components, and engine systems are detected and stored in the ECM. The ECM transmits DTC's to the EST to assist with diagnostic action. The ECM also provides DTC's emitted by the engine.

Electronic Speedometer and Tachometer Provisions

The engine control system calibrates vehicle speed to 157,157 pulses/mile. Dip switches no longer need to be changed when components affecting speed calibration are changed. However, the new speed calibration information must be programmed with an Electronic Service Tool.

The tachometer signal is generated by the ECM by computing the CMP signal. The result of this calculation is transmitted to the instrument dash cluster via the J1939 Datalink and the EST via the ATA Datalink.

Engine Over Temperature Protection System (Coolant Temperature Compensation)

Coolant Temperature Compensation reduces fuel delivery if engine coolant temperature is above the cooling system specifications. Fueling is reduced proportionally to the design limit exceeded. Fuel reduction is calibrated to a maximum of 40% before standard engine warning or optional warning/shutdown is engaged. If warning or shutdown occurs, a Diagnostic Trouble Code is stored in the ECM memory.

NOTE – Coolant Temperature Compensation may be omitted on emergency vehicles that require 100% power on demand.

Event Logging System

The event logging system records engine operation above maximum rpm (overspeed), high coolant temperature, low coolant level, or low oil pressure. This information and readings for the odometer / hourmeter are stored in the ECM memory and may be accessed using the EST.

Engine Crank Inhibit

Engine Crank Inhibit will not allow the starting motor to crank if the engine is running or the automatic transmission is in gear. Engine Crank Inhibit (ECI) is an optional system for vehicles with manual transmissions.

Electronic Accelerator Pedal

The Electronic Accelerator Pedal eliminates the mechanical linkage used with conventional accelerator pedals. An accelerator position sensor, part of the accelerator pedal assembly, provides the ECM with an analog voltage signal representing the driver's demand for power.

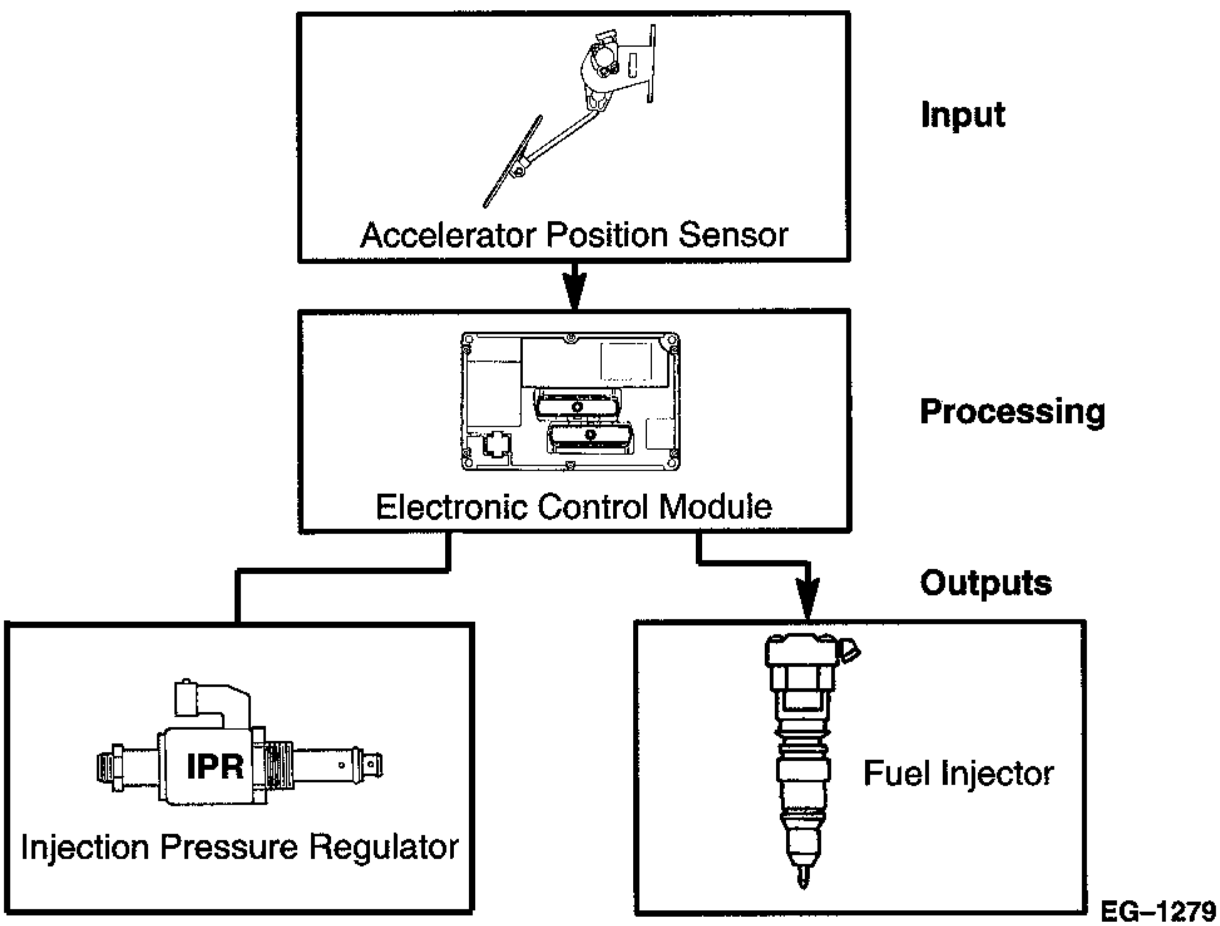


Figure 25 Electronic Accelerator Pedal System

Cruise Control

Cruise Control regulates vehicle speed using automotive style, on/off, set/accel buttons. Speed control is disabled when the service brakes are applied, the clutch pedal is depressed, or the automatic transmission is placed in neutral. The accelerator pedal can be used to increase speed from the selected cruise speed.

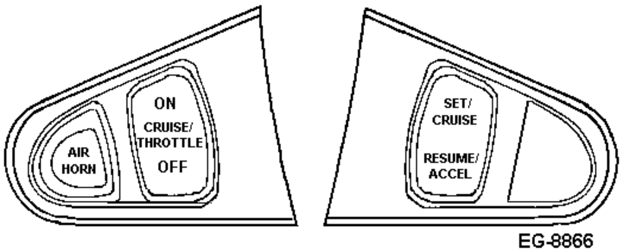


Figure 26 Cruise Control Buttons on the Steering Wheel

Cold Ambient Protection (CAP)

The CAP system safeguards the engine from damage caused by prolonged periods of idle at no load during cold weather conditions. CAP also improves cab warm up.

CAP maintains engine coolant temperature by increasing the engine rpm to a programmed value when the Ambient Air Temperature is below 32°F (0°C), the Engine Coolant Temperature is below 149°F (65°C), and the engine has been idling with no load for more than 5 minutes.

CAP is standard on all trucks without an Idle Shutdown Timer, with a clutch switch (manual transmission), or a neutral safety switch (automatic transmission).

OPTIONAL FEATURES

Engine Speed Control for PTO

DT 466 and DT 530 engines are compatible with both stationary and mobile PTO applications. Remote and in-cab throttle controls are available. Throttle control can be used as an electronic hand throttle during warm up procedures or idle operation during cold weather.

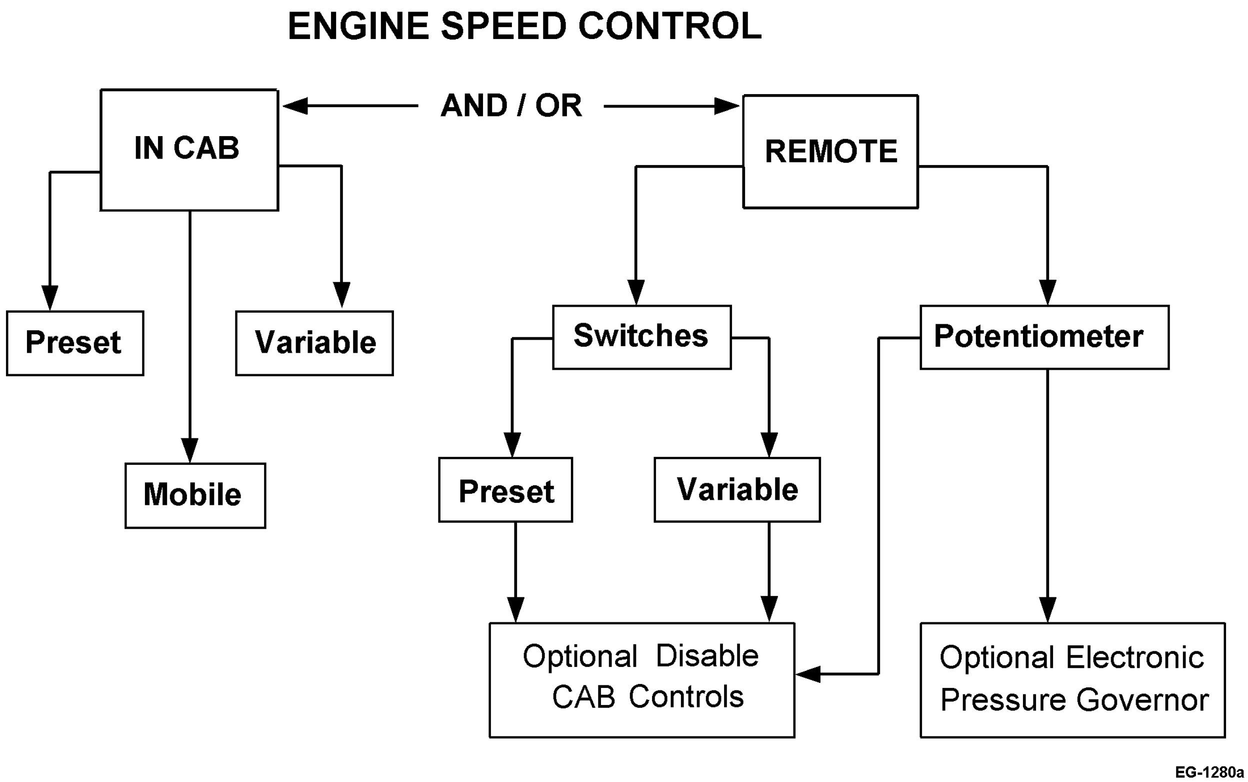


Figure 27 Engine Speed Control

Road Speed Limiting/Governor

The Road Speed Limiting/Governor limits speed to maximum vehicle speed programmed by the customer.

Body Equipment Manufacturer Provisions

Additional circuits and connector junction blocks are provided in the engine compartment on the left side of the cowl. These circuits include provisions for:

- Remote engine speed control
- Remote PTO (engine speed) control commands
- Additional power and control circuits for after market added equipment

The standard electrical system provides breakout connections to the remote PTO.

Engine Warning System

The Engine Warning System illuminates the red ENGINE lamp and actuates a buzzer for:

- High coolant temperature
- Low coolant level
- Low oil pressure

Refer to Engine Warning System (See Figure 28, page 37).

Engine Shutdown System

The engine warning system is included with the engine shutdown system. The engine shutdown system shuts down the engine after 30 seconds of operation past critical threshold values for coolant temperature or oil pressure, or both.

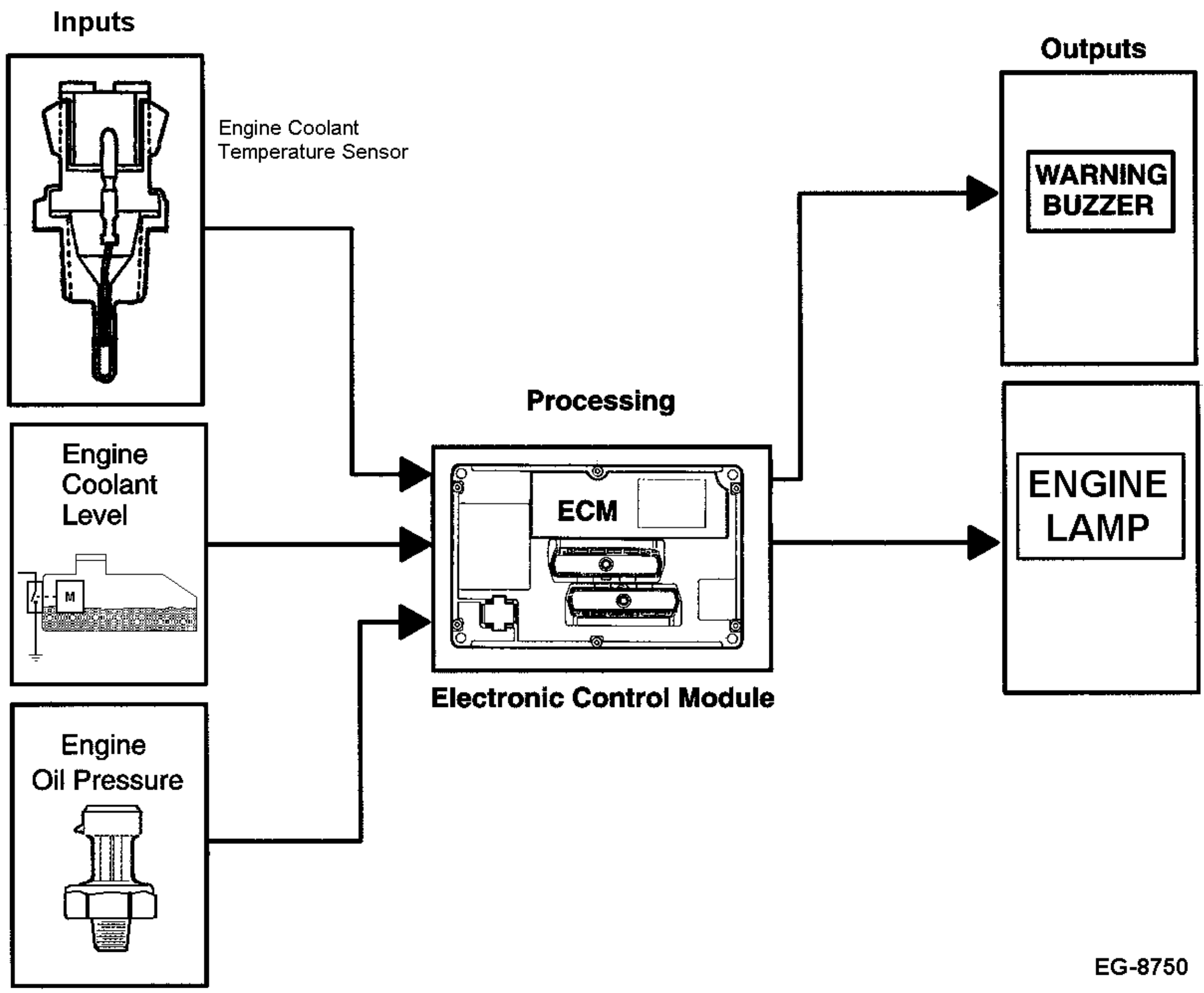


Figure 28 Engine Warning System

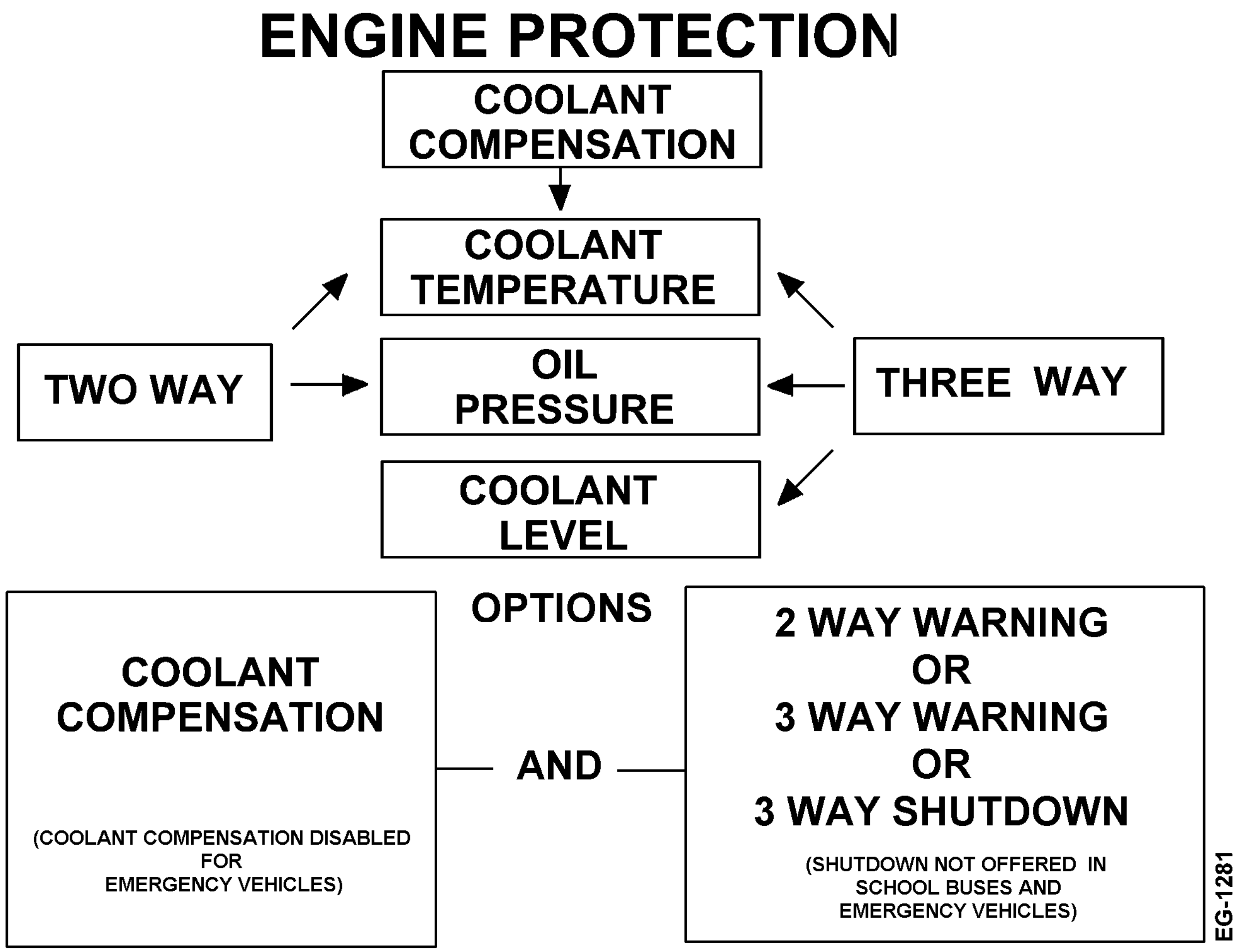


Figure 29 Engine Protection System

Idle Shutdown (Optional)

Idle Shutdown provides automatic engine shutdown after idle time exceeds 2 to 120 minutes. The owner or operator can program extended idle time for maximum or minimum intake air temperatures. If Idle shutdown is triggered, the ECM will flash the red ENGINE lamp, sound the buzzer 30 seconds, and set a DTC code before engine shutdown. When Idle Shutdown is selected, Cold Ambient Protection is automatically disabled.

Electronic Pressure Governor (EPG)

The Electronic Pressure Governor can be used on trucks equipped with hydraulic pumps when output pressure is controlled by adjusting engine rpm (i.e. fire trucks, etc.). Body builder connections are provided and the ECM can be programmed for this purpose on request. This feature can be programmed to fit the needs of the operator. Engine rpm, ramp rate, and Electronic Pressure Governor gain adjustments are among the available variables.

Engine Fan (Control)

Engine Fan control allows the ECM to regulate engagement and disengagement of the engine fan depending on Engine Coolant Temperature (ECT) or air conditioning demand. The ECM can also be programmed to use engine fan control to retard engine speed.

DIAGNOSTIC SOFTWARE SELF TEST OPERATION

Diagnostics Overview

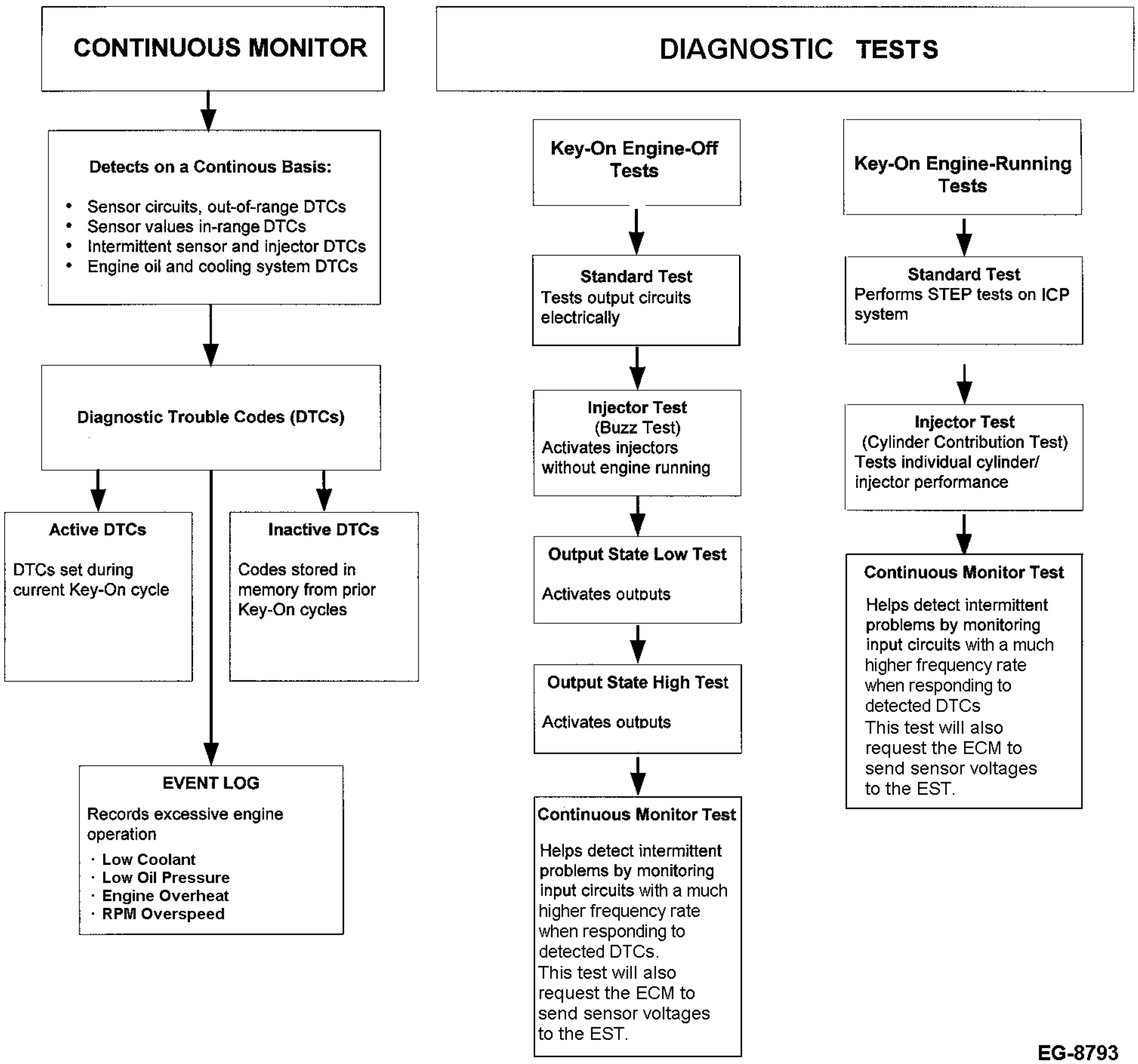


Figure 30 Diagnostic Trouble Code Detection

Diagnostic Trouble Code Access Procedure

To display ECM Diagnostic Trouble Codes using the EST refer to Diagnostic Testing in Section 5 (See CHECK AND CLEAR DIAGNOSTIC TROUBLE CODES (DTC), page 404).

To display ECM Diagnostic Trouble Codes when the EST is not available use the following procedure:

A. Set the parking brake and turn the Ignition Key ON.

B. Press and release the **CRUISE ON** button and the **RESUME/ACCEL** button simultaneously. If no faults are present, the cluster odometer will display NO FAULTS. If codes are present they will be flashed out using the red and amber ENGINE lamps on the gauge cluster.

To read the Diagnostic Trouble Codes, count each time the amber **ENGINE** lamp flashes, continue with the following sequence below. This sequence occurs each time the Cruise Control buttons are depressed together to access the Diagnostic Trouble Codes.

A. The red ENGINE lamp will flash once to indicate the beginning of **ACTIVE** DTC's.

B. The amber ENGINE lamp will flash repeatedly signaling the Active DTC's.

   NOTE – All DTC's are three digits. Code 111 indicates no Diagnostic Trouble Codes have been detected.

C. Count the flashes in sequence. After each digit of the code a short pause will occur. Three flashes and a pause would indicate number 3. Two flashes, a pause, three flashes, a pause, and two flashes and a pause would indicate Diagnostic Trouble Code 232. If there is more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

After all active DTC's have flashed, the red ENGINE lamp will flash twice to indicate the start of **INACTIVE** DTC's. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once between each DTC.

After all DTC's have been sent, the red ENGINE lamp will flash three times indicating END OF MESSAGE.

NOTE – To repeat DTC transmission, repeat the above procedure by depressing both Cruise Control buttons. The ECM will once again send the stored DTC's.

Clearing Inactive Diagnostic Trouble Codes

A. Set park brake (required for correct ESC signal and to clear codes).

B. Turn key switch to the IGN/ON position.

C. Depress and hold the CRUISE ON and RESUME/ACCEL buttons simultaneously.

D. Continue holding the Cruise Control buttons. Depress and release the accelerator pedal three (3) times within a six (6) second interval.

E. Release the Cruise Control buttons.

F. Inactive codes will be cleared.

CONTINUOUS MONITOR

DiagnosticTrouble Codes

The Electronic Control Module (ECM) continuously monitors and detects Out of Range, Rationality, and System Faults.

Each Diagnostic Trouble Code has three numbers that identify the source of a malfunction measured or monitored electronically. Most Diagnostic Trouble Codes indicate the source and the Failure Mode. The Failure Mode identifies one of the following signal readings:

- **Out of Range High** (voltage over normal operating range)
- **Out of Range Low** (voltage under normal operating range)
- **In Range** (within normal operating range but not rational)

When the ignition key is ON, the ECM will record and set a Diagnostic Trouble Code if an input signal is Out of Range High or Out of Range Low during normal operation. The ECM also monitors the operation of systems and determines if systems are In Range. If a system falls outside a predetermined range, the ECM will record and set a Diagnostic Trouble Code.

During normal engine operation, the ECM automatically performs several tests to detect Diagnostic Trouble Codes. When Diagnostic Trouble Codes are detected, the ECM often executes a DTC management strategy to allow continued, though sometimes degraded, vehicle operation.

The ECM also continuously sets Diagnostic Trouble Codes associated with the injection control system, an improvement from previous versions that required specific diagnostic tests to access fault codes.

Event Log

With the engine running, Engine Events are permanently recorded in the ECM; Engine Events can be retrieved with the Electronic Service Tool (EST). Standard Engine Events include excessive coolant temperature and engine rpm (overspeed). With the engine running, Event Engine Hours are monitored and recorded in the ECM. Event Engine Hours include data resulting from overheating (coolant temperature), low coolant level, low oil pressure, and operation beyond maximum rpm. This information and odometer / hourmeter readings are stored in the ECM memory.

DIAGNOSTIC TESTS

Key-On Engine-Off Standard Test

During the Key-On Engine-Off Standard Test the ECM completes the following:

1. Internal processing and memory test.
2. Output Circuit Check (OCC). The Output Circuit Check looks for circuit shorts, open circuits in the ECM, harnesses, and IPR actuator by operating the ECM output circuits and measuring each circuit response. The OCC does not evaluate mechanical or hydraulic functions.
3. Logs Diagnostic Trouble Codes in memory if a circuit fails a test.

The following circuits are checked by the ECM during this test:

- Engine Crank Inhibit relay (ECI)
- Injection Pressure Regulator (IPR)
- Engine Fan (EFN)
- Vehicle Retarder (VRE)

When the test is complete, the EST will display all detected Diagnostic Trouble Codes.

NOTE – When the Electronic Service Tool (EST) is not available, the Key-On Engine-Off Standard Test and the Output Circuit Check can be performed by following the steps below.

Key-ON Engine-OFF Standard Test and Output Circuit Check (OCC) Procedure

A. Set park brake (required for correct ESC signal).

B. Turn ignition key to the ON position.

C. Press and release the CRUISE ON and the RESUME/ACCEL buttons simultaneously two (2) times within three (3) seconds.

D. Key-ON Engine-OFF Standard Test and OCC will run and codes will flash.

Key-On Engine-Off Injector Test

The Key-On Engine-Off Injector Test checks for electrical problems in fuel delivery components (injectors). This test can only be done after completing the Engine Off Standard Test using the Electronic Service Tool.

During the Key-On Engine-Off Injector Test, the ECM will actuate the injectors 1 through 6 in numerical order, not the firing order. Each electrical circuit and solenoid for the injectors will be monitored and evaluated for correct operation. If an electronic component does not meet specifications, an active Diagnostic Trouble Code will be logged. However, during Hard Start/No Start conditions, the sound of injectors may not be heard because of cold, thick oil.

Key-On Engine-Off Output State Low Test

The purpose of the Output StateTest is to allow the techician to check the operation of the ECM controlled actuators. During this test, actuators are controlled by the ECM. The ECM will pull down or pull up the output voltage in order to activate or deactivate the acuator. The low state will activate those components that are normally controlled by the ECM completing the ground circuit. While this test is running the technician can check the state of these actuators.

During this test the output of the circuit in question can be monitored with a Digital Multimeter (DMM). The DMM measures high or low voltages when outputs are toggled. The actual voltage will vary within the circuit tested. The EST will not display voltage or problems with circuits. A breakout tee or breakout box and digital multimeter are required to monitor circuits or actuator. Diagnostic Trouble Codes will not be set by the ECM during this test.

Key-On Engine-Off Output State High will test those components that are normally controlled by the ECM sending voltage to the actuator. While this test is running the technician can check the state of these actuators. The ECM will not check the state of the actuator nor will it log codes in this test.

During this test the output of the circuit in question can be monitored with a Digital Multimeter (DMM). The DMM measures high or low voltages when outputs are toggled. The actual voltage will vary within the circuit tested. The EST will not display voltage or problems with circuits. A breakout tee or breakout box and digital multimeter are required to monitor circuits or actuator. Diagnostic Trouble Codes will not be set by the ECM during this test.

The following actuators and signals are toggled during the Key-On Engine-Off Output State Test:

- Starter Power Relay (ECI)
- Injection Pressure Regulator (IPR)
- Engine Fan (EFN)
- Vehicle Retarder Relay (VRE)

Key-On Engine-Off Continuous Monitor Test

The Key-On Engine-OFF Continuous Monitor Test troubleshoots intermittent connections at sensors and actuators.

The Electronic Service Tool is used to monitor the following circuits:

- Accelerator Position Sensor (APS)
- Intake Air Temperature Sensor (IAT)
- Camshaft Position Sensor (CMP)
- Data Communication Link (DCL)
- Engine Coolant Temperature (ECT)
- Engine Oil Pressure (EOP)
- Injection Control Pressure (ICP)
- Manifold Absolute Pressure (MAP)
- Remote Accelerator Pedal Sensor (RPS)
- Engine Oil Temperature (EOT)
- Barometric Absolute Pressure Sensor (BAP)

TEST PROCEDURE

During this test, wiggle all suspected circuit connectors and wires. This movement allow the ECM to identify any momentary circuit continuity interruptions. The computer speaker will “BEEP” if an interruption in continuity is found and a related Diagnostic Trouble Code will be displayed on the Diagnostic screen. If at all possible, view the screen while doing this, as hearing the BEEP will likely be difficult in a busy shop environment.

Selecting this test also enables the ECM and Master Diagnostics to display the following sensor signal voltages in a International Text View window.

- APS Signal Volts
- BAP Signal Volts
- EBP Signal Volts
- ECM Signal Volts
- ECT Signal Volts
- EOP Signal Volts
- EOT Signal Volts
- EPG Signal Volts
- IAT Signal Volts
- ICP Signal Volts
- MAP Signal Volts
- RPS Signal Volts

Key-On Engine-Running Standard Test

The ECM evaluates the hydraulic performance of the Injection Control Pressure System. The ECM monitors the Injection Control Pressure (ICP) sensor signal values and compares those values with expected values. After the test, the ECM returns engine to normal operation and sends Diagnostic Trouble Codes set during the test.

Test Procedure

1. The ECM increases engine idle speed to a set value.
2. The ECM signals the IPR valve to set the injection control pressure to rated speed pressure. If IPR performance is acceptable, the ECM will command the IPR valve to reduce the pressure in steps, while continuing to monitor the performance of the injection control pressure system.

   NOTE – To perform these KOER tests, the following conditions are required:

   - **Engine coolant temperature must be at least 160°F.**
   - **Battery voltage must be higher than 12.5 volts.**
   - **Vehicle Speed Sensor (VSS) signal should not be present.**
   - **If active Diagnostic Codes are present, the cause must be repaired and the Diagnostic Trouble Codes cleared before running this test.**

Key-On Engine-Running Injector Test

NOTE – The Engine Running Standard Test must be done before starting the Engine Running Injector Test.

The “Injector Test” is designed to detect problems with injection and combustion events. Performing a cylinder contribution test will analyze the individual contribution of each of the power cylinders. Its primary function is to detect a bad injector, but it will detect problems that could affect the overall performance of the power cylinders (i.e.: valves, pushrods, pistons, rings, etc.)

During this 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 in severe cases, but there still is the possibly of (a misfire?) that will not set a code. Under these circumstances you'll need the aid of the EST and MD software.

When this test begins the engine speeds in increments to 850 rpm. The ECM will increase the normal amount of fuel delivery (overfuel) to the injector of the cylinder being tested. The ECM monitors the reduction of fuel required to operate the remaining injectors to maintain a constant speed. Then the ECM limits the fuel delivery (underfuel) to the same injector and monitors the increase in fuel delivery to the remaining injectors. The ECM compares the fuel delivery during overfuel to fuel delivery change (underfuel). If the difference or change is not the ECM expects, it will set a code for the non-contributing cylinder. This test is performed in numerical order, beginning with cylinder 1. Once cylinder number 6 is finished, the test is complete. Only severe case will set a Diagnostic Trouble Code. On engines with more than one severely scuffed injector, rpm fluctuation can be enough to stop the cylinder contribution test.

The KOER Injector Test detects injection and combustion problems, including problems that could affect the overall performance of the power cylinder (i.e. valves, push rods, pistons, rings, etc).

Key-On Engine-Running Continuous Monitor Test

The KOER Continuous Monitor Test troubleshoots intermittent connections at sensors and actuators.

The Electronic Service Tool is used to monitor the following circuits:

- Accelerator Position Sensor (APS)
- Intake Air Temperature Sensor (IAT)
- Camshaft Position Sensor (CMP)
- Data Communication Link (DCL)
- Engine Coolant Temperature (ECT)
- Engine Oil Pressure (EOP)
- Injection Control Pressure (ICP)
- Manifold Absolute Pressure (MAP)
- Remote Accelerator Pedal Sensor (RPS)
- Engine Oil Temperature (EOT)
- Barometric Absolute Pressure Sensor (BAP)

TEST PROCEDURE

1. Select the KOER Continuous Monitor Test from the Diagnostic drop-down menu.

2. Wiggle all suspected circuit connectors and wires. This movement is very helpful to Master Diagnostics in identifying any momentary circuit continuity interruptions. The EST can detect Diagnostic Trouble Codes much more rapidly if this method is used. The computer speaker will “BEEP” if an interruption in continuity is found and a related DTC will be displayed in the Diagnostic screen. If at all possible, view the screen while doing this, as hearing the BEEP will likely be difficult in a busy shop environment.

   Selecting this test enables the ECM and Master Diagnostics to display the following sensor signal voltages in a International Text View window.

   - APS Signal Volts
   - BAP Signal Volts
   - EBP Signal Volts
   - ECM Signal Volts
   - ECT Signal Volts
   - EOP Signal Volts
   - EOT Signal Volts
   - EPG Signal Volts
   - IAT Signal Volts
   - ICP Signal Volts
   - MAP Signal Volts
   - RPS Signal Volts

Table of Contents

DIAGNOSTIC FORMS

INTRODUCTION,

Two Types of Forms

The purpose of engine diagnostic forms is to provide the customer with satisfaction as well as assist the technician in troubleshooting DT 466 and DT 530 diesel engines. Diagnostic forms provide a guide to finding problems quickly and easily and to avoid unnecessary repairs and expense. Diagnostic forms should be taken 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 DT 466 and DT 530 diesel engines.

1. **Hard Start / No Start and Performance Engine Diagnostics, EGED-220**.

    A. The left front side of form EGED-220 (See Figure 31, page 53) is used to diagnose hard start or no start conditions. 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 Procedures must be done in sequence; performing the tests out of order could cause incorrect results. See Section 2, Hard Start / No Start and Performance Engine Diagnostics for detailed instructions.

    B. The right front side of form EGED-220 (See Figure 31, page 53) is used to diagnose engine performance concerns while the engine is running. 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. The tests must be done in sequence; Performing the tests out of order could cause incorrect results. See figures on the rear side of the form for part location, test and hookup points. See Section 2, Performance Engine Diagnostics for detailed instructions.

    C. The reverse side of the form is a series of illustrations. They show the location of test points and how to hook up test equipment at each test point described on the front side of the form (when applicable) (See Figure 32, page 54).

2. **Electronic Control System Diagnostics, EGED-225**

    A. The front side of this form EGED-225 contains two tables and an engine electrical diagram. They cover Signal Values associated with each of the ECM pin connections for the engine, and chassis components of the vehicle. The electrical diagram covers the engine mounted components, ECM pin connections and related wire numbering (See Figure 67, page 154).

    B. The rear side of the form contains an electrical diagram covering all the electronic chassis mounted components, ECM pin connections and related wire numbering (See Figure 68, page 155).

NOTE – Information relating to this form is discussed and located in Section 3.

Vehicle Information

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 fuel filter on left side of engine block. The VIN is located on the driver's side door jamb.

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 ECM is calibrated to the correct horsepower and emissions level. The ENGINE HORSEPOWER/EMISSIONS INFORMATION is located on the emission label located on the intake manifold/valve cover. The ENGINE FAMILY RATING CODE can only be accessed with the EST (Electronic Service Tool).

The TECHNICIAN and UNIT number is useful information for reference only (See Table 1, page 52).

Table 1 Table 1 Diagnostic Form Required Information

Date:	Miles:	Hours:	Technician:	Injector P/N:	Turbocharger P/N:
Eng. Sn.	VIN:		Unit #	Engine Family Rating Code:	
Eng. HP:	Ambient Temp.		Coolant Temp:		Complaint:

Instructions for Engine Diagnostic Forms

NOTE – Information obtained during Hard Start / No Start or Performance Diagnosis should be recorded in the appropriate box of the Hard Start / No Start or Performance Diagnostic form (See Table 2, page 53). If there are any differences between the "Specification" box and the recorded data, correct as necessary and repeat the checks. Retain this information for future operating analysis.

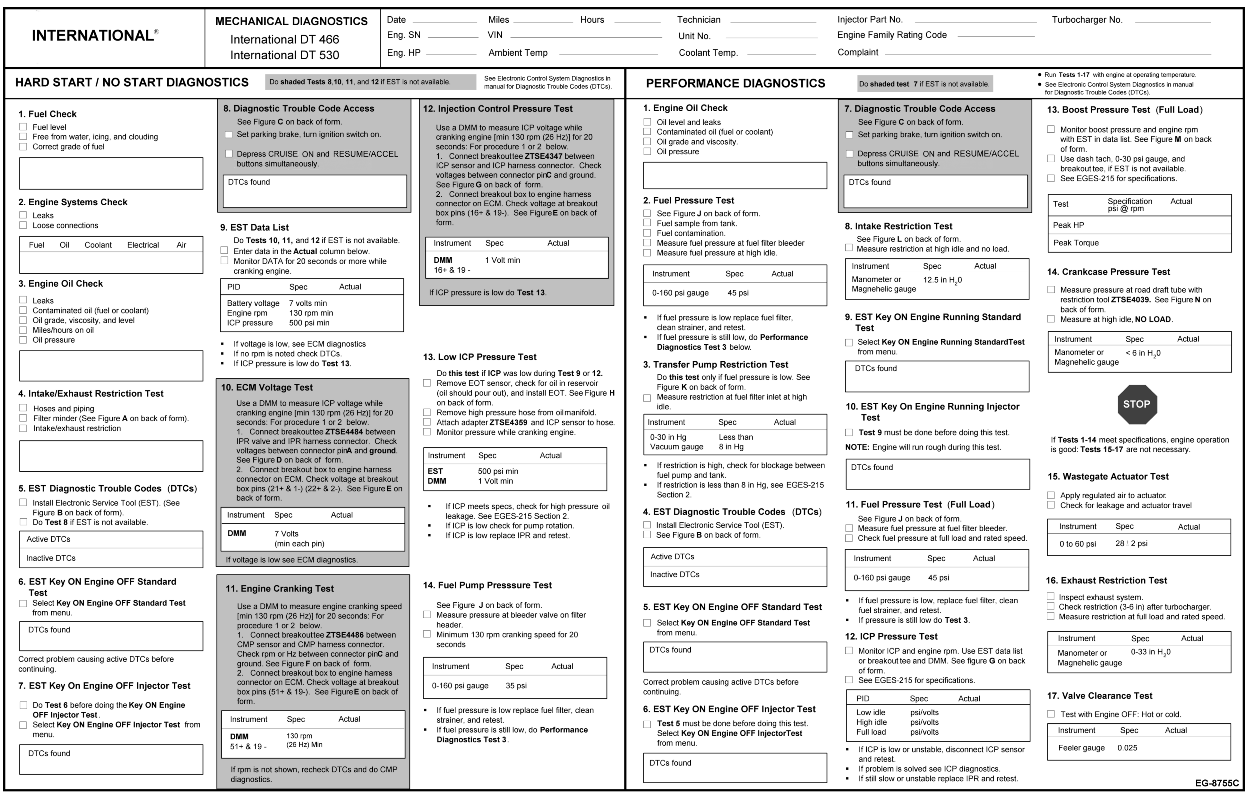
Diagnostic form EGED-220 is available in 50 sheet pads from:

International® Truck and Engine Corporation
Printing, Procurement and Distribution
4956 Wayne Road
Battle Creek, Michigan 49015

The following pages have supporting information and instructions for the combined Mechanical Diagnostic form EGED-220.

Table 2 Table 2 Mechanical Diagnostic Form Sample from EGED-220

9. EST Data List		
• Do Tests 10,11 and 12 if EST is not available		
• Monitor DATA for 20 seconds or more while cranking		
PID	Spec	Actual
Battery Voltage	7 Volts min.	
Engine rpm	130 rpm min.	
ICP Pressure	500 psi min.	
• If voltage is low, see ECM diagnostics		
• If no rpm is noted, check DTC's		
• If ICP pressure is low, do Test 13		



INTERNATIONAL®

MECHANICAL DIAGNOSTICS
International DT 466
International DT 530

Date ____ Miles ____ Hours ____ Technician ____ Injector Part No. ____ Turbocharger No. ____
Eng. SN ____ VIN ____ Unit No. ____ Engine Family Rating Code ____
Eng. HP ____ Ambient Temp ____ Coolant Temp. ____ Complaint ____

HARD START / NO START DIAGNOSTICS

Do **shaded Tests 8**,**10**, **11**, and **12** if EST is not available.

See Electronic Control System Diagnostics in manual for Diagnostic Trouble Codes (DTCs).

1. Fuel Check
- ☐ Fuel level
- ☐ Free from water, icing, and clouding
- ☐ Correct grade of fuel

2. Engine Systems Check
- ☐ Leaks
- ☐ Loose connections

Fuel	Oil	Coolant	Electrical	Air

3. Engine Oil Check
- ☐ Leaks
- ☐ Contaminated oil (fuel or coolant)
- ☐ Oil grade, viscosity, and level
- ☐ Miles/hours on oil
- ☐ Oil pressure

4. Intake/Exhaust Restriction Test
- ☐ Hoses and piping
- ☐ Filter minder (See Figure **A** on back of form).
- ☐ Intake/exhaust restriction

5. EST Diagnostic Trouble Codes (DTCs)
- ☐ Install Electronic Service Tool (EST). (See Figure **B** on back of form).
- ☐ Do **Test 8** if EST is not available.

Active DTCs
Inactive DTCs

6. EST Key ON Engine OFF Standard Test
- ☐ Select **Key ON Engine OFF Standard Test** from menu.

DTCs found

Correct problem causing active DTCs before continuing.

7. EST Key On Engine OFF Injector Test
- ☐ Do **Test 6** before doing the **Key ON Engine OFF Injector Test**.
- ☐ Select **Key ON Engine OFF Injector Test** from menu.

DTCs found

8. Diagnostic Trouble Code Access

See Figure **C** on back of form.
- ☐ Set parking brake, turn ignition switch on.
- ☐ Depress CRUISE ON and RESUME/ACCEL buttons simultaneously.

DTCs found

9. EST Data List

Do **Tests 10, 11,** and **12** if EST is not available.
- ☐ Enter data in the **Actual** column below.
- ☐ Monitor DATA for 20 seconds or more while cranking engine.

PID	Spec	Actual
Battery voltage	7 volts min	
Engine rpm	130 rpm min	
ICP pressure	500 psi min	

- If voltage is low, see ECM diagnostics
- If no rpm is noted check DTCs.
- If ICP pressure is low do **Test 13**.

10. ECM Voltage Test

Use a DMM to measure ICP voltage while cranking engine [min 130 rpm (26 Hz)] for 20 seconds: For procedure 1 or 2 below.
1. Connect breakouttee **ZTSE4484** between IPR valve and IPR harness connector. Check voltages between connector pin **A** and **ground**. See Figure **D** on back of form.
2. Connect breakout box to engine harness connector on ECM. Check voltage at breakout box pins (21+ & 1-) (22+ & 2-). See Figure **E** on back of form.

Instrument	Spec	Actual
DMM	7 Volts (min each pin)	

If voltage is low see ECM diagnostics.

11. Engine Cranking Test

Use a DMM to measure engine cranking speed [min 130 rpm (26 Hz)] for 20 seconds: For procedure 1 or 2 below.
1. Connect breakouttee **ZTSE4486** between CMP sensor and CMP harness connector. Check rpm or Hz between connector pin **C** and ground. See Figure **F** on back of form.
2. Connect breakout box to engine harness connector on ECM. Check voltage at breakout box pins (51+ & 19-). See Figure **E** on back of form.

Instrument	Spec	Actual
DMM 51+ & 19 -	130 rpm (26 Hz) Min	

If rpm is not shown, recheck DTCs and do CMP diagnostics.

12. Injection Control Pressure Test

Use a DMM to measure ICP voltage while cranking engine [min 130 rpm (26 Hz)] for 20 seconds: For procedure 1 or 2 below.
1. Connect breakouttee **ZTSE4347** between ICP sensor and ICP harness connector. Check voltages between connector pin **C** and ground. See Figure **G** on back of form.
2. Connect breakout box to engine harness connector on ECM. Check voltage at breakout box pins (16+ & 19-). See Figure **E** on back of form.

Instrument	Spec	Actual
DMM 16+ & 19 -	1 Volt min	

If ICP pressure is low do **Test 13**.

13. Low ICP Pressure Test

Do **this test** if **ICP** was low during **Test 9** or **12.**
- ☐ Remove EOT sensor, check for oil in reservoir (oil should pour out), and install EOT. See Figure **H** on back of form.
- ☐ Remove high pressure hose from oil manifold.
- ☐ Attach adapter **ZTSE4359** and ICP sensor to hose.
- ☐ Monitor pressure while cranking engine.

Instrument	Spec	Actual
EST	500 psi min	
DMM	1 Volt min	

- If ICP meets specs, check for high pressure oil leakage. See EGES-215 Section 2.
- If ICP is low check for pump rotation.
- If ICP is low replace IPR and retest.

14. Fuel Pump Presssure Test

See Figure **J** on back of form.
- ☐ Measure pressure at bleeder valve on filter header.
- ☐ Minimum 130 rpm cranking speed for 20 seconds

Instrument	Spec	Actual
0-160 psi gauge	35 psi	

- If fuel pressure is low replace fuel filter, clean strainer, and retest.
- If fuel pressure is still low, do **Performance Diagnostics Test 3**.

PERFORMANCE DIAGNOSTICS

Do **shaded test 7** if EST is not available.

- Run **Tests 1-17** with engine at operating temperature.
- See Electronic Control System Diagnostics in manual for Diagnostic Trouble Codes (DTCs).

1. Engine Oil Check
- ☐ Oil level and leaks
- ☐ Contaminated oil (fuel or coolant)
- ☐ Oil grade and viscosity.
- ☐ Oil pressure

2. Fuel Pressure Test
- ☐ See Figure **J** on back of form.
- ☐ Fuel sample from tank.
- ☐ Fuel contamination.
- ☐ Measure fuel pressure at fuel filter bleeder
- ☐ Measure fuel pressure at high idle.

Instrument	Spec	Actual
0-160 psi gauge	45 psi	

- If fuel pressure is low replace fuel filter, clean strainer, and retest.
- If fuel pressure is still low, do **Performance Diagnostics Test 3** below.

3. Transfer Pump Restriction Test

Do **this test** only if fuel pressure is low. See Figure **K** on back of form.
- ☐ Measure restriction at fuel filter inlet at high idle.

Instrument	Spec	Actual
0-30 in Hg Vacuum gauge	Less than 8 in Hg	

- If restriction is high, check for blockage between fuel pump and tank.
- If restriction is less than 8 in Hg, see EGES-215 Section 2.

4. EST Diagnostic Trouble Codes (DTCs)
- ☐ Install Electronic Service Tool (EST).
- ☐ See Figure **B** on back of form.

Active DTCs
Inactive DTCs

5. EST Key ON Engine OFF Standard Test
- ☐ Select **Key ON Engine OFF Standard Test** from menu.

DTCs found

Correct problem causing active DTCs before continuing.

6. EST Key ON Engine OFF Injector Test
- ☐ **Test 5** must be done before doing this test. Select **Key ON Engine OFF InjectorTest** from menu.

DTCs found

7. Diagnostic Trouble Code Access

See Figure **C** on back of form.
- ☐ Set parking brake, turn ignition switch on.
- ☐ Depress CRUISE ON and RESUME/ACCEL buttons simultaneously.

DTCs found

8. Intake Restriction Test

See Figure **L** on back of form.
- ☐ Measure restriction at high idle and no load.

Instrument	Spec	Actual
Manometer or Magnehelic gauge	12.5 in H_20	

9. EST Key ON Engine Running Standard Test
- ☐ Select **Key ON Engine Running StandardTest** from menu.

DTCs found

10. EST Key On Engine Running Injector Test
- ☐ **Test 9** must be done before doing this test.

NOTE: Engine will run rough during this test.

DTCs found

11. Fuel Pressure Test (Full Load)

See Figure **J** on back of form.
- ☐ Measure fuel pressure at fuel filter bleeder.
- ☐ Check fuel pressure at full load and rated speed.

Instrument	Spec	Actual
0-160 psi gauge	45 psi	

- If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest.
- If pressure is still low do **Test 3**.

12. ICP Pressure Test
- ☐ Monitor ICP and engine rpm. Use EST data list or breakout tee and DMM. See figure **G** on back of form.
- ☐ See EGES-215 for specifications.

PID	Spec	Actual
Low idle	psi/volts	
High idle	psi/volts	
Full load	psi/volts	

- If ICP is low or unstable, disconnect ICP sensor and retest.
- If problem is solved see ICP diagnostics.
- If still slow or unstable replace IPR and retest.

13. Boost Pressure Test (Full Load)
- ☐ Monitor boost pressure and engine rpm with EST in data list. See Figure **M** on back of form.
- ☐ Use dash tach, 0-30 psi gauge, and breakout tee, if EST is not available.
- ☐ See EGES-215 for specifications.

Test	Specification psi @ rpm	Actual
Peak HP		
Peak Torque		

14. Crankcase Pressure Test
- ☐ Measure pressure at road draft tube with restriction tool **ZTSE4039.** See Figure **N** on back of form.
- ☐ Measure at high idle, **NO LOAD**.

Instrument	Spec	Actual
Manometer or Magnehelic gauge	< 6 in H_20	

STOP

If **Tests 1-14** meet specifications, engine operation is good: **Tests 15-17** are not necessary.

15. Wastegate Actuator Test
- ☐ Apply regulated air to actuator.
- ☐ Check for leakage and actuator travel

Instrument	Spec	Actual
0 to 60 psi	28 ± 2 psi	

16. Exhaust Restriction Test
- ☐ Inspect exhaust system.
- ☐ Check restriction (3-6 in) after turbocharger.
- ☐ Measure restriction at full load and rated speed.

Instrument	Spec	Actual
Manometer or Magnehelic gauge	0-33 in H_20	

17. Valve Clearance Test
- ☐ Test with Engine OFF: Hot or cold.

Instrument	Spec	Actual
Feeler gauge	0.025	

EG-8755C

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Figure 31 Hard Start / No Start Engine Diagnostics form EGED-220 Front Side

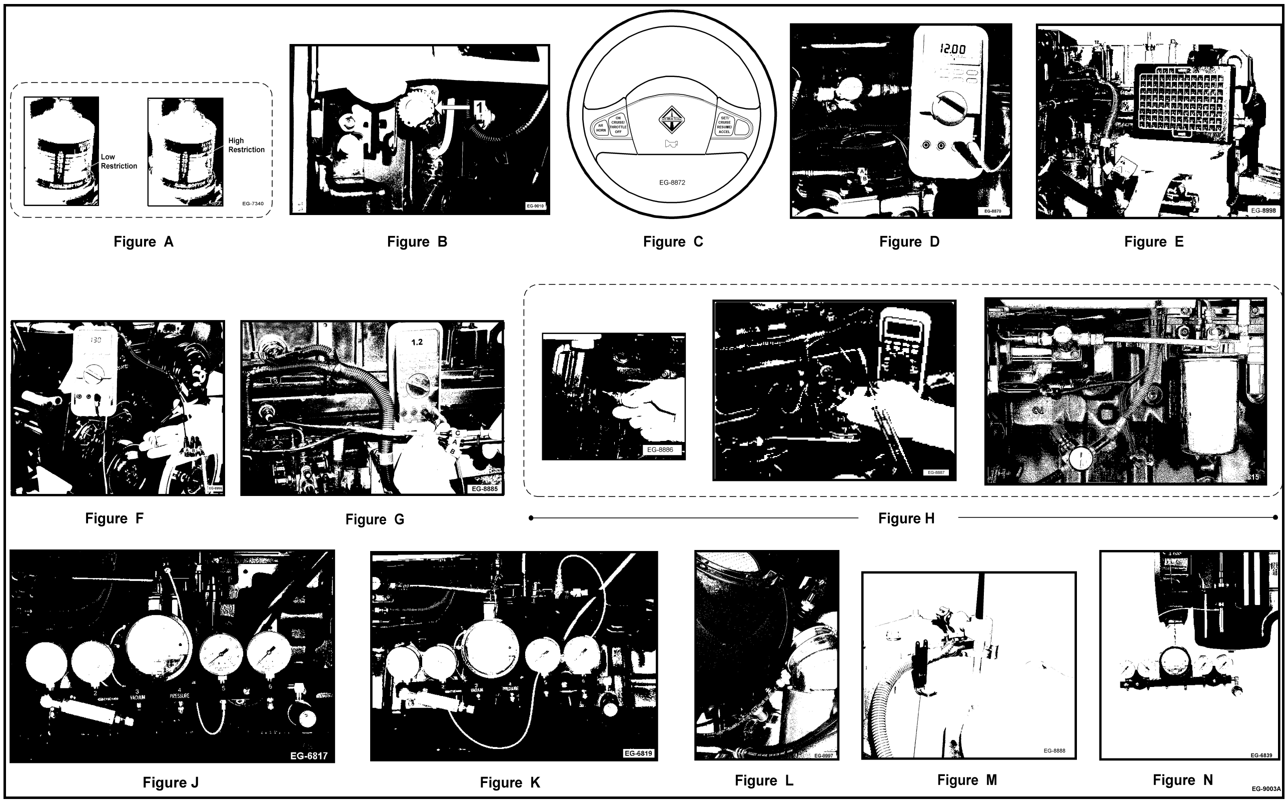

Figure 32 Hard Start / No Start Engine Diagnostics form EGED-220 Rear Side

HARD START / NO START DIAGNOSTICS

FUEL CHECK

Table 3

1. Fuel Check • Fuel level • Free of water-icing and clouding • Correct grade of fuel

Purpose

To determine if the engine has clean fuel for efficient engine operation.

Test Procedure

1. Take fuel sample from fuel tank.

   NOTE – Fuel must be the correct grade, clean, and undiluted.

> **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

2. Check for air in fuel. If air is suspected, check for air leaks in the supply line to the fuel transfer pump. Install a piece of clear plastic hose between the filter and the transfer pump inlet. Crank the engine and check for air bubbles.

   NOTE – Cold weather can cause fuel waxing in some grades of diesel fuel. Waxing will restrict or stop fuel flow through the fuel filter.

3. Check for gasoline or kerosene in the diesel fuel.

4. If engine oil is in the fuel, injector O-ring leaks and lower injection control pressure are likely. If these conditions are suspected, do the following:

   a. Drain some fuel from the fuel filter and check fuel color. If fuel sample is dark, compare the sample to the correct grade of uncontaminated fuel.

   b. If the comparison is inconclusive, remove the fuel filter. Use a filter cutter to cut and expose the filter element. If the element is black, oil may have entered fuel system past injector O-rings.

NOTE – If fuel quality is good, but the engine will not start, depress priming valve plunger. If the plunger has no resistance, the fuel system is out of fuel or has air in it. Do Test 14 (See Table 16, page 89) to check fuel pressure.

Possible Causes

- No fuel in tank.
- The in-line fuel valve (if equipped) could be shut off.
- Fuel supply line could be broken or crimped.
- The tank pickup tube could be clogged or cracked.
- Supplemental filters or water separators may be plugged or leaking allowing air to enter the fuel system.
- Water or contaminants in fuel tank.
- Ice in fuel lines.
- Fuel grade may not be suitable for cold temperatures.
- Fuel could be waxed or jelled (usually Grade 2-D).

Tools Required

- Clear container (approximately 1 Quart or 1 Liter)

ENGINE VISUAL CHECK

Table 4

2. Engine Systems Check				
• Leaks • Loose connections				
Fuel	Oil	Coolant	Electrical	Air

Purpose

Visual inspection of the engine for possible hard or no start conditions.

Test Procedure

1. Inspect fuel tank and lines for damage and leaks.
2. Check oil line from high pressure pump to oil supply manifold for oil leaks.
3. Inspect entire cooling system for leaks.
4. Check air induction system for leaks. Refer to Air Induction System Inspection and Pressure Test .
5. Inspect engine wiring harness for correct routing and protection against rubbing or chaffing. Inspect for connected CMP and IPR.

   NOTE – Engine will not start with IPR or CMP disconnected

6. Check sensor, relay, and control module connections.
7. All connections must be seated, in good condition, and free from damage or corrosion.

> **WARNING – To avoid personal injury, do not under any circumstances allow smoking, an electric spark or open flame near the battery or explosion may occur.**

8. Inspect battery cable and fuse battery connections for corrosion.

   NOTE – ECM harness connections must be torqued to 50 in·lb (5.65 N·m).

Possible Causes for Hard or No Start Conditions.

- Loose or leaking fuel supply lines could cause fuel system to lose prime.
- Kinked or blocked fuel supply lines will restrict fuel flow.
- Excessive fuel or oil leaks.
- Engine coolant leaks may indicate serious engine problems.

- Damaged or incorrectly installed electronic connectors.

NOTE – The Camshaft Position Sensor (CMP) and Injection Pressure Regulator valve (IPR) are the most critical electronic components to inspect if the engine fails to start.

Air Induction System Inspection

1. Inspect air cleaner housing for damage or distortion that could allow unfiltered air into the engine.

   NOTE – Unfiltered air will cause accelerated engine wear.

2. Inspect for end seal movement inside the housing. End seal movement is indicated if the seal contact area is polished. A polished contact area indicates that unfiltered air has passed by the filter element and into the engine.
3. Inspect air cleaner element for end cap dents, holes, damaged seals, and soot.
4. Inspect air intake hoses and clamps for tightness and positioning over sealing beads.
5. Inspect the chassis mounted charge air cooler and piping.

Air Induction System Pressure Test

1. Mask the outer diameter of air cleaner air inlet with duct tape and plug air cleaner canister drain.
2. Remove the air cleaner restriction indicator or tubing to the air cleaner. Install a plug to seal the opening.
3. Find the cold air discharge pipe containing a plug. Remove the plug and connect a manually regulated air supply with a pressure gauge refer to Regulated Air Supply (See Figure 33, page 58).

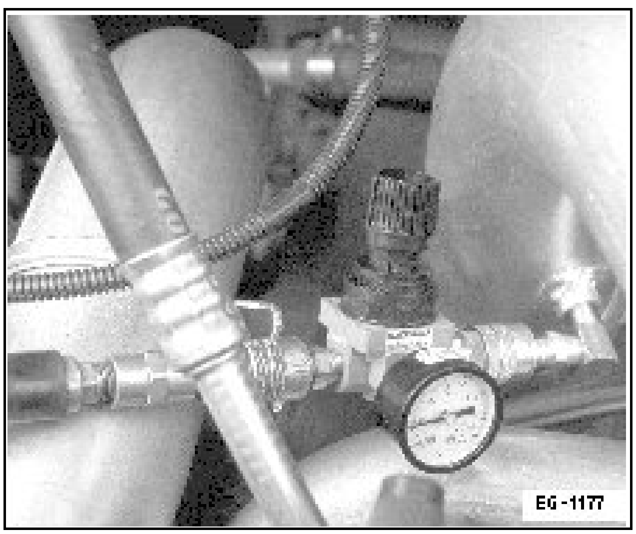

Figure 33 Regulated Air Supply

4. Apply 5 -8 psi of air pressure to the air induction system. A constant air supply is needed to replace air lost through opened intake valves.
5. Coat areas **a** through **f** listed below with a soap solution and check for leaks: refer to Air Induction System Leakage (See Figure 34, page 59).

a. Air cleaner body surface around the outlet pipe.

b. Air cleaner outlet pipe to air cleaner body junction.

c. All clamped hose and gasket connections between air cleaner outlet and intake manifold / valve cover. This includes turbocharger connections.

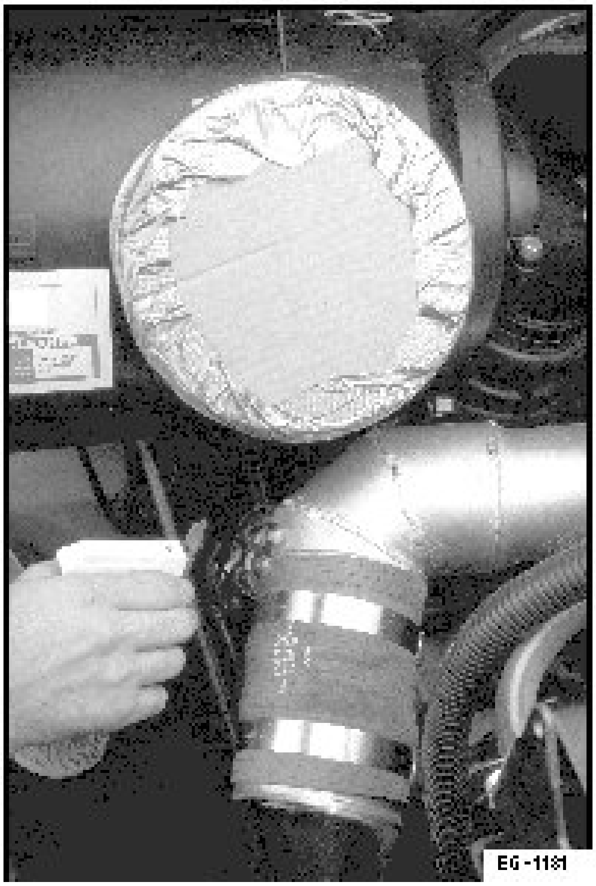

Figure 34 Checking For Air Induction System Leakage

d. Surface of all air induction piping and hoses between air cleaner and intake manifold / valve cover.

e. Air compressor air inlet piping from the air cleaner tube to and including the fitting and the gasket.

f. Piping to the air charge cooler.

6. Leakage is not permitted between air cleaner and turbocharger (suction side). If leaks are found, tighten hose clamps. If leaks continue, replace all parts as necessary. Retest corrected area.

   NOTE – Air induction leaks could indicate dirt in the engine. Dirt can cause pistons rings to wear or break causing high oil consumption and excessive blue smoke and pitting or erosion of the turbocharger compressor wheel. If leaks are found, test crankcase pressure.

Tools Required

- Inspection Lamp
- Air Pressure Regulator

- Soap Solution

ENGINE OIL CHECK

Table 5

3. Engine Oil Check
• Leaks • Contaminated oil (fuel or coolant) • Oil grade, viscosity and level • Miles/hours on oil • Oil pressure

Purpose

To check engine oil level, quality, and pressure.

Test Procedure

1. Park vehicle on level ground. Check oil level with oil level gauge (allow sufficient time for oil to drain back to oil pan).
   A. If there is little or no oil in the crankcase the fuel injectors will not work correctly.
   B. If the oil level is above full, the engine has been incorrectly serviced, or fuel is diluting the oil. Check for fuel odor in oil.
2. Inspect oil for color and odor. Milky white oil and an ethylene glycol odor will indicate coolant contamination.
3. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 oil below 20°F (-6.7°C)**. Long oil drain intervals can cause increased oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures. See lube oil chart in the engine operator's manual for the correct grade of oil for vehicle operation in various temperature ranges.

Possible Causes of Incorrect Fuel Injection

- Low oil level - oil leak, oil consumption, or incorrect servicing.
- High oil level - Incorrect servicing, fuel dilution possibly from lift pump.
- Oil contamination with coolant - Oil cooler, head gasket porosity, (accessories i.e. water cooled air compressors).
- Incorrect viscosity for ambient operating temperature.

Tools Required

- None

INTAKE / EXHAUST RESTRICTION CHECK

Table 6

4. Intake/Exhaust Restriction Test • Hoses and piping • Filter minder, (see figure **A** on back of form) • Intake/exhaust restriction

Purpose

To determine if intake or exhaust restriction is causing hard or no start conditions.

NOTE – High intake or exhaust restriction can cause a large amount of black or blue smoke when starting the engine.

Inspection

Inspect the following parts for restriction, damage, or incorrect installation:

1. Air cleaner inlet and ducting.

2. Air cleaner housing, filter element, and gaskets.

   IMPORTANT – Filter Minder: Intake restriction should be below 25 in H_20 @ full load **or** 12.5 in H_20 @ high idle. When the filter element reaches maximum allowable restriction, the yellow indicator (See Figure 35, page 63) will reach the top of window and automatically lock in this position.

   NOTE – See Performance Diagnostics for Intake Restriction details (See Table 24, page 106).

3. Exhaust system piping.

Possible Causes of Intake or Exhaust Restriction

- Snow, plastic bags, or other foreign material can restrict air flow in the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been left in the intake system.
- Tailpipe or muffler may be damaged or collapsed.
- Catalytic converter (if equipped) may be restricted.
- Retarder could be stuck in the closed position.

Figure 35 Intake Restriction Filter Minder

Tools Required

- None

EST DIAGNOSTIC TROUBLE CODES (DTC'S)

Table 7

5. EST Diagnostic Trouble Codes (DTC's)
• Install Electronic Service Tool (EST), (see figure B on back of form).
• Do TEST 8, if EST is not available.
Active DTC's
Inactive DTC's

Purpose

To determine if the Electronic Control Module (ECM) has detected Diagnostic Trouble Codes (DTC's) that could cause hard or no start conditions.

Test Procedure

NOTE – Do Test 8, if EST is not available (See Table 10, page 70)

NOTE – Turn all accessories and ignition OFF, before connecting Electronic Service Tool (EST) tool to the American Trucking Association (ATA) diagnostic connector.

Connect the EST to the ATA diagnostic connector. The ATA connector is located below the left side dash panel next to the cab courtesy lamp (See Figure 36, page 64).

NOTE – The EST will need to be booted up when plugged into the ATA connector. Refer to the EST operators manual.

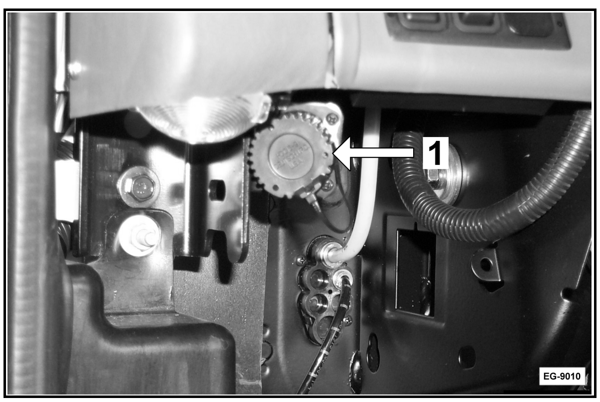

Figure 36

1. ATA Connector (shown with protective cap in place)

If there are any DTC's, they will appear on the screen along with a description of the code. DTC's will be listed as either Active, Inactive, or Active/Inactive.

Active codes are DTC's that are occurring now. In an electronic control system an active code indicates that the condition that caused the code is now present in the system.

Inactive DTC's are from previous ignition Key ON cycles and are stored in memory. An Inactive DTC indicates that the condition that caused the code is not present in the electronic control system in this key cycle. An Active Code will become an inactive code when the ignition key is turned Off.

The Active / Inactive label will occur on the EST when the code is intermittent during the key cycle. The code was active at some time during the key cycle but is now inactive.

Record all DTC's on Electronic Control System Diagnostic Form EGED-220.

Possible Causes

- Camshaft Position (CMP) sensor active DTC's
- Injection Pressure Regulator (IPR) output circuit check fault

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

EST KEY-ON ENGINE-OFF STANDARD TEST

Table 8

6. EST Key-ON Engine-OFF Standard Test • Select Key-ON Engine-OFF Standard Test from menu.
DTC's found
Correct problem causing active DTC's before continuing.

Purpose

To identify electrical malfunctions that have been detected by the Electronic Control Module (ECM) self test.

Test Procedure

1. Set park brake (required for correct ESC signal).
2. Use Master Diagnostics to display the DTC window.
3. Go to DIAGNOSTIC drop-down menu and clear all Diagnostic Trouble Codes (DTC's) before doing any Key-ON Engine-OFF Standard Test.
4. Go to Key-ON Engine-OFF Standard Test in the Diagnostics drop-down menu.
5. Turn the ignition key ON.

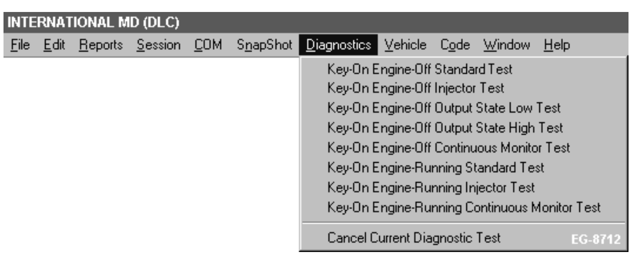

Figure 37 Diagnostics Drop-Down Menu

6. Click the Diagnostics drop-down menu and select Key-ON Engine-OFF Standard Test (See Figure 37, page 66).
7. This will cause the electronics to perform an internal self-test. This test must be performed before starting another Key-ON Engine-OFF Test.

When the first half of the Key-ON Engine-OFF Standard Test is over, the ECM will automatically perform the Output Circuit Check (OCC). The Output Circuit Check can detect faults that will not be found while the engine is running. After the test is complete the screen will show DTC's found. Scroll down to find additional DTC's, if they appear to be off the screen. Only new DTC's will be displayed as DTC's found.

NOTE – To repeat this test select the Diagnostic drop-down menu and click on Key-ON Engine-OFF Standard Test.

NOTE – When the Electronic Service Tool (EST) is not available, the Key-On Engine-Off Standard Test and the Output Circuit Check can be performed by following the steps below.

Key-ON Engine-OFF Standard Test and Output Circuit Check (OCC) Procedure

A. Set park brake (required for correct ESC signal).

B. Turn ignition key to the ON position.

C. Press and release the CRUISE ON and the RESUME/ACCEL buttons simultaneously two (2) times within three (3) seconds.

D. Key-ON Engine-OFF Standard Test and OCC will run and codes will flash.

Possible Causes

- Defective electrical components or circuitry.
- Output circuit check fault for Injection Pressure Regulator (IPR).

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

EST KEY-ON ENGINE-OFF INJECTOR TEST

Table 9

7. EST Key-ON Engine-OFF Injector Test
• Do test 6 before doing the Key-ON Engine-OFF Injector Test. • Select Key-ON Engine-OFF Injector Test from menu.
DTC’s found

Purpose

To determine if the fuel injectors are working (electronically) by energizing the injectors in a programmed sequence. The Electronic Control Module (ECM) monitors this test and transmits DTC’s, if the injectors are not working correctly.

Test Procedure

NOTE – Engine-OFF Standard Test must be done first, to access the Key-ON Engine-OFF Injector Test.

After the Key-ON Engine-OFF Standard Test has been completed, select the Diagnostics drop-down menu to access the Key-ON Engine-OFF Injector Test (See Figure 38, page 68).

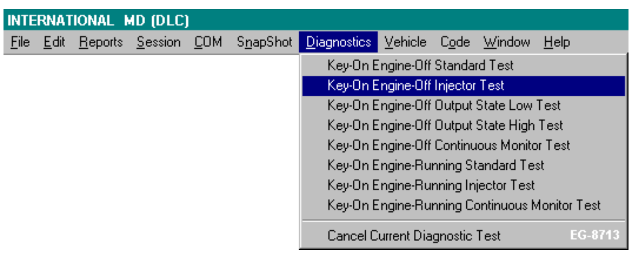

Figure 38 Key-ON Engine-OFF Injector Test

During this test, injector solenoids should click when actuated. If a series of rapid clicks are not heard for each injector, one or more injectors are not activating. After the Key-ON Engine-OFF Injector Test, the detected codes will be displayed. More DTC’s can be found by scrolling down the Diagnostic Trouble Code screen.

Record DTC’s found on Engine Control System Diagnostics form EGED-220.

Possible Causes

- Bad wiring harness connection on injector solenoid
- Open or shorted engine wiring harness to injectors
- Defective injector solenoid
- Defective ECM

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC’s are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

- See Injector Drive Circuits, Section 3 (See Injector Drive Circuits (INJ), page 288).

DIAGNOSTIC TROUBLE CODE ACCESS

Table 10

8. Diagnostic Trouble Code Access
See figure **C** on the back of form.
• Set Parking Brake, turn ignition switch ON.
• Depress CRUISE ON and RESUME/ACCEL buttons simultaneously.
DTC's found

Purpose

To read DTC's detected by the Electronic Control Module (ECM) if the Electronic Service Tool (EST) is not available, or if the EST will not communicate with the ECM.

The Cruise Control buttons on the steering wheel act as an interface between the Operator and the ECM. The resulting flashes of the amber ENGINE lamp indicates the ECM is performing a series of electronic tests.

Diagnostic Trouble Code Access Procedure

To display Diagnostic Trouble Codes, set the parking brake and turn the ignition key to the ON position. Press and release the CRUISE ON button and the RESUME/ACCEL button simultaneously (See Figure 39, page 70).

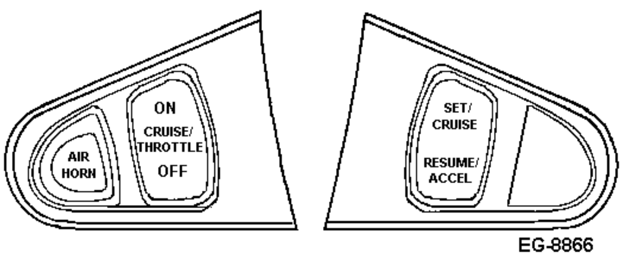

Figure 39 Cruise Control Buttons on Steering Wheel

When the test is complete, the ECM will flash the red ENGINE lamp and the amber ENGINE lamp to signal the Diagnostic Trouble Codes. Read the Diagnostic Trouble Codes by following the sequence below. This following sequence occurs each time the two Cruise Control buttons are depressed to access the Diagnostic Trouble Codes:

1. The red ENGINE lamp will flash once to indicate the beginning of **ACTIVE** DTC's.

2. The amber ENGINE lamp will flash repeatedly signaling the active DTC's.

   NOTE – All DTC's are three digits. Code 111 indicates no Diagnostic Trouble Codes have been detected.

3. Count the amber flashes in sequence. After each digit of the code a short pause will occur. **Three flashes** and a pause would indicate number 3. **Two flashes**, a pause, **three flashes**, a pause, and **two flashes** and a pause would indicate Diagnostic Trouble Code **232**. If there is more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

After all active DTC's have flashed, the red ENGINE lamp will flash twice to indicate the start of **INACTIVE** DTC's. Count the flashes from the amber **ENGINE** lamp. If there is more than one inactive code, the red ENGINE lamp will flash once between each DTC.

After all DTC's have been sent, the red ENGINE lamp will flash three times indicating END OF MESSAGE.

To repeat DTC transmission, press and release CRUISE ON and RESUME/ACCEL buttons once. The ECM will once again send the stored DTC's.

Clearing Inactive Diagnostic Trouble Codes

A. Set park brake (required for correct ESC signal and to clear codes).

B. Turn key switch to the IGN/ON position.

C. Depress and hold the CRUISE ON and RESUME/ACCEL buttons simultaneously.

D. Continue holding the Cruise Control buttons. Depress and release the accelerator pedal three (3) times within a six (6) second interval.

E. Release the Cruise Control buttons.

F. Inactive codes will be cleared.

Key-ON Engine-OFF Standard Test and Output Circuit Check (OCC)

1. Set park brake (required for correct ESC signal).
2. Turn ignition key to the ON position.
3. Press and release the CRUISE ON and the RESUME/ACCEL buttons simultaneously two (2) times within three (3) seconds.
4. Key-ON Engine-OFF Standard Test and OCC will run and codes will flash.

Possible Causes

- Electronic component or circuitry failures.

Tools Required

- None

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

EST DATA LIST

Table 11

9. EST Data List		
Do tests 10, 11, 12 if EST is not available.		
• Enter data in the **Actual** column below.		
• Monitor DATA for 20 seconds or more while cranking engine.		
PID	Spec	Actual
Battery Voltage	7 Volts min.	
Engine rpm	130 rpm min.	
ICP Pressure	500 psi min.	
• If voltage is low, see ECM Diagnostics.		
• If no rpm is noted, check DTC's.		
• If ICP is low, do Test 13.		

Purpose

To determine if systems needed for starting meet operating specifications.

Test Procedure

IMPORTANT – Test must be done with fully charged batteries.

WARNING – To avoid personal injury, do not under any circumstances allow smoking, an electric spark or open flame near the battery or explosion may occur.

WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.

To measure battery voltage, engine cranking rpm, and Injection Control Pressure (ICP), read Electronic Service Tool (EST) data, while cranking the engine for a minimum of 20 seconds.

If an EST is not available, use a Digital Multimeter (DMM) as an alternative to perform the following tests:

Connect the EST tool to the American Trucking Association (ATA) diagnostic connector. The connector is on the underside of the dash panel (left side) inside the cab in most applications. Use Master Diagnostics to view Battery Voltage, Engine rpm, and ICP pressure while cranking (See MASTER DIAGNOSTICS (MD 32), page 394).

1. Turn ignition switch ON.

2. Crank the engine and read data on the screen. The data will be displayed when the engine begins to crank. The battery voltage must be 7 or more volts.

3. If voltage to the Electronic Control Module (ECM) drops below 7 volts, the ECM will not remain powered up. If the ECM does not get power through the ECM relay, the engine will not start.

4. Engine cranking speed must generate the required ICP to operate the fuel injectors and create the required compression to ignite the fuel. If the EST shows **0** rpm during engine cranking, the ECM may not be receiving a signal from the Camshaft Position (CMP) sensor.

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

6. If the EST indicates low or no injection control pressure, check oil level in oil reservoir (on front cover). Remove the engine harness connector from the Engine Oil Temperature (EOT) sensor. Remove the EOT sensor from the front cover. Oil should drain from the internal reservoir. If oil does not drain from the sensor hole continue to crank the engine.

   NOTE – Proceed with caution when removing sensor. Do not completely remove if oil is present.

7. If the oil reservoir level continues to fall, the primary lube oil pump may be inadequate in its duty to supply oil to the reservoir. See Low ICP Pressure Test 13 (See Table 15, page 84).

Possible Causes

- Low battery voltage - Failed batteries, high resistance at battery cable connections, or in wiring to the ECM.
- Defective ECM power relay
- Blown 40A in-line fuse (in battery box) which supplies voltage to the ECM
- Low cranking rpm - Can be caused by electrical system malfunctions, incorrect oil viscosity, or long oil change intervals in cold ambient temperatures.
- No engine rpm indication on EST while cranking the engine. - This can be caused by a faulty CMP sensor or faulty circuitry to the ECM. Recheck for DTC's after cranking engine. See EST, Diagnostic Trouble Codes (See Table 7, page 64) or Diagnostic Trouble Code Access (DTC) (See Table 10, page 70).
- Low ICP Pressure - This could indicate a leak in the high pressure oil system or a defective ICP sensor.
- A defective high pressure oil pump, pump drive, defective Injection Pressure Regulator (IPR), or electronic controls for the regulator could also cause low injection control pressure.

Tools Required

Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

To troubleshoot low voltage at ECM Power Supply see:

- Electronic Control Module Power Supply Diagram (See Figure 114, page 238)
- Electronic Control Module Power Supply Circuit (See Figure 115, page 239)
- ECM PWR Circuit Diagnostics (See Table 59, page 239)

No engine rpm indication during cranking - See CMP sensor diagnostics

- Camshaft Position Sensor Functions (See Figure 96, page 200)
- Camshaft Position Sensor Circuit Diagram (See Figure 97, page 201)
- Camshaft Position Sensor and Circuit Diagnostics (See Table 54, page 201)

No Injection Control Pressure - See Injection Control Pressure (ICP) sensor diagnostics

- ICP Sensor Circuit Diagram Using a Breakout Tee (See Figure 137, page 283)
- ICP Sensor Voltage Checks (See Table 71, page 283)
- ICP Sensor Troubleshooting Flowchart (See Figure 138, page 287)
- ICP Sensor Circuit Specifications (See Table 72, page 284)

No or low injection control pressure and no electronic DTC's

- See Test 13 - Low ICP Pressure Test (See Table 15, page 84)

ECM VOLTAGE TEST

Table 12

10. ECM Voltage Test		
Use a DMM to measure ECM voltage while cranking the engine [min 130 rpm (26 Hz)] for 20 seconds: For procedure 1 or 2 below. 1. Connect breakout tee **ZTSE4484** between IPR valve and IPR harness connector. Measure voltage at connector pin A and chassis ground while cranking. See figure **D** on back of form. 2. Connect Breakout Box to vehicle harness connector on ECM. Measure voltage at breakout box pins (21+ & 1-), (22+ & 2-), (24+ & 23-) while cranking. See figure **E** on back of form.		
Instrument	Spec.	Actual
DMM	7V (min. each pin)	
If voltage is low, See ECM diagnostics.		

Purpose

Do this test only if the EST is not available. To determine the voltage available to the Electronic Control Module (ECM). The ECM requires 7 volts minimum to operate and drive the fuel injectors. Use the following test procedure if the Electronic Service Tool (EST) is unavailable or fails to function correctly. Low battery power or an electronic failure may inhibit the EST from receiving diagnostic data.

Test Procedure

Voltage Measurement at Battery

IMPORTANT – Tests must be done with fully charged batteries.

> ⚠ **WARNING – To avoid personal injury, do not under any circumstances allow smoking, an electric spark or open flame near the battery or explosion may occur.**

1. Turn accessories OFF and connect a Digital Multimeter (DMM) across the battery terminals.

> ⚠ **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

2. Crank the engine.

3. Record the lowest voltage. If the voltage is below 7 volts, the ECM power relay may be resetting, resulting from low voltage and current from the batteries, or problems in the starting system.

4. If voltage is within specification, perform Voltage Measurement At ECM with Breakout Tee on IPR or Breakout Box.

ECM Voltage Measurement with Breakout Tee

1. Remove the IPR harness from the IPR sensor.

2. Install IPR Breakout Tee ZTSE4484 between sensor and harness.

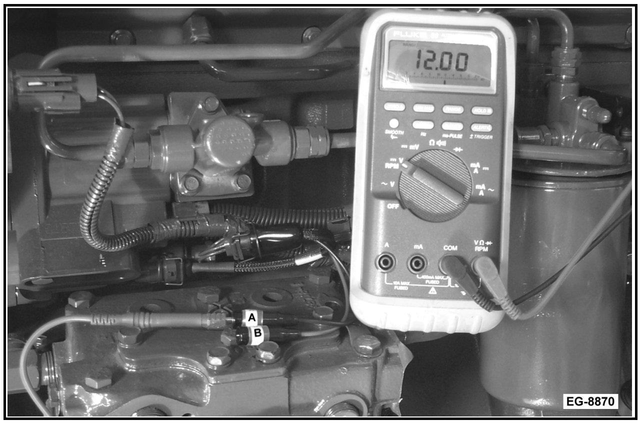

Figure 40 ECM Voltage Measurement with Breakout Tee

3. Place the DMM negative lead (black) onto a clean ground. Place the DMM positive lead (red) to Pin A . See ECM Voltage Measurement with Breakout Tee (See Figure 40, page 76).

4. Record the lowest voltage for pin A (red) while the engine is cranking for 20 seconds minimum.

ECM Voltage Measurement with Breakout Box

1. Remove the 60 pin chassis (lower) connector harness from the ECM.

2. Install the Breakout Box connector to the chassis female connection on the ECM. Reconnect the chassis harness connector to the Breakout Box connector.

   NOTE – Torque Connector to ECM To 50 in·lbs (5.65 N·m).

3. Connect leads of the voltmeter to each test point (21+ & 1-), (22+ & 2-), (24+ & 23-) on the Breakout Box. See Measuring ECM Voltage with Breakout Box (See Figure 41, page 77).

4. Record the lowest voltage for each test point while cranking engine.

5. If voltage is lower than 7 volts, repair the ECM power feed circuit. Refer to ECM Power Circuit diagnostics.

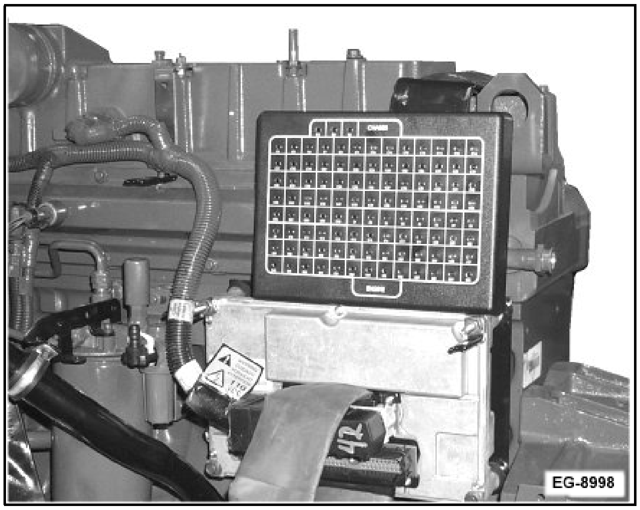

Figure 41 Measuring ECM Voltage with Breakout Box

Possible Causes

- Low battery voltage – Failed batteries, high resistance at battery cable connections, or defective starter.
- Low or no battery voltage to the ECM – Can be caused by high resistance, or an open power feed circuit to the ECM or its power relay. The ECM power circuit fuse in battery box may be open, or the ECM power relay may be defective.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- IPR Breakout Tee (ZTSE4484) (optional)
- DMM (ZTSE4357) (optional)
- Breakout Box (ZTSE4445) (optional)

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

To troubleshoot low voltage at ECM Power Supply see:

- Electronic Control Module Power Supply Diagram (See Figure 114, page 238)
- Electronic Control Module Power Supply Circuit (See Figure 115, page 239)
- ECM PWR Circuit Diagnostics (See Table 59, page 239)

ENGINE CRANKING RPM

Table 13

11. Engine Cranking Test		
Use a DMM to measure engine cranking speed for 20 seconds: For procedure 1 or 2 below. 1. Connect breakout tee **ZTSE4486** between CMP sensor and CMP sensor harness connector. Measure rpm or Hz at connector pin C and ground. See figure **F** on back of form. 2. Connect breakout box to engine harness connector on ECM. Measure voltage at Breakout Box pins (51+ & 19-). See figure **E** on back of form.		
Instrument	Spec.	Actual
DMM, 51+ & 19-	130 rpm (26 Hz) min.	
If rpm is not shown, recheck DTC's and see CMP diagnostics.		

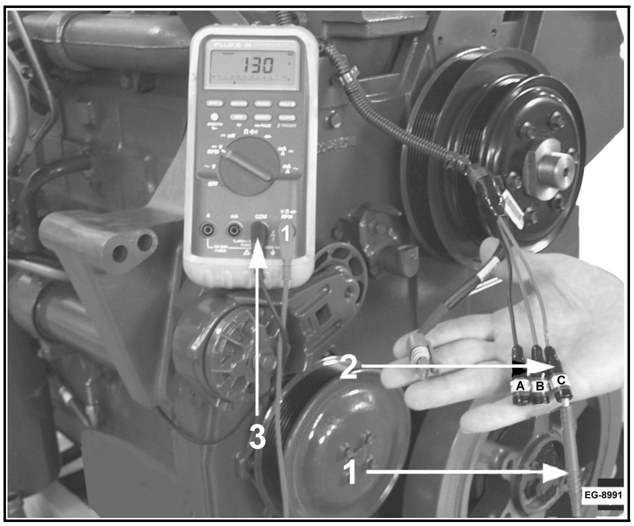

Figure 42 Measuring Cranking Speed at CMP Sensor

1. DMM Positive Probe (red)
2. Signal Pin (C) (green)
3. DMM Ground Probe (engine ground)

Purpose

NOTE – When using a DMM in the 4 cycle RPM mode the meter reading must be divided by 12 to equal the actual rpm of the engine. When reading Hertz (Hz) the meter reading is 1/5 the actual rpm. 26Hz = 130 rpm.

To determine the correct engine cranking speed to start the engine. Use the following test procedure if the Electronic Service Tool (EST) is unavailable or fails to function correctly. Low battery power or an electronic failure may inhibit the EST from receiving diagnostic data.

Test Procedure

IMPORTANT – Test must be performed with fully charged batteries.

Engine cranking rpm must generate the required ICP to operate the fuel injectors and to create enough compression to ignite the fuel.

Measuring Cranking rpm with Breakout Tee

WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.

1. Connect Breakout Tee (ZTSE4486) between CMP sensor and CMP sensor harness connector (See Figure 42, page 78).
2. Place DMM negative probe (black) onto a good engine ground.
3. Place DMM knob to the **V / RPM** setting, then toggle to select **RPM** or **Hz** in the display.
4. Crank engine for a minimum of 20 seconds and measure engine cranking rpm (Hz) at CMP signal green connector (C).
5. Record engine cranking speed on the diagnostic form.

Measuring Cranking RPM with Breakout Box

1. Remove engine connector (60 pin) from the ECM.
2. Install Breakout Box (ZTSE4445) adapter connectors to the engine and chassis female connections on the ECM. Reconnect engine harness connector to the Breakout Box adapter connector.

   NOTE – Torque connector to ECM to 50 in·lbs (5.65 N·m).

3. Connect the (+ lead) of the Digital Multimeter (DMM) to terminal 51 and the (- lead) to terminal 19. Select the **V / RPM** setting, then toggle to select **RPM** or **Hz** in the display. See Measuring Engine Cranking rpm with Breakout Box (See Figure 43, page 79).
4. Crank the engine and check the DMM. A minimum of 130 rpm (26 Hz) is necessary to start the engine.
5. Record cranking engine rpm on diagnostic form EGED-220.

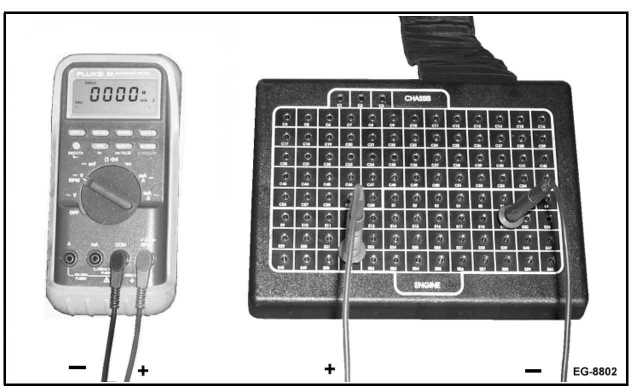

Figure 43 Measuring Engine Cranking RPM with Breakout Box

If DMM indicates **0** frequency/rpm during engine cranking, the ECM will not receive a signal from the CMP sensor. See CMP sensor diagnostics(See Camshaft Position Sensor (CMP), page 200), in Section 3, Electronic Control System Diagnostics.

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

NOTE – If no frequency/engine rpm is measured with the DMM, check for DTC's. See Test 5 (See Table 7, page 64) or Test 8 (See Table 10, page 70) and Camshaft Position (CMP) sensor diagnostics.

Possible Causes

- Low cranking rpm - Starting system electrical malfunctions, incorrect oil grade, or long oil change intervals in cold ambient temperature conditions.
- No engine rpm - Poor electrical connection at CMP sensor connector for wiring harness, wiring harness to sensor (open or shorted), or a defective CMP sensor will cause a **0** frequency / engine rpm indication.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- CMP Breakout Tee (ZTSE4486)
- Digital Multimeter (ZTSE4357)
- Breakout Box (ZTSE4445)

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

No engine rpm indication during cranking - See CMP sensor diagnostics

- Camshaft Position Sensor Functions (See Figure 96, page 200)
- Camshaft Position Sensor Circuit Diagram (See Figure 97, page 201)
- Camshaft Position Sensor and Circuit Diagnostics (See Table 54, page 201)

INJECTION CONTROL PRESSURE TEST

Table 14

12. Injection Control Pressure Test		
Use a DMM to measure ICP voltage while cranking engine [min 130 rpm (26 Hz)] for 20 seconds: For procedure 1 or 2 below. 1. Connect breakout tee **ZTSE4347** between ICP sensor and ICP sensor harness connector. Measure voltage between connector pin C & ground. See figure **G** on back of form. 2. Connect breakout box to engine harness connector on ECM. Measure voltage at breakout box pins (16+ & 19-). See figure **E** on back of form.		
Instrument	Spec	Actual
DMM, 16+ & 19-	1 Volt min.	
If ICP pressure is low do Test 13.		

Purpose

To determine injection control pressure during cranking.

NOTE – Two alternate methods can be used if the Electronic Service Tool (EST) is unavailable or fails to function. Low battery voltage or electronic failures will inhibit the EST from receiving diagnostic data.

ICP Voltage Measurement with Breakout Tee

Measuring Injection Control Pressure Using Breakout Tee ZTSE4347.

1. Remove engine harness connector at ICP sensor.
2. Connect the ICP Breakout Tee between the engine harness connector and the ICP sensor.
3. Connect Digital Multimeter (DMM) leads (red +) to the Breakout Tee Signal Circuit (green), and (black –) to the Signal Ground (black) as shown in photo Measuring Injection Control Pressure (Voltage) (See Figure 44, page 82).

> **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

4. Crank engine and observe DMM voltage reading. Record reading on diagnostic form EGED-220. If voltage is low, check oil level in reservoir (at EOT sensor) for correct oil level necessary to operate the fuel injectors. If oil level is correct, go to Low ICP Pressure Test 13 (See Table 15, page 84).

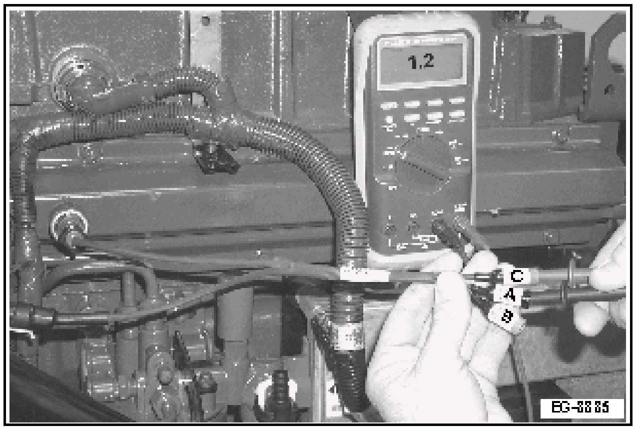

Figure 44 Measuring Injection Control Pressure (Voltage)

ICP Voltage Measurement with Breakout Box

Measuring Injection Control Pressure Using a Breakout Box ZTSE4445.

1. Remove upper engine harness (60 pin connector) from the ECM.

2. Install Breakout Box adapter connector to the engine connector on the ECM. Reconnect engine harness connector to the Breakout Box adapter connector.

   NOTE – Torque connector to ECM to 50 in·lbs (5.65 N·m).

3. Connect the positive lead of the DMM to terminal 16 and the negative lead to terminal 19 (See Figure 45, page 82).

4. Crank the engine while observing the DMM and record the injection control pressure voltage signal on the diagnostic form. **If Injection Control Pressure (ICP) pressure is low, see Low ICP Pressure Test 13 (See Table 15, page 84)**.

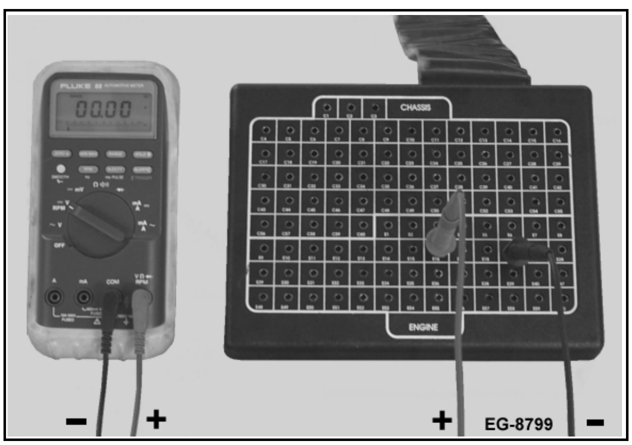

Figure 45 Measuring Injection Control Pressure Using Breakout Box (Alternate Method)

Possible Causes

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

- ICP sensor faulty or incorrect sensor
- No oil in the engine
- Oil reservoir leak down possibly through the high pressure pump internal 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

- Electronic Service Tool (EST) with Master Diagnostics software
- DMM (ZTSE4357)
- ICP sensor Breakout Tee (ZTSE4347) (optional)
- Breakout Box (ZTSE4445) (optional)

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

To troubleshoot the IPR valve see the following:

- Injection Pressure Regulator Circuit Diagrams (See Figure 142, page 295)
- Injection Pressure Regulator and Circuit Diagnostics (See Table 74, page 295)

No Injection Control Pressure - See Injection Control Pressure (ICP) sensor diagnostics

- ICP Sensor Circuit Diagram Using a Breakout Tee (See Figure 137, page 283)
- ICP Sensor Voltage Checks (See Table 71, page 283)
- ICP Sensor Troubleshooting Flowchart (See Figure 138, page 287)
- ICP Sensor Circuit Specifications (See Table 72, page 284)

LOW INJECTION CONTROL PRESSURE TEST

Table 15

13. Low ICP Pressure Test		
Do this Test 13 if ICP was low during Test **9** or **12**.		
• Remove EOT sensor, check for oil in reservoir (oil should pour out). Reinstall EOT sensor. See figure **H** on back of form.		
• Remove high pressure hose from oil manifold.		
• Attach adapter **ZTSE4359** and ICP sensor to hose.		
• Monitor pressure while cranking engine.		
Instrument	Spec	Actual
EST	500 psi min.	
DMM	1 Volt min.	
• If ICP meets specs, check for high pressure oil leakage under the valve cover.		
• If ICP is low check for pump rotation.		
• If ICP is still low replace IPR and retest.		

Purpose

To find the cause of low ICP pressure that prevents engine from starting.

Test Procedure

NOTE – If DTC's were detected previously, the problems causing the DTC's should be repaired before performing this test.

1. Remove engine harness connector from Engine Oil Temperature (EOT) sensor on left rear of front cover.

> ⚠ **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

2. Remove EOT sensor from the front cover (See Figure 46, page 85). Oil should pour out. If oil level is low, crank engine and recheck level. If level does not increase, lube oil pump may not be supplying the proper amount of oil to the reservoir. If the oil level was above the EOT sensor, reinstall the sensor and go to the next step.

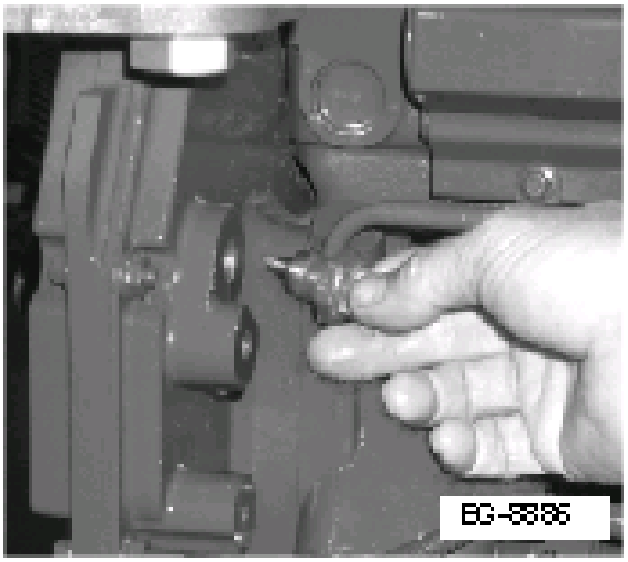

Figure 46 Checking Oil Level in Oil Reservoir

3. Disconnect high pressure oil hose from the high pressure oil manifold and install the adapter from Hydraulic Fitting Kit into the end of the high pressure hose (See Figure 47, page 85).

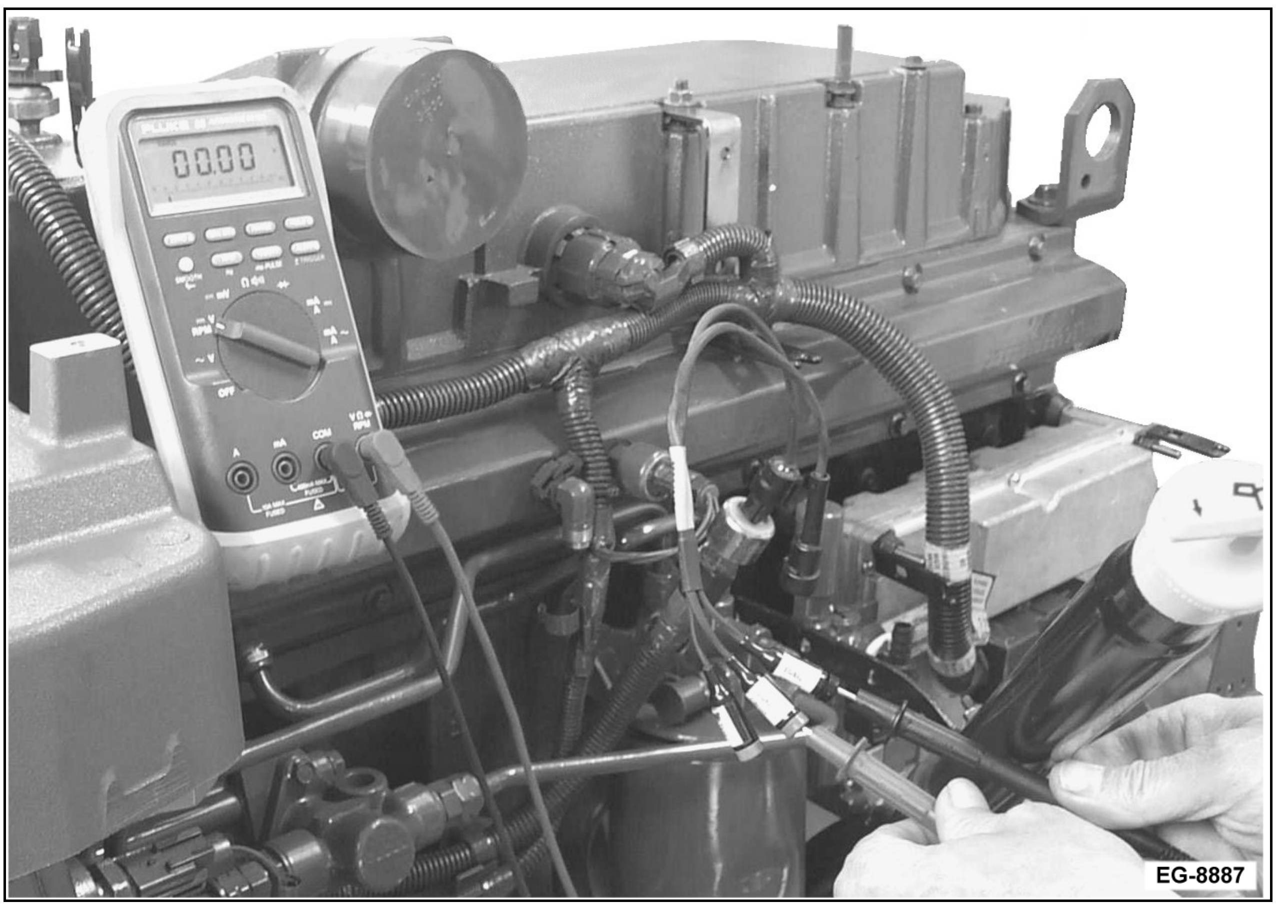

Figure 47 Low ICP Pressure Test

NOTE – An alternative method would be to install another ICP sensor into the adapter and hose leaving the original ICP sensor in place.

4. Disconnect ICP sensor engine harness connector and remove ICP sensor.

5. Install ICP sensor adapter into end of the high pressure oil hose.

   NOTE – If the EST is to be used for measuring ICP pressure, reconnect ICP engine harness connector to ICP sensor. Monitor and record ICP pressure while cranking engine.

   NOTE – If the EST is unavailable follow the remaining steps outlined below.

6. Install ICP Breakout Tee ZTSE4347 between the ICP sensor and ICP engine harness connector.

7. Connect (+) lead of the Digital Multimeter (DMM) to green terminal and the (-) lead to black terminal of the Breakout Tee.

8. Monitor ICP pressure (signal voltage) while cranking engine and record on diagnostic form.

9. If ICP pressure is greater than 500 psi or 1 volt, go to ICP Leakage Test. If ICP pressure is less than 500 psi or 1 volt, do the following. Install a breakout tee and measure voltage at red pin. Voltage should be 12 ± 0.5V. Ground the green pin to the chassis ground while cranking. If pressure is above 500 psi or 1V refer to IPR Diagnostics in Section 3. If pressure is still low proceed with the following steps.

> **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

   A. Remove fuel transfer pump on the housing.
   B. Crank the engine and check rotation of the fuel transfer pump camshaft inside the housing. If camshaft is not rotating, remove high pressure pump and tighten drive gear. Reinstall high pressure pump. Recheck ICP pressure while cranking engine.
   C. If pressure is low, replace IPR valve and recheck ICP pressure.
   D. If pressure is still low, replace high pressure oil pump.

ICP Leakage Test

1. Remove intake manifold/valve cover.

2. Remove ICP sensor and adapter plug (used previously) from high pressure hose. Reattach hose to oil manifold. Remove the other end of the hose from the high pressure pump and connect an air pressure regulator to the (removed) hose as shown in the illustration ICP Leakage Test (See Figure 48, page 87).

3. Apply 100 psi to the oil manifold.

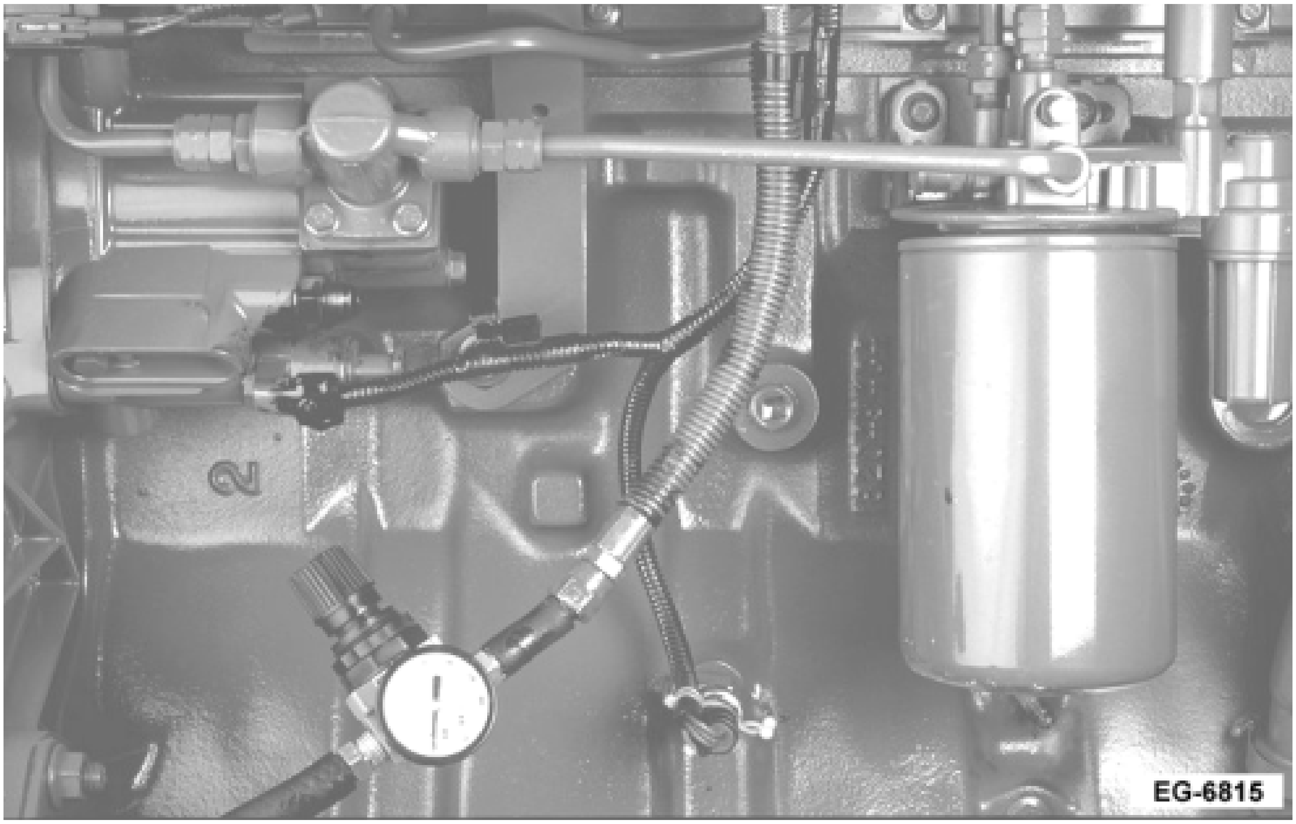

Figure 48 ICP Leakage Test

4. Inspect for leakage around the base of each fuel injector.

If an injector leaks, remove and inspect injector for damage or worn O-rings.

If injectors do not leak, perform a Key-On Engine-Off Injector Test with air pressure still applied. Check oil discharge from each injector. Oil discharge should be equal. Excess oil leakage indicates defective fuel injectors.

To find injector leaks, remove air supply and regulator from the high pressure hose and follow the procedure below.

A. Connect an **automotive cylinder leak tester** to the high pressure hose and apply air pressure from the cylinder leak tester.

B. Conduct an Key-On Engine-Off Injector Test to determine the percent of cylinder leakage for each actuated injector. Remove and inspect injectors showing the most leakage.

C. If none of the injectors have excessive leakage, remove all injectors. Inspect all O-rings for wear and damage. Replace faulty O-rings.

   If oil entered the fuel system, drain fuel tank(s) of contaminated fuel.

Possible Causes

Low injection pressure (voltage) indicates low oil pressure to the injectors. This may be caused by

- No oil in engine
- Oil reservoir leak (possibly through check valve for the high pressure pump)
- Cracked or porous cylinder head
- Cracked or porous fuel/oil manifold
- Defective high pressure pump
- Injector O-ring leak
- Injector body leak
- Internal leakage of HEUI injector
- IPR valve stuck open
- Pump drive gear loose or damaged
- Faulty lube oil pump unable to fill reservoir
- Faulty IPR wires

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- ICP adapter fitting from Hydraulic Fitting Kit (ZTSE4359)
- DMM (ZTSE4357) (optional)
- ICP sensor Breakout Tee (ZTSE4347)(optional)

Supplemental Diagnostics

- If DTC’s are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

FUEL PUMP PRESSURE TEST

Table 16

14. Fuel Pump Pressure Test		
See figure **J** on back of form.		
• Measure at bleeder valve on filter header.		
• Minimum 130 rpm cranking speed for 20 seconds.		
Instrument	Spec	Actual
0-160 psi gauge	35 psi min.	
• If pressure is low, replace fuel filter, clean fuel strainer and retest.		
• If pressure is still low, do **Performance Diagnostics Test 3.**		

Purpose

To determine correct fuel pressure to start and run the engine.

NOTE – If vehicle has an optional fuel/water separator and a water-in-fuel probe, check with driver to determine if the water-in-fuel lamp was lit during vehicle operation.

Test Procedure

1. Remove air bleed valve on fuel filter header (See Figure 49, page 90). Install 1/8 in (3 mm) pipe fitting.
2. Connect a line from the fitting to Gauge Bar (See Figure 50, page 90).
3. Measure fuel pressure by cranking engine for 20 seconds and record maximum pressure on diagnostic form and compare to specifications. If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest. If pressure is low perform the following:

   WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.

   a. Remove fuel return line and install plug into fuel return opening.
   b. Crank engine and check fuel pressure gauge. If pressure rises, replace fuel return valve and recheck fuel pressure. If pressure does not increase, see Transfer Pump Restriction, Performance Diagnostics, Test 3 (See Table 19, page 96).

   NOTE – Several crank cycles may be required to purge air out of the fuel system.

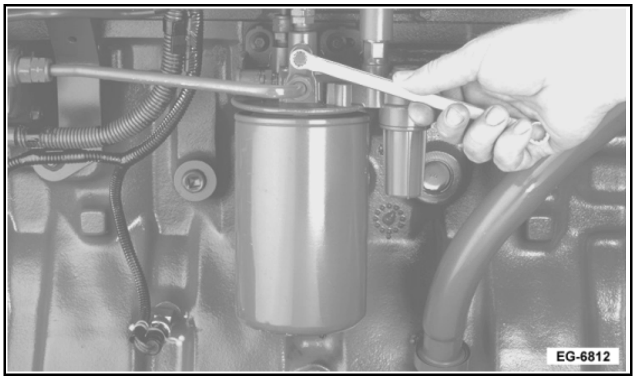

Figure 49 Removing Air Bleeder Valve

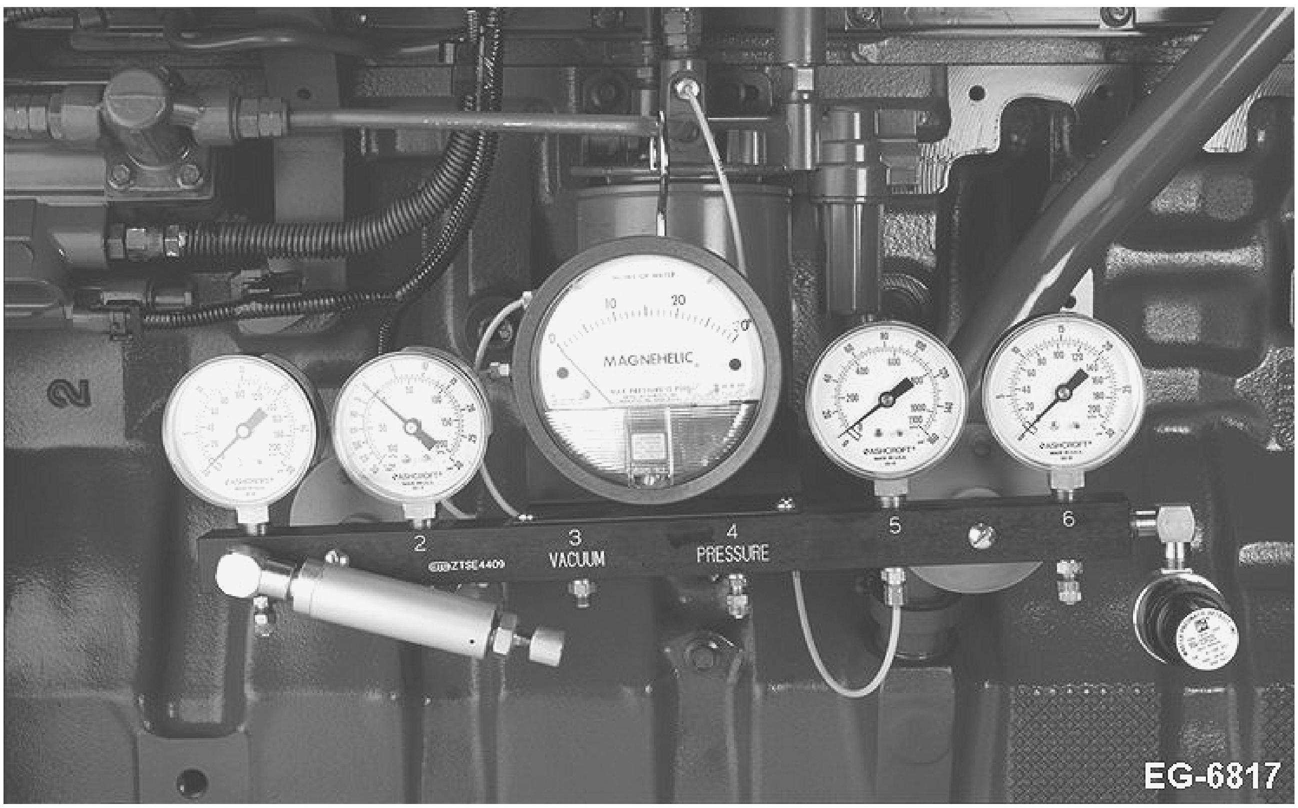

Figure 50 Measuring Fuel Pressure with Gauge Bar (PS94-831-3)

Low Fuel Pressure Possible Causes

- No fuel in tank.
- Dirt or fuel jelling in cold ambient temperatures. Replace fuel filter, clean fuel strainer, and retest.
- Debris in the fuel regulator valve.
- A kinked or severely bent fuel supply line or blockage at the pickup tube or any restriction between the inlet to the transfer pump and the tank pickup tube.
- A loose fuel line on the suction side of the fuel system could allow air into the system.
- Defective fuel transfer pump.

TOOLS REQUIRED

- Gauge Bar (PS94-831-3) or fuel pressure gauge, appropriate line with 1/8 in (3 mm) NPT fitting.

PERFORMANCE DIAGNOSTICS

ENGINE OIL CHECK

Table 17

1. Engine Oil Check • Check oil level and leaks. • Contaminated oil (fuel or coolant) • Check oil grade and viscosity. • Oil pressure

Purpose

To check engine oil level and quality and determine if oil pressure is correct for the injection control pressure system.

Test Procedure

1. Park vehicle on level ground. Check oil level with oil level gauge. If the oil level is, the fuel injectors will not work correctly.

   If the oil level is above full, the engine has been incorrectly serviced, or fuel is diluting the oil. Check oil for fuel odor.

2. Inspect oil for color and odor. Milky white oil and an ethylene glycol odor indicates coolant contamination.

3. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 motor oil below 20°F (-6.7°C)**. Long oil drain intervals can cause increased oil viscosity; Thicker oil will make engine cranking and starting more difficult below freezing temperatures. See lube oil chart in the engine operator's manual for the correct grade of oil for vehicle operation in various temperature ranges.

Possible Causes

- Oil level low - Oil leak, oil consumption, incorrect servicing.
- Oil level high - Incorrect servicing, fuel dilution from lift pump.
- Oil contamination with coolant - Oil cooler, head gasket, porosity, (accessories i.e. water cooled air compressors.)

Tools Required

- None

FUEL PRESSURE TEST

Table 18

2. Fuel Pressure Test See figure **J** on back of form. • Take fuel sample from tank. • Check fuel for contamination. • Measure fuel pressure at fuel filter bleeder. • Measure fuel pressure at high idle.		
Instrument	Spec	Actual
0-160 psi gauge	45 psi min.	
• If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest. • If fuel pressure is still low, do **Performance Diagnostics Test 3.**		

Purpose

To determine if fuel system has clean fuel and correct pressure to start and run the engine.

Sufficient / Clean Fuel Test

1. Take fuel from tank.

   NOTE – Fuel must be correct grade, clean, and undiluted.

2. Inspect fuel. Fuel must be clean, free of air, contaminants, water, icing or clouding. Fuel should be straw colored. Fuel with a colored dye (red or blue) indicates designation for off-highway use.

3. Check for gasoline or kerosene odors. Engine oil in the fuel may indicate an injector O-ring leak and loss of injection control pressure. See Hard Start/No Start Diagnostic Test 13, Low ICP Pressure Test, which includes ICP Leakage Test in Section 2 (See Table 15, page 84) to determine the cause of oil in the fuel. Drain tank and properly dispose of contaminated fuel.

Fuel Pressure Test

1. Remove air bleed valve on fuel filter header (See Figure 51, page 93). Install a 1/8 in (3 mm) pipe fitting in place of the bleed valve.

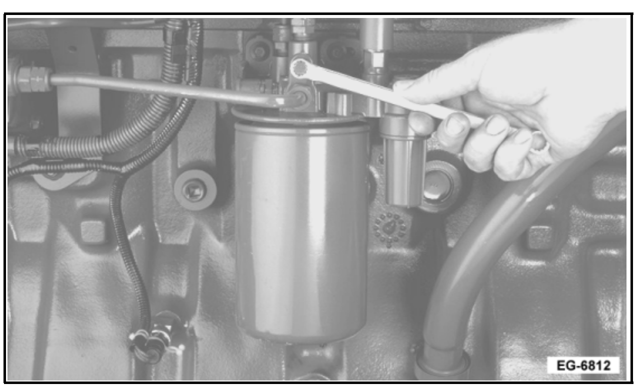

Figure 51 Removing Air Bleeder Valve

2. Connect a line from the fitting to Gauge Bar. See Measuring Fuel Pressure with Gauge Bar (See Figure 52, page 94).

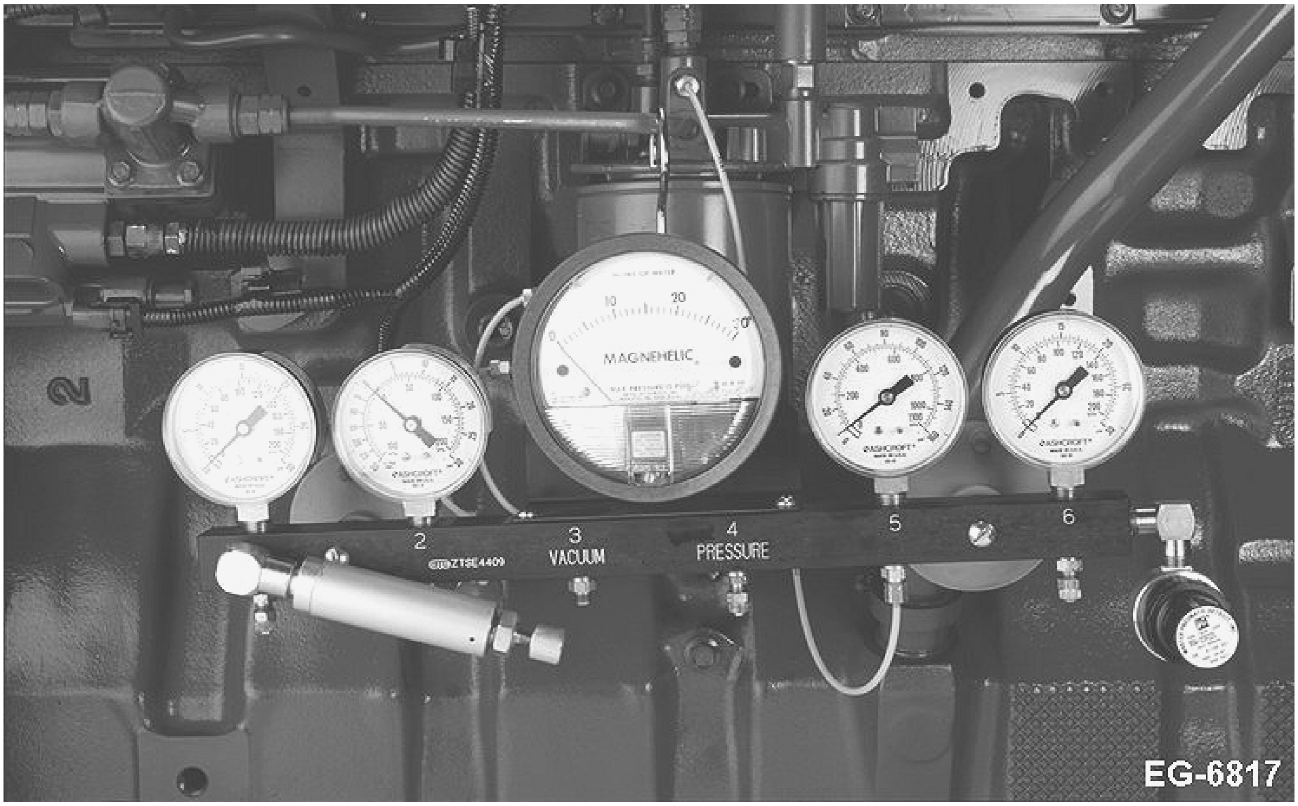

Figure 52 Measuring Fuel Pump Pressure with Gauge Bar (PS94-831-3)

3. Measure fuel pressure at high idle. Record pressure on diagnostic form and compare to specifications. **If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest. If pressure is low do the following:**

> **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to cranking engine.**

   a. Remove fuel return line and install plug (to prevent fuel from exiting) into fuel return opening.

   b. Crank engine and check fuel pressure gauge. If fuel pressure rises, replace fuel return valve and recheck fuel pressure. If fuel pressure does not increase, do Transfer Pump Restriction Test 3 (See Table 19, page 96).

   NOTE – Perform Test 25, Fuel Pressure Full Load before removing pressure test equipment.

Possible Causes

- No fuel in tank
- In-line fuel valve shut off (if equipped)
- Fuel supply line from tank broken, crimped or kinked.

- Incorrect fuel grade for cold temperatures. Fuel waxed or jelled (most likely grade 2 fuel). Pickup tube in tank could be clogged or cracked.
- Water, ice, or contaminants in the tank and fuel system stopping fuel flow.
- Plugged supplemental filters or water separators causing the fuel system to draw air.

Tools Required

- Clear container (approximately 1 Quart or 1 Liter)
- Gauge Bar (PS94-831-3) and appropriate line with 1/8 in (3 mm) NPT fitting

TRANSFER PUMP RESTRICTION TEST

Table 19

3. Transfer Pump Restriction Test		
Perform this test only if fuel pressure is low. See figure **K** on back of form.		
• Measure restriction at fuel filter inlet @ high idle.		
Instrument	Spec	Actual
0-30 in Hg vacuum Gauge	< 8 in Hg	
• If restriction is high, check for blockage between fuel pump and tank.		
• If restriction is < 8 in Hg, see EGES-215.		

Purpose

To determine if low fuel pressure is caused by excessive restriction in the fuel supply line from the fuel tank to the transfer pump inlet.

Test Procedure

1. Connect a Tee between the fuel filter inlet and fuel supply line. Connect a line from the Tee to a 0-30 in Hg vacuum gauge on Gauge Bar. See measuring Transfer Pump Restriction with Gauge Bar (See Figure 53, page 97).

   NOTE – Transfer pump restriction test will only detect a restriction in the fuel line (filter header to tank) or tank pickup. Restriction between the transfer pump and the strainer will not be detected by this test.

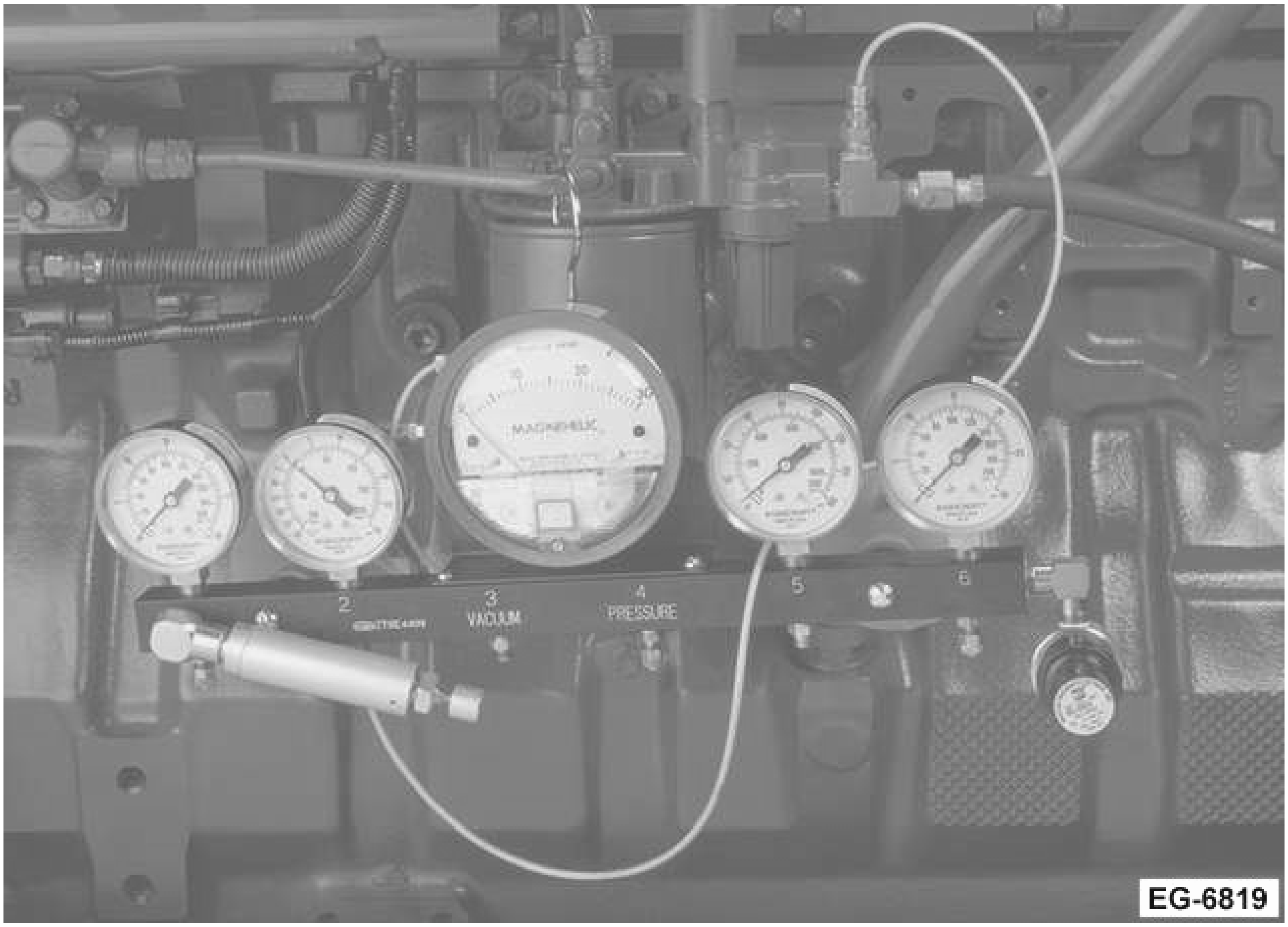

Figure 53 Measuring Transfer Pump Restriction with Gauge Bar

2. Measure fuel inlet restriction at high idle and record reading on diagnostic form.

3. If restriction exceeds 8 in Hg, locate the restriction on the suction side of the fuel system and correct. If restriction is within specifications or very low, check for air ingestion between fuel inlet and the transfer pump inlet by performing the following.

   a. Remove fuel supply line. Connect a clear plastic line to the fuel inlet fitting and connect the fuel supply line to clear plastic line.

   b. Check for air bubbles in the clear plastic line while engine is running at high idle. If air bubbles are seen, inspect fuel system for suction leaks. Repair system, if necessary. If air bubbles were not present, remove clear plastic line.

   > **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to starting engine.**

   c. Install plug to seal off the fuel inlet. Start engine and run at high idle. Vacuum reading should be greater than 22 in Hg. If less, check for air ingestion from the vacuum gauge to the transfer pump. If no leak is found, replace transfer pump.

NOTE – If no leaks are found on the inlet side of the fuel system, while the transfer pump is providing > 22 in Hg. vacuum, replace fuel return valve. Recheck fuel pressure to verify the valve was defective.

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.
- Primary fuel filter or fuel/water separator clogged.
- 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.
- Primary fuel filter or fuel/water separator may be ingesting air into fuel system via loose connections etc.
- Fuel return valve defective or stuck open due to debris.
- Defective fuel transfer pump.

Tools Required

- Gauge Bar (PS94-831-3)
- Tee or reworked hollow screw fitting
- NPT pipe adapter and appropriate fuel lines

EST DIAGNOSTIC TROUBLE CODES (DTC'S)

Table 20

4. EST Diagnostic Trouble Codes
• Install Electronic Service Tool (EST).
• See figure **B** on back of form.
Active DTC's
Inactive DTC's

Purpose

To determine if the Electronic Control Module (ECM) has detected Diagnostic Trouble Codes (DTC's) that could cause engine performance problems.

Test Procedure

1. Turn accessories and ignition switch OFF.

2. Connect the **International** interface cable from the Electronic Service Tool (EST) to the American Trucking Association (ATA) diagnostic connector. The ATA diagnostic connector is located below the dash panel (left side) (See Figure 54, page 99).

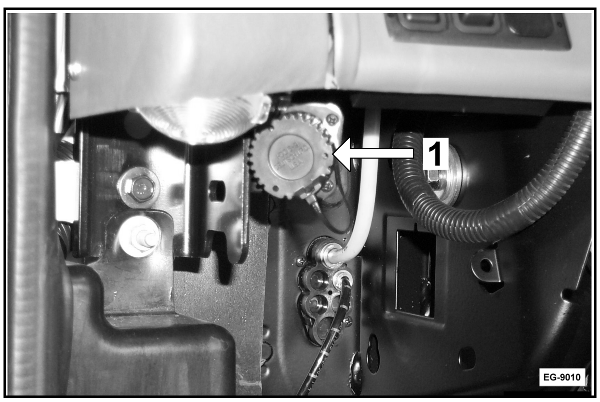

Figure 54

1. ATA Connector (shown with protective cap in place)

NOTE – ATA connectors may require a 6 pin to 9 pin cable adapter.

3. Use the EST to view the DTC's, refer to Master Diagnostics (See MASTER DIAGNOSTICS (MD 32), page 394).

If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

Record DTC's on Electronic Control System Diagnostics form EGED-220.

NOTE – Active DTC's indicate systems that must be repaired before continuing with the Diagnostic form EGES-220.

Possible Causes

- Electronic malfunctions that can be detected by the ECM continuously.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- Adapter Cable, 6 pin to 9 pin (ZTSE4467)(optional)

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

EST KEY-ON ENGINE-OFF STANDARD TEST

Table 21

5. EST Key-ON Engine-OFF Standard Test • Select Key-ON Engine-OFF Standard Test from menu.
DTC's Found
Correct problem causing active DTC's before continuing.

Purpose

To determine electrical malfunctions detected by the Electronic Control Module (ECM). This requires an Output Circuit Check self test.

Test Procedure

1. Record and clear Diagnostic Trouble Codes.
2. Turn ignition key ON.
3. Select Key-ON Engine-OFF Standard Test from the Diagnostics drop-down menu (See Figure 37, page 66).

This will cause the electronics to perform an internal self-test. The internal self-test must be completed before another Key-ON Engine-OFF test can be started.

When the internal self-test is complete, the screen will show all active Diagnostic Trouble Codes found in the self-test. Scroll down for other DTC's if they appear to be off the screen. Only new DTC's are displayed.

The test is repeated by selecting, Key-ON Engine-OFF Standard Test in the Diagnostics sub-menu.

Possible Causes

- Defective electrical components or circuitry.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

EST KEY-ON ENGINE-OFF INJECTOR TEST

Table 22

6. EST Key-ON Engine-OFF Injector Test
Test 5 must be done before doing this test. • Select Key-ON Engine-OFF Injector Test from menu.
DTC's Found

Purpose

To determine if fuel injector electronics are working correctly, by energizing each injector in a programmed sequence. The Electronic Control Module (ECM) will monitor the Key-On Engine-OFF Injector Test and transmit DTC's if injectors or related electrical circuits are not working correctly.

Test Procedure

NOTE – The Engine-OFF Standard Test must be done before starting the Key-On Engine-OFF Injector Test.

When the Engine-OFF Standard Test is over, select the Diagnostics drop down menu and click on Key-On Engine-OFF Injector Test (See Figure 55, page 102).

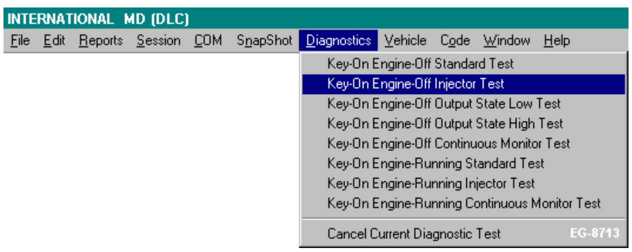

Figure 55

During the Key-ON Engine-OFF Injector Test, injector solenoids should rapidly click or buzz when actuated. If clicks are not heard, the injectors are not working. When the Key-ON Engine-OFF Injector Test is over, detected DTC's will be displayed. More DTC's can be found by scrolling down.

See Section 3 Electronic Control System Diagnostics (See Table 48, page 162).

Record DTC's found on Diagnostic Form EGED-220.

Possible Causes

- Bad wiring harness connection at injector solenoid.
- Open or shorted engine wiring harness to injectors.
- Defective injector solenoids.
- Defective ECM.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

DIAGNOSTIC TROUBLE CODE ACCESS

NOTE – Accessing Diagnostic Trouble Codes using the Cruise Control buttons is primarily used as a backup method when an EST is not available.

Table 23

7. Diagnostic Trouble Code Access
See figure **C** on back of form. • Set Parking Brake, turn ignition switch ON. • Depress CRUISE ON and RESUME/ACCEL buttons simultaneously.
DTC's Found

Purpose

To read DTC's detected by the Electronic Control Module (ECM), if the Electronic Service Tool (EST) is not available, or if the EST **does not** receive Self Test Input data.

The Cruise Control buttons on the steering wheel act as an interface between the Operator and the ECM. The resulting display of the flashing amber ENGINE lamp indicates the ECM is performing a series of electronic tests.

Test Procedure

To display Diagnostic Trouble Codes, set the parking brake and turn the ignition key to the ON position. Press and release the CRUISE ON button and the RESUME/ACCEL button simultaneously (See Figure 56, page 104). **Do not start the engine.**

When the test is complete, the ECM will flash the red **ENGINE** lamp and the amber **ENGINE** lamp to signal the Diagnostic Trouble Codes.

To read the Diagnostic Trouble Code count each time the amber **ENGINE** lamp flashes follow the sequence below. This sequence occurs each time the Cruise Control buttons are depressed to access the Diagnostic Trouble Codes.

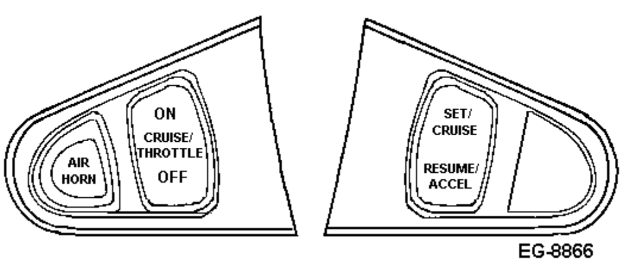

Figure 56 Cruise Control Buttons on Steering Wheel

1. The red **ENGINE** lamp will flash once to indicate the beginning of **ACTIVE** DTC's.

2. The amber **ENGINE** lamp will flash repeatedly signaling the active DTC's.

   NOTE – All DTC's are three digits. Code 111 indicates no Diagnostic Trouble Codes have been detected.

3. Count the flashes in sequence. After each digit of the code a short pause will occur. **Three flashes** and a pause would indicate number 3. **Two flashes**, a pause, **three flashes**, a pause, and **two flashes** and a pause would indicate Diagnostic Trouble Code **232**. If there is more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

After all active DTC's have flashed, the red ENGINE lamp will flash twice to indicate the start of **INACTIVE** DTC's. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once between each DTC.

After all DTC's have been sent, the red ENGINE lamp will flash three times indicating END OF MESSAGE.

To repeat DTC transmission, press and release the CRUISE ON and RESUME/ACCEL buttons once. The ECM will once again send the stored DTC's. If DTC's are set, see Engine Diagnostic Trouble Codes (See Table 48, page 162).

Clearing Inactive Diagnostic Trouble Codes

A. Set park brake (required for correct ESC signal and to clear codes).
B. Turn key switch to the IGN/ON position.
C. Depress and hold the CRUISE ON and RESUME/ACCEL buttons simultaneously.
D. Continue holding the Cruise Control buttons. Depress and release the accelerator pedal three (3) times within a six (6) second interval.
E. Release the Cruise Control buttons.
F. Inactive codes will be cleared.

Possible Causes

- Electronic component or circuitry failures.

Tools Required

- None

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

INTAKE RESTRICTION TEST

Table 24

8. Intake Restriction Test		
See figure **L** on back of form.		
• Measure restriction at high idle and no load.		
Instrument	Spec	Actual
Manometer or Magnehelic Gauge	12.5 in H_20	

Purpose

To determine if the intake/air cleaner is restricted. A restricted intake/air cleaner will cause low power and poor fuel economy.

NOTE – High intake restriction may cause excessive black or blue smoke when starting the engine.

Inspect Air Intake Restriction Indicator

1. See Operation and Maintenance Manual, for details about the air cleaner restriction gauge and indicator.

   NOTE – Replace the air cleaner element when restriction reaches the maximum allowable limit. Measure restriction with a service indicator, water manometer, or magnehelic gauge.

2. Check air cleaner elements for damaged gaskets or dents. Replace as necessary.

3. Inspect inlet piping for debris.

Single Element Air Cleaner

Measure air cleaner restriction as follows:

1. Attach the restriction test gauge to water manometer or magnehelic gauge with air cleaner housing tap. See Restriction Test (access location) (See Figure 57, page 107).

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 H_2O (3.13 kPa).

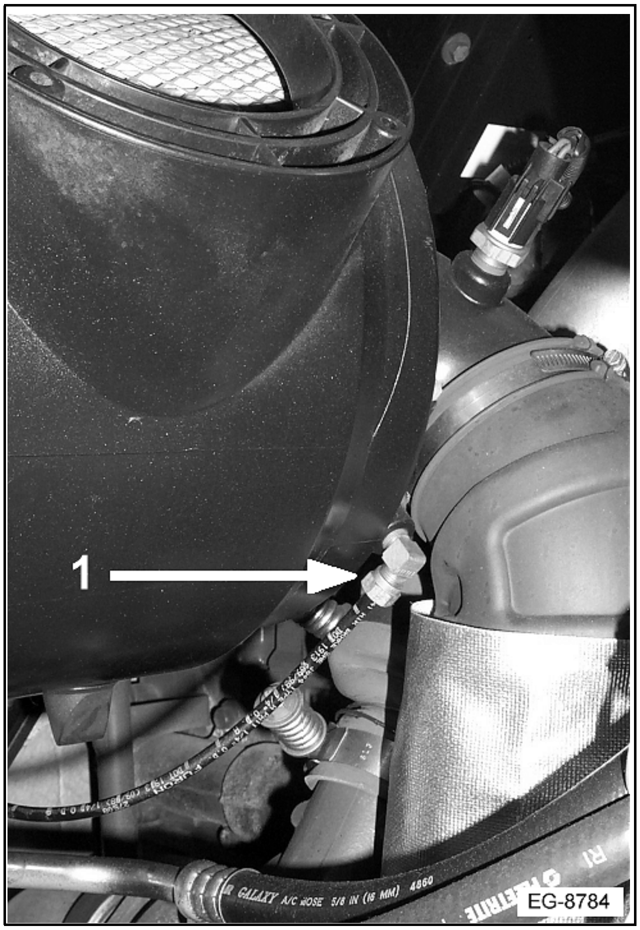

Figure 57 1. Intake Restriction Test Access Location

NOTE – The true maximum air cleaner restriction can only be obtained when operating the engine at full load and rated horsepower. The vehicle mounted indicator or vacuum gauge will sense maximum restriction. When 25 in H_2O (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 H_2O (3.13 kPa) is measured at no load.

NOTE – High air cleaner restriction can cause turbocharger seals to unseat, causing oil to be drawn in around 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 restriction connection is 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:

Visual Inspection Procedure:

NOTE – Two different types of indicators appear on the air cleaner elements. This is the result of two separate vendors supplying air cleaner elements to International during assembly. Replace the element when the green dot disappears from the element or from the window in the retaining nut.

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

Two different types:

1. Dual Element Air Cleaner with Indicator in End Cap (See Figure 58, page 108).
2. Dual Element Air Cleaner Retaining Nut Indicator (See Figure 59, page 109).

IMPORTANT – Each supplier's retaining nut requires a different torque value.

Dual Element Air Cleaner with Indicator in End Cap, **60-75 in·lbs (6.8-8.5 N·m)**.

Dual Element Air Cleaner Retaining Nut Indicator, **120 in·lbs (13.6 N·m)**.

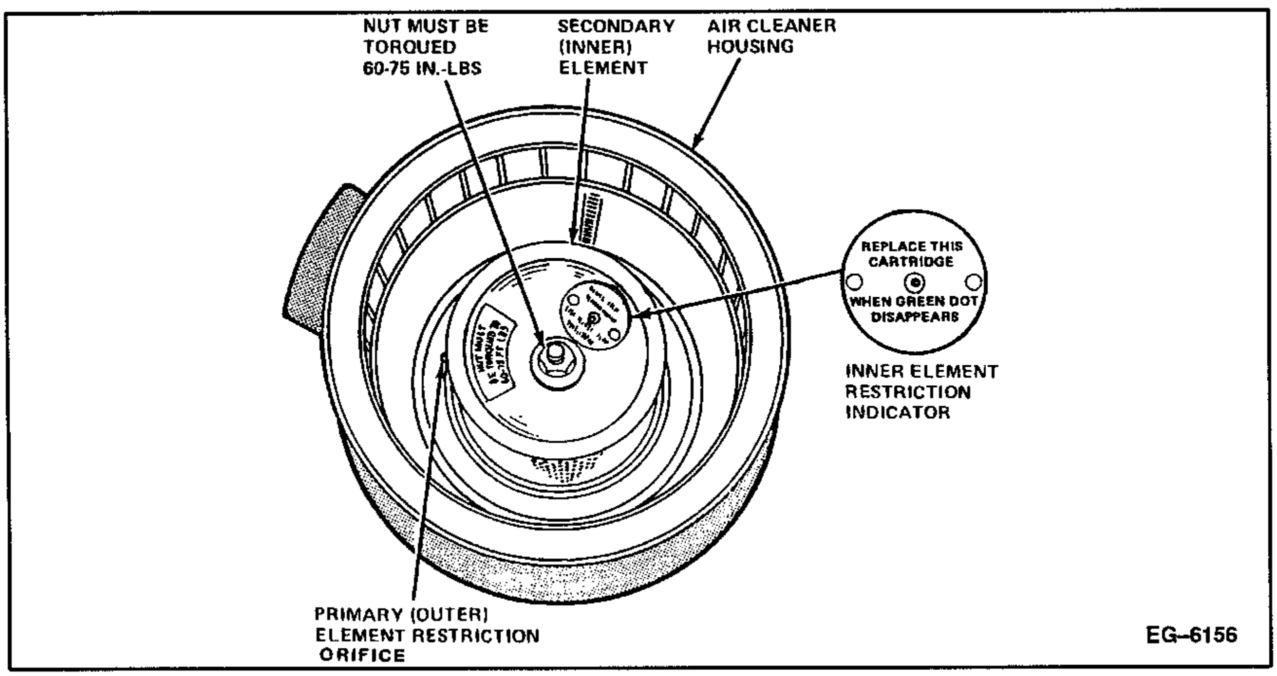

Figure 58 Dual Element Air Cleaner with Indicator in End Cap

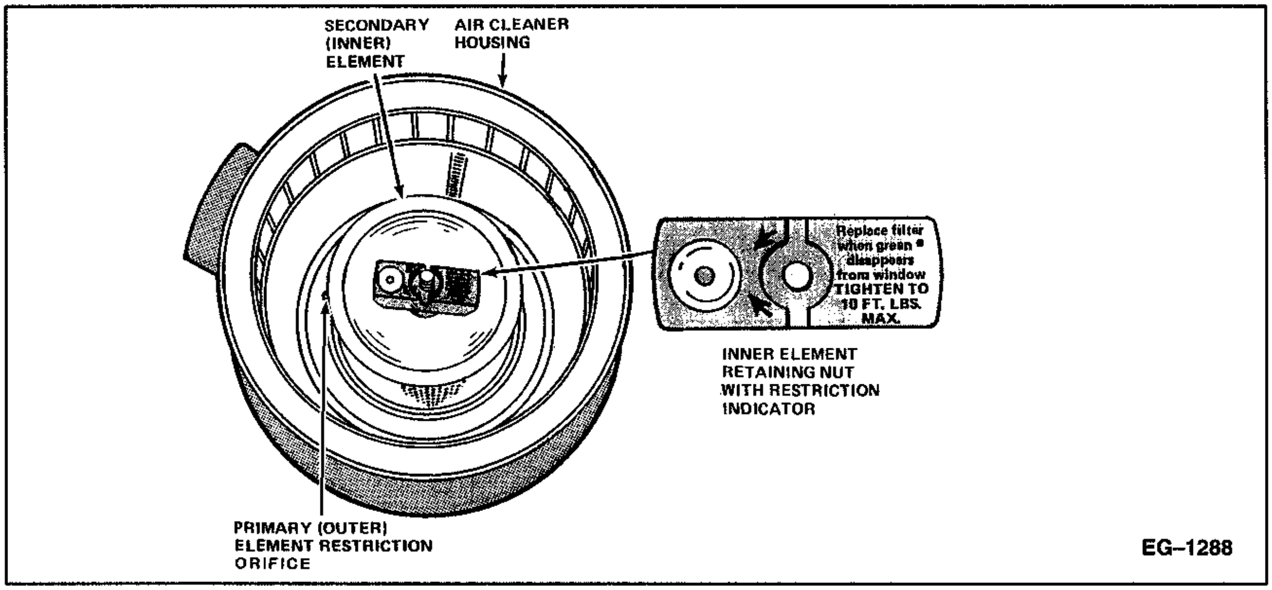

Figure 59 Dual Element Air Cleaner Retaining Nut Indicator

Possible Causes

- Dirty air cleaner element.
- Snow, plastic bags, or other foreign material may restrict air flow in the air cleaner inlet. Repaired engines, may have rags or cap plugs in the intake system.

Tools Required

- Gauge Bar (PS94-831-3)
- Magnehelic Gauge or Water Manometer

EST KEY-ON ENGINE-RUNNING STANDARD TEST

Table 25

9. EST Key-ON Engine-Running Standard Test **NOTE – Engine must be above 160°F** • Select Key-ON Engine-Running Standard Test from menu.
DTC's Found

Purpose

To verify correct operation and specification ranges for engine actuators and electronic sensors. The Electronic Service Tool (EST) signals the Electronic Control Module (ECM) to perform the Key-ON Engine-Running Standard Test. The ECM will activate the actuators, monitor sensor feedback signals, and send fault codes for actuators or sensors to the EST.

Test Procedure

IMPORTANT – Before running the Key-ON Engine-Running Standard Test, set parking brake and make sure the transmission is in neutral.

1. Start and run engine until it reaches 160°F (71°C) minimum.

   NOTE – Engine coolant temperature must reach 160°F (71°C) minimum for the ECM to accurately test engine actuators and sensors. If engine coolant temperature is below self test range, the EST tool will show ECT Out of Self Test Range.

2. Select the Key-ON Engine-Running Standard Test from the Diagnostic drop-down menu.

   The ECM will start the Key-ON Engine-Running Standard Test. It will command the engine to accelerate to a predetermined rpm and operate the Injection Pressure Regulator (IPR) valve.

Possible Causes:

- Defective or inoperative ICP sensor or IPR valve
- Oil leakage in high pressure Injection Control System
- Defective high pressure pump
- Open or shorted wiring harness to ICP or IPR
- Loose or corroded engine wiring harness for ICP or IPR

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

EST KEY-ON ENGINE-RUNNING INJECTOR TEST

Table 26

10. EST Key-ON Engine-Running Injector Test **NOTE – Engine must be above 160°F** Test **9** must be done before doing this Test. • **Note**: Engine will run rough during this test.
DTC's Found

Purpose

To verify that all power cylinders are contributing equally.

Test Procedure

NOTE – The Engine Running Standard Test (Test 9) must be done first to gain access to the Engine Running Injector Test.

After the Engine Running Standard Test, select Engine Running Injector Test from the Diagnostic drop-down menu (See Key-On Engine-Running Injector Test, page 362).

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.

Record the DTC's on Electronic Control System Diagnostics form EGED-220.

Possible Causes

- Broken compression rings, leaking or bent valves, bent push rods or connecting rods
- Open or shorted engine wiring harness to injectors
- Defective injectors and/or solenoids

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

FUEL PRESSURE TEST (FULL LOAD)

Table 27

11. Fuel Pressure Test (Full Load)		
See figure **J** on back of form. • Measure fuel pressure at fuel filter bleeder. • Measure pressure at full load, rated speed.		
Instrument	Spec	Actual
0-160 psi gauge	30 psi min.	
• If pressure is low, replace fuel filter, clean fuel strainer and retest. • If pressure is still low, go to Test 3.		

Purpose

To determine if the fuel system is supplying the engine with the proper fuel quantity and pressure at full load conditions.

Test Procedure

WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to starting engine.

NOTE – If the fuel filter has a water-in-fuel probe, ask the vehicle operator if the water-in-fuel lamp (yellow) is illuminated during vehicle operation.

1. If pressure gauge is not connected to fuel system in Test 2, remove air bleed valve on fuel filter header. Install 1/8 in (3 mm) pipe fitting in place of the bleed valve (See Figure 51, page 93).

2. Connect a line from the fitting to the 0-160 psi gauge of the Gauge Bar. See Measuring Fuel Pressure with Gauge Bar (See Figure 52, page 94). 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. 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 and accelerate to rated speed and 100% load.

   NOTE – Drive the vehicle uphill or fully loaded to reach the correct engine loading at rated engine speed.

4. Measure fuel pressure and record on Mechanical Diagnostics form EGED-220. If pressure is not within specifications, replace fuel filter, clean fuel strainer, and recheck fuel pressure. If fuel pressure remains low after replacing the filter, perform Transfer Pump Restriction Test 3 (See Table 19, page 96).

NOTE – Several crank cycles may be required to purge the air from the fuel system after replacing the fuel filter.

Possible Causes:

- A clogged fuel filter or fuel strainer could cause high restriction and low fuel pressure. Replace fuel filter, clean strainer, and retest.
- Debris in the fuel regulator valve will cause low fuel pressure, see Test 3 (See Table 19, page 96).
- A kinked or severely bent fuel supply line, or blockage at the pickup tube could cause restriction and low fuel pressure, see Test 3 (See Table 19, page 96).
- 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, see Test 3 (See Table 19, page 96).
- The fuel pump could have internal damage, e.g. seized plunger or leaking check valves.
- A restriction from the transfer pump inlet to the fuel tank can cause low fuel pressure.
- A restriction between the fuel inlet fitting, strainer and transfer pump inlet can cause low fuel pressure.

Tools Required

- Gauge Bar (PS94-831-3) and appropriate line with 1/8 in NPT fitting

ICP PRESSURE TEST

Table 28

12. ICP Pressure Test • Monitor ICP pressure and engine rpm. Use EST data list or breakout tee and DMM. See figure **G** on back of form. • See EGES-215 for specifications.		
PID	Spec	Actual
Low Idle	psi/volts	
High Idle	psi/volts	
Full Load	psi/volts	
• If ICP is low or unstable, disconnect ICP sensor and retest. • If problem is resolved, see ICP diagnostics. • If pressure is still low or unstable, replace IPR and retest.		

Purpose

To determine if the high pressure lube oil system is providing sufficient hydraulic pressure to operate the injectors.

Test Procedure

Test should be performed at full load in conjunction with Fuel Pressure Test (Full Load) Test 11 (See Table 27, page 112), and Boost Pressure Test 13 (See Table 29, page 117).

NOTE – Turn all accessories and the ignition off, before connecting Electronic Service Tool (EST) tool to American Trucking Association (ATA) diagnostic connector.

1. Connect the EST to the ATA data link connector. See ATA Connector Location (See Figure 36, page 64).
2. Start Master Diagnostics and select the pre-configured session entitled Road Performance. 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 and accelerate to rated speed and 100% load.

   NOTE – Drive the vehicle uphill or fully loaded to reach the correct engine load at rated engine speed.

3. Read maximum pressure for ICP pressure and record on Electronic Control System Diagnostic form EGED-220.
4. Stop the vehicle, read psi for low and high idle ICP pressures, and record on Electronic Control System Diagnostic form EGED-220.

Alternate Method for Measuring ICP Using (Breakout Tee)

1. Remove engine harness connector from ICP sensor.
2. Connect ICP Breakout Tee to the removed engine harness connector and the ICP sensor.
3. Place a DMM in cab of vehicle and connect a long set of leads (+Green, -Black) to the Breakout Tee utilizing the connection points as shown in Measuring Injection Control Pressure Using Breakout Tee (See Figure 44, page 82).

4. Operate vehicle under load as described in Test Procedure Step 2 page 114.

Possible Causes

Low voltage for injection control pressure indicates insufficient oil pressure to operate the fuel injectors (perform ICP Leakage Test). This may be caused by:

- Defective IPR valve
- Defective High Pressure Pump
- Injection Control Pressure system leakage
- ECM commanding the IPR valve to reduce injection control pressure due to:
    a. Low Boost Pressure
    b. Incorrect signal from Accelerator Position Sensor (APS)
    c. Incorrect signal from ICP sensor or wrong ICP sensor

ICP Oil Aeration Test

High-pressure oil supplies the mechanical force needed to push fuel into the cylinder for combustion. Aerated oil can retard the timing of fuel injection into the cylinder. When aerated oil is suspected, perform the following steps.

> ⚠ **WARNING – To avoid personal injury, be certain that the transmission is in neutral, parking brake is applied, and drive wheels are blocked prior to starting engine.**

ICP Oil Aeration Test

1. Start engine and bring to normal operating temperature.
2. Raise engine speed to high idle. Note ICP value (ICP will rise when the engine goes to high idle and then settle to a lower value within a few seconds. Record the lower value).
3. Hold engine speed at high idle for 2 minutes.
4. Watch the ICP value during this time period. Compare with the initial value. If ICP rises and continues to increase in value, the lube oil is being aerated.

Possible causes of oil aeration include overfilled sump, cracked pickup tube, and missing or faulty pickup tube gasket.

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- DMM (ZTSE4357) (optional)
- ICP Breakout Tee (ZTSE4347) (optional)

Supplemental Diagnostics

- If DTC's are set, see DTC column on Engine Diagnostic Trouble Codes (See Table 48, page 162).

See ICP diagnostics in Electronic Control System Diagnostics, Section 3

- ICP Sensor Circuit Diagram Using a Breakout Tee (See Figure 137, page 283)
- ICP Sensor Voltage Test (See Table 71, page 283)
- ICP Sensor Troubleshooting Flowchart (See Figure 138, page 287)
- ICP Sensor Circuit Specifications (See Table 72, page 284)

See IPR diagnostics in Electronic Control System Diagnostics, Section 3:

- Injection Pressure Regulator Circuit Diagrams (See Figure 142, page 295)
- Injection Pressure Regulator and Circuit Diagnostics (See Table 74, page 295)

BOOST PRESSURE TEST

Table 29

13. Boost Pressure Test (Full Load)		
• Monitor boost pressure and engine rpm with the EST in data list. See figure M on back of form. • Use dash tach, 0-30 psi gauge, breakout tee and DMM if EST is not available. • Measure pressure at full load and rated speed. • See EGES-215 for specifications.		
Test	Spec. psi @ rpm	Actual
Peak HP		
Peak Torque		

Purpose

To determine if the engine can develop necessary boost pressure for required power.

Test Procedure

Test should be performed at full load in conjunction with Fuel Pressure (Full Load) Test 11 (See Table 27, page 112) and ICP Pressure Test 12 (See Table 28, page 114).

NOTE – Turn accessories and ignition off, before connecting Electronic Service Tool (EST) to the American Trucking Association (ATA) diagnostic connector.

1. Start Master Diagnostics and select the pre-configured session entitled Road Performance.
2. Drive vehicle on road until the engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor and accelerate to rated speed and 100% load.

   NOTE – Drive the vehicle uphill or fully loaded to reach the correct engine loading at rated engine speed.

3. Record intake manifold boost at full load rated engine speed.

Alternate Test Procedure

1. Remove plug from boost pipe, install adapter fitting, and connect a line as shown in Boost Pressure Tap Location (See Figure 60, page 118). If no plug is on the boost pipe, remove the Manifold Absolute Pressure sensor at intake manifold/valve cover. Install a Tee fitting and reinstall MAP sensor and the test line to the tee.

   NOTE – MAP sensor must be connected during Boost Pressure Test.

2. Route the line from the engine compartment to the inside of the vehicle cab.

   IMPORTANT – Make certain that the test pressure line does not get crimped, chaffed or come in contact with any extremely hot engine surface.

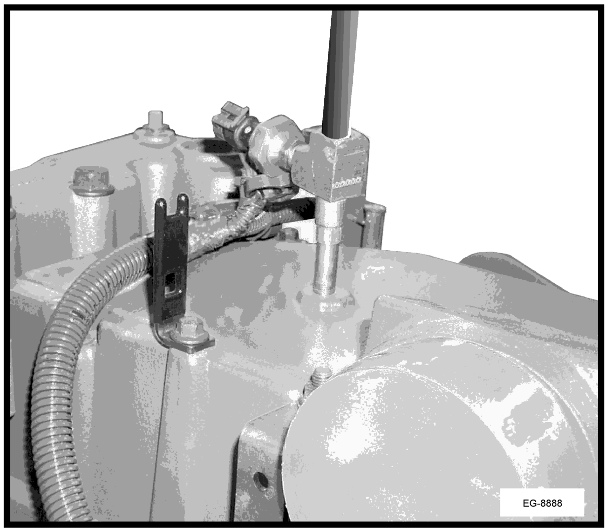

Figure 60 Boost Pressure Tap Location (Center of Intake Manifold / Valve Cover)

3. Temporarily install the Gauge Bar in the cab of the vehicle. Connect the line routed from the boost pressure tap location or Tee at MAP sensor to the appropriate pressure gauge.

4. Drive vehicle on road until the engine reaches operating temperature. Find an open section of road and select a suitable gear. Depress the accelerator pedal (full depression) to the floor and accelerate to rated speed and 100% load.

   NOTE – Drive the vehicle uphill or fully loaded to reach the correct engine loading at rated engine speed.

5. Record intake manifold boost pressure at full load rated engine speed.

   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 DTC’s
- Defective injectors
- Defective turbocharger
- Base engine failure

Tools Required

- Electronic Service Tool (EST) with Master Diagnostics software
- Gauge Bar (PS94-831-3) and a Tee fitting (optional)

CRANKCASE PRESSURE TEST

Table 30

14. Crankcase Pressure Test • Measure at road draft tube with restriction tool **ZTSE4039**. See figure **N** on back of form. • Measure at high idle, NO LOAD.		
Instrument	Spec	Actual
0 to 60 in H_2O Magnehelic Gauge	< 6 in H_2O	

Purpose

To measure power cylinder condition.

Test Procedure

1. Park vehicle on level ground.
2. Make sure breather tube is clean and the valve cover/intake manifold is tight.
3. Make sure engine oil level is not above full mark and the oil level gauge is secured.
4. Install Crankcase Breather Tool (ZTSE4039).

   NOTE – If engine is equipped with a breather extension tube, it will need to be removed for testing purposes.

5. Connect a line from the crankcase breather tool to a water manometer or the magnehelic gauge on Gauge Bar, (See Figure 61, page 120).
6. Run engine to reach normal engine operating temperature before measuring crankcase pressure.
7. Perform engine crankcase pressure test with engine at high idle (no load) rpm. Allow the gauge reading to stabilize before taking the pressure reading.
8. Record crankcase pressure on Electronic Control System Diagnostic form EGED-220.

   IMPORTANT – Do not plug the breather tube during the crankcase pressure test. Plugging the tube can cause crankshaft and turbocharger seals to leak.

9. Remove crankcase breather tool and place breather extension tube back into service.

Possible Causes

Excessive crankcase pressure **with** high oil consumption indicates:

- Dirt in air induction system. Perform Air Induction System Pressure Test (See Figure 33, page 58).
- Badly worn or broken piston rings
- Badly worn or scored cylinder sleeves
- Leaking valve seals or worn valve guides

- A restricted orifice in Crankcase Breather Tool

Excessive crankcase pressure **without** high oil consumption indicates:

- Leaking intake manifold/valve cover gasket
- Air compressor effecting crankcase pressure. Remove compressor discharge line to remove its influence.

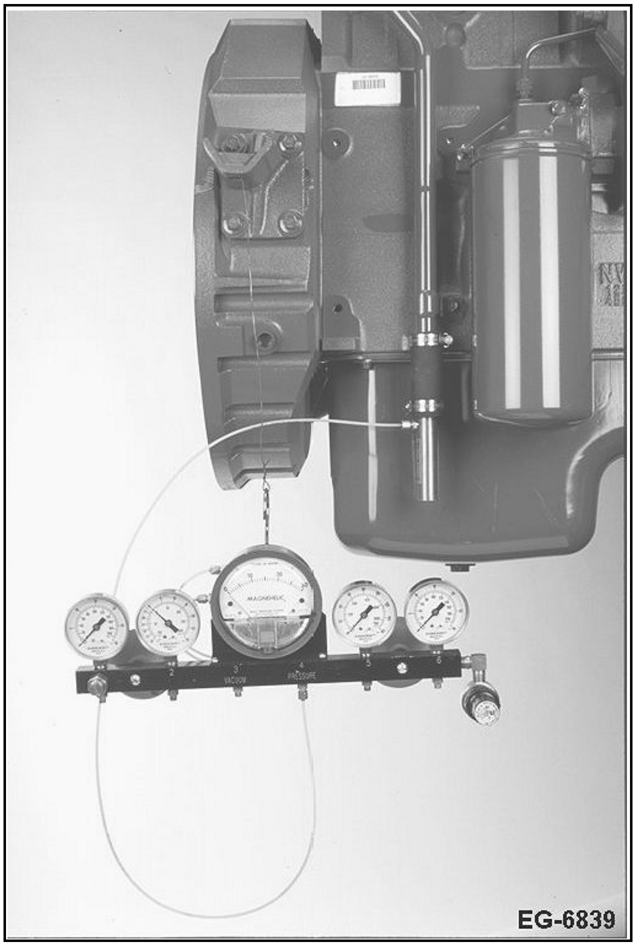

Figure 61 Crankcase Pressure Test

Tools Required

- Magnehelic Gauge on Gauge Bar (PS94-831-3)
- Crankcase Breather Tool (ZTSE4039)

NOTE – If Tests 1–14 meet specifications, engine operation is good: Tests 15–17 are not necessary.

WASTEGATE ACTUATOR TEST

Table 31

15. Wastegate Actuator Test • Apply regulated air to actuator. • Check for leakage and actuator travel.		
Instrument	Spec	Actual
0 to 60 psi gauge	28 ± 2 psi	

Purpose

To determine if the wastegate actuator works correctly.

Test Procedure

1. Remove actuator boost line from turbocharger compressor housing.
2. Connect an air regulator with a 0-60 psi gauge to the actuator boost line. See Wastegate Actuator Test (See Figure 62, page 122).
3. Mark actuator shaft with paint pen.
4. Spray leak detector around the actuator housing. Slowly apply air pressure to the actuator. Movement of the actuator shaft (indicated by position of paint mark) should start between 26 and 30 psi.

If the actuator shaft moves 0.015 in (0.369 mm) or more and the housing does not leak air, the actuator is good. If the actuator shaft moves less than 0.015 in (0.369 mm) and the housing leaks air, the actuator must be replaced. Before replacing the actuator, remove the turbocharger.

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.

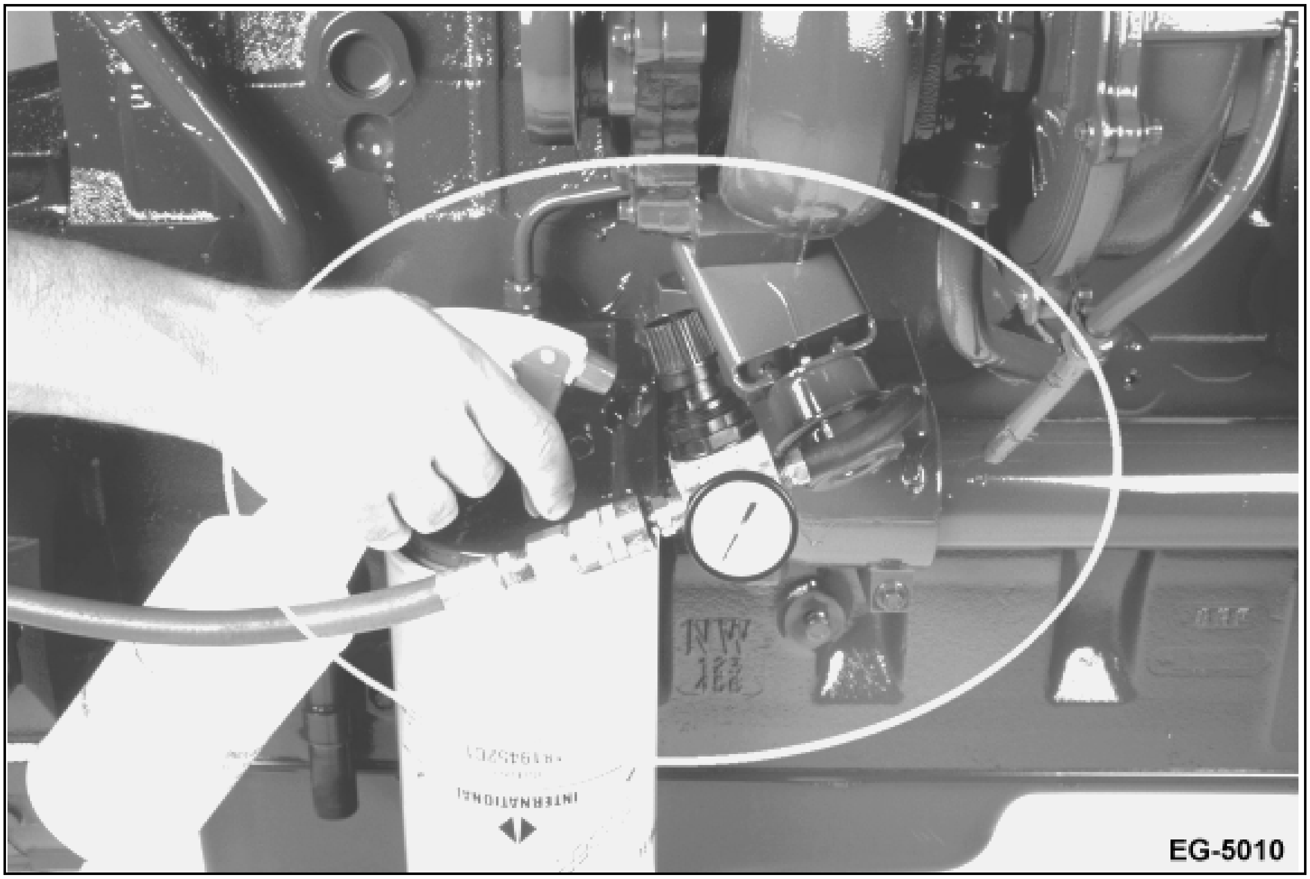

Figure 62 Wastegate Actuator Test

EXHAUST RESTRICTION TEST

Table 32

16. Exhaust Restriction Test • Inspect exhaust system. • Check restriction about 3-6 in after turbo outlet. • Measure at full load and rated speed.		
Instrument	Spec	Actual
Manometer or Magnehelic gauge	0-33 in H_20	

Purpose

To check for restrictions in the exhaust system likely to cause engine performance problems.

Test Procedure

1. Drill and braze a 1/8 in NPT male connector onto a straight section of exhaust pipe approximately 3 to 6 in after the bend in the exhaust pipe. See Measuring Exhaust Restriction (See Figure 63, page 124).
2. Connect coiled copper tubing (min. of 1 ft.) to the connector before attaching the plastic tubing from Gauge Bar.

   NOTE – The coiled copper tubing helps to prevent the plastic tubing from melting.

3. Connect the other end of the plastic tubing to a water manometer or magnehelic gauge on the Gauge Bar.
4. Obtain the data at rated speed on a chassis dynamometer or fully loaded on the highway. The engine must be at normal operating temperature.
5. Exhaust pressures over specification indicate exhaust system restriction and reduced engine power. Replace muffler or exhaust piping.

Possible Causes

- Collapsed exhaust piping
- Restricted exhaust piping
- Damaged muffler
- Malfunctioning retarder

Tools Required

- Gauge Bar (PS94-831-3) or Water Manometer

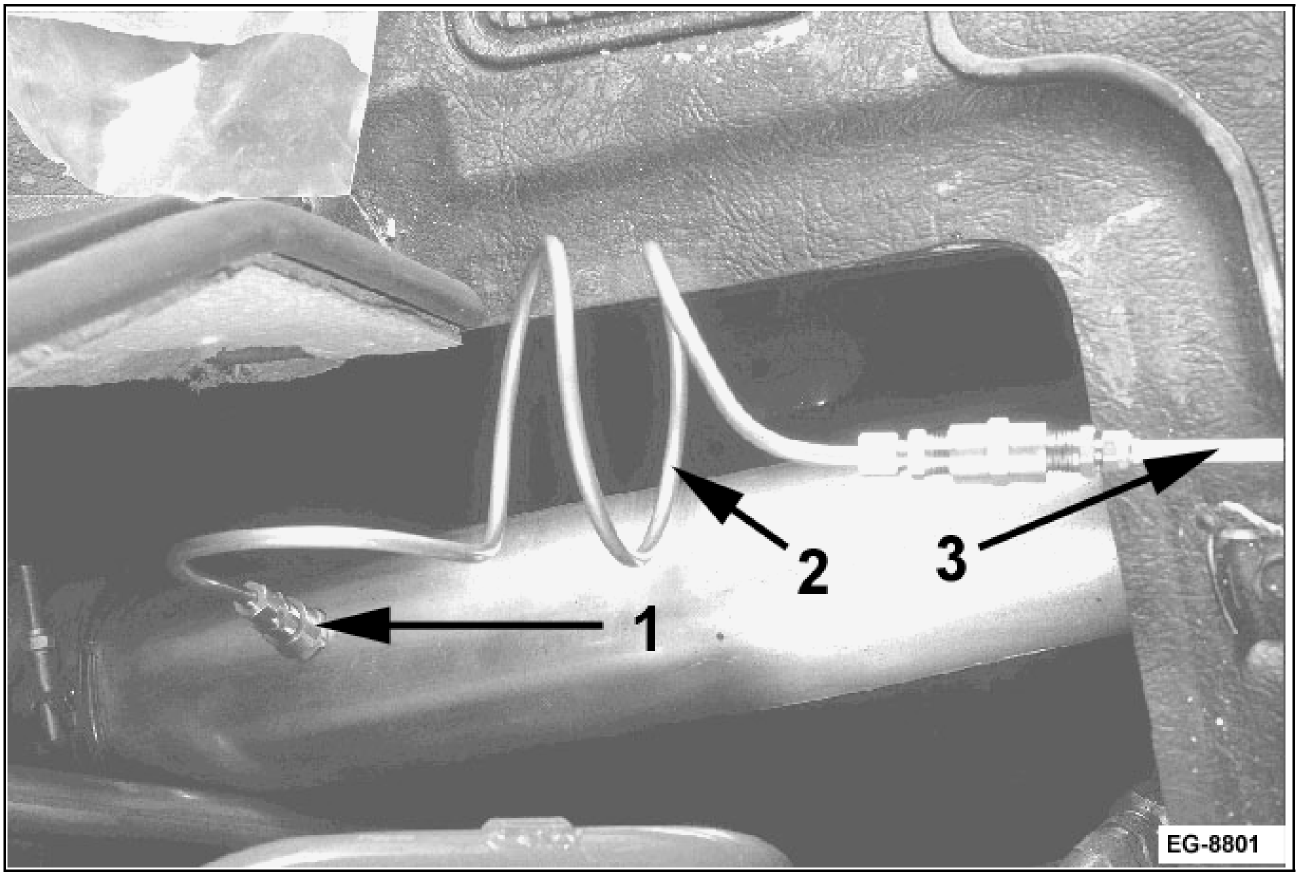

Figure 63 Measuring Exhaust Restriction

1. 1/8 NPT Male Connector
2. Copper Tubing (coiled) 12 in (31 cm) minimum
3. Plastic Tubing

VALVE CLEARANCE TEST

Table 33

17. Valve Clearance Test		
• Engine OFF: Hot or Cold		
Instrument	Spec	Actual
Feeler gauge	0.025 in (0.635 mm)	

Purpose

To determine correct valve clearance.

Test Procedure

1. Remove the valve cover/intake manifold.

2. Rotate the crankshaft until piston No.1 is on the compression stroke and the timing mark on the damper pulley is aligned with the TDC mark on the front cover.

   NOTE – Make sure piston No.1 is on the compression stroke by turning both push rods by hand to verify both valves are closed. The valves are closed when the push rods are loose and can be turned easily.

3. Check valve lash by inserting feeler gauge between the rocker arm and valve stem tip. If adjustment is required, loosen the locknut and turn the valve adjustment screw until the valve lever can support the feeler gauge. See Checking and Adjusting Valve Lash (See Figure 64, page 125).

4. Tighten the locknut once the adjustment is set and remove the feeler gauge. Continue checking and adjusting valves (if necessary) following the valve sequence shown in Valve Adjustment Sequence Chart (See Table 34, page 126). Identify valve numbers and locations on the rocker arm. See Intake and Exhaust Valve Locations (See Figure 65, page 126).

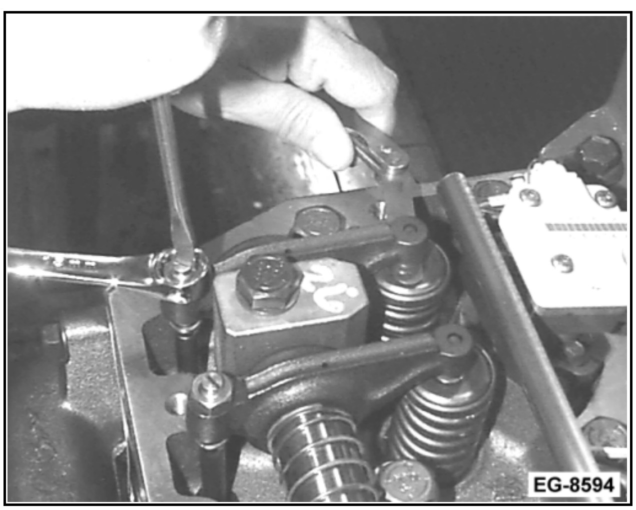

Figure 64 Checking and Adjusting Valve Lash

Table 34

WITH	ADJUST VALVES											
Cylinder Number	1		2		3		4		5		6	
No. 1 Piston T.D.C. (Compression)	INT 1	EXH 2	INT 3			EXH 6	INT 7			EXH 10		
No. 6 Piston T.D.C. (Compression)				EXH 4	INT 5			EXH 8	INT 9		INT 11	EXH 12

NOTE – Six valves are adjusted with the No. 1 piston at TDC (compression stroke) and the remaining six are adjusted with the No. 6 piston at TDC (compression stroke). See Intake and Exhaust Valve Locations (See Figure 65, page 126), and Valve Lash Adjustment Chart (See Table 35, page 126).

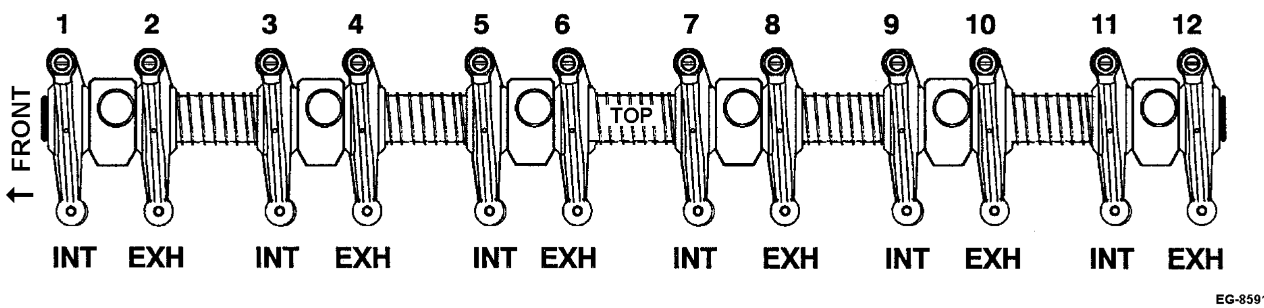

Figure 65 Intake and Exhaust Valve Locations

Table 35

VALVE LASH ADJUSTMENT CHART		
ENGINES	**INTAKE in (mm)**	EXHAUST **in (mm)**
DT 466	0.025 (0.635)	0.025 (0.635)
DT 530		

5. Install the valve cover/intake manifold. Tighten mounting bolts to 13 lb·ft, 156 lb·in, (17.6 N·m). See Torquing Valve Cover/Intake Manifold (See Figure 66, page 127).

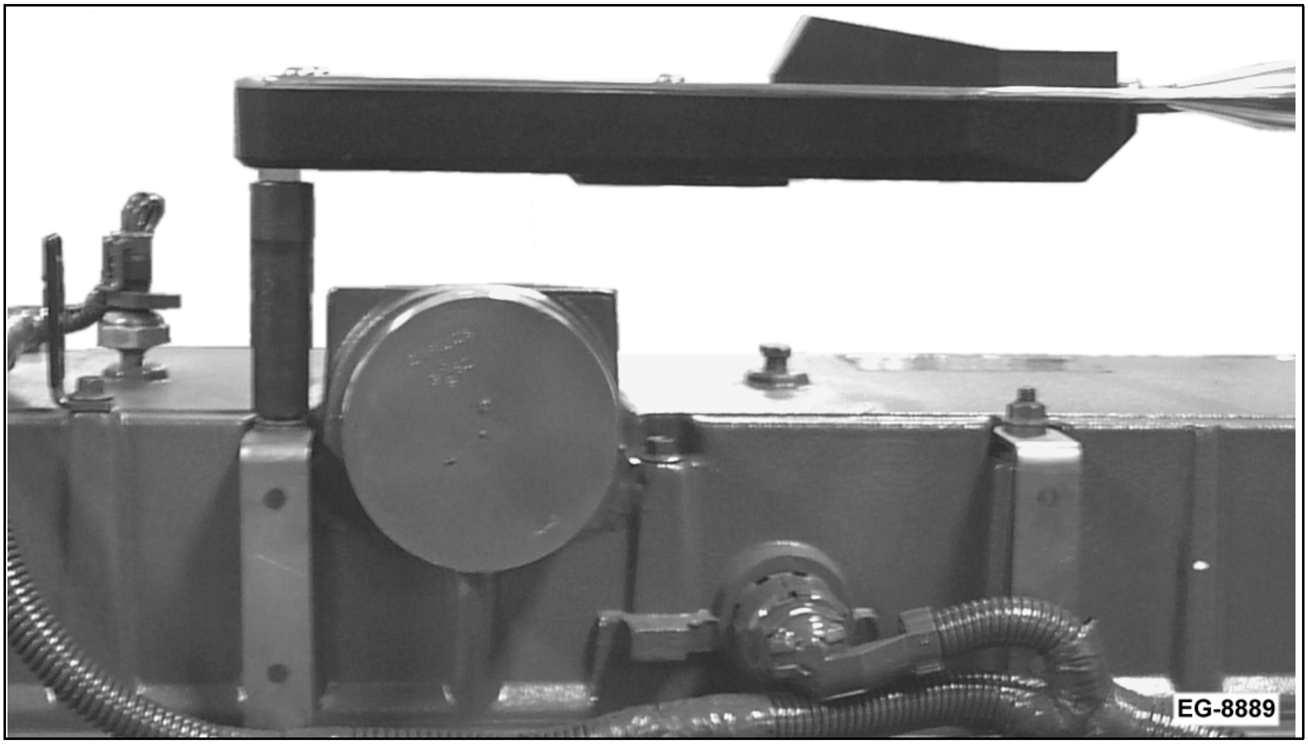

Figure 66 Torquing Valve Cover / Intake Manifold

Possible Causes

- Worn valve train
- Valve seat or face wear

Tools Required

- Feeler Gauge
- Torque Wrench

PERFORMANCE SPECIFICATIONS

2001 MODEL YEAR

DT 466/195 hp @ 2300 rpm (520 ft·lbf torque @ 1400 rpm)

Table 36 DT 466/195 hp @ 2300 rpm (520 ft·lbf torque @ 1400 rpm)

DT 466/195 hp @ 2300 rpm (520 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMB]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466/C195
Engine Rating	195 BHP @ 2300 rpm
Engine Family Rating Code	1121
Injector Part Number, Original Equipment	1830560C2
Turbocharger Part Number	1836093C92
Turbine A/R Ratio	1.11
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2775
High Idle Speed– rpm with automatic transmission	2775
Low Idle Speed — rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1668 ± 300 psi (11.5 ± 2 MPa) 2.3 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3046 ± 150 psi (21 ± 1 MPa) 4.0 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 36 DT 466/195 hp @ 2300 rpm (520 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) – Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed) Intake Manifold Pressure (Full Load, Peak Torque)	22.0 ± 2 psi (152 ± 14 kPa) @ 2300 rpm 8.5 ± 2 psi (59 ± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/215 hp @ 2300 rpm (560 ft·lbf torque @ 1400 rpm)

Table 37 DT 466/215 hp @ 2300 rpm (560 ft·lbf torque @ 1400 rpm)

DT 466/215 hp @ 2300 rpm (560 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMC]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466/C215
Engine Rating	215 BHP @ 2300 rpm
Engine Family Rating Code	1131
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number (Wastegate)	1836092C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2775
High Idle Speed– rpm with automatic transmission	2775
Low Idle Speed — rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1668 ± 300 psi (11.5 ± 2 MPa) 2.3 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (23.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 37 DT 466/215 hp @ 2300 rpm (560 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed)	22.0 ± 2 psi (152 ± 14 kPa) @ 2300 rpm
Intake Manifold Pressure (Full Load, Peak Torque)	11.0 ± 2 psi (76 ± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/215 hp @ 2300 rpm (540 ft·lbf torque @ 1400 rpm)

Table 38 DT 466/215 hp @ 2300 rpm (540 ft·lbf torque @ 1400 rpm)

DT 466/215 hp @ 2300 rpm (540 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NNG]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466/CL215
Engine Rating	215 BHP @ 2300 rpm
Engine Family Rating Code	1151
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number (Wastegate)	1836092C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2775
High Idle Speed– rpm with automatic transmission	2775
Low Idle Speed — rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1668 ± 300 psi (11.5 ± 2 MPa) 2.3 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (23.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 38 DT 466/215 hp @ 2300 rpm (540 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed)	22.0 ± 2 psi (152 ± 14 kPa) @ 2300 rpm
Intake Manifold Pressure (Full Load, Peak Torque)	11.0 ± 2 psi (76 ± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/230 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)

Table 39 DT 466/230 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)

DT 466/230 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMD]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466/C230
Engine Rating	230 BHP @ 2300 rpm
Engine Family Rating Code	1141
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2775
High Idle Speed– rpm with automatic transmission	2775
Low Idle Speed– rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1305 ± 300 psi (9 ± 2 MPa) 1.9 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (23.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 39 DT 466/230 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed) Intake Manifold Pressure (Full Load, Peak Torque)	22.0 ± 2 psi (152 ± 14 kPa) @ 2300 rpm 11.5 ± 2 psi (76 ± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/215 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)

Table 40 DT 466 /215 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)

DT 466 /215 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMG]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466 /CH215
Engine Rating	215 BHP @ 2300 rpm
Engine Family Rating Code	1122
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number, (Wastegate)	1836092C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2600
High Idle Speed– rpm with automatic transmission	2450
Low Idle Speed– rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1668 ± 300 psi (11.5 ± 2 MPa) 2.3 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3118 ± 150 psi (21.5 ± 1 MPa) 4.0 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 40 DT 466 /215 hp @ 2300 rpm (620 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed)	21.5 ± 2 psi (148 ± 14 kPa) @ 2300 rpm
Intake Manifold Pressure (Full Load, Peak Torque)	12.5 ± 2 psi (86± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/230 hp @ 2300 rpm (660 ft·lbf torque @ 1400 rpm)

Table 41 DT 466/230 hp @ 2300 rpm (660 ft·lbf torque @ 1400 rpm)

DT 466 /230 hp @ 2300 rpm (660 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMH]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466 /CH230
Engine Rating	230 BHP @ 2300 rpm
Engine Family Rating Code	2132
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number, (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2600
High Idle Speed– rpm with automatic transmission	2450
Low Idle Speed– rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1305 ± 300 psi (9.0± 2 MPa) 1.9 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (21.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 41 DT 466/230 hp @ 2300 rpm (660 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed)	22.0 ± 2 psi (152 ± 14 kPa) @ 2300 rpm
Intake Manifold Pressure (Full Load, Peak Torque)	12.5 ± 2 psi (86± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 466/250 hp @ 2300 rpm (800 ft·lbf torque @ 1400 rpm)

Table 42 DT 466/250 hp @ 2300 rpm (800 ft·lbf torque @ 1400 rpm)

DT 466 /250 hp @ 2300 rpm (800 ft·lbf torque @ 1400 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMK]	
DT 466 Series Diesel Engine Specifications	
Engine Model	DT 466 /CH250
Engine Rating	250 BHP @ 2300 rpm
Engine Family Rating Code	2152
Injector Part Number Original Equipment	1830560C2
Turbocharger Part Number, (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed– rpm with manual transmission	2600
High Idle Speed– rpm with automatic transmission	2450
Low Idle Speed– rpm	700
Injection Control Pressure/Voltage @ Low Idle No Load	580 ± 75 psi (4 ± 0.5 MPa) 1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle No Load	1305 ± 300 psi (9.0± 2 MPa) 1.9 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (21.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 42 DT 466/250 hp @ 2300 rpm (800 ft·lbf torque @ 1400 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310.3 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed)	22.5 ± 2 psi (155 ± 14 kPa) @ 2300 rpm
Intake Manifold Pressure (Full Load, Peak Torque)	18.0 ± 2 psi (124 ± 14 kPa) @ 1400 rpm
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min. - Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 530/275 hp @ 2000 rpm (800 ft·lbf torque @ 1200 rpm)

Table 43 DT 530/275 hp @ 2000 rpm (800 ft·lbf torque @ 1200 rpm)

DT 530 /275 hp @ 2000 rpm (800 ft·lbf torque @ 1200 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMX]	
DT 530 Series Diesel Engine Specifications	
Engine Model	DT 530 /C275
Engine Rating	275 BHP @ 2000 rpm
Engine Family Rating Code	5121
Injector Part Number Original Equipment	1830691C1
Turbocharger Part Number, (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed – rpm with manual transmission	2425
High Idle Speed – rpm with automatic transmission	2425
Low Idle Speed – rpm	700
Injection Control Pressure/Voltage @ Low Idle, No Load	435 ± 75 psi (3 ± 0.5 MPa) 0.8 ± 0.2V
Injection Control Pressure/Voltage @ High Idle, No Load	1305 ± 300 psi (9 ± 2 MPa) 1.9 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3408 ± 150 psi (23.5 ± 1 MPa) 4.4 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 43 DT 530/275 hp @ 2000 rpm (800 ft·lbf torque @ 1200 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310 kPa)
Fuel Inlet Restriction, Max.	6 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.49 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed) Intake Manifold Pressure (Full Load, Peak Torque)	24 ± 2 psi (164 kPa ± 14 kPa) @ 2000 15 ± 2 psi (105 kPa ± 14 kPa) @ 1300
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (8.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min.-Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 530/300 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm)

Table 44 DT 530/300 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm)

DT 530 /300 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm)	
50 State 2001 Model Year	
[Engine Unit Code 12NMT]	
DT 530 Series Diesel Engine Specifications	
Engine Model	DT 530 /C300
Engine Rating	300 BHP @ 2000 rpm
Engine Family Rating Code	5151
Injector Part Number Original Equipment	1830691C1
Turbocharger Part Number, (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed – rpm with manual transmission	2425
High Idle Speed– rpm with automatic transmission	2425
Low Idle Speed – rpm	700
Injection Control Pressure/Voltage @ Low Idle, No Load	580 ± 150 psi (4 ± 1 MPa)1.0 ± 0.2V
Injection Control Pressure/Voltage @ High Idle, No Load	1233 ± 300 psi (8.5 ± 2 MPa)1.8 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3191 ± 150 psi (22 ± 1 MPa)4.1 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 44 DT 530/300 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed) Intake Manifold Pressure (Full Load, Peak Torque)	23.0 ± 2 psi (158 ± 14 kPa) @ 2000 19.0 ± 2 psi (131 ± 14 kPa) @ 1200
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min.-Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts

DT 530/330 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm)

Table 45 DT 530/330 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm)

DT 530 /330 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm) 50 State 2001 Model Year [Engine Unit Code 12NMW]	
DT 530 Series Diesel Engine Specifications	
Engine Model	DT 530 /C330
Engine Rating	330 BHP @ 2000 rpm
Engine Family Rating Code	6161
Injector Part Number Original Equipment	1830691C1
Turbocharger Part Number, (Wastegate)	1836094C92
Turbine A/R Ratio	0.89
Injection Timing	Nonadjustable
High Idle Speed – rpm with manual transmission	2425
High Idle Speed– rpm with automatic transmission	2425
Low Idle Speed – rpm	700
Injection Control Pressure/Voltage @ Low Idle, No Load	508 ± 150 psi (3.5 ± 1 MPa)0.9 ± 0.2V
Injection Control Pressure/Voltage @ High Idle, No Load	1378 ± 300 psi (9.5 ± 2 MPa)2.0 ± 0.5V
Injection Control Pressure/Voltage @ Rated Speed and Full Load	3191 ± 150 psi (22 ± 1 MPa)4.1 ± 0.3V
Intake And Exhaust Valve Clearance (Engine Off)	
Intake	0.025 in (0.635 mm)
Exhaust	0.025 in (0.635 mm)

Table 45 DT 530/330 hp @ 2000 rpm (950 ft·lbf torque @ 1200 rpm) (cont.)

Data Taken At: High Idle, No Load, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured at Engine Side of Air Cleaner)	
Air Cleaner Restriction (High Idle, No Load), Max.	12.5 in H_2O (3.13 kPa)
Fuel Pressure, Min.	45 psi (310 kPa)
Fuel Inlet Restriction, Max.	6.0 in Hg Vacuum (20.3 kPa)
Crankcase Pressure Using Restrictor Tool ZTSE4039, Max.	6.0 in H_2O (1.5 kPa)
Data Taken At: Full Load, Rated Speed On Chassis Dynamometer Or Highway, Stabilized Operating Temperature	
Air Cleaner Restriction (Measured @ Air Cleaner Outlet) — Max	25 in H_2O (6.25 kPa)
Intake Manifold Pressure (Full Load, Rated Speed) Intake Manifold Pressure (Full Load, Peak Torque)	24.0 ± 2 psi (165 ± 14 kPa) @ 2000 20.0 ± 2 psi (138 ± 14 kPa) @ 1200
Exhaust Backpressure (After Turbocharger), Max.	41 in H_2O (10.2 kPa)
Smoke Opacity Smoke Opacity Following SAE J1667 snap-acceleration smoke test procedure and applicable corrections made with a J1667 compliant smoke meter.	20% or Greater Indicates Potential Problem
Measure Water Temperature Differential Across The Radiator With Engine On A Chassis Dynamometer, At Full Load And Ambient Temperature Of 80°F (26.7°C) Or Above	
Water Temperature Differential Across Radiator	6-12°F (3.3-6.6°C)
Data Taken After Engine Reaches Stabilized Operating Temperature	
Lube Oil Temperature (Oil Gallery), Max.	250°F (121°C)
Lube Oil Pressure At Operating Temperature (Stabilized)	
Low Idle, Min.	15 psi (103.4 kPa)
Rated Speed, Min.-Max.	40-70 psi (276-483 kPa)
Minimum Cranking rpm Required to Start the Engine	150 rpm
Minimum Battery Voltage Required to Start the Engine	7 Volts
Minimum ICP Pressure / Voltage Required to Start the Engine	870 psi / 1.25 Volts