HARD START/NO START DIAGNOSTICS

INTRODUCTION

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

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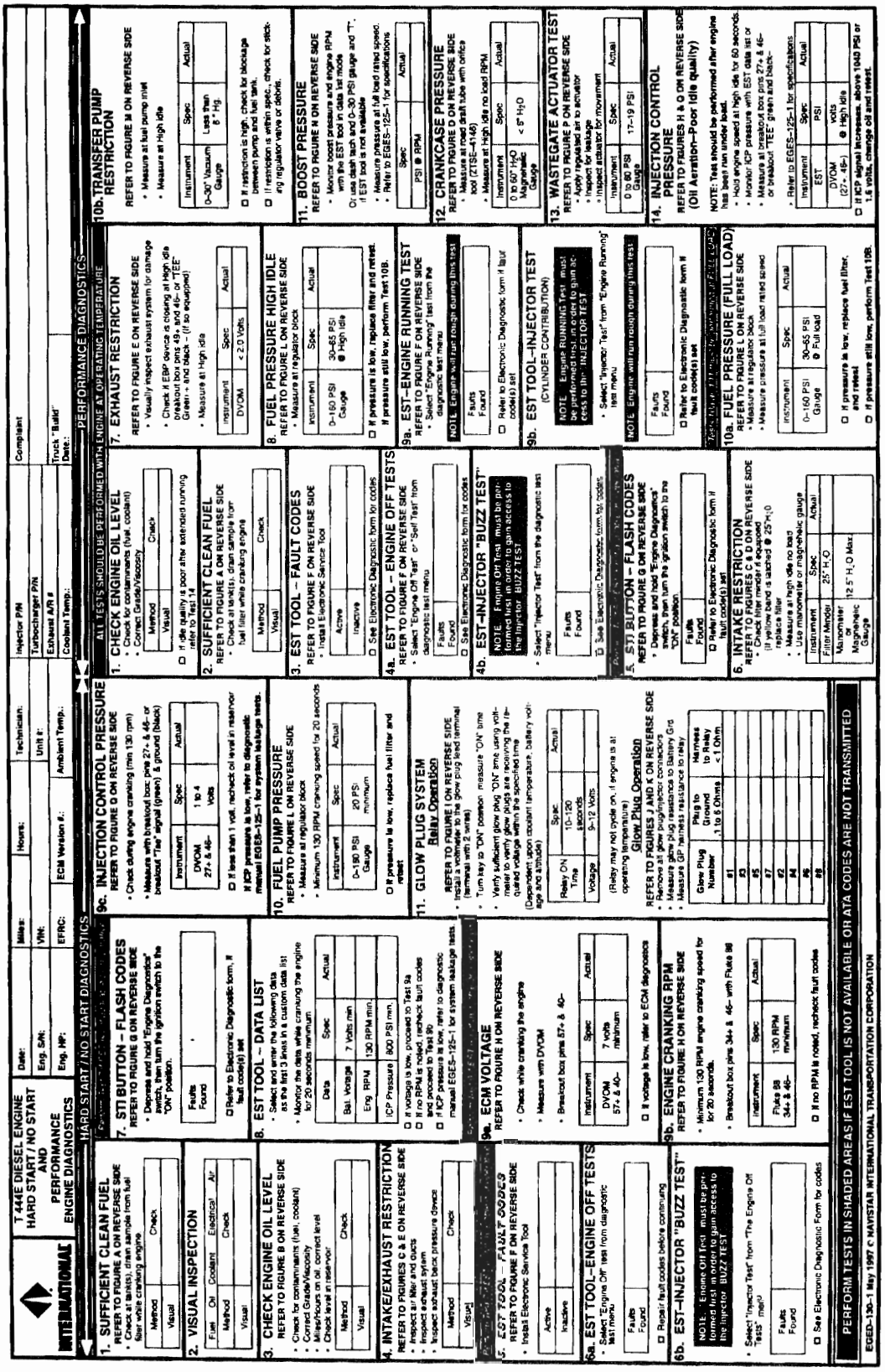
HARD START/NO START DIAGNOSTICS

HARD START NO\START & PERFORMANCE DIAGNOSTIC FORM EGED–130–1 (FRONT SIDE)



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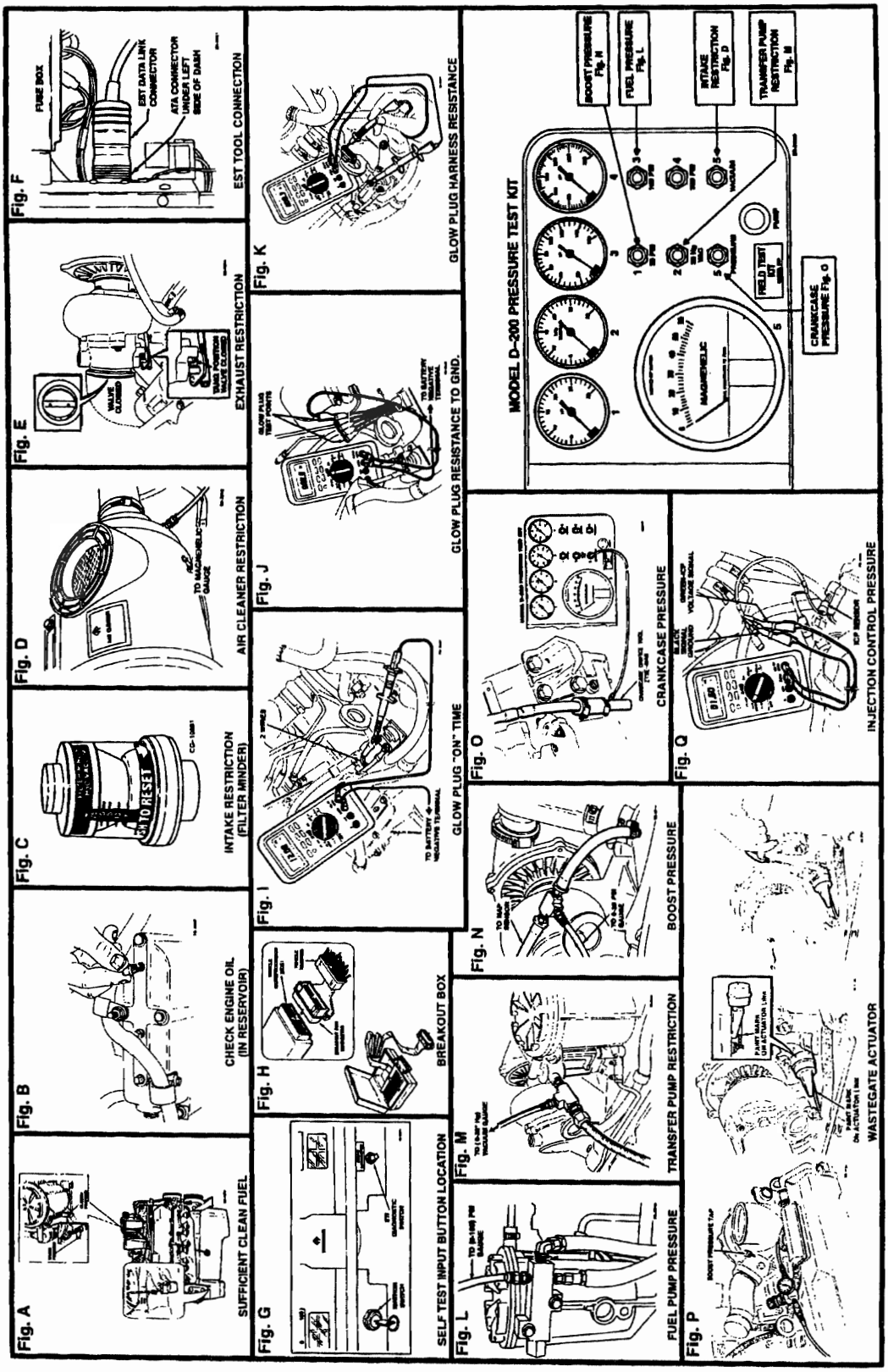
HARD START/NO START DIAGNOSTICS

HARD START NO\START & PERFORMANCE DIAGNOSTIC FORM EGED–130–1 (REAR SIDE)



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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
SUFFICIENT CLEAN FUEL

FROM FORM EGED–130–1

1. SUFFICIENT CLEAN FUEL

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

Method	Check
Visual	

PURPOSE

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

TEST PROCEDURE

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

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

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

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

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

LOW OR NO FUEL POSSIBLE CAUSES

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

TOOLS REQUIRED

Clear container approximately 1 quart.

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T 444E ENGINE
SUFFICIENT CLEAN FUEL (Continued)

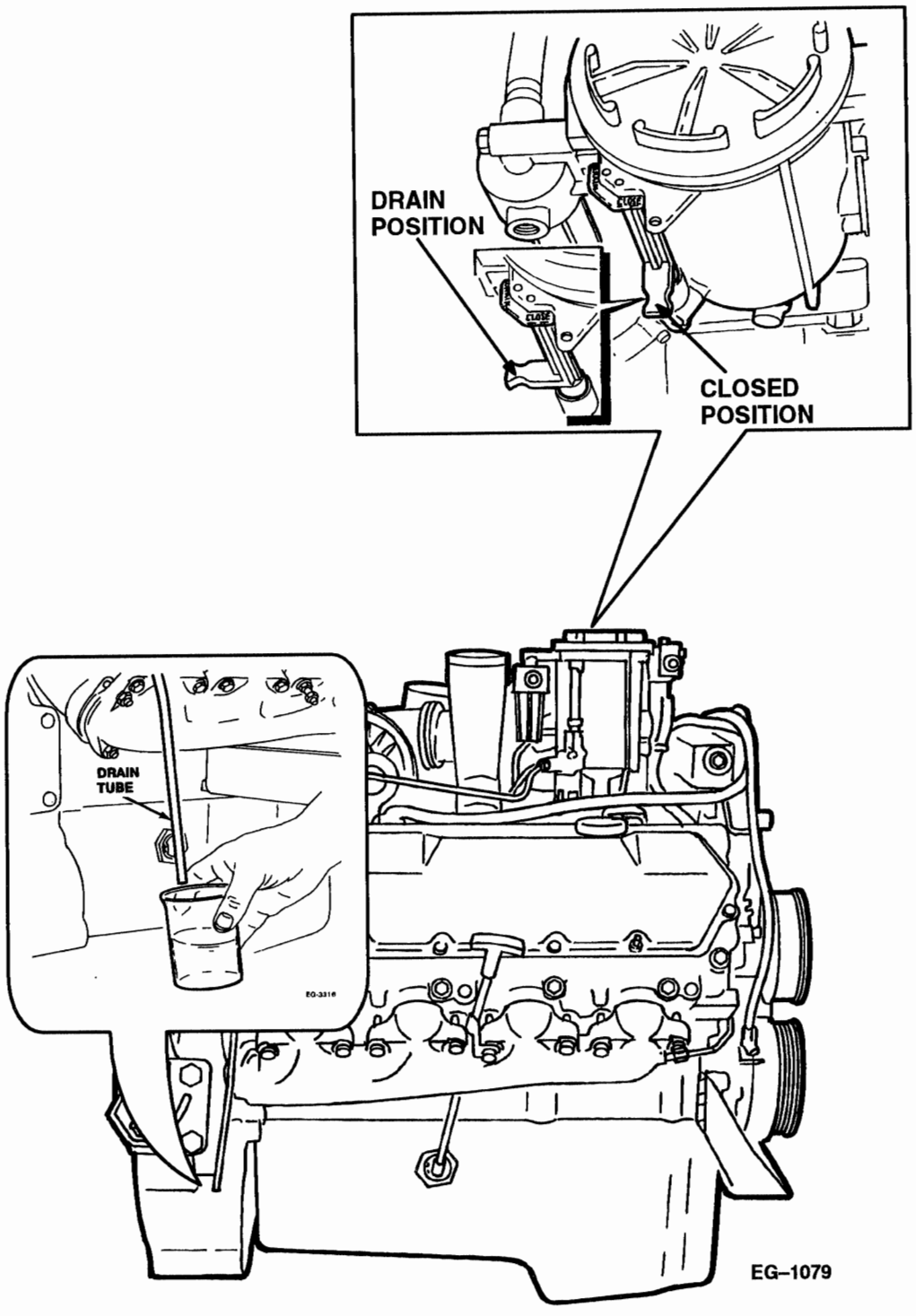

Figure 2.2–1. – Fuel Drain

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
VISUAL INSPECTION

FROM FORM EGED–130–1

2. VISUAL INSPECTION

Fuel Oil Coolant Electrical Air	
Method	Check
Visual	

PURPOSE

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

TEST PROCEDURE

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

POSSIBLE CAUSES

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

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

TOOLS REQUIRED

Inspection light

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T 444E ENGINE
CHECK ENGINE OIL LEVEL

FROM FORM EGED–130–1

3. CHECK ENGINE OIL LEVEL

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

Method	Check
Visual	

PURPOSE

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

TEST PROCEDURE

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

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

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

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

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

POSSIBLE CAUSES

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

TOOLS REQUIRED

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

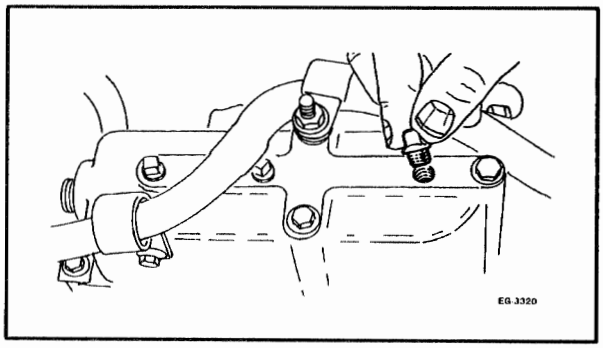

Figure 2.2–2. – Checking Oil Level in Reservoir

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
INTAKE/EXHAUST RESTRICTION

FROM FORM EGED–130–1

4. INTAKE/EXHAUST RESTRICTION

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

Method	Check
Visual	

PURPOSE

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

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

VISUALLY INSPECT:

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

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

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

POSSIBLE CAUSES

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

TOOLS REQUIRED

None

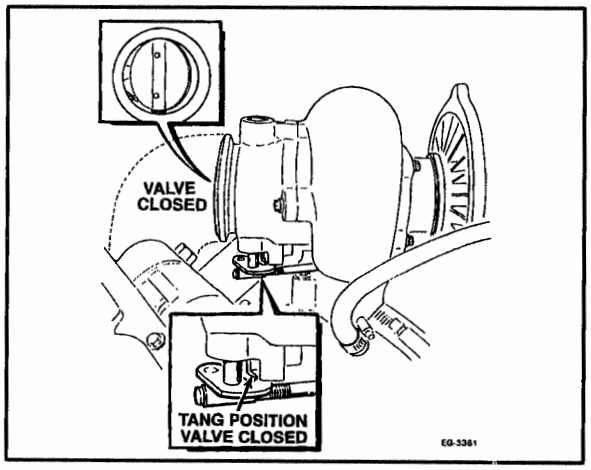

Figure 2.2–3. – Exhaust Back Pressure Valve Closed

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T 444E ENGINE
EST TOOL–FAULT CODES

FROM FORM EGED–130–1

5. EST TOOL–FAULT CODES

- Install Electronic Service Tool

Active	
Inactive	

PURPOSE

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

TEST PROCEDURE

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

Connect the Electronic Service Tool (EST) to the American Trucking Association (ATA) diagnostic connector. The connector is located on the lower left kick panel **(Figure 2.2–4.)** inside the cab. The screen of the reader should light up as soon as the tool is plugged in.

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

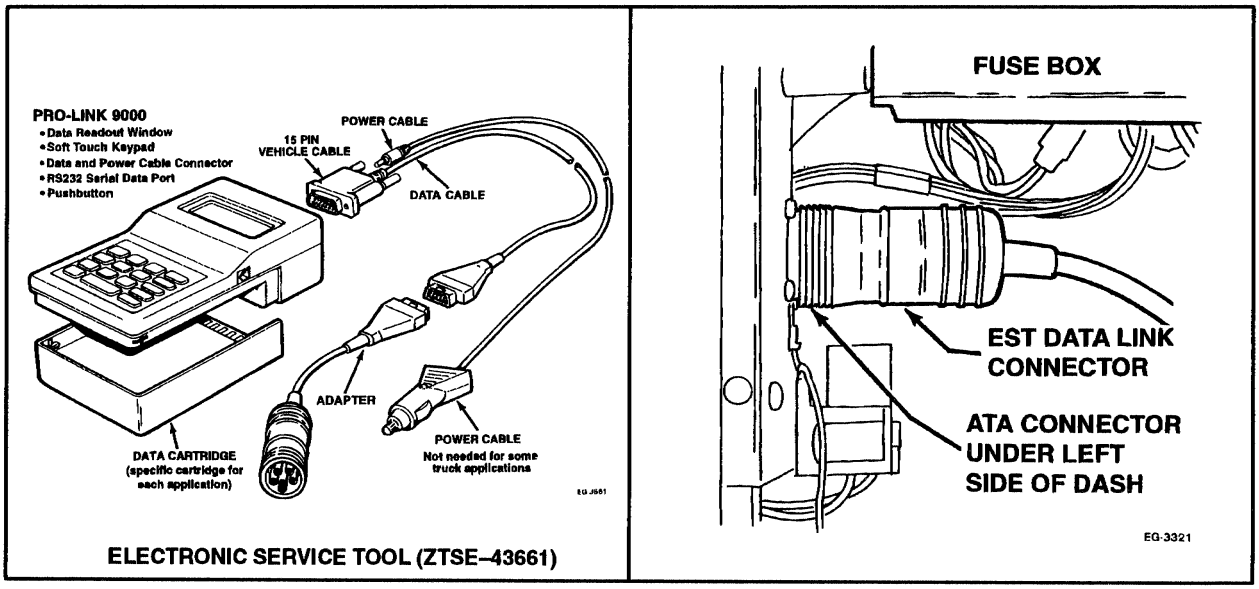

Figure 2.2–4. – Electronic Service Tool/ATA Connector Location

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

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

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

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

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HARD START/NO START DIAGNOSTICS

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

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

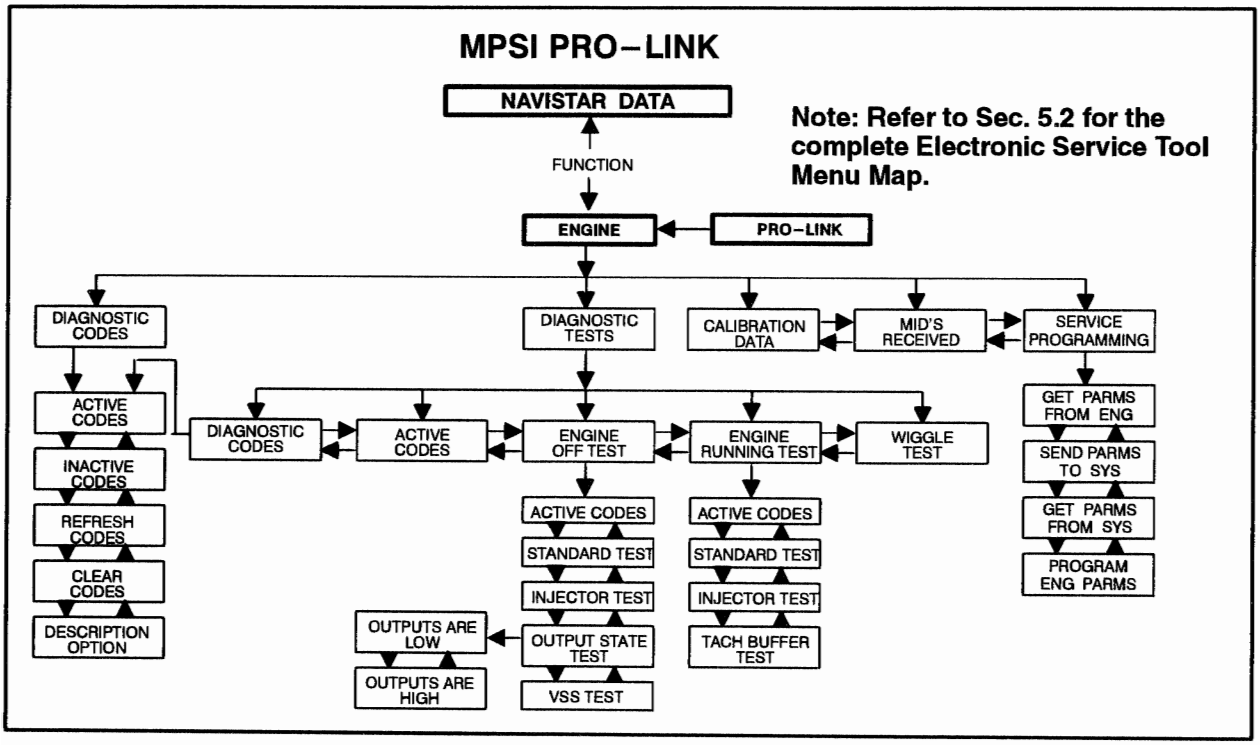
NAVISTAR MRD ENGINE MENU
↑ DIAGNOSTIC CODES ↓

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

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

NAVISTAR MRD DIAGNOSTIC CODES
↑ ACTIVE CODES ↓

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



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

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

NAVISTAR MRD DIAGNOSTIC CODES		
↑	INACTIVE CODES	↓

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

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

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

POSSIBLE CAUSES

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

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

TOOLS REQUIRED

PRO–LINK 9000 (ZTSE–43661)

SUPPLEMENTAL DIAGNOSTICS

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

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
EST TOOL–ENGINE OFF TESTS

FROM FORM EGED–130–1

6a. EST TOOL–ENGINE OFF TESTS

- Select "Engine Off" test from diagnostic test menu

Faults Found	

- ☐ Repair fault codes before continuing

PURPOSE

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

TEST PROCEDURE

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

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

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

```
NAVISTAR MRD
SELECT DESIRED
MENU
[ENGINE] ↔ PRO–LINK
```

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

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

```
NAVISTAR MRD
ENGINE MENU

↑    DIAGNOSTIC TESTS    ↓
```

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

```
NAVISTAR MRD
DIAGNOSTIC TESTS

↑    ENGINE OFF TESTS    ↓
```

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

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

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

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

POSSIBLE CAUSES

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

TOOLS REQUIRED

PRO–LINK 9000 (ZTSE–43661)

SUPPLEMENTAL DIAGNOSTICS

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

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T 444E ENGINE
EST–INJECTOR "BUZZ TEST"

FROM FORM EGED–130–1

6b. EST–INJECTOR "BUZZ TEST"

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

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

Faults Found	

☐ See Electronic Diagnostic Form for Codes

PURPOSE

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

TEST PROCEDURE

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

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

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

NAVISTAR MRD
DIAGNOSTIC TESTS

↑ INJECTOR TEST ↓

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

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

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

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

POSSIBLE CAUSES

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

TOOLS REQUIRED

PRO–LINK 9000 (ZTSE–43661)

SUPPLEMENTAL DIAGNOSTICS

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

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
STI–BUTTON FLASH CODES

FROM FORM EGED–130–1

7. STI–BUTTON FLASH CODES

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

Faults Found	

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

PURPOSE

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

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

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

TEST PROCEDURE

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

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

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

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

1. The **"OIL/WATER"** light will flash one time to indicate the beginning of **Active** fault codes.
2. The **"WARN ENGINE"** light will flash repeatedly signaling the active fault codes.

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

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

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

After all codes have been sent, the **"OIL/WATER"** light will flash three times indicating "END OF MESSAGE".

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

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

POSSIBLE CAUSES

- Electronic component or circuitry failures.

TOOLS REQUIRED

None.

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

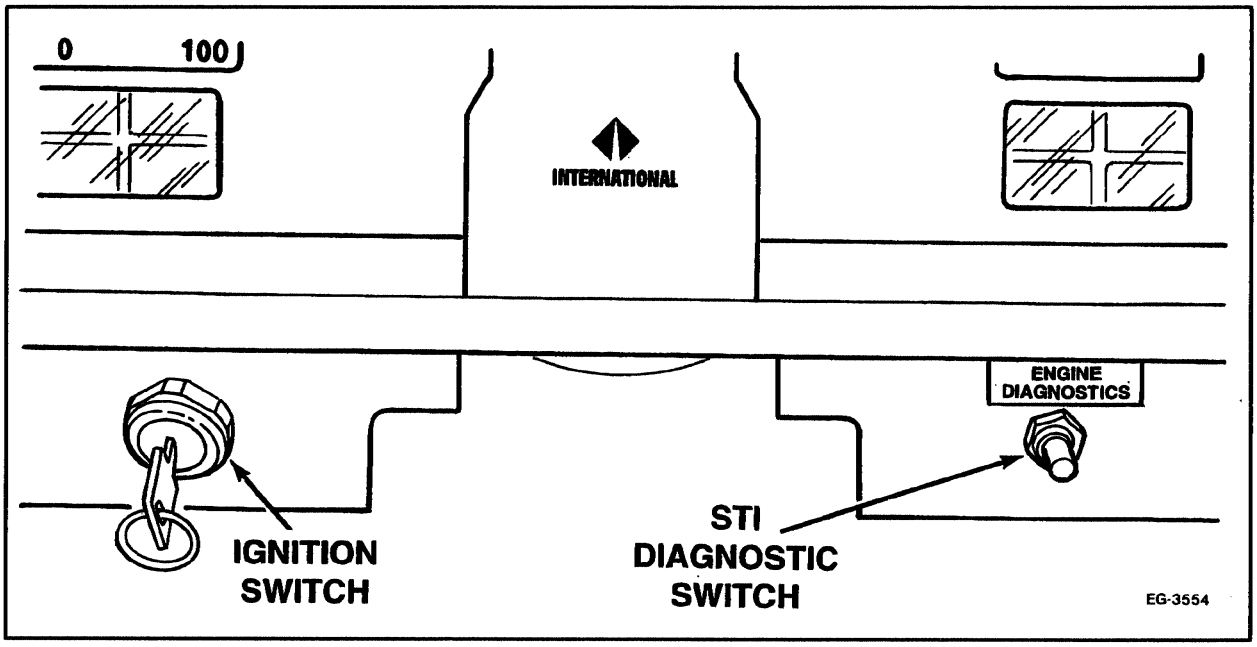

Figure 2.2–5. – Self Test Input (STI) Diagnostic Switch Location on Vehicle Dash

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
EST TOOL–DATA LIST

FROM FORM EGED–130–1

8. EST TOOL–DATA LIST

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

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

☐ If voltage is low, proceed to Test 9a.

☐ If no RPM is noted, recheck fault codes and proceed to Test 9b.

☐ If ICP pressure is low, refer to diagnostic manual EGES–125–1 for system leakage tests

PURPOSE

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

TEST PROCEDURE

IMPORTANT NOTE

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

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

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

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

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

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

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

■ BATT VOLTS	12.5
ENG. OIL TEMP	75 F
AMBIENT AIR	75 F
COOLANT TEMP	75 F

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

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

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

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T 444E ENGINE
EST TOOL–DATA LIST (Continued)

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

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

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

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

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

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

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

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

POSSIBLE CAUSES

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

TOOLS REQUIRED
PRO–LINK 9000 (ZTSE–43661)

SUPPLEMENTAL DIAGNOSTICS

- Starting system diagnostics. Refer to Electrical section CTS–5110 of the Truck Service Manual.
- Low voltage at ECM. Refer to Electronic Control Module Power Supply (ECM PWR) in (Section 3.5) Electronic Control System Diagnostics.
- No Engine RPM indication during engine cranking. Refer to CMP sensor diagnostics in Electronic Control System Diagnostics Section 3.5.
- No Injection Control Pressure. Refer to Injection Control Pressure (ICP) sensor, IPR valve diagnostics in Electronic Control System Diagnostics Section 3.5.
- No injection control pressure and no electronic faults. – Refer to Test 9C.
- If ICP pressure is low, refer to High Pressure Leakage Tests on page NO TAG.

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
ECM VOLTAGE

FROM FORM EGED–130–1

9a. ECM VOLTAGE

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

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

□ If voltage is low, refer to ECM diagnostics

PURPOSE

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

TEST PROCEDURE

TESTS MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

VOLTAGE MEASUREMENT AT BATTERY

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

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

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

VOLTAGE MEASUREMENT AT THE ECM RELAY

The ECM power relay is located **(Refer to Section 7, Vehicle and Component Illustrations)** on the engine cowl and mounted on a bracket over the IDM.

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

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

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

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

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T 444E ENGINE
ECM VOLTAGE (Continued)

VOLTAGE MEASUREMENT AT ECM WITH BREAKOUT BOX (Continued)

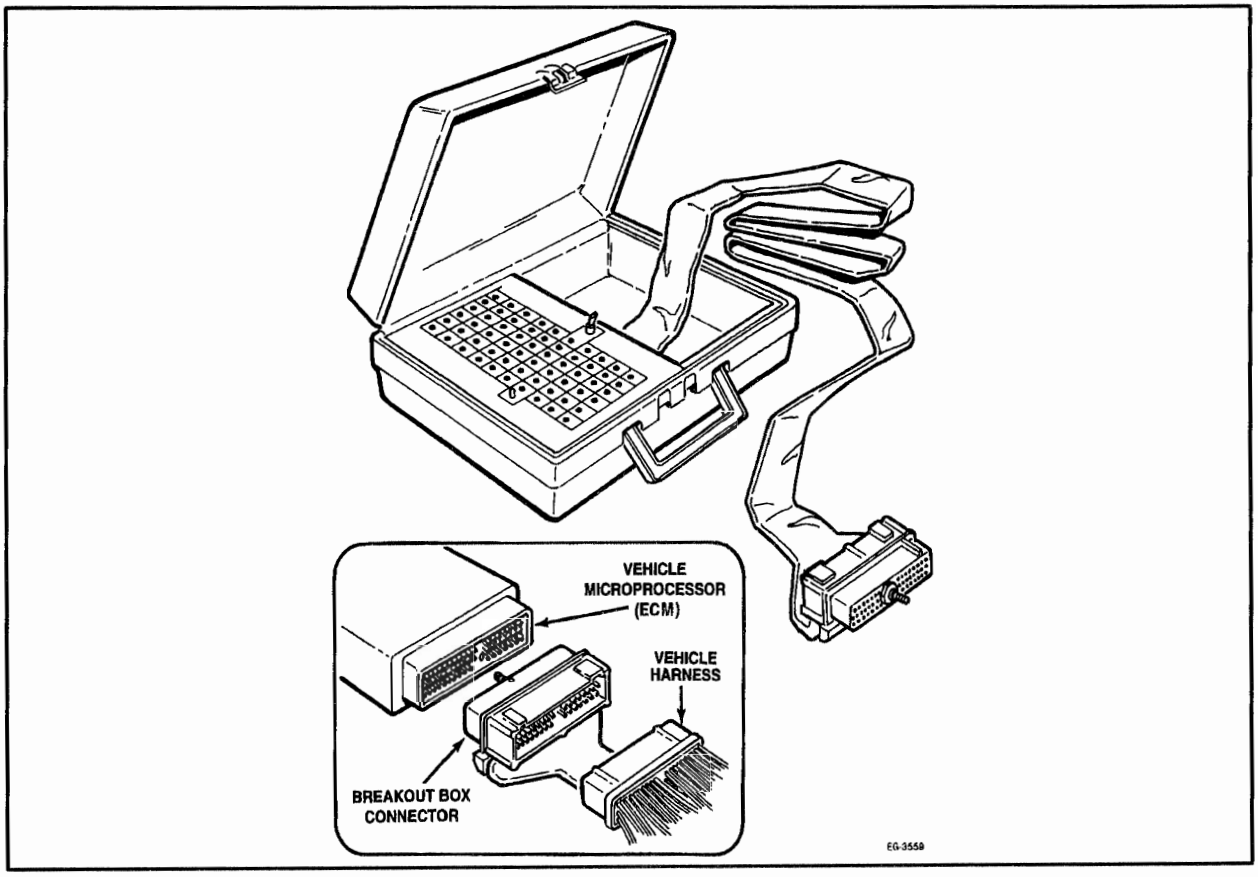

Figure 2.2–6. – Breakout Box (ZTSE–4346)

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

POSSIBLE CAUSES

- Low battery voltage. Due to "faulty" batteries, high resistance at battery cable connections or defective starter.
- Low or no battery voltage to the ECM. – May be due to high resistance or an open circuit in the power feed circuit to the ECM or it's power relay. The ECM power circuit fuse, F5, may be open or the ECM power relay may be defective.

TOOLS REQUIRED
DVOM and breakout box.

SUPPLEMENTAL DIAGNOSTICS

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

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
ENGINE CRANKING RPM

FROM FORM EGED–130–1

9b. ENGINE CRANKING RPM

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

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

☐ If no RPM is noted, recheck fault codes

PURPOSE

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

TEST PROCEDURE

TEST MUST BE PERFORMED WITH FULLY CHARGED BATTERIES.

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

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

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

CHECKING CRANKING RPM WITH BREAKOUT BOX

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.
2. Remove the 60 way connector from the Electronic Control Module (ECM). Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.
4. Connect the (+ lead) of the Fluke 88 to terminal 34 and the (– lead) to terminal 46. Select the DC voltage scale and press the "RPM" button.
5. Crank the engine while observing the Fluke 88. A minimum of 130 RPM is necessary to start the engine.
6. Record cranking engine RPM on diagnostic form.

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

POSSIBLE CAUSES

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

TOOLS REQUIRED

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

SUPPLEMENTAL DIAGNOSTICS

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

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T 444E ENGINE
INJECTION CONTROL PRESSURE

FROM FORM EGED–130–1

9c. INJECTION CONTROL PRESSURE

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

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

☐ If less than 1 volt, recheck oil level in reservoir.

If ICP pressure is low, refer to diagnostic manual EGES–125–1 for system leakage tests.

PURPOSE

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

TEST PROCEDURE

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

1. Remove the weather cover at the engine cowl located on the upper driver's side of vehicle.
2. Remove the 60 way connector from the ECM. Attach the adapter of the breakout box to the ECM and secure the bolt in the center of the adapter.
3. Reattach the 60 way connector to the adapter and secure the bolt in the center of the plug to the adapter.
4. Connect the positive lead of the DVOM to terminal 27 and the negative lead to terminal 46.
5. Crank the engine while observing the DVOM and record the injection control pressure voltage signal on diagnostic form. **If Injection Control Pressure (ICP) pressure is low, refer to High Pressure Leakage Tests.**

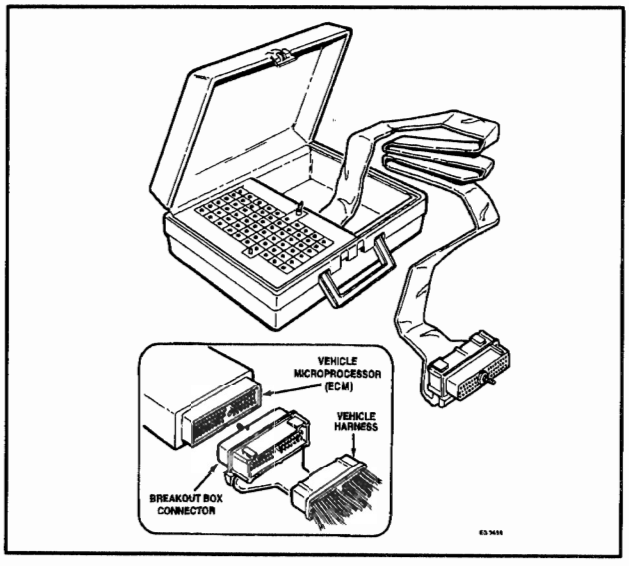

Figure 2.2–7. – Breakout Box (ZTSE–4346)

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
INJECTION CONTROL PRESSURE – Continued

ALTERNATE METHOD OF MEASURING INJECTION CONTROL PRESSURE USING (BREAKOUT "TEE")

1. Remove engine harness connector at ICP sensor.
2. Connect the breakout "TEE" to the removed engine harness connector and the ICP sensor.
3. Connect DVOM leads (+Green, –Black) to the breakout "TEE" as shown in **Figure 2.2–8.**
4. Crank engine and observe DVOM voltage reading. Record reading on diagnostic form. If voltage is low, recheck oil level in reservoir to confirm the reservoir contains a sufficient supply of oil to enable the injection control system to function properly. **If oil level is ok, proceed to High Pressure Leakage tests.**

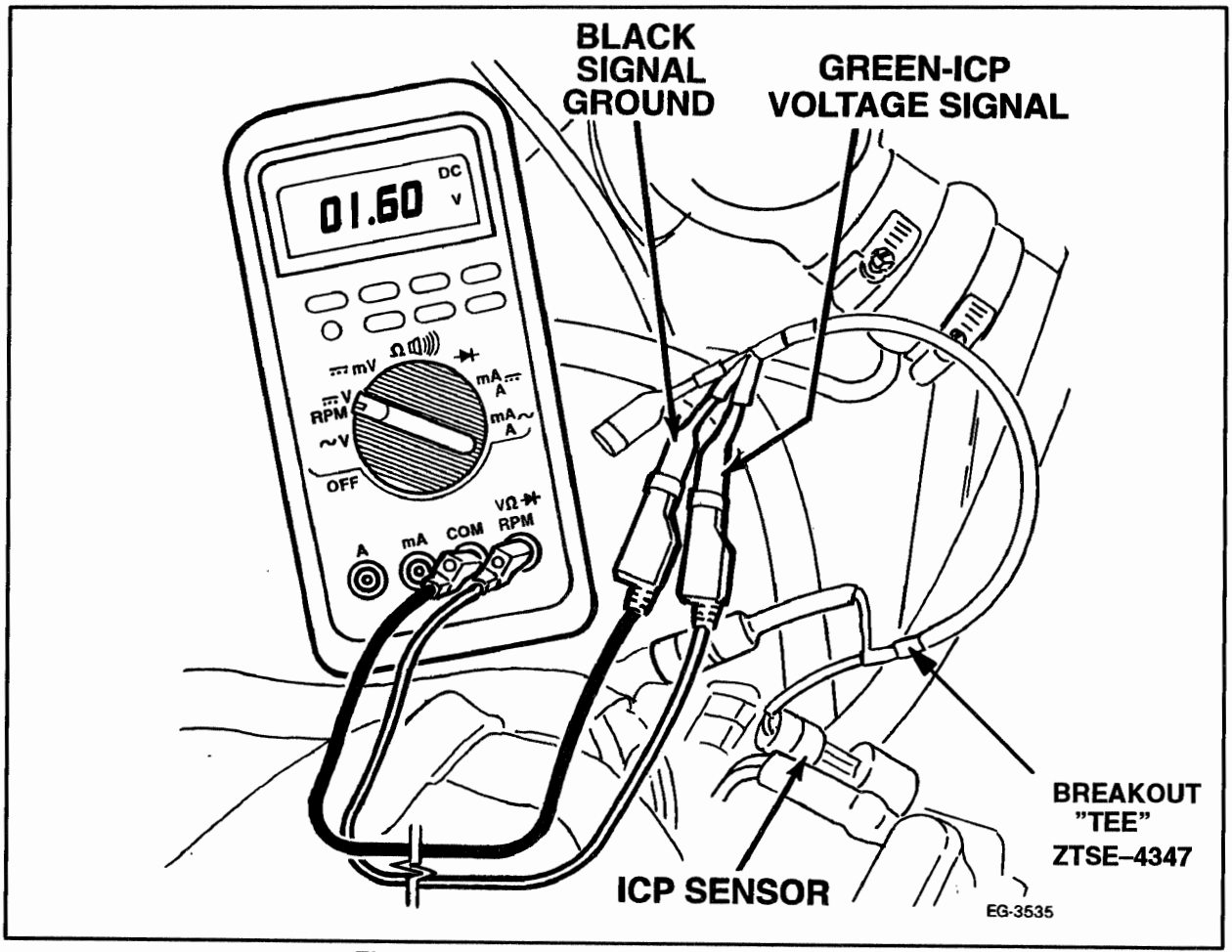

Figure 2.2–8. – Injection Control Pressure.

T 444E ENGINE
HIGH PRESSURE LEAKAGE TESTS

ISOLATE RIGHT CYLINDER HEAD

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

CAUTION THE ENGINE MAY START!

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

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

CAUTION !

OIL IS UNDER HIGH PRESSURE

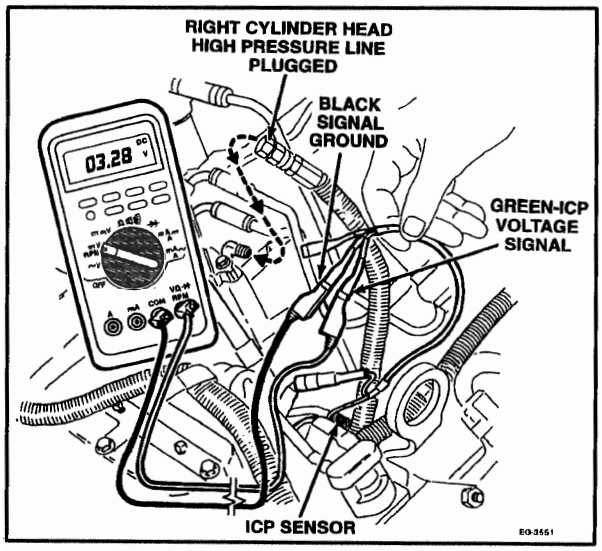

Figure 2.2–9. – Isolating Right Cylinder Head

ISOLATE LEFT CYLINDER HEAD

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

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

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

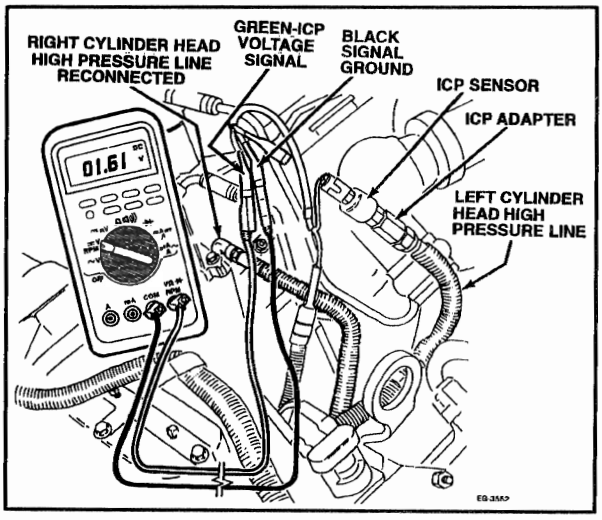

Figure 2.2–10. – Isolating Left Cylinder Head

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
HIGH PRESSURE LEAKAGE TESTS (Continued)

IPR AND HIGH PRESS PUMP TEST

If injection control pressure is still low after isolating both cylinder heads, leave the ICP sensor adapter in the left hose and reinstall the flare plug to block the right high pressure hose **(Figure 2.2–11.)** and crank the engine. This has effectively deadheaded the high pressure pump. If pressure is still not developed, inspect the IPR (Injection Pressure Regulator) valve for debris and/or replace with a known good valve and retest. If pressure is still low, check the high pressure pump and drive gear. The gear may be loose or the pump may be defective.

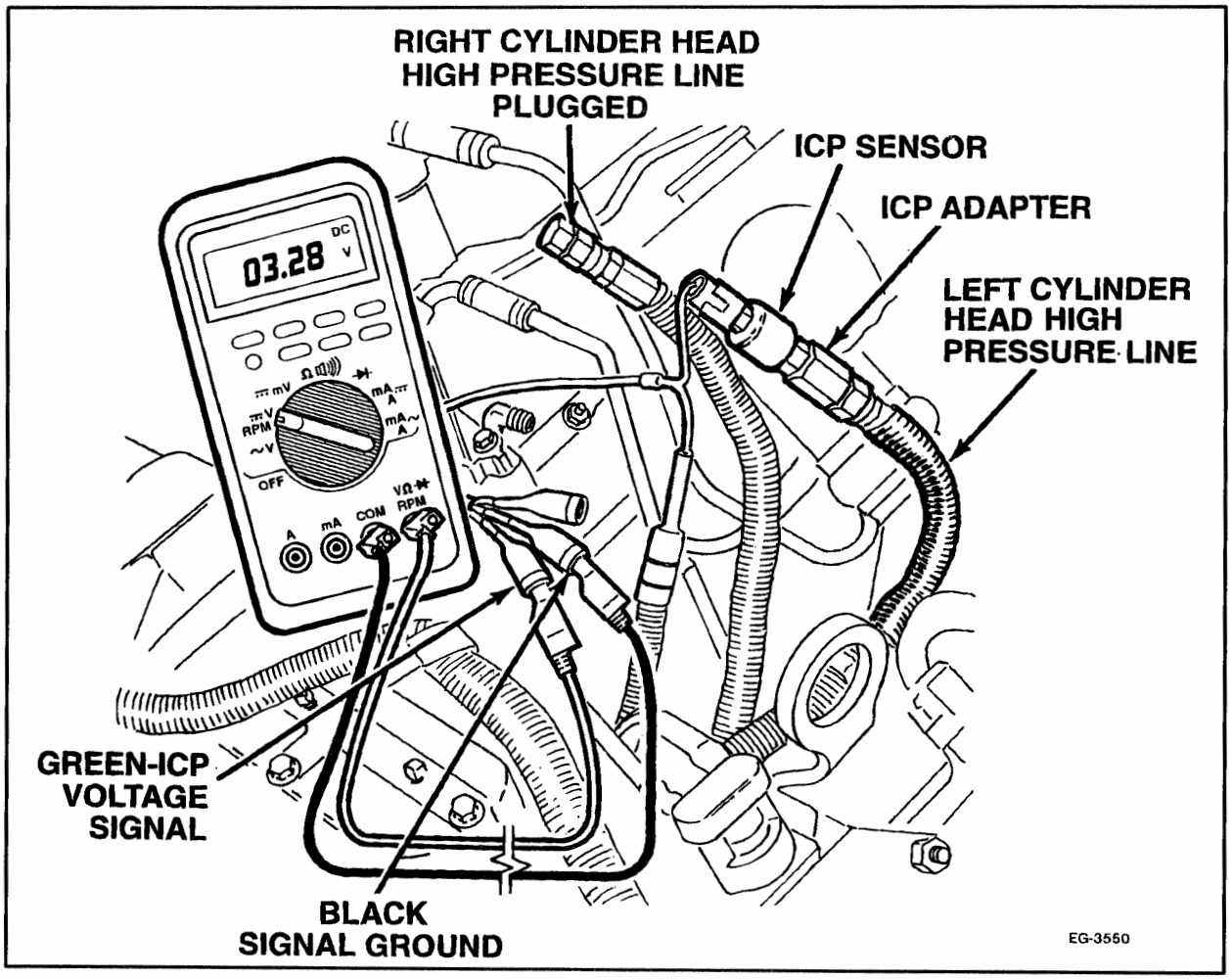

Figure 2.2–11.– IPR and High Pressure Pump Test

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T 444E ENGINE
ICP LEAKAGE TEST

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

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

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

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

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

B. Conduct an Injector "Buzz" test and observe the percent cylinder leakage while each injector is activated. Remove and inspect injectors which exhibit a greater amount of leakage compared to the others.

C. If none of the injectors indicate an excessive amount of leakage, remove all injectors. Inspect all "O" rings for wear and damage. All "O" rings should be replaced.

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

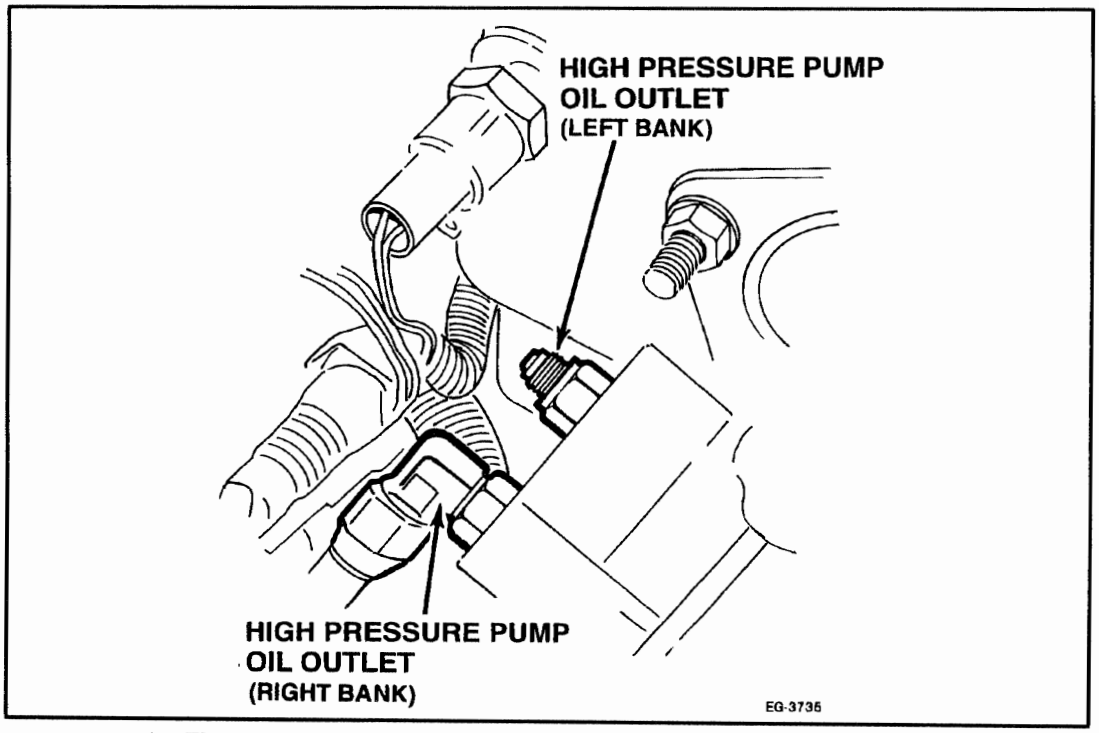

Figure 2.2–12. – High Pressure Pump Oil Outlet Locations

HARD START/NO START DIAGNOSTICS

T 444E ENGINE
ICP LEAKAGE TEST (Continued)

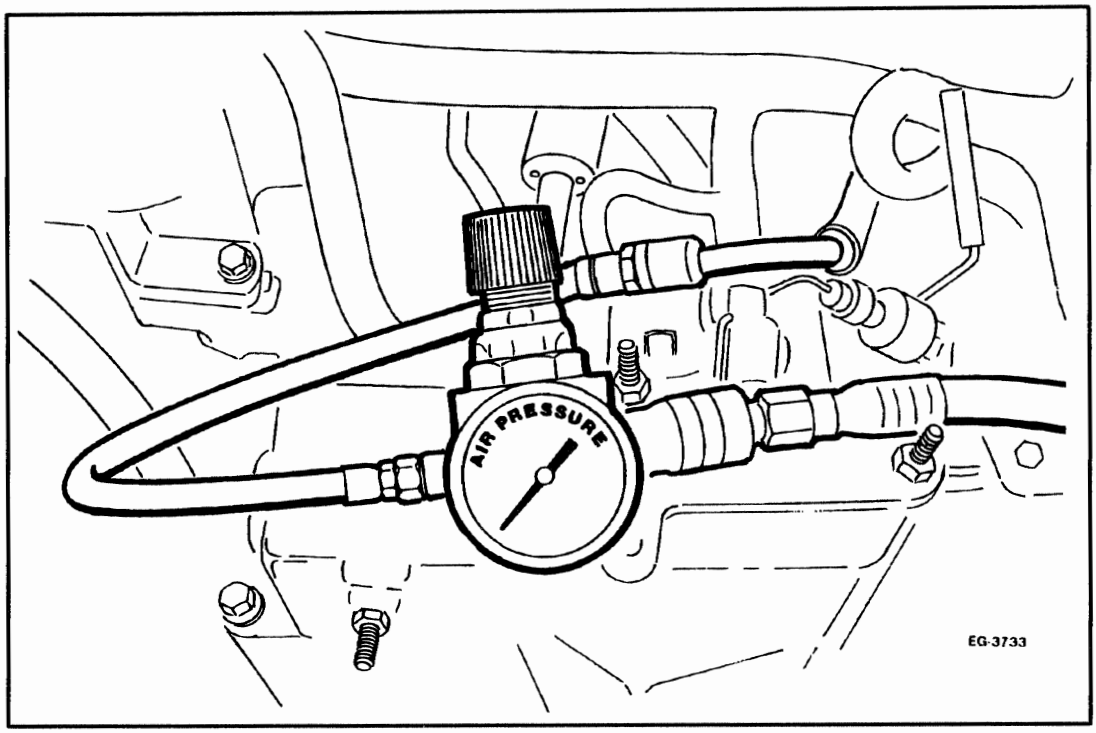

Figure 2.2–13. – ICP Leakage Test

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

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

TOOLS REQUIRED:
DVOM, ICP sensor breakout "T" (ZTSE–4347), ICP adapter and an Aero Equip size 6 flare plug.

SUPPLEMENTAL DIAGNOSTICS

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

T 444E ENGINE
FUEL PUMP PRESSURE

FROM FORM EGED–130–1

10. FUEL PUMP PRESSURE

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

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

☐ **If pressure is low, replace fuel filter and retest.**

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

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

TEST PROCEDURE

1. Remove 1/8" pipe plug located on the fuel regulator block **(Figure 2.2–14.)**. Install 1/8 inch (3 mm) pipe fitting in place of the pipe plug.
2. Connect a line from the fitting to the 0–160 PSI gauge of the Model D–200 Pressure Test Kit.
3. Measure fuel pressure by cranking engine for 20 seconds and observing maximum pressure. Record pressure on diagnostic form and compare to specifications. **If fuel pressure is low, change the fuel filter and retest.**

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

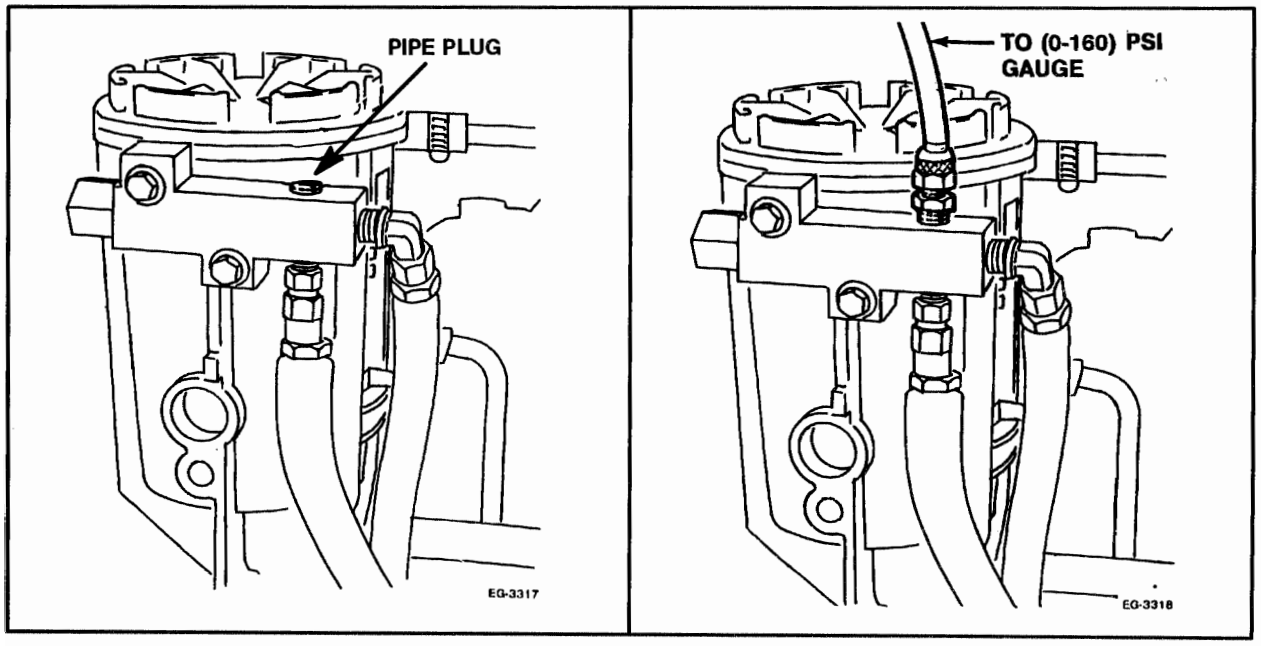

Figure 2.2–14. – Fuel Transfer Pump Pressure Check

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
FUEL PUMP PRESSURE (Continued)

POSSIBLE CAUSES

- A fuel filter could cause high restriction and low fuel pressure because of dirt or fuel jelling in cold ambient temperatures. Change filter and retest.
- A kinked or severely bent fuel supply line or blockage at the pickup tube could cause restriction and therefore low fuel pressure.
- A loose fuel line on the suction side of the fuel system could cause air to be ingested into the system and cause low fuel pressure.
- The fuel pump could have internal damage, e.g. ruptured diaphragm, seized plunger or leaking check valves.

TOOLS REQUIRED

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

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T 444E ENGINE
GLOW PLUG SYSTEM

FROM FORM EGED–130–1

11. GLOW PLUG SYSTEM

Relay Operation

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

(Dependent upon coolant temperature, battery voltage and altitude)

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

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

GLOW PLUG OPERATION

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

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

PURPOSE

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

TEST PROCEDURE:
GLOW PLUG "ON" TIME

Connect a DVOM **(Figure 2.2–15.)** to the glow plug feed terminal (terminal with 2 wires) on the glow plug relay. The DVOM will verify that the glow plugs are receiving the required voltage (9–12v) for the specified amount of time. Turn the ignition key to the "ON" position. **DO NOT ATTEMPT TO START ENGINE.** Note the time in seconds from when the ignition key is turned "ON" until the glow plug relay de–engergizes (0 volts indication on the DVOM).

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

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
GLOW PLUG SYSTEM (Continued)

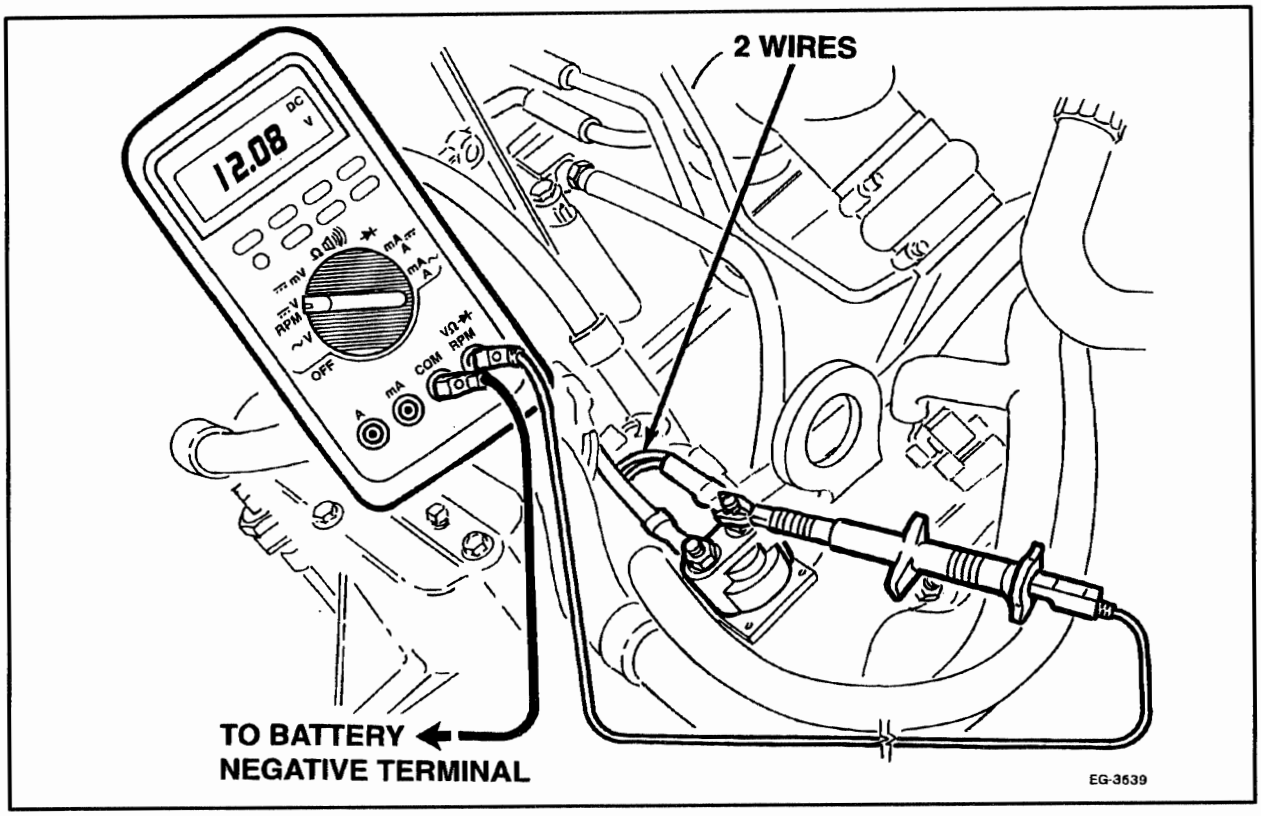

Figure 2.2–15. – Measuring Glow Plug/Relay "ON" Time

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

POSSIBLE CAUSES

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

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

T 444E ENGINE
GLOW PLUG SYSTEM (Continued)

TEST PROCEDURE:

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

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

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

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

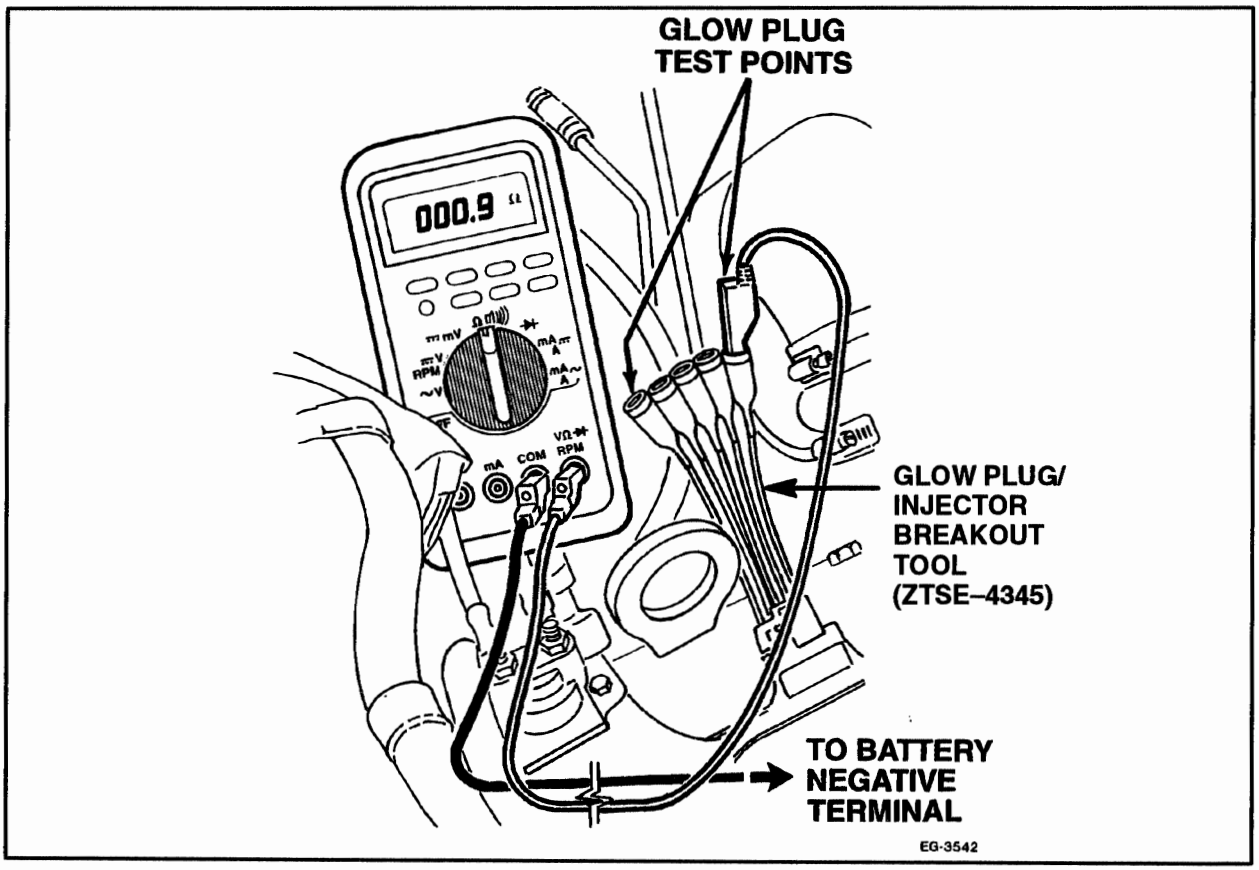

Figure 2.2–16. – Measuring Glow Plug Resistance to Gnd.

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

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

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HARD START/NO START DIAGNOSTICS

T 444E ENGINE
GLOW PLUG SYSTEM (Continued)

TEST PROCEDURE:
GLOW PLUG HARNESS RESISTANCE TO RELAY

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

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

TOOLS REQUIRED

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

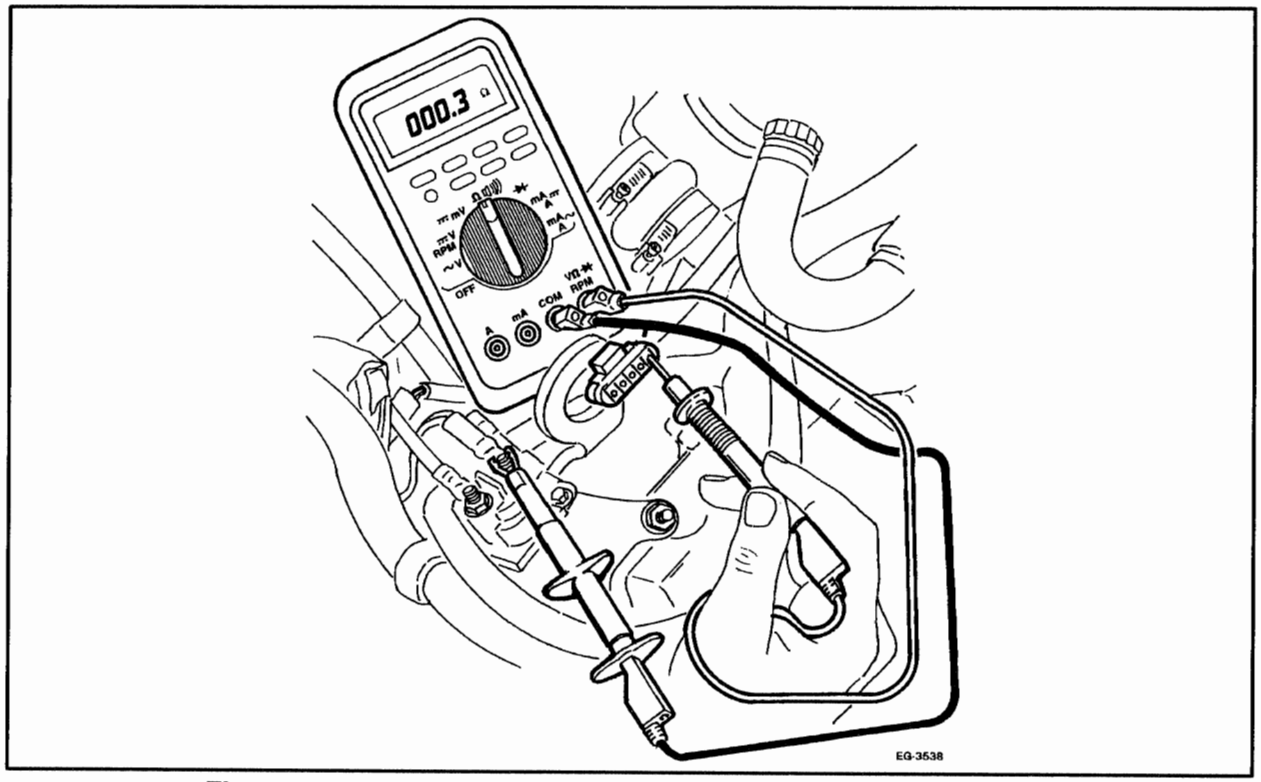

Figure 2.2–17. – Measuring Glow Plug Harness Resistance to Relay

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