FORD 7.3L POWERSTROKE TECHNICAL INFORMATION AND TROUBLESHOOTING GUIDE

7.3 NAVISTAR ® FORD® DIT DIESEL QUICK REFERENCE INFORMATION

AP: Accelerator Pedal Position sensor Load/demand input; PCM uses this to determine mass fuel desired, adjusts fuel delivery through IPR duty cycle and fuel pulse width and injection timing; **5 volts in, 0.5-0.7 volts at idle, 4.5 volts at WOT**. **PID: AP**

BARO: Barometric pressure sensor Strategy input; PCM uses this to adjust fuel quantity and injection timing for optimum running and minimum smoke, also glow plug on time to aid starting at higher altitudes; **5 volts in, @4.6 volts/14.7 psi** at sea level, decreasing as altitude increases. **PID: BARO** (pressure)

CMP: Camshaft Position sensor Strategy and load input; PCM uses this to monitor engine speed to determine engine state and load, and cylinder position in order to control timing and fuel delivery; Hall Effect sensor which generates a digital voltage signal; high, **12 volts, low, 1.5 volts**. **PID: RPM**

DTC: Diagnostic Trouble Code System malfunction or fault codes stored in the PCM to aid in diagnosis.

EBP: Exhaust Back Pressure sensor Feedback input; PCM uses this to monitor and control EPR operation; **5.0 volts in, 0.8-1.0 volts/14.7 psi KOEO** or at idle, increases with engine RPM/load, decreases as altitude increases. **PID: EBP** (pressure), EBP V (volts)

EOT: Engine Oil Temperature sensor Strategy input; PCM uses this for determining glow plug on time, EPR actuation, idle speed, fuel delivery and injection timing and adjusts as temperature increases; **5.0 volts in, 4.37 volts@32°F, 1.37volts@176°F, .96volts@205°F**. **PID: EOT** (degrees)

EPR: Exhaust Back Pressure Regulator, also EBP regulator Output: For quicker engine warm-up at cold temperatures. If the IAT is below 37°F (50°F some models) and the EOT is below 140°F (168° some models) the PCM sends a duty cycle signal to a solenoid which controls oil flow from the turbo pedestal. This causes a servo to close a valve at the turbo exhaust outlet. The PCM monitors the EBP input to determine if the EPR needs to be disabled to provide power for increased load, then reapplies the EPR as load demand decreases until EOT or IAT rises. **PID: EPR** (duty cycle), EBP (pressure)

GPC: Glow Plug Control Output; The PCM energizes the glow plug relay for 10 to 120 seconds depending on EOT and BARO. PID: GPC (time) GPL: Glow Plug Light Output. The PCM controls the "Wait to start" light independently from the GPC output; 1 to 10 seconds depending on EOT and BARO. **PID: GPL**.

GPM: Glow Plug Monitor Feedback input; On 1997 and newer California emission vehicles, the PCM monitors glow plug relay output voltage to determine if any glow plugs are burned out or if the relay is functioning. PID: GPML (left bank current), GPMR (right bank current), GPMC (relay output)

IAT: Intake Air Temperature sensor Strategy input; The PCM uses this for EPR control. 5 volts in, **3.897volts@32°F, 3.09@68°F, 1.72@122°F**. **PID: IAT** (degrees)

ICP: Injection Control Pressure sensor Feedback input; The PCM monitors the high pressure oil system to determine if it needs to be increased if load demand increases. It also uses this to stabilize idle speed, **volts in, 1.0volt@580psi, and 3.22volts@2520psi**.

PID: ICP (pressure), ICP V (voltage)

ICP should be over 500 but 480-550 is normal Spikes to 2200 while cranking

IPR Duty-Cycle: 10-15% Accelerator Pedal Position between 10-15%

WOT ICP DC should not exceed 65% and ICP should not drop below 1800PSI with Pedal Position between 70-80%

EXBP should be 10-15psi with EBPV closed and not exceed 45psi at WOT

Note: EXBP showing low (3-5psi) that barley rises with acceleration indicates bad sensor or plugged tube.

- At start up the ICP 400 to 700 psi.
- At idle the ICP 400 to700 psi and the IPR duty cycle is 9 to 14%
- At cruise ICP is 700 to 1200 psi and IPR is 15 to 20%
- Normal acceleration ICP is 1200 to 2000 psi and IPR is 20 to 30%
- Under WOT the ICP can go up 3600 psi but don't worry if it is less 3000 psi is Just fine and the IPR is 35% or higher.

Note: If you are not seeing any ICP pressure = bad ICP sensor or it seems low (Going bad ICP sensor) you can unplug the ICP sensor that should default it to 700 psi.

IDM: Injector Driver Module the PCM sends a Cylinder Identification and Fuel Demand Control signal to the IDM. The IDM sends a **110 volt** signal to the injectors. It then grounds each injector as fuel is required for that cylinder. Fuel Pulse width is increased to deliver more fuel. The IDM sends a feedback signal to the PCM for fault detection.

PID: Fuel PW Fuel Pulse Width signal from PCM (milliseconds)

IPR: Injection Pressure Regulator Output; the PCM controls the high pressure oil system by varying the duty cycle of the IPR. The IPR controls the oil bypass circuit of the high pressure pump. 0%=full return to sump (open valve), 100%=full flow to injectors (closed valve). The PCM monitors the system with the ICP input. The PCM can control fuel delivery to the injectors by increasing the IPR duty cycle which increases fuel pressure through the injector nozzles.

PID: IPR (% of duty cycle), MFDES Mass Fuel Desired an internal PCM calculation based on load demand (MG)

IVS: Idle Validation Switch Strategy input; On-off switch that the PCM uses to identify required operating mode; idle or power. **0 volts at idle, 12 volts off idle**. **PID: IVS** (off/on)

MAP: Manifold Absolute Pressure sensor Strategy and feedback input; The PCM monitors manifold pressure to control fuel delivery in order to minimize smoke. It also optimizes injection timing for detected boost. It also monitor boost to limit fuel delivery to control maximum turbo boost. Frequency output; **111Hz / 14.7 psi, 130Hz / 20psi, 167Hz / 30psi. PID: MAP (pressure baseline 14.7psi), MAP HZ** (frequency), MGP Manifold Gauge Pressure (pressure base line 0psi) turbo boost.

MAT: Manifold Air Temperature sensor Strategy input; The PCM uses this signal to adjust fuel and timing. 99 model/year engines. **PID: MAT**

MIL: Malfunction Indicator Lamp "Check Engine" or "Service Engine" light that the PCM illuminates when certain system faults are present.
PCM: Powertrain Control Module, also ECU or ECM for Electronic Control Unit or Module The computer which monitors sensor inputs and calculates the necessary output signals to the engine control systems. It also checks for readings outside of normal parameters a records trouble codes for these faults.

PID: Parameter Identification, also Data Stream or Sensor Data Sensor readings displayed to a scan tool that represent sensor readings to- and output signals from the PCM.

USEFUL PID COMPARISONS

AP--Accelerator Pedal--and IVS--Idle Validation Switch: IVS should switch state when **AP voltage is approximately 0.2-0.3 volts higher than base idle position.**

ICP Injection Control Pressure **IPR** Injection Pressure Regulator and **MFDES** Mass Fuel Desired: ICP should rise as IPR duty cycle increases; MFDES and IPR should rise at the same rate as load and/or demand increases (actual readings may not match); i.e. **ICP: 500psi, IPR: 12%, MFDES: 10MG @ 500 RPM; ICP: 900 psi, IPR: 22%, MFDES: 20MG @ 1800 RPM (cruise). ICP: 1800 psi IPR: 50%, MFDES: 40MG @ 3000 RPM *under Hard Acceleration.**

ICP Injection Control Pressure and **RPM Camshaft Position Sensor**: After 3 minutes at 3300 RPM, ICP pressure should be below **1400 psi for Federal, 1250 psi for California Emissions, and 1500 psi for 99.5. At idle, ICP should be 550 - 700 psi for Federal, 400 - 600 for California and stable.**

V PWR Battery Voltage **RPM Camshaft Position Sensor ICP** Injection Control Pressure **FuelPW** Fuel Pulse Width: When starting V PWR should be **above 10 VDC, ICP should be at least 500 psi, 100 RPM, and FuelPW 1mS - 6mS. Once the PCM recognizes CMP speed and cylinder ID, FuelPW should default to 0.42mS, 0.60mS for 99 up, until ICP reaches starting pressure.**

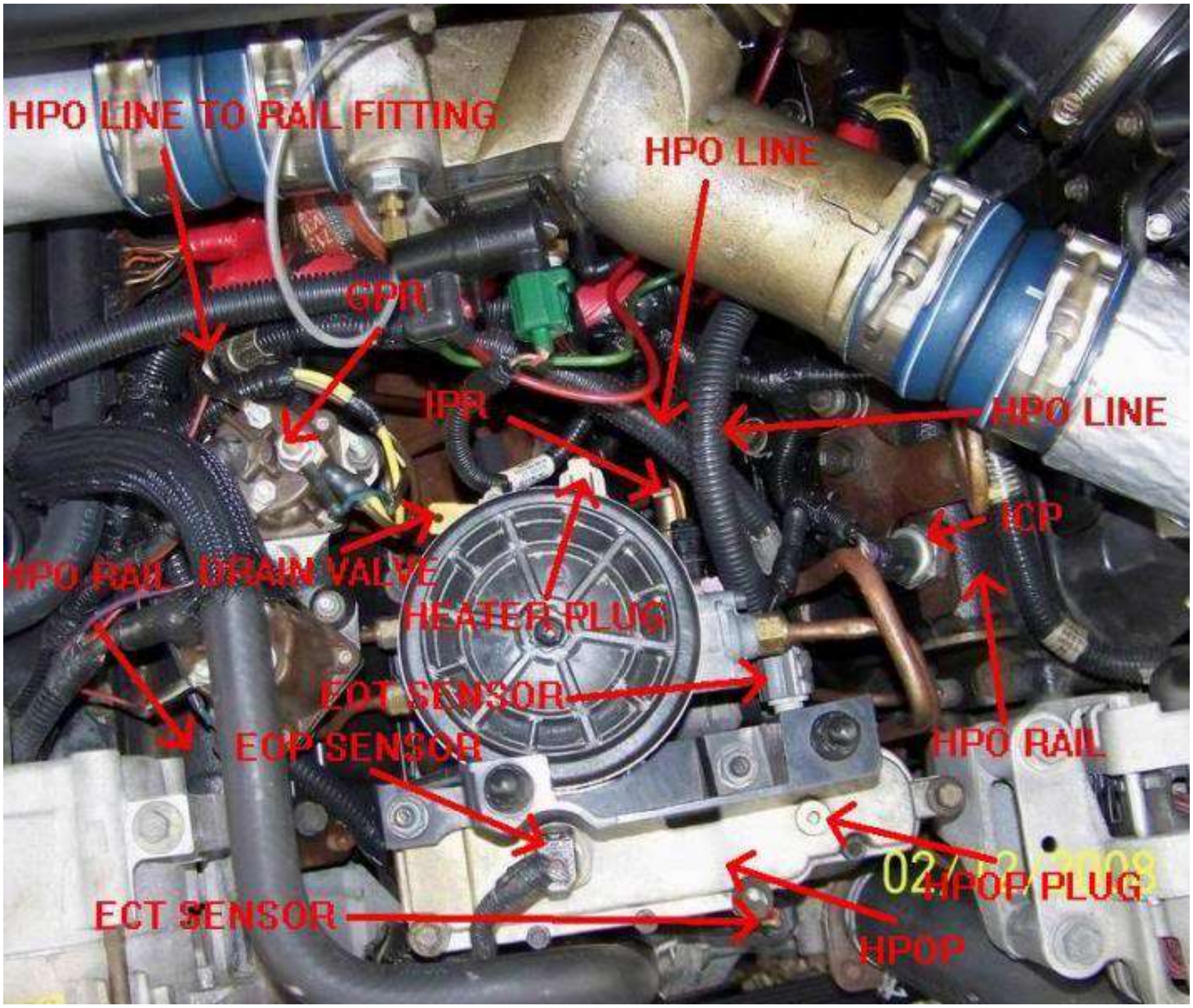
EOT Engine Oil and **IAT** Intake Air Temperatures: After a cold soak, before starting **EOT and IAT should be within 10°F of each other, Key-On Engine Off**.

BARO Barometric **MAP** Manifold Absolute and **EBP** Exhaust Back-pressures: **All three should indicate atmospheric pressure (14.7psi at sea level) and read within 0.5 psi of each other, Key-On Engine Off.**

ICP Injection Control Pressure and **ICP** VICP Voltage: **ICP should read 0 psi, ICP V should read 0.20-0.25 volts - Key-On Engine Off.**

EBP: Exhaust Back Pressure **MGP** Manifold Gauge Pressure and **RPM Camshaft Position Sensor**: **At full throttle in neutral, EBP should be below 28psi, at full throttle in fourth (manual) or third (auto) gear, MGP should be 15psi.**

LOCATIONS OF SENSORS, LINES, AND WIRING:



7.3L INJECTOR "BUZZ" TEST: The Injector "Buzz" Test can be used to look for a faulty fuel injector. It is best to run this test on a totally cold engine, one that has sat overnight and has not been started. Initiate the "Buzz" test and then listen carefully to the injectors as the test is completed. First, all 8 injectors will "Buzz" at the same time. Then, the IDM will "Buzz" the injectors in numerical order (1, 2, 3, 4, 5, 6, 7, and 8). Remember that cylinders 1-3-5-7 are on the passenger side and 2-4-6-8 are on the driver's side, with cylinders 1 & 2 being at the front of the engine. You should hear a strong "Buzz" bouncing from side to side for all 8 injectors. If one of the injectors doesn't "Buzz", you've found a problem cylinder. It is important to note that when an injector fails to

"Buzz" properly, you will still hear the other 7 injectors make a faint buzz...this is a designed function to protect the IDM. Remember, the buzz test is not an audio test only, you should get fault codes with this test.

Note: Because the IDM will "buzz" the other 7 injectors faintly during individual cylinder tests, it is possible for the "Buzz" test to report no problems detected. If the "Buzz" test reports no failures, but you don't hear a particular cylinder "Buzz"...more than likely there is a problem with that injector.

It should also be noted that an injector failing a "Buzz" test can have many causes. The injector can be in a failed state (loose armature plate screw, bad solenoid, etc.), the UCV (under valve cover) gasket or harness could be damaged or disconnected, the main engine harness could be damaged or the IDM could be damaged. Further inspection will be necessary to determine the actual problem...but at least you now have a place to start.

Quick KOEO Sensor Checks: There are a few sensors that can be easily checked with a Scan Tool. Starting with a "Dead Cold" engine (let it sit overnight, don't start), connect to the truck with the scan tool. Check the following: Oil Temp should closely match the current Ambient Temperature Readings for Exhaust Back pressure, Manifold Absolute Pressure and Barometric Pressure should all be within 1/2 psi of each other (this should be true with the engine either warm or cold).

Note: with the engine running, MAP and EBP values are "Pressure + Baro". For example, if Baro is 14.7 and there is 2psi of boost, MAP will read 16.7. Also, there is a calculated PID called "Manifold Gauge Pressure" that doesn't have the Baro pressure added in).

KOER (Key-On Engine Running) On-Demand Test: On the 7.3L, the primary purpose of this test is to check the functionality of the High Pressure Oil System and the Exhaust Back Pressure Solenoid. On the 6.0L this test may return Misfire, VGT or Glow Plug codes.

7.3L Powerstroke Starting Req.:

Vehicle Power: 10.5v
RPM Signal: 100rpm
ICP: 0.85v (about 500psi)
Fuel Pulse Width: 1 to 6 milliseconds

6.0L Powerstroke Starting Req.:

Vehicle Power: 10.5v
RPM Signal: 100rpm
ICP: 0.85v (about 500psi)
Fuel Pulse Width: 0.5 to 2 Milliseconds

Note: the above starting requirements for both 7.3L and 6.0L Powerstroke Diesels assume the following:

- Sufficient Base Engine Oil Level and Pressure
- Acceptable Quality Fuel
- Sufficient Fuel Pressure
- Sufficient Air Supply
- Proper Glow Plug Operation
- Proper Injection Timing (PCM Controlled)

P1298 - "IDM Failure" (7.3L): This code can be set by a low battery. Connect a battery charger, clear codes and re-run KOEO tests. If this code doesn't return, check charging system and batteries and repair as necessary. If the code returns, IDM is suspect.

P1316 - "IDM Codes Detected" (7.3): IDM Codes are stored in memory in the IDM itself. The P1316 DTC is an indication that there are stored IDM Codes that need to be retrieved and/or cleared. Executing a "Clear Codes" will clear both PCM and IDM codes...DO NOT CLEAR CODES until you have retrieved and reviewed the codes stored in the IDM Please keep in mind that IDM Codes are stored in memory. If you have a code indicating a fault, but there is no drivability problem, the fault may not currently exist. After taking note of the codes, execute a "Clear Codes". At this time you should be able to re-run the above tests with no IDM codes generated. If one or more IDM codes are still present after the "Clear Codes" command has been successfully executed and the above tests performed again, the fault still exists and further examination is necessary.

P1211 - "ICP Higher / Lower than Desired" (7.3): We all know that this code is commonly caused by "Hot Chips" that are demanding more Injection Control Pressure (ICP) than the High Pressure Oil Pump can deliver. For what it's worth, these are the exact parameters that trigger this code:

- ICP 410psi Higher Than Desired for 7 Seconds
- ICP 280psi Lower than Desired for 7 Seconds

This code can also be caused by legitimate High Pressure Oil System issues. Below is a list of some of the causes: Failed or Sticking IPR (Injection Pressure Regulator) Failed or Weak HPOP (High Pressure Oil Pump) Any Leak in High Pressure Oil System (O-ring, stuck injector, etc.) Low Fuel Pressure (Rare) P1280 / P1281 / P1283 - (7.3L)

The above codes are related to ICP also. If the Service Engine Soon (SES) light is on and these codes are present, the ICP reading through any scan tool will not be accurate as the PCM is using a "default" ICP value. These codes are all "electrical" in nature. Common causes are shorts between the Red and White IPR wires or between the Red IPR wire and ground. These can also sometimes indicate a PCM problem.

FICM SYNC and IDM:

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Below is a list of some of the causes:

- Failed or Sticking IPR (Injection Pressure Regulator)
- Failed or Weak HPOP (High Pressure Oil Pump)
- Any Leak in High Pressure Oil System (O-ring, stuck injector, etc.)
- Low Fuel Pressure or air in fuel
- P1280 / P1281 / P1283 - (7.3L)

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VEHICLE HIGH PRESSURE OIL PUMP (HPOP) HEALTH CHECK

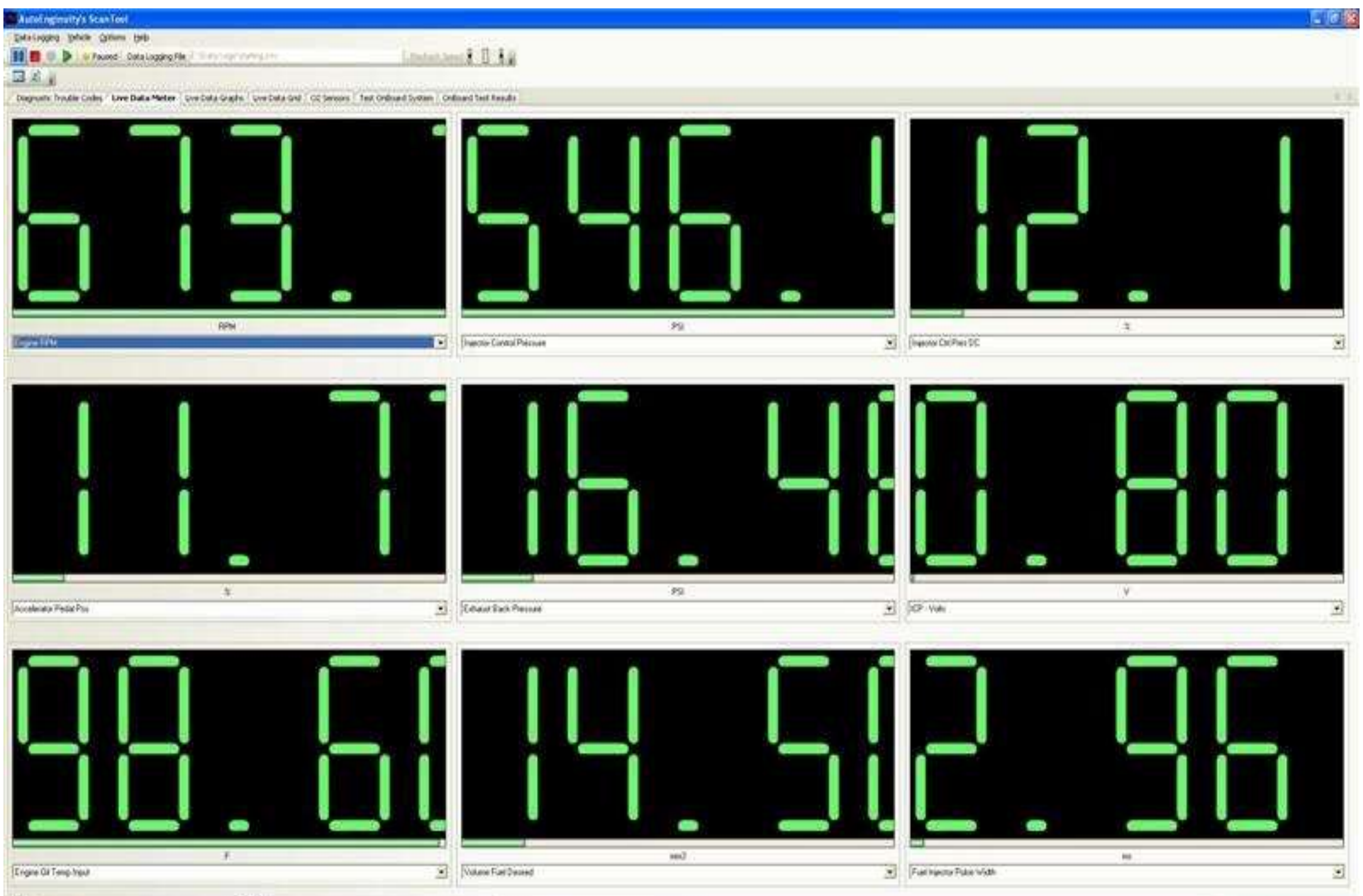
Sensor Table (See Examples Below)

Engine RPM	Injector Control Pressure	Injector CRTL Pres. DC
Accelerator Pedal Position	Exhaust Backpressure	ICP – Volts
Engine Oil Temp	Volume Fuel Desired	Fuel Injector Pulse Width

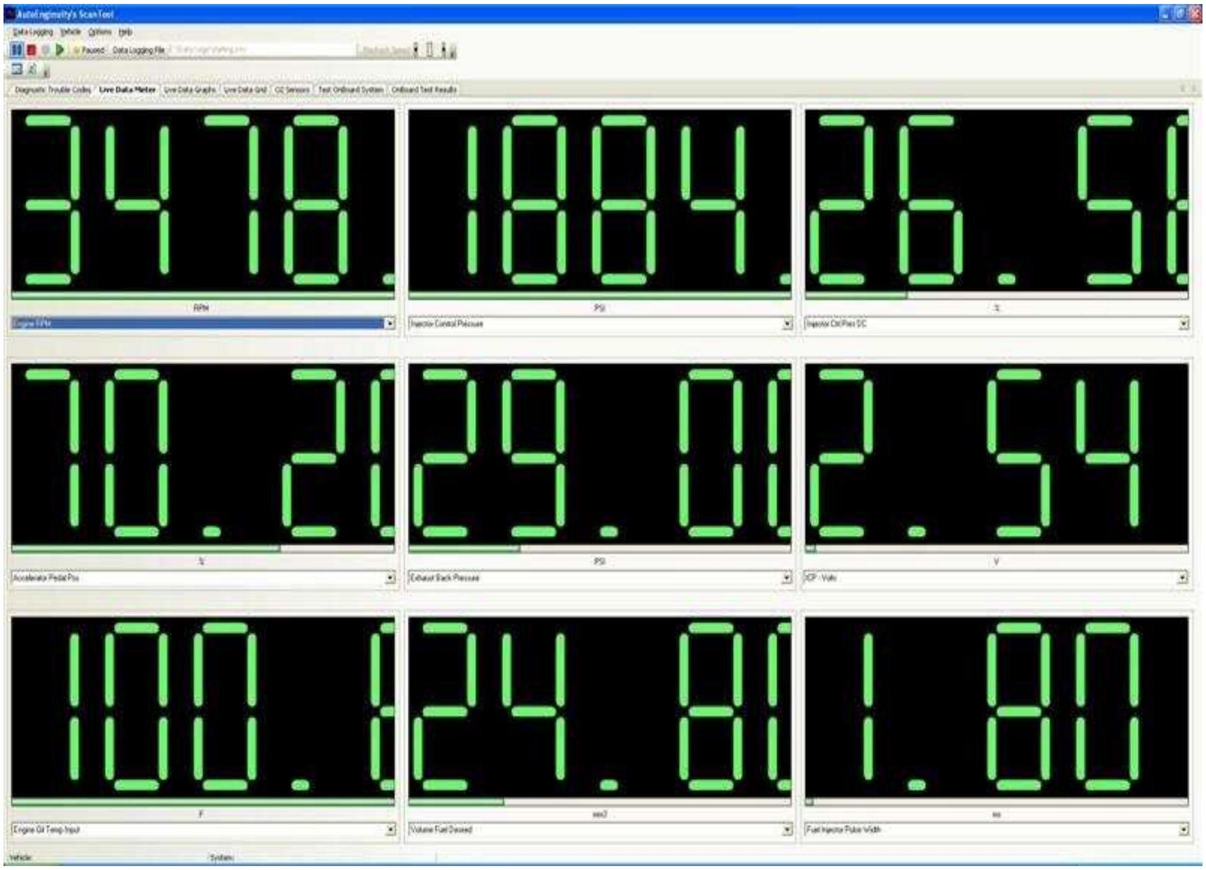
1. Connect to Enhanced Powertrain Module

2. Select the following sensors in Live Data
   a. Engine RPM b. Injector Control Pressure c. Injector CRTL Pressure DC d. Accelerator Pedal Position
   Exhaust Backpressure e. ICP – Volts f. Engine Oil Temp g. Volume Fuel Desired
   h. Fuel Injector Pulse Width

ENGINE AT IDLE:



ENGINE AT WIDE OPEN THROTTLE (WOT)



At Idle Injector Control Pressure should be _> 500psi_ (on a fully warmed truck pressure will generally be between 480psi and 550psi.

If you are monitoring during cranking you can see spikes upwards of 2200psi.

The IPR (Injector CRTL Pressure DC) should be between 10-15% at idle with the Accelerator Pedal Position also between 1015%. At WOT Injector CRTL Pressure DC should not exceed 65% with ICP not below 1800psi and Accelerator Pedal Position between 70-80%.

- *Note: DO NOT PERFORM THE WOT TEST WITH AN AFTERMARKET TUNE OR CHIP THE REV LIMITER MAY HAVE BEEN REMOVED CHECK WITH YOUR TUNER OR CHIP MANUFACTURER.*

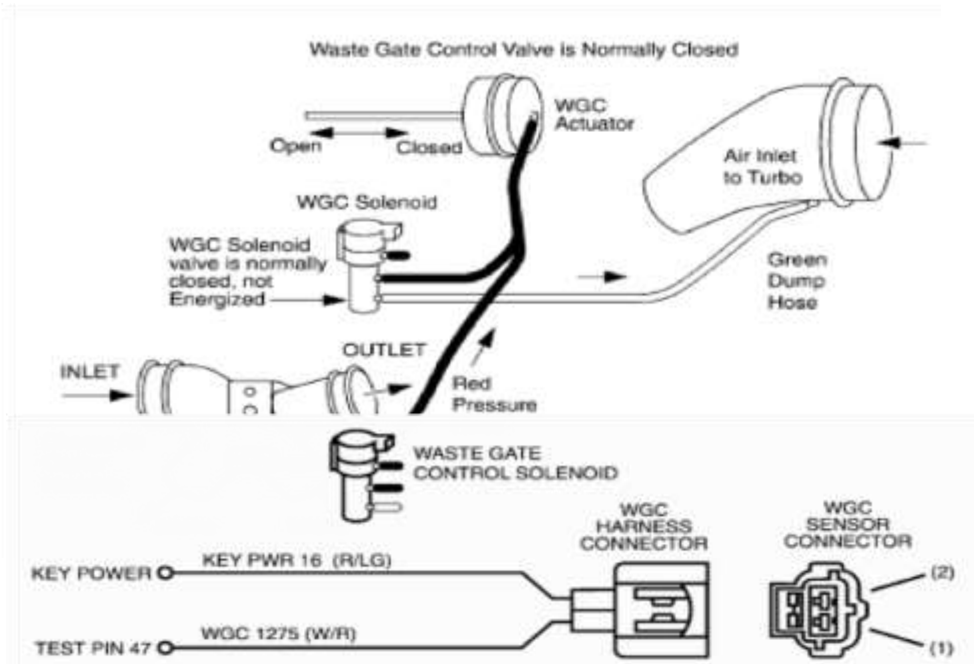
EXHAUST BACKPRESSURE should be between 10-15psi at idle (above example taken with EBPV closed) and should not exceed 45psi at WOT. A very low pressure at idle 3-5psi that just barely rises with acceleration can be a sign of a clogged tube and sensor or a bad sensor if cleaning doesn't fix it. This is best done over the road for the most accurate results.

- ICP volts can be used to diagnose a bad sensor with a multi-meter if a scan tool is not available. See Table Below

Pressure (PSI)	Pressure (MPA)	Sensor Voltage
0	0	.02v
200	1.5	.4v
400	3	0.73v
600	4	.96v
800	5.5	1.2v
1000	7	1.4v
1200	8	1.6v
1400	9.7	1.9v
1600	11	2.1v
1800	12.4	2.3v
2000	13.8	2.6v
2200	15.2	2.8v
2400	16.5	3v
2600	18	3.3v
2800	19.3	3.5v
3000	20.6	3.8v

TURBO WASTEGATE

A wastegated turbo is designed to reach maximum boost sooner than a conventional turbo, but over boosting will cause damage to the turbo. The PCM will control the boost pressure by duty cycle to the solenoid to maximize boosting performance (no more than 16-1/2 psi). When pressure is supplied on the red hose going to the actuator (solenoid NOT energized) the valve will open, dumping boost. When low or no pressure is on the red hose going to the actuator (solenoid is being energized), the valve will stay closed.



Connect to the Enhanced Powertrain System and select the following PID's in Live Data.

1. Wastagate Control Solenoid Duty Cycle
2. Manifold Absolute Pressure
3. Barometric Pressure
4. Manifold Gauge Pressure
5. Intake Air Temp
6. Manifold Air Temp
7. Vehicle speed

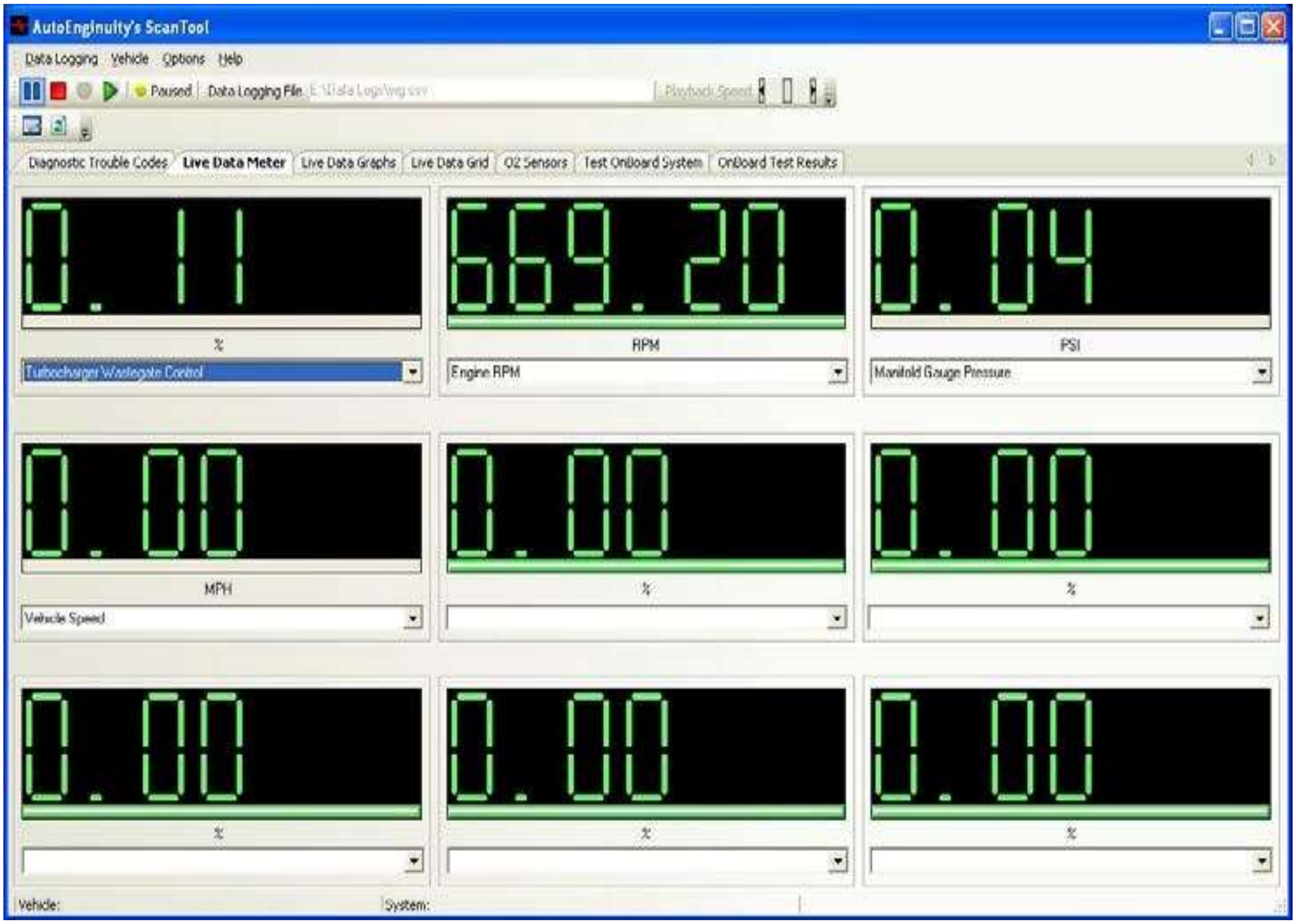
At idle or WOT in park or neutral duty cycle will be ~0.11% (Wastagate open). At about 5 mph the duty cycle will go to 90-100% and the Wastagate will be closed (pressure dumping back to intake via green line). As Manifold Gauge Pressure climbs duty cycle will decrease and the solenoid will close the dump valve and apply pressure to the Wastagate actuator opening the Wastagate.

Mechanical checks: Resistance between pin 1 & ground on the Wastagate solenoid connector should be >10Kohms. Resistance between pin 1 & 2 should be < 50ohms. Voltage with KEY ON ENGINE OFF between pin 2 and ground should be > 10.5vdc. Leak checks should be carried out on both red and green lines as well as the solenoid and actuator should hold a vacuum. This can be accomplished by removing the red line from the actuator and applying a slight vacuum to the red line this will test the red line and solenoid, then apply vacuum to the actuator.

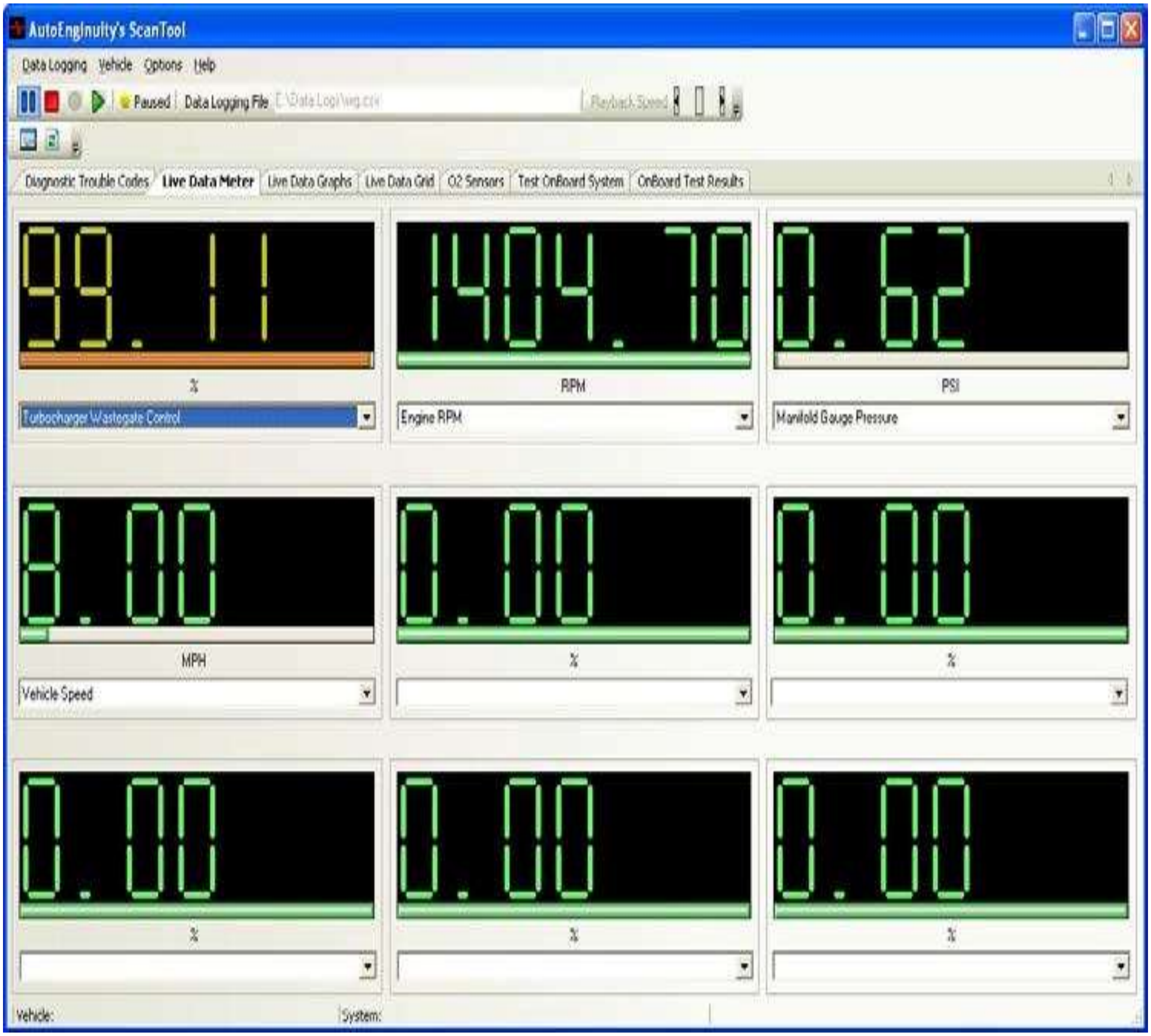
Other items to check while viewing live data: Manifold Air Temp should = Intake Air Temp within a degree or 2 with KEY ON ENGINE OFF, Manifold Gauge Pressure should = Boost Gauge (if present) and should equal Manifold Absolute Pressure – (minus) Barometric Pressure while driving. If these values are not equal further diagnostics are needed for the effected sensor.

Wastegate Duty Cycle on Left Top, Engine RPM in Top Middle, Manifold Gauge Pressure (Boost) on Top Right, and Vehicle Speed Middle Left:

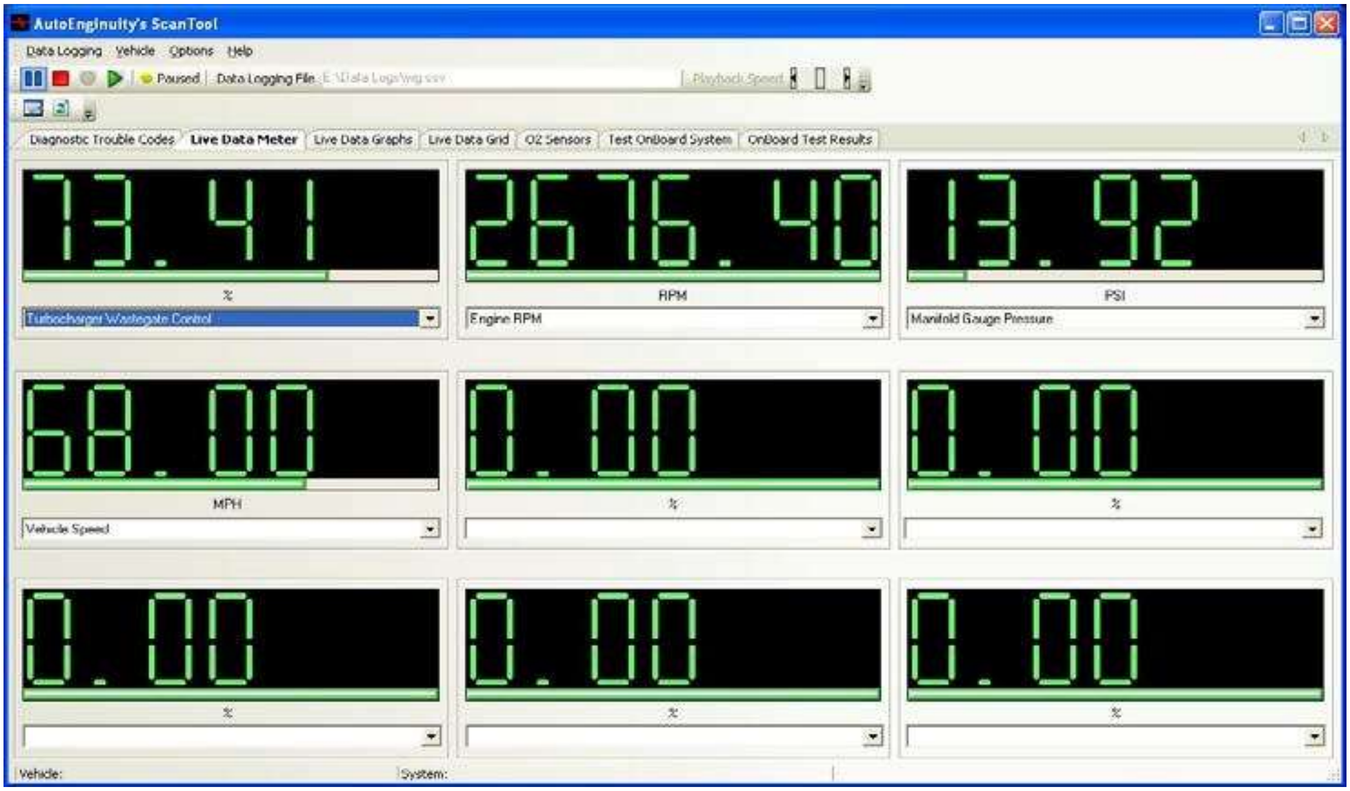
WASTEGATE AT ENGINE IDLE



WASTEGATE CLOSED STARTING ACCELERATION

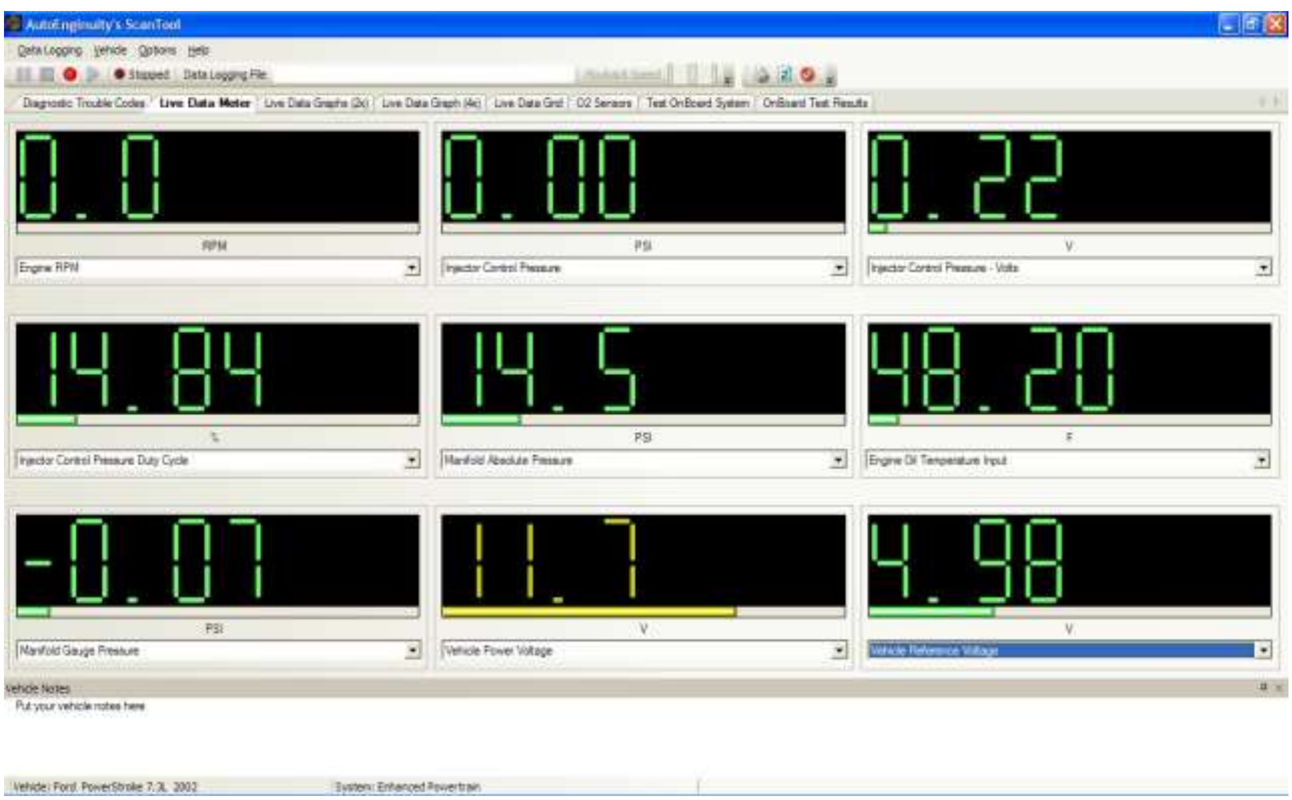


WASTEGATE OPENING UNDER ACCELERATION



TROUBLESHOOTING INJECTION CONTROL PRESSURE (ICP) *OR* INJECTION PRESSURE REGULATOR (IPR) ISSUES WITH AUTOENGINUITY (FORD ENHANCED BUNDLE)

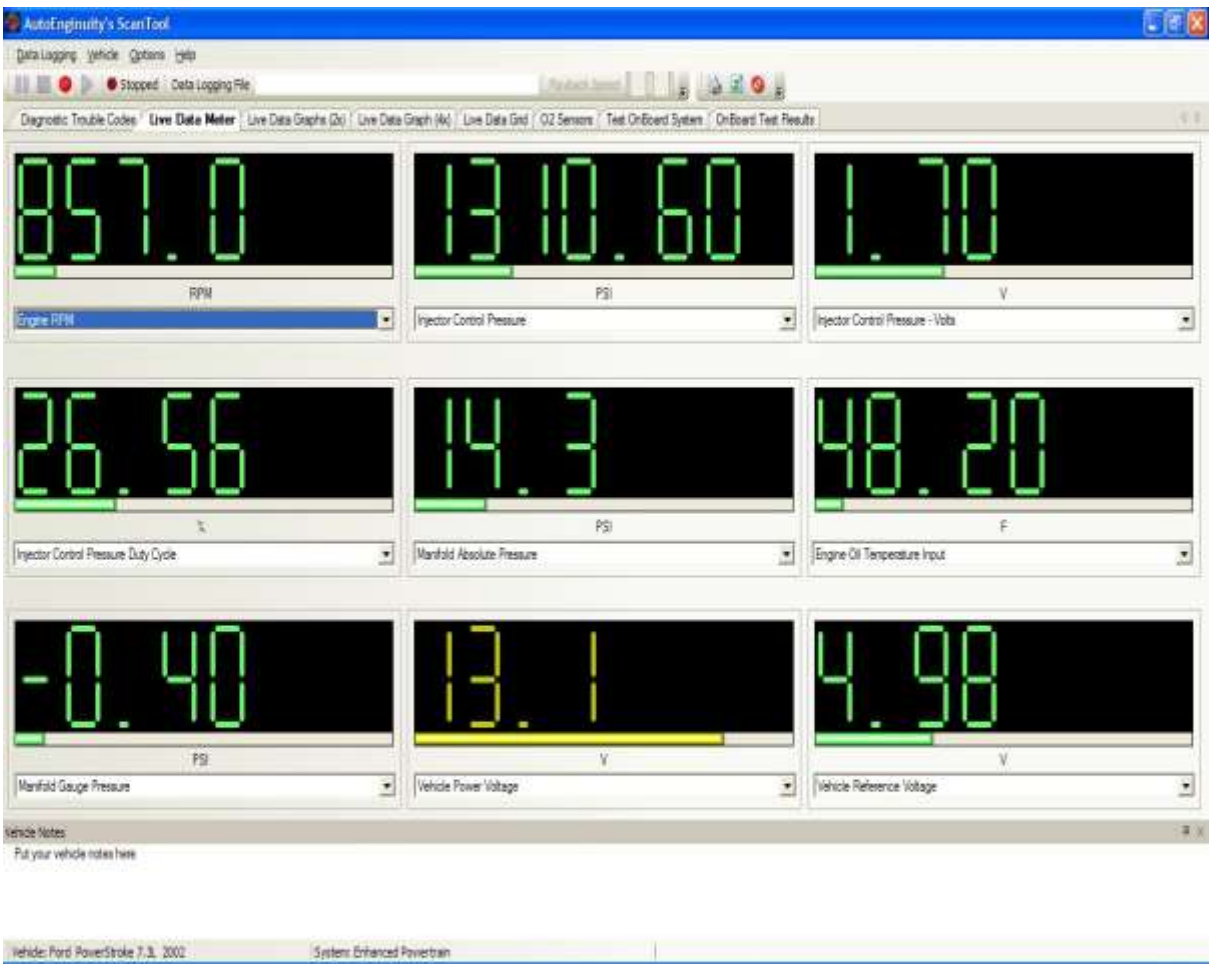
- Plug in your AutoEnginuity connector to the OBD II Port.
- Turn on the ignition to run.
- Start AutoEnginuity and connect to the Enhanced Powertrain System.
- On the Live Data Meter Tab select the following.
- Engine RPM
- Injector Control Pressure (ICP)
- Injector Control Pressure Duty Cycle (IPR Duty Cycle Percentage)
- Injector Control Pressure Volts
- Engine Oil Temperature Input
- Optional: Manifold Absolute Pressure, Manifold Gauge Pressure, Vehicle Power Voltage, & Vehicle Reference Voltage.
- With the engine off you should have results similar to below?
- ICP should be 0.0
- IPR DC % should be around 0.22 volts



7.3 NAVISTAR ® FORD® DIT DIESEL QUICK REFERENCE INFORMATION

CHECK THE FOLLOWING BEFORE RUNNING ANY TESTS:

- Verify engine oil is clean (oil should have less than 5,000 miles) and sufficient quantity (in cross hatch section on dip stick). Dirty oil can cause drivability and rough running conditions.
- OEM fuel pressure is 51 psi +/- 4 psi. This must be checked with a separate gauge. The PCM does not monitor fuel pressure on the 7.3L engine.
- Check the oil level in the HPOP reservoir. It should be within a 1" from the top of the reservoir. Remove the HPOP reservoir plug to verify.
- Now you can start the engine and verify the ICP/IPR live data.
- You can see the ICP is at 1310 PSI and IPR Duty Cycle is at 26.56%.
- As Engine Oil Temperature increases, Engine RPM, ICP & IPR DC will decrease.



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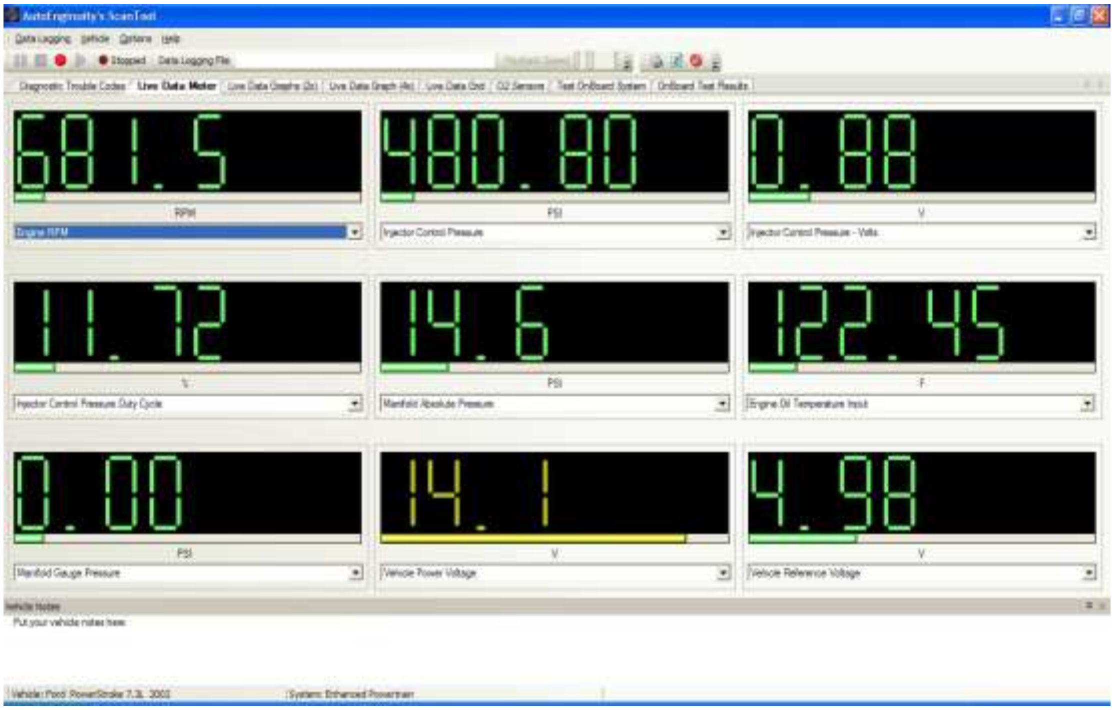
Following engine oil warms up (160ºF), you should witness a drop in both Engine RPM, ICP and IPR DC.

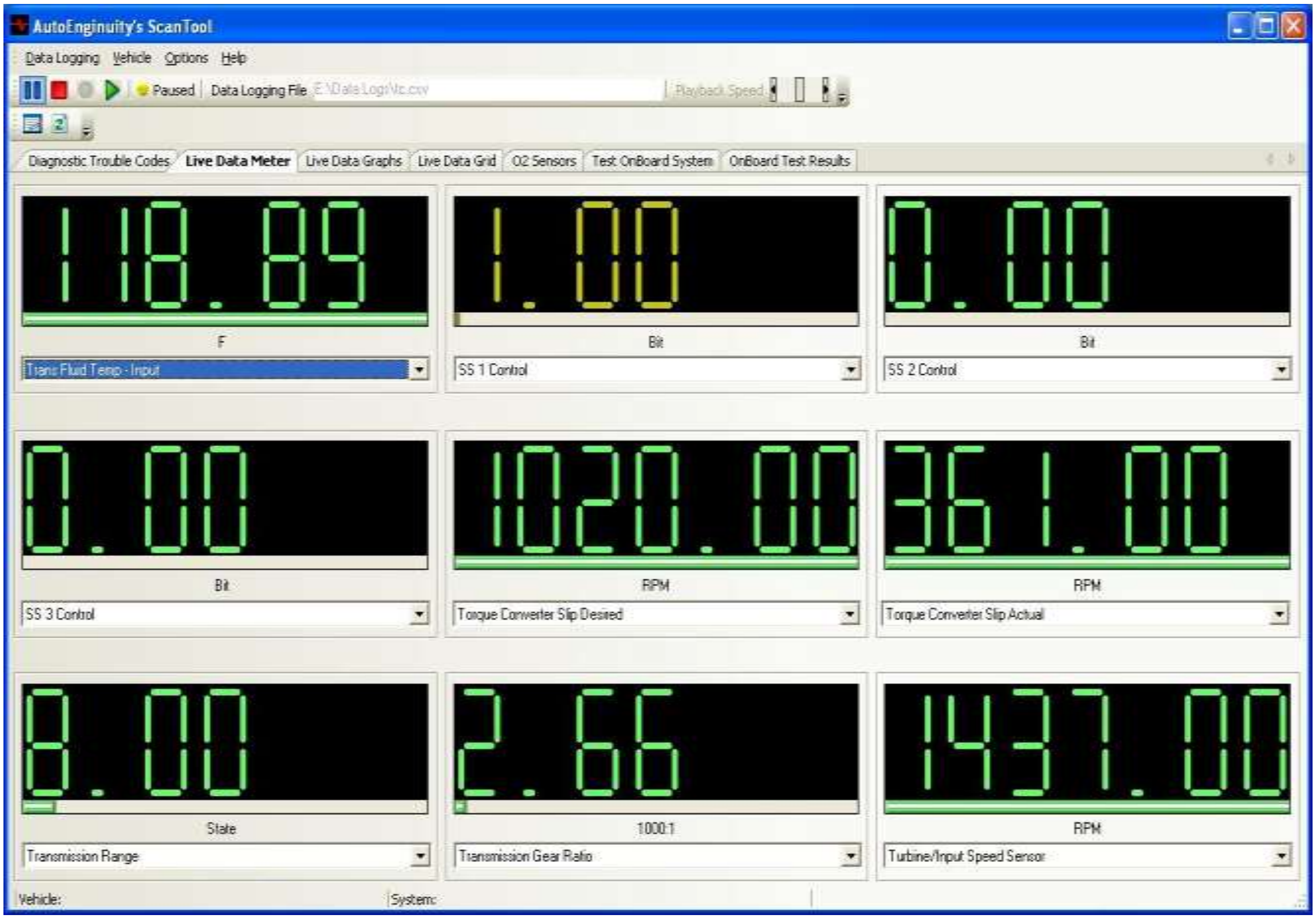


- Check the Injection Pressure Regulator (IPR) Duty Cycle under a load.
- Drive the vehicle at Wide Open Throttle (WOT) under a load (pulling a hill).
- Verify the IPR Duty Cycle Does not increase above 65% with ICP less than 2000 psi.
- If you see greater than 65% Duty Cycle, you may have a faulty IPR, Weak HPOP, or leaks in the high pressure oil system (injector O-rings). Individual component testing may be required.

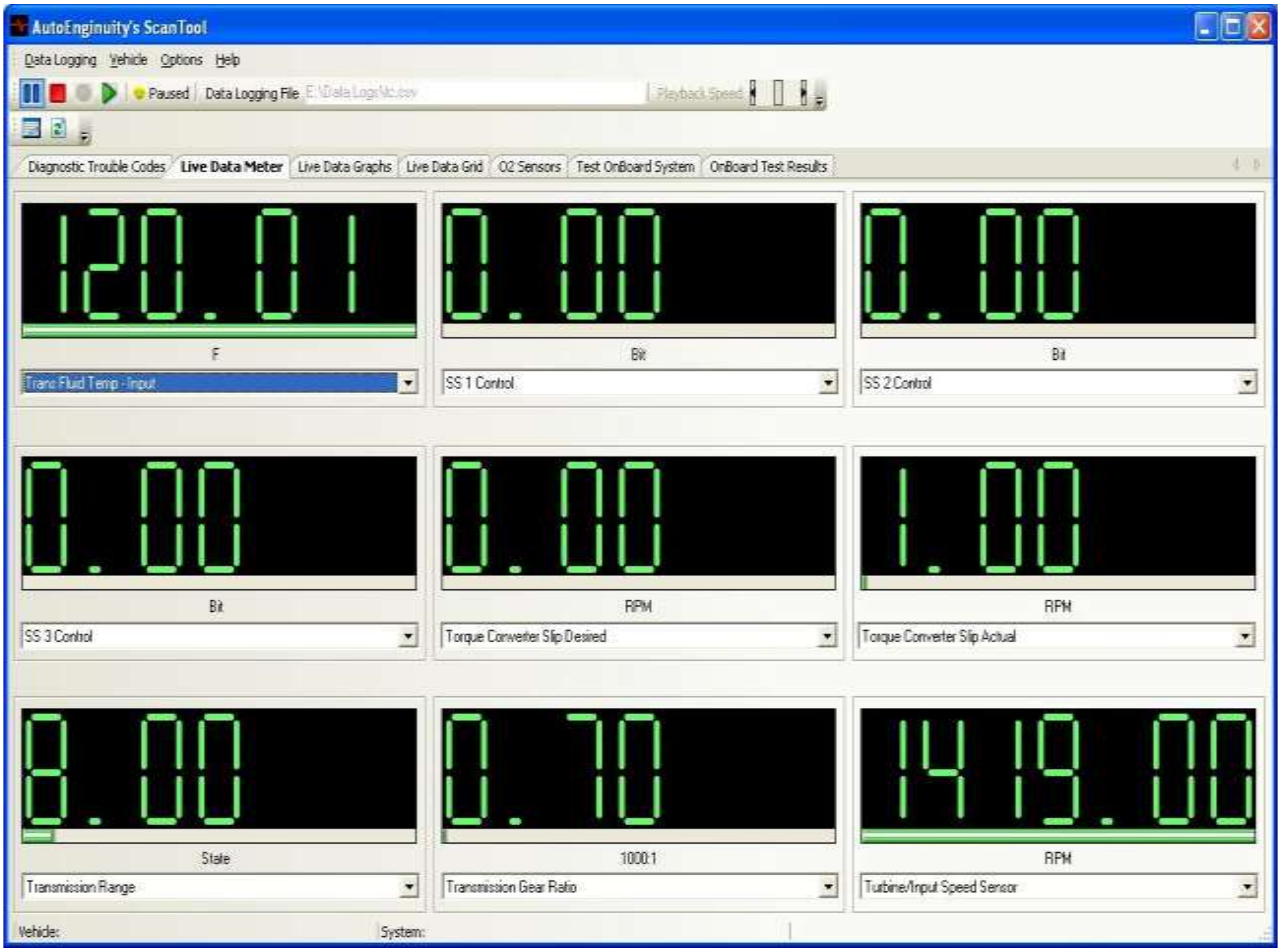
TORQUE CONVERTER SLIP:

- With the above sensors selected (at this point Vehicle Speed can be substituted for Transmission Range) start a data log or have an assistant drive and watch Torque Converter Slip Actual (TCA) and Torque Converter Slip Desired (TCD). Desired is what the PCM is commanding and Actual is how much it is actually slipping measured in RPM.

- In drive at 0 speed TCD should read 1020 rpm and TCA should be Engine RPM – Turbine Input Speed Sensor.



Once up to speed and the Shift Solenoids have been commanded through the gears the TC will lock and TCD will go to 0 and a healthy torque converter will have *< 5 rpm of slip*.



CYLINDER CONTRIBUTION TEST (CCT) / CYLINDER ROTATIONAL VELOCITY PERDEL (CRV):

CCT - Cylinder Contribution Test: The CCT is done with the more powerful scan tools - this is in contrast with a scan *gauge*. A scan gauge reads data, and a scan *tool* reads the data as well, but it can also send commands to the modules on the vehicle. The PCM monitors the Cam Position Sensor (CPS), this is the sensor that knows not only how fast the engine is turning, but exactly which cylinder is TDC. By monitoring the time it takes to get from one TDC to the next, the PCM can sense when a single cylinder is "contributing" to turning the engine, when it's not, and when it's only doing a *partial* job. This is where the CCT comes in - it tells the PCM to monitor the performance of the engine for about 2 minutes, then report a "fail" of the specific cylinder(s) that have a time-to-TDC above a threshold. It also reports other codes, like Intake Air Heater... but I am unsure of the entire list

What is the threshold? PERDEL above 2% will do it

The proper procedure for a CCT:

1. Get the engine up to operating temperature (at least 140 degrees F).
2. Once things are toasty, turn off all cab heating/cooling.
3. Put the vehicle in Drive - I am unsure what to say to those with manual transmissions. Maybe idle in 1st gear on level ground will work, but I don't know.
4. Start the CCT from your scan tool.
5. Don't touch the throttle, just sit and sip your selected soft drink.

Optional, but useful - select *Cylinder Rotational Velocity* for all 8 cylinders, plus Engine Oil Temperature. Start recording before triggering the CCT, and stop recording within about 30 seconds after the test is done. This will give you a manageable amount of data to view on playback.

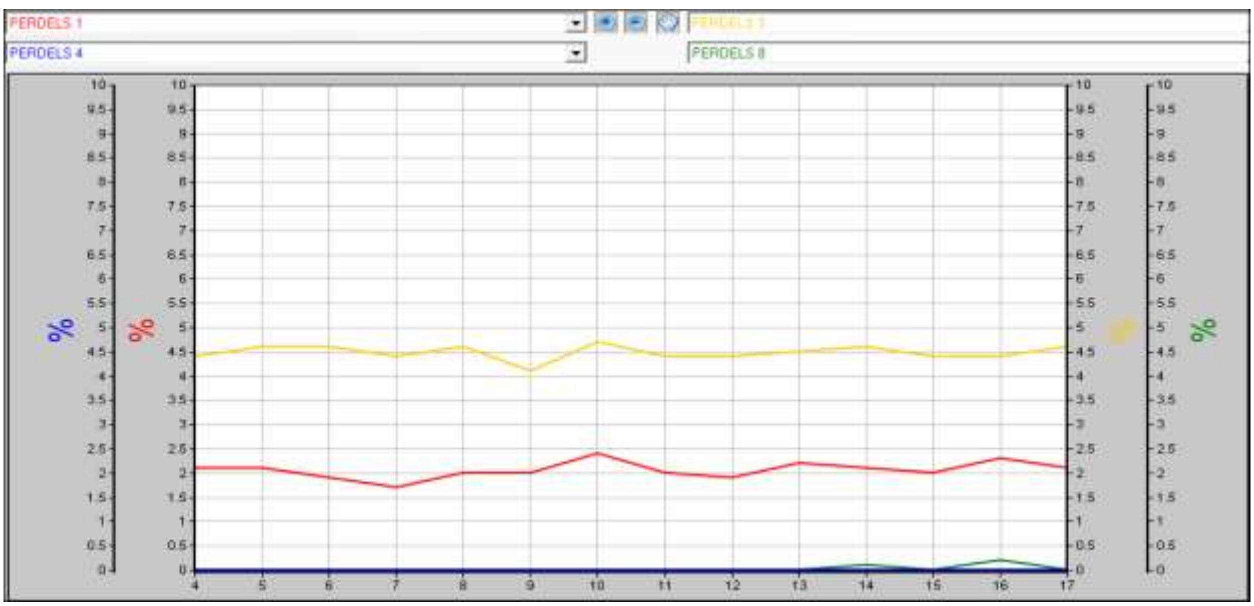
When the test is done, you will get "P0269 - Cylinder 3 Injector Circuit Contribution / Balance Fault" (as an example of a fail), or you may only get the common "P0541 - Intake Air Heater a Circuit Low", which is a pass on trucks with the AIH-delete mod. #8 frequently "false-fails" the CCT with the gray CPS, and #3 sometimes false-fails as well. This is when the CRV is helpful.

<u>CRV - Cylinder Rotational Velocity</u>: As mentioned before, the PCM measures the time between each cylinder TDC, and the CRV is a reading you can see/record on the data display with a number value - with zero as ideal. That number value is referred to as a PERDEL (from the teaser above).

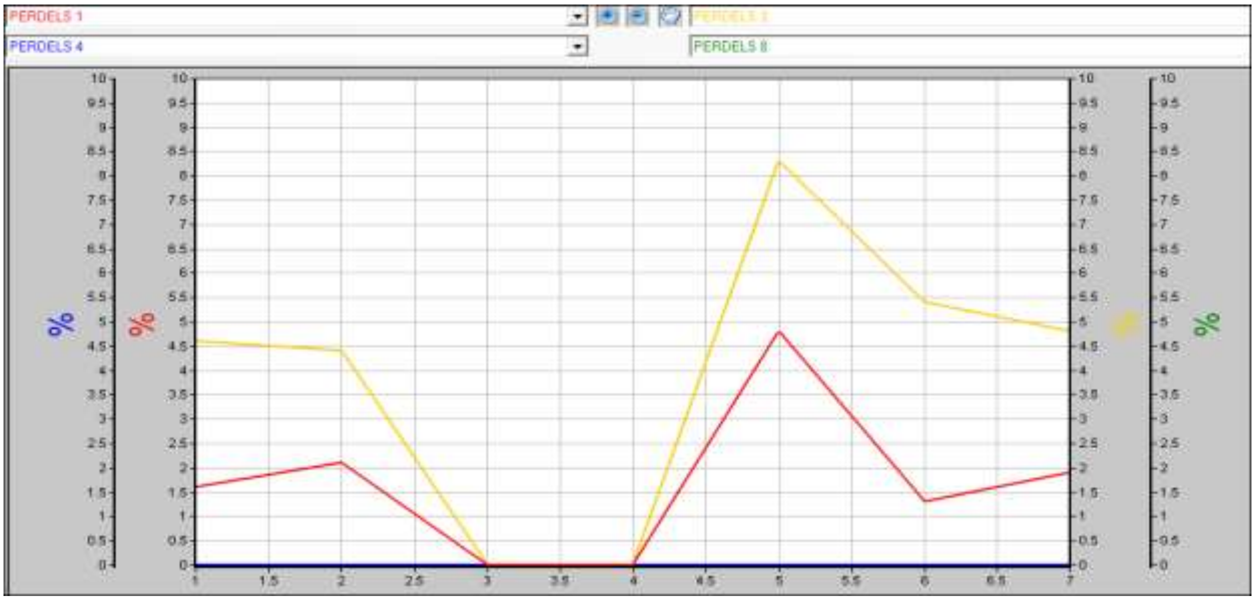
<u>PERDEL</u> - *Percent Delta*: Any time it takes longer for a single cylinder to reach TDC than another cylinder, that delay is measured in percent - with 7 to 9 being about max for a dead hole. Any number into the double-digits would likely warrant looking at something other than the injectors alone. You'll feel a PERDEL of 3, but it will be subtle at idle. You may or may not feel a PERDEL of 2, but *I* can feel it - and hear it. All the cylinders read at or near zero (not easy to achieve with some of the CPSs), except for the troublemakers.

MAX scale to 10%, this make graphing much easier. AE has a *default scale of 100%, and graphing a 5%* reading would hardly be noticeable. When looking for a bad hole, you don't want those lines on the graph under 10% to wiggle like worms - you want them to pop like prairie dogs.

Just for comparison - here is the graph from the same truck under the same conditions within a few minutes of the data taken above, except the readings were taken in neutral:



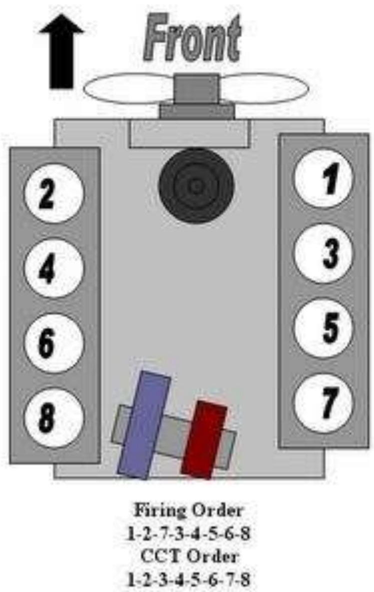
Caveats: A high PERDEL doesn't always mean "pull this injector". I don't yet know for sure what happens when you have a *hot* stick. An over-fueling stick could possibly make a high PERDEL on the hot one *and* the subsequent *healthy* injector - or it may just show a high PERDEL on one or the other. This question may be resolved as more readings and experience are amassed by the brotherhood.



TEST DESCRIPTIONS QUICK TEST OPERATION: AUTOENGINUITY

Quick Test is performed by retrieving KOEO, KOER, and Continuous DTCs.

Special Notes: Before running Quick Test, always perform the necessary visual checks and safety precautions listed below.



Visual Check

- Inspect the air cleaner and inlet ducting.
- Check system wiring harness for proper connections, bent or broken pins, corrosion, loose wires, proper routing, etc.
- Check the PCM, sensors and actuators for physical damage.
- Check the engine coolant for proper level and mixture.
- Check the transmission fluid level and quality.
- Make all necessary repairs before continuing with Quick Test.

VEHICLE PREPARATION

- Perform ALL safety steps required to start and run vehicle tests. Apply parking brake, place shift lever firmly into PARK position (NEUTRAL on manual transmission and all F650/750), block drive wheels, etc.
- **Turn off ALL electrical loads-radios, lights, A/C, blower, fans, etc.**
- Start engine and bring up to normal operating temperature before running Quick Test.

KEY-ON-ENGINE-OFF (KOEO) ON-DEMAND SELF-TEST

Key-On-Engine-Off (KOEO) On-Demand Self-Test is a functional test of the PCM performed on demand with the Key-On-Engine-Off. This test will check that all inputs and outputs (circuits, sensors, regulators, relays and solenoids) connected to the PCM are electrically operating without fault, with the exception of the Injector Driver Module DTCs. The IDM stores both historical and hard IDM fault codes; to ensure that IDM DTC is a hard fault, you must first clear continuous DTCs (be sure to record all fault codes before clearing). After clearing, rerun self-test; a fault must be present at the time of testing for the KOEO on Demand Self-Test to detect the fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

KEY-ON-ENGINE-OFF (KOEO) INJECTOR ELECTRICAL SELF-TEST

Key-On-Engine-Off (KOEO) Injector Electrical Self-Test is a functional test of the PCM performed on demand with the Key-On-Engine-Off. This test determines if the injector circuits and solenoids are electrically operating without fault. All injectors will first buzz (audible feedback of the injector solenoids energizing the injector valves) together for approximately 2 seconds, then each injector will buzz for approximately 1 second in numerical order (1 through 8). The IDM stores all historical IDM fault codes; to ensure that the DTC is a hard fault, you must first clear continuous DTCs (be sure to record all IDM fault codes before clearing). After clearing, rerun self-test; a fault must be present at the time of testing for the KOEO Injector Electrical Self-Test to detect the fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

KEY-ON-ENGINE-OFF (KOEO) OUTPUT STATE SELF-TEST

Key-On-Engine-Off (KOEO) Output State Self-Test is a functional test of the PCM performed on demand with the Key-On-Engine-Off. This test is designed to cycle outputs high and low. After pressing the trigger to start the test, you must then depress and release the accelerator pedal to cycle the outputs high: solenoids, wait to start lamp, IDM relay, TCIL, FDCS, CID and EF. The second time the accelerator pedal is depressed and released the outputs are cycled low, with the exception of the glow plug relay, which is cycled on for 5 seconds the first time only that the accelerator is pressed and released. This Self-Test does not set any codes.

KEY ON ENGINE RUNNING (KOER) SWITCH (SW) SELF-TEST

KEY ON ENGINE RUNNING (KOER) Switch Self-Test is a functional test of the PCM performed on demand with the engine running. This test is designed to set DTC(s) if the test does not detect a transition on one or more of the switches. After pressing the trigger to start the test, wait 5 seconds before running through the driver-operated controls to eliminate the chance of setting a false IVS code. The accelerator pedal must first be depressed and released to begin test, then the Parking Brake, Speed Control ON, OFF, SET, RESUME, COAST, Transmission Control or Clutch. The last to be depressed and released must be the brake pedal, which will test both the brake pressure applied (BPA) switch and the brake ON/OFF (BOO) switch.

KEY ON ENGINE RUNNING (KOER) ON-DEMAND SELF-TEST

> *Note*: On F-Series 650/750, only the injection control pressure (ICP) check is performed.

KEY ON ENGINE RUNNING (KOER) On-Demand Self-Test is a functional test of the PCM performed on demand with the engine running. Temperature is not a factor, but A/C must be turned off. A check is made on the injection control pressure (ICP), exhaust back pressure (EBP), and manifold intake air heater (MIAH) systems. During this test, engine rpm will increase; the PCM will first command ICP high and low, then command EBP high and low. A fault must be present at the time of testing for the KOER On Demand Self-Test to detect a fault. If a fault is detected, a Diagnostic Trouble Code (DTC) will be the output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

KEY ON ENGINE RUNNING (KOER) CYLINDER CONTRIBUTION SELF-TEST

KEY ON ENGINE RUNNING (KOER) Cylinder Contribution Self-Test is a functional test of the PCM performed on-demand with the engine running, A/C off and engine oil temperature above 21°C (70 °F). This test will determine if all cylinders are contributing equally to engine performance. The PCM will test all 8 cylinders continuously during the test; there is no change in engine speed or operation that can be detected by the technician. The test checks for cylinder-to-cylinder changes in engine rpm, and sets a code if the rpm change is not within a pre-calibrated range. The test checks for weak injectors or low compression cylinders. A fault must be present at the time of testing for the KOER Cylinder Contribution Self-Test to detect a fault, so the engine operating condition at which the idle is the worst will produce the best test results. For automatic transmission vehicles, the best results are reached with the parking brake set and the transmission in DRIVE. If a fault is detected, a Diagnostic Trouble Code (DTC) will be output on the data link at the end of the test when requested by a scan tool. Only a hard fault code (DTC) will be displayed.

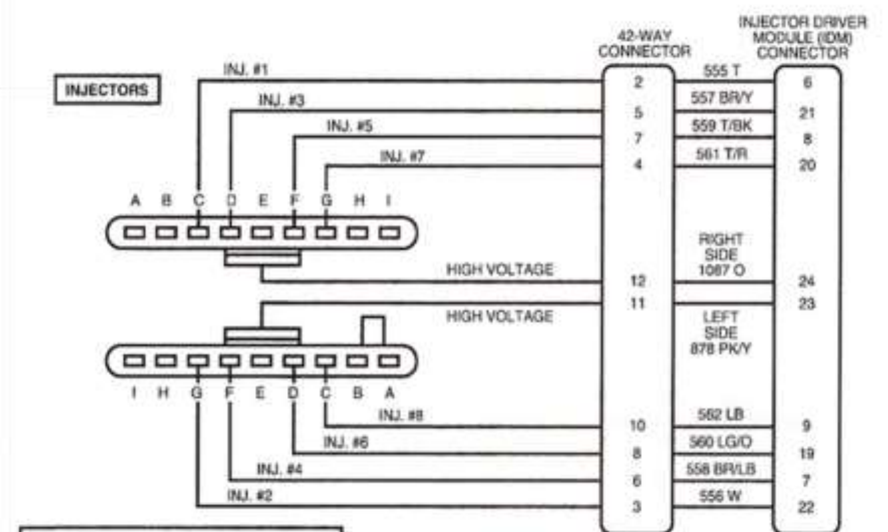
KEY ON ENGINE RUNNING (KOER) GLOW PLUG MONITOR SELF-TEST

Note: This test is not performed on F-Series 650/750.

KEY ON ENGINE RUNNING (KOER) Glow Plug Monitor Self-Test (California F-Series and Excursion) is a functional test of the glow plug system performed on demand with the engine running and the A/C off. Battery voltage must be maintained at 10-14 volts during this test. If necessary, press the accelerator pedal to increase voltage to the specified level. The PCM will activate the Glow Plug Control Module (GPCM) and monitor the glow plug circuits. A fault must be present at the time of testing for the test to detect a fault. The trouble codes will be sent to the PCM on the diagnostic line and then output to the NGS.

UNDER VALVE COVER HARNESS (UVHC) INJECTOR DRIVER MODULE (IDM) 42 PIN DIAGNOSTIC TROUBLE CODE (DTC) CHART. APPLICABLE FOR THE 1999-2003 7.3L POWER STROKE DIESEL ENGINES

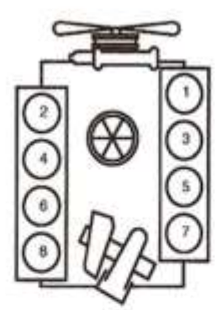
If a low side short to ground condition is determined by the IDM, this condition will be transmitted to the PCM via the EF signal. The PCM will enable the CHECK ENGINE light and command minimum fuel to the affected bank.



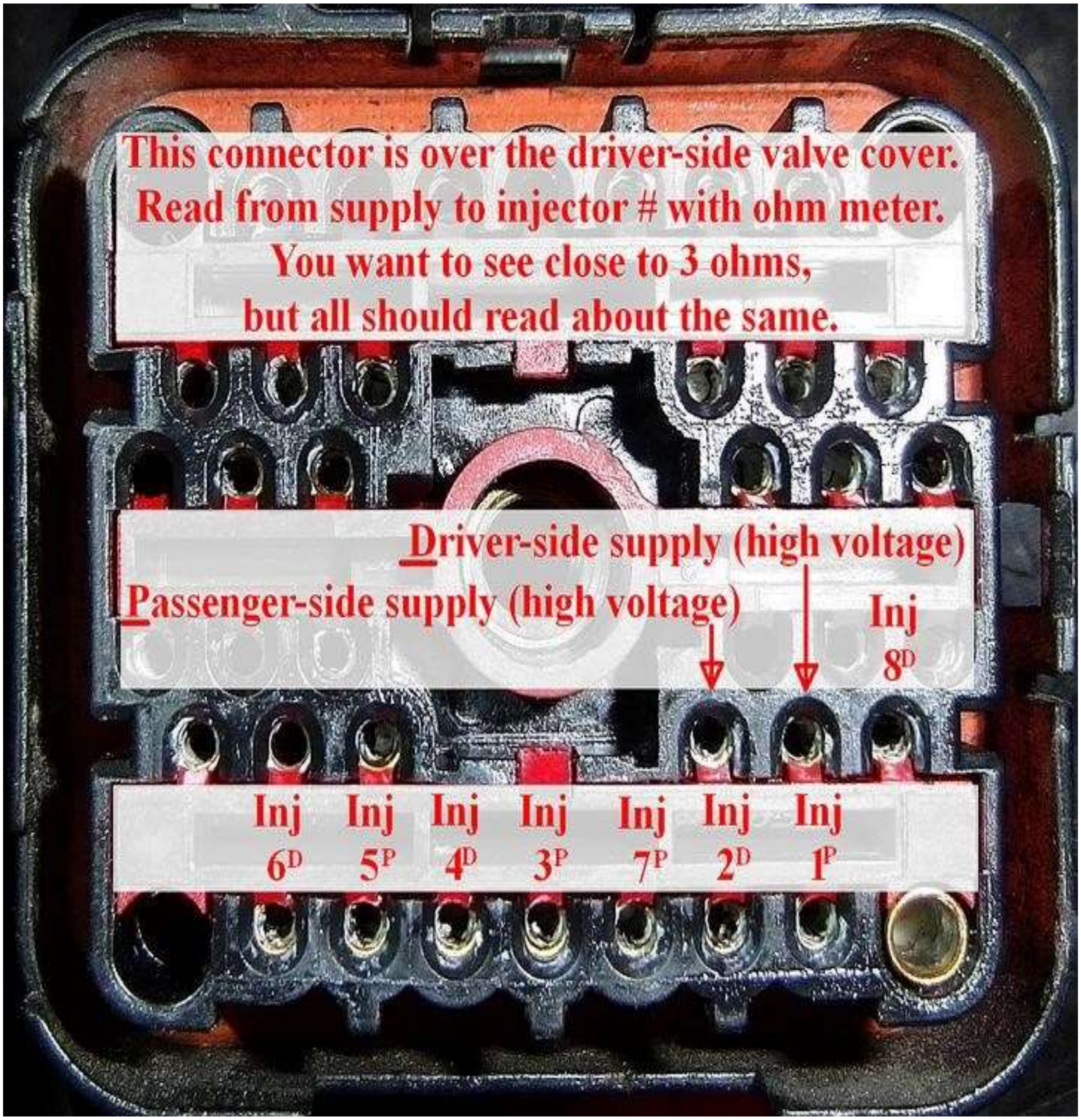
INJECTOR CONNECTORS VIEWED INTO MATING SURFACES.

INDIVIDUAL INJECTOR DIAGNOSTIC TROUBLE CODES					
	LOW SIDE SHORT TO GROUND	LOW SIDE SHORT TO BATTERY	CYLINDER CONTRIBUTION TEST	HIGH TO LOW SIDE SHORT	HIGH TO LOW SIDE OPEN
CYL. #1	0261	0262	0263	1261	1271
CYL. #2	0264	0265	0266	1262	1272
CYL. #3	0267	0268	0269	1263	1273
CYL. #4	0270	0271	0272	1264	1274
CYL. #5	0273	0274	0275	1265	1275
CYL. #6	0276	0277	0278	1266	1276
CYL. #7	0279	0280	0281	1267	1277
CYL. #8	0282	0283	0284	1268	1278

INJECTOR BANK DIAGNOSTIC TROUBLE CODES
1291 HIGH SIDE #1 (RIGHT) SHORT TO GRD. OR B+
1292 HIGH SIDE #2 (LEFT) SHORT TO GRD. OR B+
1293 HIGH SIDE OPEN, RIGHT GROUP
1294 HIGH SIDE OPEN, LEFT GROUP
1295 MULTIPLE FAULTS ON BANK #1 (RIGHT)
1296 MULTIPLE FAULTS ON BANK #2 (LEFT)
1297 HIGH SIDES SHORTED TOGETHER



FIRING ORDER
1-2-7-3-4-5-6-8
(CCT ORDER 1-2-3-4-5-6-7-8)


This connector is over the driver-side valve cover.
Read from supply to injector # with ohm meter.
You want to see close to 3 ohms,
but all should read about the same.
Driver-side supply (high voltage)
Passenger-side supply (high voltage)
Inj 8D
Inj 6D
Inj 5P
Inj 4D
Inj 3P
Inj 7P
Inj 2D
Inj 1P

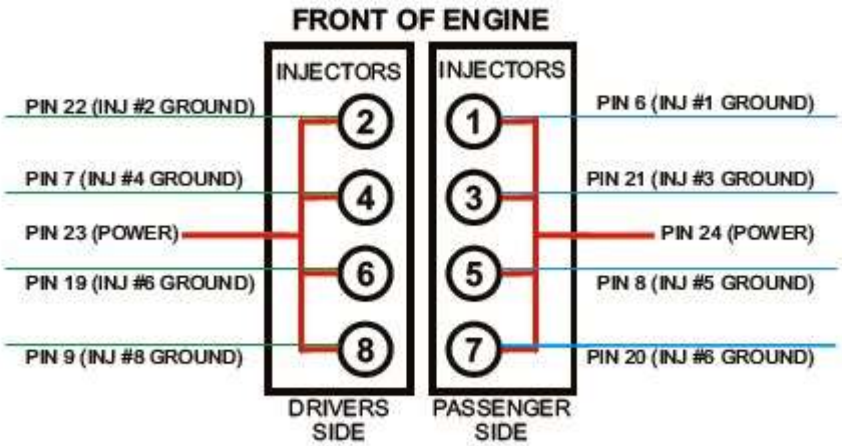
FORD INJECTOR DRIVER (IDM) MODULE REPLACE & DIAGNOSTICS:

The IDM module can fail as a result of an internal failure or be damaged by other malfunctioning components on the vehicle. In order to assist in the diagnosis of the IDM module and ensure the replacement module is not damaged when installed, the following tests and procedures should be performed.

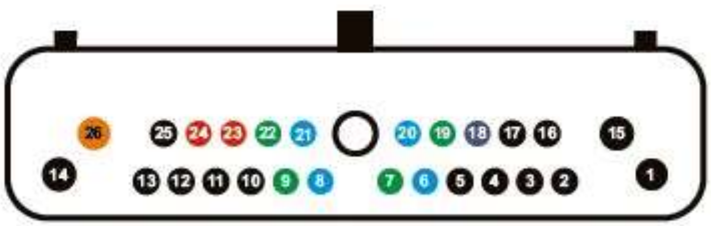
Injector Resistance and Wiring Tests

The IDM module can fail as a result of an internal failure or be damaged by other malfunctioning components on the vehicle. In order to assist in the diagnosis of the IDM module and ensure the replacement module is not damaged when installed, the following tests and procedures should be performed. A common failure found on the Powerstroke 7.3L injection system is faulty electrical wiring between the IDM module and the fuel injectors. The wiring passes through connectors which are molded into the valve cover gaskets (see Figures 1 and 2). The following test ensures the wiring between the IDM module and injectors are within specification. This procedure will also test for defective injector solenoid(s). By measuring the resistance (ohms) between each injector's power-feed and ground circuit, the total circuit and wiring resistance can be verified. This ensures that there are no shorted or open circuits to the injectors.

7.3 NAVISTAR ® FORD® DIT DIESEL QUICK REFERENCE INFORMATION



	PINS	CIRCUIT TEST	VALUE
TEST 1	23 & 22	Left Bank Power Feed to Inj. #2 Ground Circuit	All Circuits 2.8-3.6 Ohms
	23 & 7	Left Bank Power Feed to Inj. #4 Ground Circuit	
	23 & 19	Left Bank Power Feed to Inj. #6 Ground Circuit	
	23 & 9	Left Bank Power Feed to Inj. #8 Ground Circuit	
	24 & 6	Right Bank Power Feed to Inj. #1 Ground Circuit	
	24 & 21	Right Bank Power Feed to Inj. #3 Ground Circuit	
	24 & 8	Right Bank Power Feed to Inj. #5 Ground Circuit	
	24 & 20	Right Bank Power Feed to Inj. #7 Ground Circuit	
TEST 2	23 & 26	Left Bank Power Feed to IDM Ground Circuit (26)	Open "OL"
	24 & 26	Right Bank Power Feed to IDM Ground Circuit (26)	
TEST 3	23 & 18	Left Bank Power Feed to Injector Ground Shield (18)	Open "OL"
	24 & 18	Right Bank Power Feed to Injector Ground Shield (18)	



IDM MODULE HARNESS CONNECTOR
VIEWED FROM TERMINAL SIDE

Testing Procedure

The following tests should be performed with the key off, the IDM harness disconnected from the module and all other harness connectors plugged in (connectors to valve covers, etc.). Measurements are taken by probing the female terminals from the connector face (where it would normally plug into the IDM module).

TEST 1: Use a multi-meter to measure the resistance between each power feed and each injector's ground circuit at the IDM harness connector. There is one power feed for each cylinder bank.

TEST 2: Measure the resistance between each power feed and ground. This should indicate an open circuit. If resistance is present check for damaged valve cover gasket connectors and the wiring beneath the valve cover gaskets (see Figures 1 & 2).

TEST 3: Check for damaged injector wiring harness; Measure the resistance between the each injector power feed and the ground shield for the injector wires.

WARNING: The wires to the injectors are shielded wire, DO NOT pierce injector wires, doing so will permanently damage the harness.

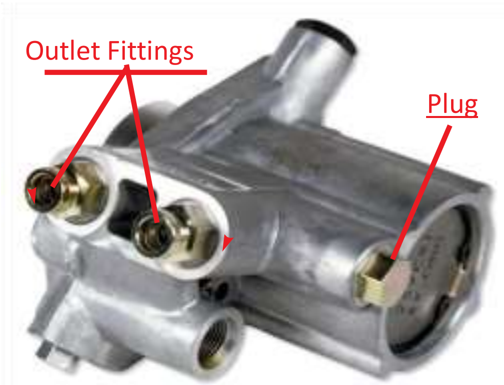
Nominal solenoid resistance for Powerstroke injectors is 2.9 Ohms. This test measures entire circuit resistance which includes wire and valve cover connector resistance. All readings for the vehicle should be consistent between each circuit. This test checks for injector circuits that are shorted to ground, which will cause immediate and permanent damage to the IDM module. The resistance between these pins should be open (infinity), indicating no path to ground. This should indicate an open circuit. If resistance is present inspect the wiring harness for damage.

NOTE: Always consult vehicle specific service and diagnostic information.

Visual Inspection – Wiring Harness & Connectors
Inspect the connectors at the valve cover gaskets for damage and proper fit. Over time the connectors can become brittle and crack. Wiggling the connectors while performing the tests on the previous page can help detect intermittent connections. If the electrical tests indicate there is a problem remove the valve cover and inspect the Injector harnesses.

HPOP PUMP LEAK REPAIR:

High pressure pumps with oil leaks at the fittings for the high pressure lines and the plug at the rear (see photo #1) can be repaired in the field using the following Ford part number 2C3Z-9G804-AA kit per TSB 03-17-01. This kit contains 3 O-rings, sealant, and instructions on how to clean and seal the fittings. Torque specs, fittings are also included.



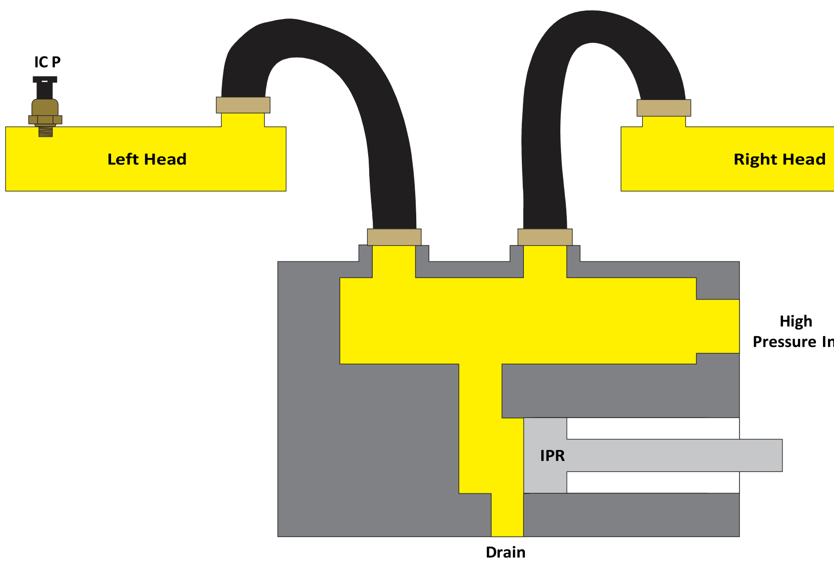
1

2

Note: Threads must be cleaned, sealant applied to the first 3 threads and the fittings and plug tightened to proper specs.

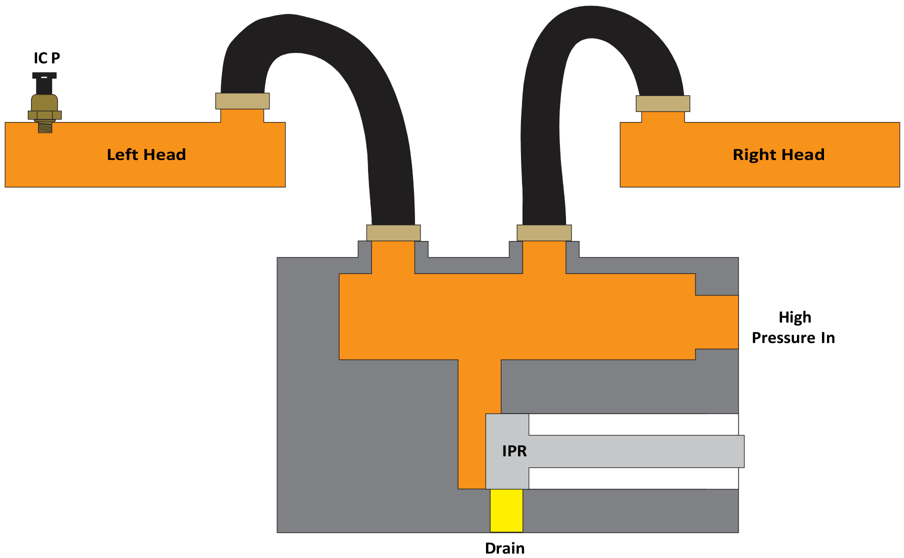
PUMP OPERATION:

The IPR acts to increase ICP by restricting the path to drain.



3

7.3 NAVISTAR ® FORD® DIT DIESEL QUICK REFERENCE INFORMATION



With max IPR% the ICP should be at its highest value.

4

The PCM attempts to increase ICP by raising the IPR%

.

KOEO	14%
Crank to Start	Less than 30% typically with no leaks and engine starts
Idle	8 - 16% @ operating temperature
Full Load	Less than 50% with no ICP system leaks
No Start (Max Command)	54% for 94 to 97 MY 65% for 98 MY or newer

Note: As a general rule 7.3 Power stroke engines require 500 psi ICP (1.0 volts ICPv) minimum to start.

ICP SYSTEM DIAGNOSTICS

P1211 sets if ICP is 410 psi above or 280 psi below the desired pressure for 7.5 seconds.

P1212 sets if 725 psi of ICP is not detected in 6 to 15 seconds of cranking.
P1280 code is for ICP circuit low (often open circuits). Typical issues include, corrosion, spread pins, or improperly crimped terminals at the ICP sensor harness connector.

If a P1280 is set, the PCM will display a default value of 725psi at idle. To verify open circuit concern use ICPv. **ICP KOEO signal voltage should be between .16 to .28 volts.**

NO START DIAGNOSTICS

IPR% goes high with no or low ICP. - A leak exists in the ICP system - P1211 or 1212 may be present.

5

Use test plugs tool # D94T 6600 A for 94 thru 98 MY
Use test plugs tool # 303-627 & 303 - 628 (Kit #T99T-1000-E) for 99 MY and newer with quick connect connections.

7.3 NAVISTAR ® FORD® DIT DIESEL QUICK REFERENCE INFORMATION

CONDENSED FROM PC/ED:

- Block off right bank (passenger side).
- Attempt to start
- Start indicates leak in right bank - Reconnect hose to right bank
- Remove right side valve cover.

Unplug injector connectors at both valve covers - Crank the engine

- Observe spill spout of the injector and top of injector bore for oil leakage.
- (No oil should be coming from the spill spouts or around the injector)
- Replace injector if oil leaks from spill spout or O-rings if leak is from injector bore.
- If no start - leak/loss may not be in right head, but ICP still low
- Block off left bank and move ICP into adapter
- Attempt to start
- Start indicates leak in left bank
- Reconnect hose to left bank and install ICP into left head - Remove left side valve cover.
- Unplug injector connectors at both valve covers - Crank the engine
- Observe spill spout of the injector and top of injector bore for oil leakage.
- (No oil should be coming from the spill spouts or around the injector)
- Replace injector if oil leaks from spill spout or O-rings if leak is from injector bore.
- If no start / low ICP on both previous tests
- Block off both high pressure lines
- Crank engine
- If pressure is below 1000 psi remove IPR valve and inspect O-rings.
- If the IPR valve O-rings are damaged replace them with kit # F6TZ-9C977-AA and retest. - If O-rings are ok, then replace the IPR valve and retest.

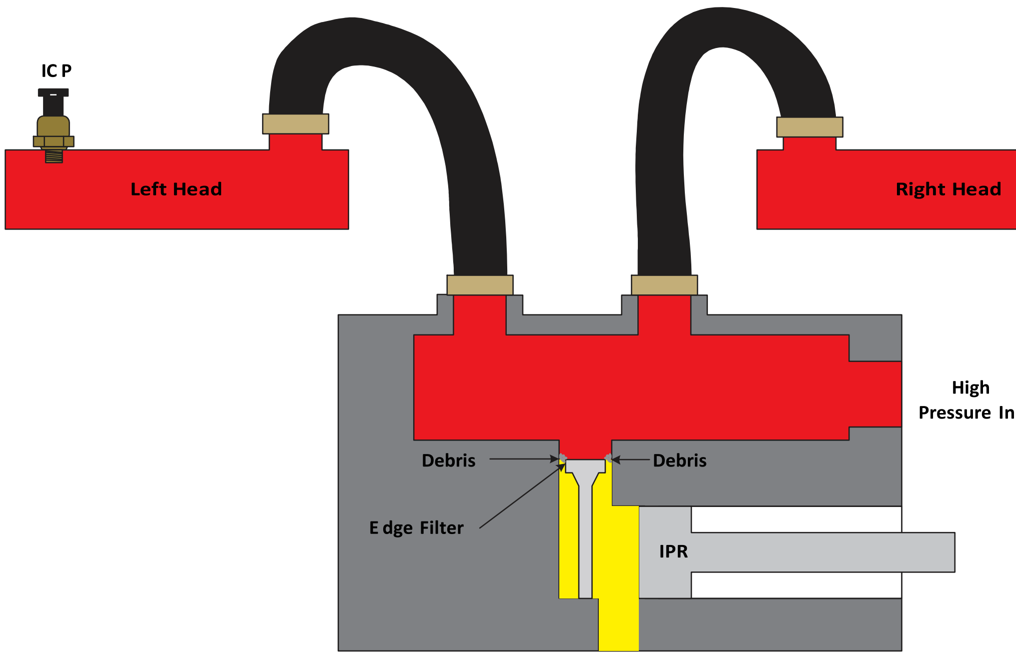
Note: Do not replace the pump and IPR at the same time. If during any repair, the oil reservoir is allowed to drain it should be refilled before attempting to restart the vehicle.

ENGINE STARTS BUT HAS A P1211 CODE

IPR% higher than expected (see chart on page #2). Stall shortly after cold start may also be a symptom. Prior to diagnosing a vehicle with a P1211, fuel pressure should be verified. This indicates a smaller leak in the high pressure system. Using the same block off plugs described earlier to block off one bank and observing IPR% when engine is running on each bank at similar rpms. Higher IPR% on one bank compared to the other would indicate a leak on the higher IPR% bank.

	LEFT BANK	**RIGHT BANK**
COMMAND	IPR% @ idle 16%	IPR% @ idle 26% (higher than other bank and out of spec)
CONDITION	Starts quickly	Long crank to start compared to left bank
FINDING	No leak	ICP system has leak on this bank

DIAGNOSING P1211 WITH IPR% LESS THAT 8 AT IDLE



Drain: ICP more than 410 psi above command for at least 7.5 seconds can set a P1211 code. IPR with low duty cycle (less than 8% @ idle) and engine running, indicates a restriction in the drain circuit. This restriction is taking the place of the IPR valve, driving the IPR duty cycle lower, with higher than expected ICP. The excess restriction will be in the reservoir, front cover, stuck IPR valve, or debris above the edge filter. The drain path through the reservoir and front cover can be visually verified. Typically the pump or IPR must be replaced to repair this concern. Do not replace both components at the same time. This often occurs after the oil pan is resealed where excess sealant is forced through the lube system (short circuit check valve) and trapped at the edge filter of the high pressure pump.

In mid-1995 the edge filter moved out of the IPR, upstream into the pump.

ABNORMAL LONG CRANK/STALLAFTER COLD START

A worn lube oil pump can negatively affect ICP system's performance in the following ways. - Cold engine, abnormal long crank to start. Oil pressure gauge on dash moves Cold engine, start then stall - then long crank to restart. Immediately prior to start. These symptoms are often miss-diagnosed as high pressure oil (ICP) concerns. Both symptoms may be caused by wear in lube oil pump or thick oil (poor maintenance). Pump wear causes a decrease in pump efficiency. Cold, thick oil becomes difficult to move. Any lube oil system failure can negatively affect the performance of the ICP system.

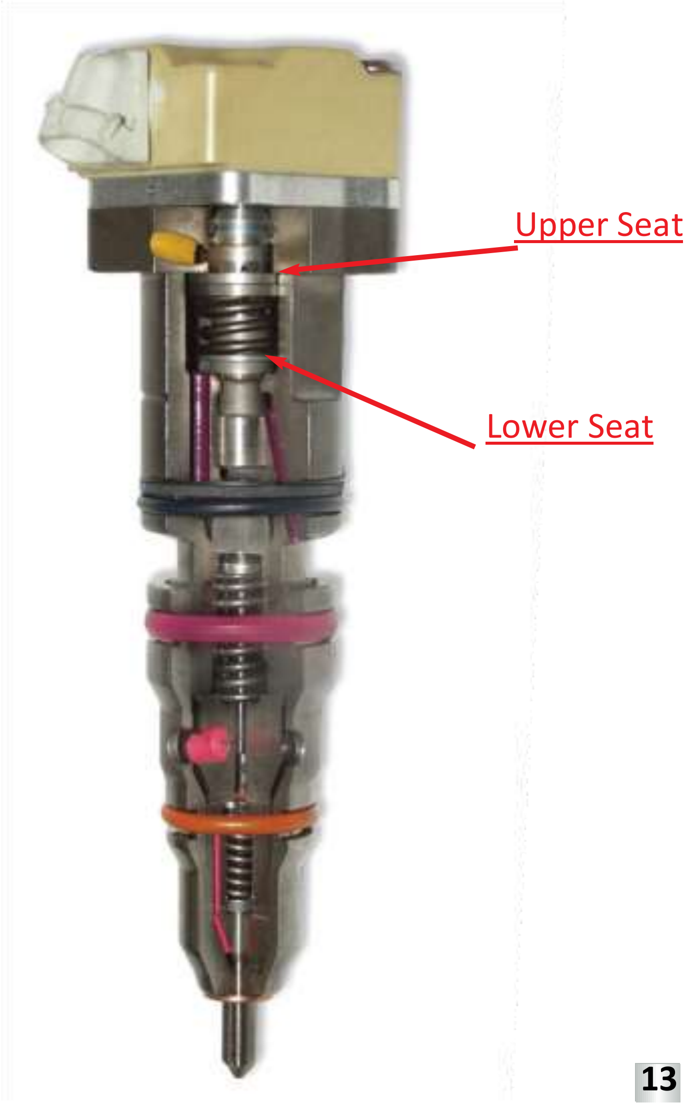
Recession greater
.00" causes long crank
start and/or

To measure pump wear, place a straight edge across the pump housing and use a feeler gauge to measure clearance between the inner gear and the straight edge. A pump with excess gear recession will contribute to hard start issues.

11

12

When replacing the pump, the directional markings (“OUT” or “Damper”) must face the vibration damper. If installed correctly there is a recess that the vibration damper fits into on the inner gear. If installed incorrectly, the inner gear will cause major damage to the front cover.



13

FOR HARD START LONG CRANK OR NO START WHERE THE INJECTORS WILL NOT BUZZ LOUDLY (HAS BACKGROUND BUZZ ONLY) WHEN COLD

Some engines have a no start/or long crank to start and the injector have a low background buzz, not a strong normal buzz. After performing the buzz test multiple times the injector may start to buzz and the engine may start and run fine the rest of the day until the next cold start. Typically, we find that this is a high mileage vehicle with poor maintenance as far as oil changes are concerned. What is occurring is that the poppet inside the injector is not able to move freely because of the thick old oil. If an oil change is performed after driving the vehicle and then driven again with new oil the next cold start the engine may improve.

Note: This concern is related to poor maintenance and extended oil change intervals. If poor maintenance is the cause, then all 8 injectors will be affected. For additional information, refer to Section 3 of the Warranty & Policy Manual under "Damage Caused by Improper Maintenance." If this is not effective refer to PC/ED injector circuitry diagnostics.

The audible sound heard while preforming an injector buzz test is the poppet stopping at the upper and lower seat during actuation.

7.3L INJECTION CONTROL PRESSURE (ICP) SENSOR R&R

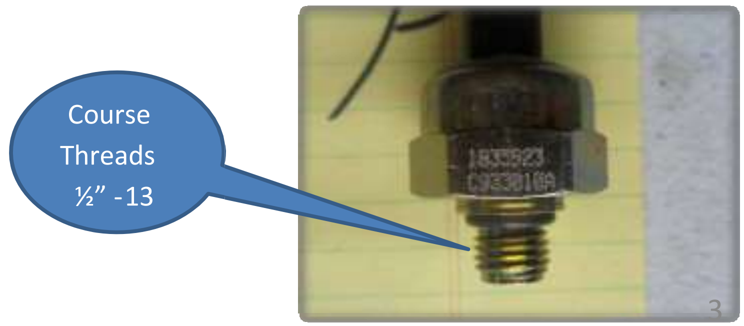
Ford P/N: F6TZ-9F838-A
International P/N 1807329C91 (old style)
International P/N 1807329C92 (new style)

The Injection Control Pressure (ICP) Sensor is located in the front of the driver's side head near the valley. It can be found just forward of the engine lifting eye. The ICP Sensor is used to measure the high pressure oil system pressure and report back to the PCM the pressure which is measured in volts. The PCM feeds the ICP sensor with a 5 volt reference voltage known as VREF. The sensor is a variable capacitor sensor (transducer). Basically it has a small pressure disc inside of it that moves with the pressure. This sensor has the 5 volts applied to it and the pressure change regulates the output voltage. Usually at idle the ICP will read about 500 psi, this correlates to about 0.88 volts. 0 psi will register around 0.22 volts. The PCM uses this data to determine how to regulate the Injector Pressure Regulator (IPR). You can disconnect the ICP sensor and the engine will use pre-set parameters programmed into it to control the IPR. You will set a Service Engine Light and it will store a code. If you are having hard start problems or erratic idle issues, try unplugging the ICP sensor and see if it changes.

One known issue with ICP sensors is they can leak internally. This allows oil to come into contact with the connections and increases resistance. This will cause the voltage to change and the PCM will incorrectly actuate the IPR. This can lead to rough idle, erratic throttle, and out of the blue shut downs.

The original ICP sensors had a reduced 5/8” hex on them that can make removal a little difficult without a crow’s foot adapter. The newer design is a full 1-1/16” and can be replaced or installed with a normal wrench.

The ICP sensor does use an O-ring to seal the interface between the sensor and the head port. The port is a standard #5 O-Ring Boss (ORB) port. The threads are ½”-20 UNF Threads. The O-Ring is a standard AS568-905 O-ring with a durometer (hardness) of 90. 90 Durometer O-rings are harder than standard part store O-rings and are designed to withstand the high pressures (3,000 psi) the sensor will be subjected to.



ICP Sensor Location on Left Head.
(Drivers Side Head)

Connector disconnected. Inspect for oil residue.

ICP Pins Inspect for oil residue.

Using a 5/8” Crow Foot Adapter and extension to remove the sensor. (Old style)

The #5 ORB Port (Notice the O-Ring sits in the recessed area.)

ICP Sensor (Old Style) with AS568-905 O-Ring installed.

How to measure ICP Sensor threads.

Using a thread pitch gauge same sensor showing the difference using (20 threads per inch) a 13 thread per inch gauge.

Poor Man's Thread Pitch Gauge: Using the old sensor next to the new one.

Old Style and New Style ICP Sensors   New Style (1-1/16" hex)

Install is pretty simple, just thread the sensor back into the port with a new O-ring installed (new sensors come with them), then use either a 5/8" or 1-1/6" crow foot adapter and torque to 21 ft-lb.

REPAIR OF THE ICP SENSOR:

General Information: A Powerstroke engine utilizes an electromagnetic valve to regulate the high pressure oil pressure on the engine to tailor the injection characteristics of the injectors. This valve is called the Injection Pressure Regulator or IPR. Actually, Cat and Ford and Navistar all use different names for it, but I call it the IPR. IPR is generally fairly trouble free, but they have been known to become sticky if debris enters the valve or if it suffers from a blown O Ring.

IPR Removal: With a little experience and the right tool, an IPR can be removed from a PSD in minutes. The IPR is located on the back of the high pressure oil pump, which is located UNDER the fuel filter assembly, down in the V of the engine. The IPR valve has been largely unchanged since its introduction in 1994. The easiest way to remove the IPR valve is to build a special IPR removal tool. Said tool is comprised of a 1/2" drive deep 6 point 29mm or 1 1/8" socket with a 4 inch piece of 1" flat iron welded across the back of it. (See picture.) Ordinarily one would just use a deep socket, but the IPR is too deep for the deepest sockets I was able to find. (See picture, not the relative lengths.) Using a 1/2" drive socket will allow the end of the IPR to go where the ratchet stub would have. Furthermore, there isn't much room between the back of the HP oil pump and the front of the turbo assembly, so the thin flat iron increases the available room.

Note: If one could find a deep enough socket, it could be used by itself.

Locate the IPR. The easiest way to do this is to trace the wires from the ICP on the driver's side HP oil rail into the main harness and then out to the IPR deep in the engine valley or known as “V”. You can identify the IPR by its shiny gold colored solenoid. (The ICP and the IPR are not connected, but the wires for both leave the harness at the same point.)

Unplug the wire from the solenoid. To do so, you need to flip the connector bail down and pull the connector out. It should come out relatively easily.

Remove the solenoid itself. Do this by removing the 3/4" nut that holds the solenoid on the back, followed by the spacer and the solenoid itself.

Using the IPR wrench described above, place it on the IPR with the flat iron towards the driver's oil rail. Tap the flat iron with a small hammer towards the rail and the plug should loosen. Give it a few twists with the wrench and then use your hand to turn it out entirely.

Removing the IPR will allow most of the HP oil reservoir to drain out into the engine valley or known as “V”. Prepare for this by placing a large amount of paper towel in the valley or known as “V” to absorb the resulting oil. It is also handy to know that a plastic champagne cork fits nicely in the IPR thread and will keep the oil from leaking out.

IPR Disassembly: An IPR is a fairly robust yet intricate item. They are easy to service, but they can be damaged.

An IPR consists of two main parts: a pilot operated valve and an electromagnetic actuator. Each part has been known to give trouble. The electromagnetic actuator is in the end the solenoid was on. The pilot operated valve is the brown end. To service the unit, first separate the pilot valve from the actuator. To do this, place the IPR in a vice. Then, use a sharp, good quality pipe wrench or similar tool to firmly grab the pilot valve body. (See picture). DO NOT ATTEMPT TO SQUEEZE THE PILOT VALVE BODY TIGHTLY IE IN A VICE OR IT WILL CRUSH AND BE RUINED. A decent working pipe wrench works well. I've opened many IPRs this way without damaging any. The pilot valve slides on the inside of the body, so if it is crushed, it will stick and not work well.

Loosening the IPR: Once loose, the body will separate easily. However, there is a tiny needle in between the body and the actuator that MUST NOT BE LOST. (See IPR Disassembly Picture for a view of the pin.) Normally this pin stays in the end of the body because of the oil that is present, but it has been known to come free. DO NOT LOSE IT. IPR Disassembly

Once the pilot valve is free of the actuator, disassemble the actuator by loosening the internal screw inside it. (No picture for this, just look inside where the pilot body screwed in.) It takes a big flat screwdriver to remove the internal screw, which is actually a guide for the actuator pin. (See IPR Exploded View Picture). Once the pin and the internal screw is removed (guide actually), shake the actuator body firmly up and down several times to get the piston out. The IPR is now fully disassembled. It is possible to disassemble the pilot valve itself, but this takes a press and jigs to do it properly.

Servicing: Three things commonly go wrong with the IPR:

<u>Debris in the pilot valve</u>: Using a small screwdriver, gently push in on the end of the pilot valve assembly. You should feel the valve move about 1/8" in and out and return to its seat with a bit of snap. Should the action of the valve be sticky at any point, use a combination of solvent, screwdriver motion and compressed air to clear any debris that may be trapped in its motion.

Debris in the actuator piston area: Thoroughly clean the actuator body, piston, guide and pin. Lubricate them well with a very thin oil or solvent. Assemble the actuator only, but do not tighten. With the solvent as the lubricant, the piston should move freely. I.E. if you shake the actuator assembly, you should hear the piston sliding around freely. This will not happen with motor oil as the lubricant.
Bad external O Rings.

Examine for wear/damage. There should be a backup ring and an O Ring. The backup ring should be nearest the actuator. Ford sells a rebuild kit consisting of the O Rings and a replacement solenoid nut.

Reassembly: Assemble the actuator end of things. Gently tighten the internal screw (guide). Don't over tighten this. It is difficult to describe how much torque it takes.

Place the pilot valve needle in the body. Screw the pilot valve body into the actuator body. Tighten, but don't overdo it.

Reinstallation: Reverse of removal. Tighten, but don't over tighten the IPR nut.

NOTE: A PSD WILL RUN INCREDIBLY ROUGH IF THE IPR NUT IS LOOSE. The symptoms of this will make you think you've got multiple bad injectors among other things. You might want to check it for tightness after a few hours of use.




TESTING ELECTRICAL SYSTEMS WITH A DIGITAL MULTIMETER

STARTER CURRENT

Starting system troubles are often confused with charging system problems. Many a dead battery has been replaced when the real cause was a faulty charging system. Be sure that the charging system is functioning properly before you replace the battery. Make sure the battery is charged and passes a load test, then look for resistance in the starter circuit if the engine still cranks slowly. Investigate excessive current draw; check for worn-through insulation, a seized or tight engine, a faulty starter, etc. If the starter turns the engine slowly, the current draw is not high, and the battery is in good condition, check the resistance in the starter circuit.

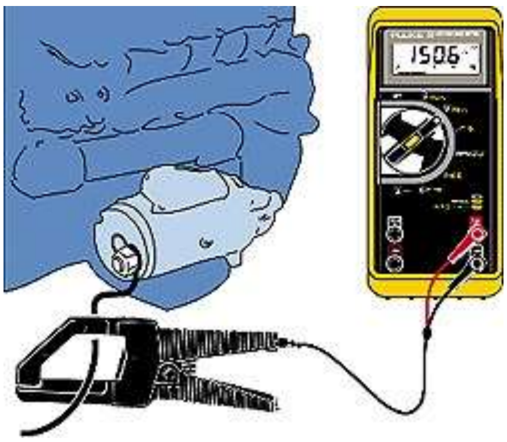


Fig 6 - Measuring Starter Current Draw *Determine how much current the starter is drawing by using Inductive Current Clamp on the starter cable. This accessory will allow the multimeter to measure starter current up to 1000 amps. Check manufacturer's specs for exact figures.*

ALTERNATOR AC LEAKAGE

An alternator generates current and voltage by the principles of electromagnetic induction. Accessories connected to the vehicles charging system require a steady supply of direct current at a relatively steady voltage level. You can't charge a battery with alternating current, so it must be rectified to direct current.

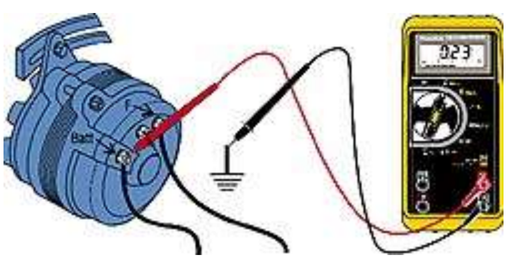


Fig 4 - Checking Ripple Voltage *Ripple voltage or (AC voltage) can be measured by switching your DMM to AC and connecting the black lead to a good ground and the red lead to the "BAT" terminal on the back of the alternator, (not at the battery). A good alternator should measure less than .5 VAC with the engine running. A higher reading indicates damaged alternator diodes.*

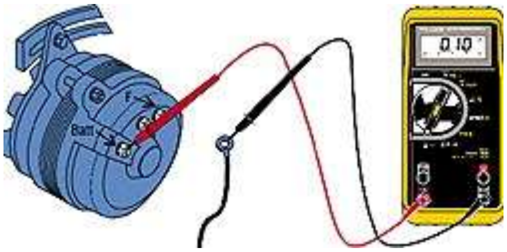


Fig 5 - Alternator Leakage Current *to check alternator diode leakage, connect the multimeter in series with the alternator output terminal when the car is not running. Leakage current should be a couple of milliamps at most; more often, it will be on the order of 0.5 milliamps. Use care when disconnecting the alternator output wire; make sure the battery is disconnected first.*

ALTERNATORS

A DMM's accuracy and digital display make regulator/alternator diagnosing and adjusting easy. First determine if the system has an integral (internal) regulator, then whether it's type A or B. Type-A has one brush connected to battery + and the other brush grounded through the regulator. Type-B has one brush directly grounded and the other connected to the regulator.

Next, isolate the problem to alternator or regulator by bypassing the regulator (full fielding). Ground Type-A field terminal. Connect Type-B field terminal to Battery +. If the system now charges, the regulator is faulty. Use a rheostat if possible. Otherwise, just idle the engine (lights on) so the voltage doesn't exceed 15V.

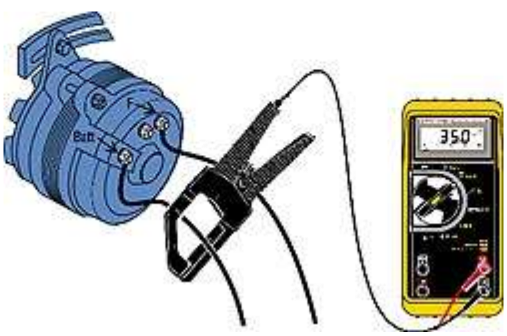
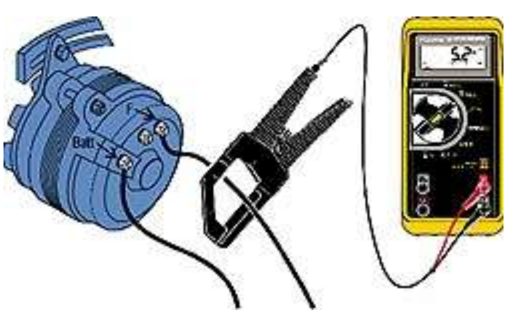


Fig 2 - Verifying a Good Alternator *The battery must be fully charged (see fig. 1). Run the engine and verify that no-load voltage is 13.8 - 15.3V (check as in fig. 1). Next, load the alternator to rated output current with a carbon pile across the battery. Run the engine @ 2000 RPM. Check the current with an 80i-410 or 80i-1010 current clamp. The unit must maintain at least 12.6V @ rated output.*

Fig 3 - Checking Field Current *Worn brushes limit field current, causing low alternator output. To test: load unit as in Figure 2 and measure field current with current clamp or use 10A jack on DMM. Readings range from 3 to 7 amps. On integral GM units: with alternator not turning, jump terminals #1 & #2 (fig. 4) together and connect both to Batt + with DMM in series set to measure 10 amps. Field current should be between 2 & 5 amps, higher current with lower battery voltage. Control battery voltage by loading it with a carbon pile.*



BATTERIES

Charging system problems often come to you as a "no-start" complaint. The battery will have discharged and the starter won't crank the engine. The first step is to test the battery and charge it if necessary (fig 1).

No-Load Test: **Charge vs %**

Voltage	Percent Charge
12.60V to 12.72V	100%
12.45V	75%
12.30V	50%
12.15V	25%

Readings obtained at 80°F (27°C)

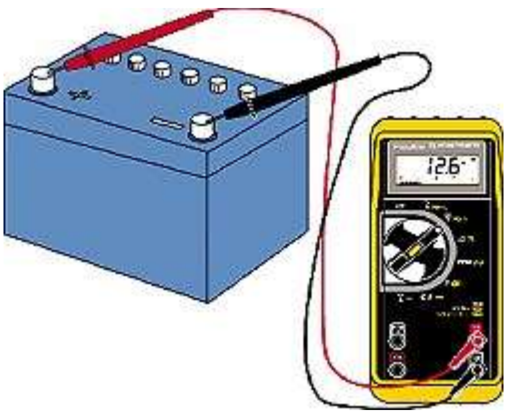


Fig 1 - Measuring System Voltage *Bleed the surface charge from the battery by turning on the headlights for a minute. Measure the voltage across the battery terminals with the lights off (see chart). When possible, individual cell specific gravity should be checked with a hydrometer. A load test should be done to indicate battery performance under load. Voltage tests*

FEEDBACK CARBURETOR

Using the built-in dwell meter to measure M/C dwell can tell you whether it's a fixed or varying cycle: Fixed dwell occurs in several instances:

1) when the engine is in open loop (cold engine)
2) the engine is under wide-open throttle (hot engine)
3) the oxygen sensor has cooled off, due to prolonged idling, and re-entered open loop (hot engine).

Varying dwell tells you the engine is in closed loop. It also indicates whether the carburetor is supplying a rich or lean mixture.

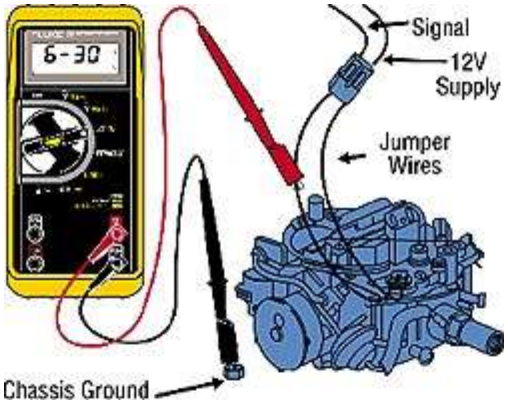


Fig 9 - Measuring Dwell on a Feedback Carburetor *The longer the solenoid's "on-time," the higher the dwell -and the leaner the fuel mixture delivered by the carburetor. The shorter the "on-time," the lower the dwell -and the richer the fuel mixture. A normally operating system will have a varying dwell, but it should average about 30%.*

CIRCUIT RESISTANCE

Ohm's law (E=IxR) tells us that even very low resistance in the starter circuit will cause the starter to turn slowly, because of low voltage. For example: in a system drawing 200 amps, 0.01 ohms resistance in the starter cable will cause a 2 volt drop in voltage at the starter; 0.01 ohms is too little for all but the most expensive and sophisticated ohmmeters to measure, but measurements of voltage drop will indicate where there is resistance.

VOLTAGE DROP

In automotive circuits even the smallest loss of voltage will cause poor performance. Set your multimeter in the mV or VDC setting and connect the meter + lead to the side of the device nearer the battery + terminal and the - lead to the side nearer the battery - terminal or ground and engage the Min/Max function. Current must be flowing for the meter to register the voltage drop found. This procedure is helpful on components and connections (both on the + feed side and - ground side) except solenoids, which read battery voltage if you measure across them when the engine is being cranked. Voltage drops should not exceed the following:

200 mV Wire or cable
300 mV Switch
100 mV Ground
0 mV to <50 mV Sensor Connections
0.0V Connections

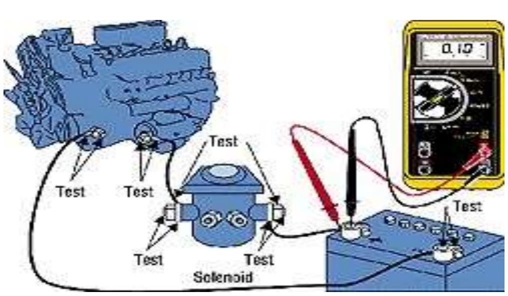


Fig 7 - Testing for Excessive Voltage Drop *Determine if there is resistance in the circuit by measuring the voltage drop across each connection and component in the starter circuit while cranking the engine. Measure the voltage drop between the battery post and the connecting cable, the solenoid posts and the wires that attach to them, and across the solenoid itself. Also check the ground side and the ground strap.*

CONDENSERS

Analog/digital multimeters can also be used for checking automotive capacitors (condensers). The movement of the bar graph will show that the DMM is charging the condenser. You'll see the resistance increase from 0 to infinity. Be sure the switch the leads and check both ways. Also make sure to check condensers, both hot and cold.

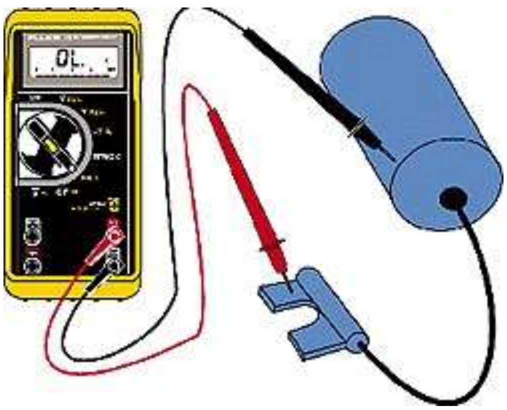


Fig 13 - Checking Condenser Leakage *Check for leaking condensers with the Ohms function. As the condenser charges up, the resistance should increase to infinity. Any other reading indicates that you should replace the condenser. If the condenser is on the car, make*

COOLING SYSTEMS / TEMPERATURE MEASUREMENT

Built-in temperature function makes it quick and easy to check engine cooling systems for proper temperature, which is critical with today's computer-controlled engines. You can also check transmissions for overheating, and heaters and air conditioning systems for proper operation. With a bead thermocouple probe, you can test thermostats and fan switches without heating them in hot water on a hot plate. You get faster, more accurate diagnosis of electrically controlled cooling systems and can compare computer data stream information with actual temperatures. On many late model cars the cooling system is sealed; the only opening is in the expansion tank. Since it doesn't have water circulating through it, you can't make an accurate temperature measurement here. The only accurate test is to measure the surface temperature of the upper tank at the radiator inlet.

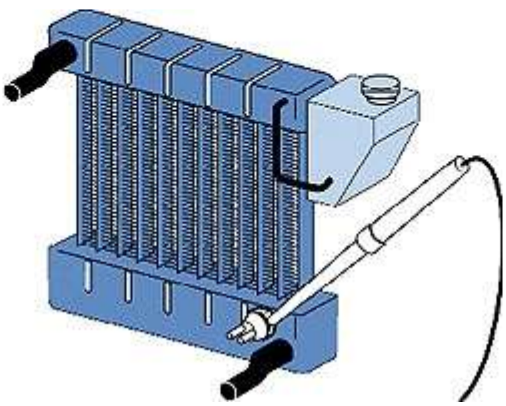


Fig 20 - Testing for Switch On-Off Temperature *Check the operation of electric cooling fans by touching the radiator tank next to the temperature switch with the temperature probe tip. Note the temperature when the fan comes on, and again when it goes off. Check your figures against factory specifications.*

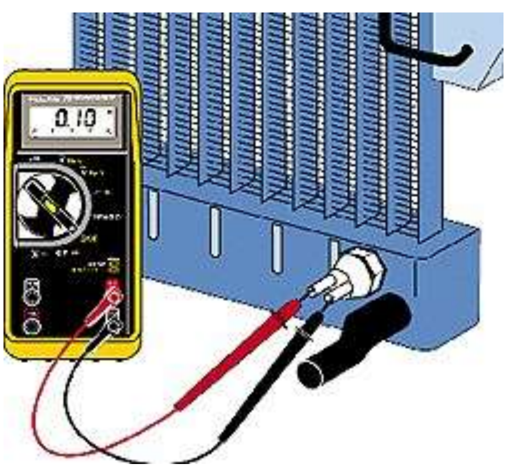


Fig 21 - Testing for Switch Continuity *Check temperature-switch continuity with the Ohms function, while the switch is in place. Test for voltage drop across the switch and from the radiator to the body ground, as described on page 8. Note: the temperature must be above the "fanon" temperature for the fan switch to be closed.*

LOCATING CURRENT DRAINS

Current drains, shorts and bad grounds are the cause of many problems. The cause of the problem often seems to have nothing to do with the symptom. But, using a DMM, you can find the cause quickly without burning a whole box of fuses. Current drains that run the battery dead are often referred to as shorts, although they may not actually be short circuits. In fact, they may be related to Keep Alive Memory or K.A.M. Shorts that blow fuses can be found using the same troubleshooting techniques used to find current drains even though the symptoms are different. CAUTION-Each vehicle manufacturer has a different procedure for locating current drains. Using the wrong testing method will give you erroneous results. To make sure you get the proper results, please refer to the vehicle manufacturer's procedure.

DUTY CYCLE

Duty cycle is the measurement made of pulse width modulated circuits, such as a charcoal canister purge solenoid. The higher the duty cycle, the longer the on-time of that circuit. The higher the on-time, the higher the flow rate, or purging of the canister. 100% duty cycle means the solenoid is on all the time. 10% duty cycle means that the circuit is energized only a small portion of the time. The ECU determines when to purge the canister and at what flow rate based upon such variables as engine temperature, how long the engine has been running since startup, vehicle speed and other parameters.

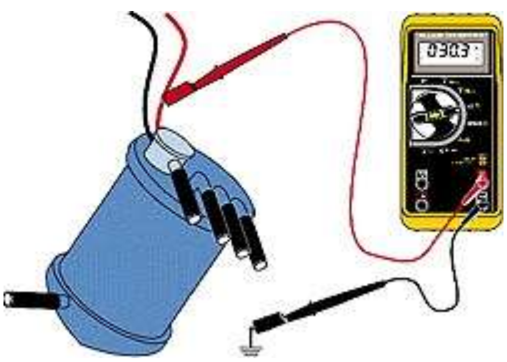


Figure 19 - Measuring Duty Cycle on a Charcoal Canister

To measure the duty cycle of a solenoid, attach the red lead to the signal wire and the black lead to a good engine ground. Select duty cycle and read the value directly.

FORD BP/MAP SENSOR

The barometric pressure/manifold absolute pressure (BP/MAP) sensor is critical in determining fuel mixture and spark advance under varying loads. Much like a Throttle Position Sensor, it must provide a smooth, gradual change in output, or drivability problems can occur. In some instances, a BP/MAP sensor can deviate without setting trouble codes. To verify its operation, you need to check its output over its full operating range.

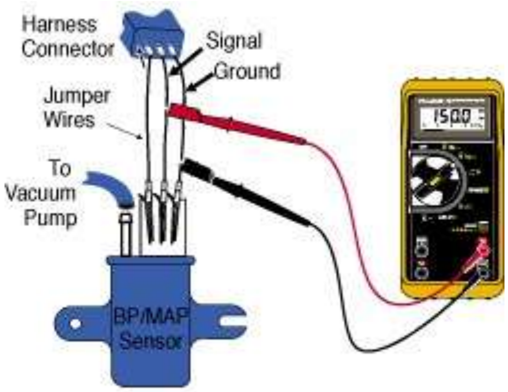


Fig 8 - Using DC-Coupled Hz to Check ***BP/MAP Sensors*** *To test the performance of a BP/MAP sensor, graph its frequency output at various levels of vacuum. Start with the sensor at 0" Hg (0 cm /hg) and read its frequency. Then note the frequency at each increase of 1" Hg (cm Hg). When you plot these frequencies, they should be in a straight line. The frequency will decrease with an increase in vacuum.*

FUEL PRESSURE

Fuel pressure is important for both performance and fuel efficiency. Maintaining proper fuel pressure under all operating conditions is the job of the fuel system. The PV350 provides critical fuel pressure readings on a multitude of fuel systems: carbureted, central point, throttle body injection or multipoint injection. Use it to check the operation of fuel pressure regulators, fuel pumps and fuel pump check valves. Fuel pressures fall into two categories: high and low. Central point, or throttle body systems typically use low pressure (10-15 psi, 70-105 kPa). Most multipoint systems use a higher pressure (35-60 psi, 240-415 kPa). Low pressure during hard acceleration can indicate that a fuel filter is starting to clog.

Fig 10 - Testing Fuel System Pressure *To test fuel pressure, use the Schrader hose adapter with the PV500 to tap into the fuel rail. (If the vehicle doesn't have a Schrader valve port, ask your local tool supplier for the appropriate adapter). Once you've taken your reading and before disconnecting the fitting, wrap a rag around it to catch any fuel spray. The safest way to do this is to disable the fuel pump and run the engine until it dies. Crank the engine a few seconds longer until all fuel pressure is relieved.*

REAR WINDOW GRID DEFOGGER

DMMs allow you to check for opens in the rear window defroster grid. The rear window glass has a series of horizontal grid lines made of a conductive ceramic silver compound that are baked onto the inside surface of the glass. Terminals are soldered to two vertical conductors called bus bars on each side of the glass; one serving as the feed connection (battery voltage) and the other as the chassis ground. Current flows through a relay to the rear grid when both the ignition switch and the rear window grid switch are turned on, usually drawing about 20 amps. (A portion of the grid can be damaged by scratching the inside of the window usually by placing items on the package shelf.) When the circuit of any horizontal grid is interrupted, no current will flow and that particular grid will not heat up. By determining where the open is, you can repair it with a grid repair kit.

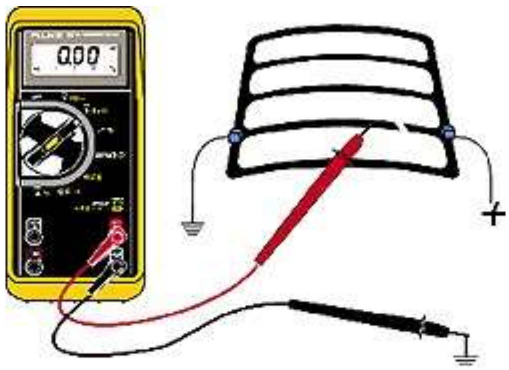


***Fig 18 - Testing Rear Window Grid with a DMM** Run the engine at idle and set the rear window grid switch to "ON". Connect the black lead from your DMM to one of the vertical "bus bars" and the red lead to the other bus bar. With the meter set to measure DC volts, the display should indicate 10 to 14 volts; a lower reading indicates a loose ground wire. With the black lead of the DMM grounded, touch each grid wire at its midpoint with the red lead. A reading of approximately 6 volts identifies a grid with no opens. A reading of 0 volts indicates the current path is broken between the midpoint and the battery side of the grid. A reading of 12 volts indicates that the circuit is open between the midpoint of the grid line and ground.*

BAD GROUNDS

High resistance among grounds can be among the most frustrating of electrical problems. They can produce bizarre symptoms that don't seem to have anything to do with the cause, once you finally find it. The symptoms include lights that glow dimly, lights that come on when others should, gauges that change when the headlights are turned on, or lights that don't come on at all. With the new computer systems, high resistance in ground wires and sensor leads can produce all sorts of unpredictable symptoms. Apply silicone dielectric lubricant, available at radio supply stores, to connections before you assemble them. This will reduce corrosion. Pay particular attention to ground terminals in the vicinity of the battery, where acid speeds corrosion. Often a wire that is corroded through except for a few strands will produce the same symptom as a corroded ground connection. Just looking at the insulated connector does not insure that the connection inside is good. Physically disconnect connectors and use a wire brush or sand paper to "shine" the metal connections.

HALL-EFFECT POSITION SENSORS

Hall-Effect position sensors have replaced ignition points in many distributors and are used to directly detect crank and/or cam position on distributor less ignition systems (DIS), telling the computer when to fire the coils. Hall-Effect sensors produce a voltage proportional to the strength of a magnetic field passing through them, which can come from a permanent magnet or an electric current. Since magnetic field strength is proportional to an electric current, Hall-Effect sensors can measure current. They convert the magnetic field into millivolts that can be read by a DMM.

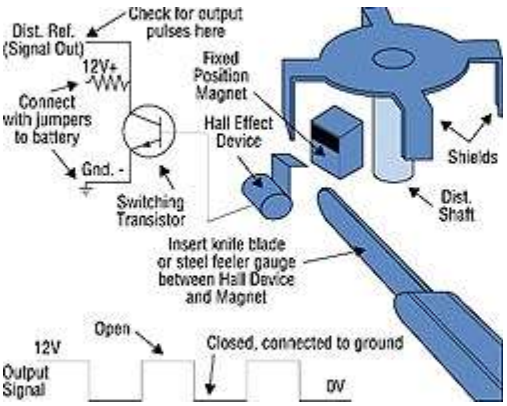


Fig 14 - Checking Hall-Effect Sensors *Check for reference voltage from battery at connector. Hall sensors require power where magnetic sensors do not. To test sensor: connect +12V from battery to power terminal, set DMM to measure volts and connect it between signal output and ground. Insert feeler blade between sensor and magnet while watching for the bar graph to move. Signal should vary from 12V to 0V.*

IGNITION COILS

Analog/digital multimeters will measure from tenths of an ohm (.01) up to 32 million ohms, making ignition tests easy to interpret. Analog meters usually can't measure less than 1 ohm.

Fig 12 - Measuring Internal Coil Resistance *If you suspect a malfunctioning ignition coil, check the resistance of primary and secondary windings. Do this when the coil is hot, and again when it is cold. Also measure from the case to each connector.*

The primary windings should have a very low resistance, typically from a few tenths of an ohm to a few ohms. The secondary windings have a higher resistance, typically in the 10,000 to 13,000 ohm range. To get the actual figures for a specific coil, check the manufacturer's specs. But as a rule of thumb, primary windings range from a few tenths of an ohm to a few ohms, and secondary winding may be 10 ohms or more.

MAGNETIC POSITION SENSORS

The magnetic type of position sensor is simply a magnet with a coil of wire wrapped around it. The clearance between the pickup and reluctor is critical. Be sure to check it. Specs are usually between 0.030" and 0.070" (0.8 mm to 1.8 mm).

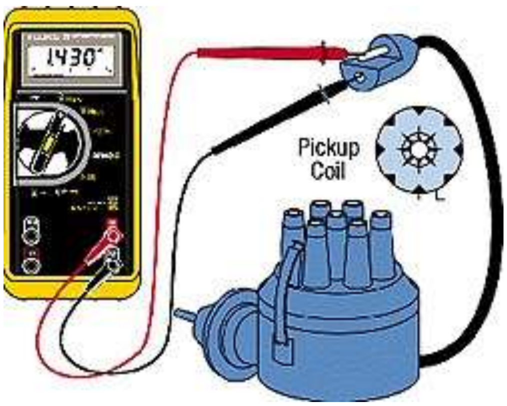


Fig 15 - Checking For Pulses from Magnetic Distributor Pickup *Disconnect the distributor from the ignition module. Connect the DMM across the pickup and set it to AC volts. When the engine is cranked, pulses should appear on the bar graph. If no pulses appear, it is likely the reluctor wheel or the magnetic pickup is faulty. Use this technique for other magnetic position sensors too. On GM cars, remove the distributor cap for access.*

EXAMPLE OF OHM'S LAW

If you measure 0.5V across a ground connection in a starter circuit, and the starter draws 100 amps, calculate the resistance as follows: Ohm's Law E = I x R

0.5V = 100A x R

Solve for R

$$R = \frac{0.5V}{100A}$$

Therefore R = .005 Ohm .005 ohm is too much, so clean the connection. .5 Volts tells you the same thing—the connection is dirty or corroded.

RPM

Inductive Pickup accessory allows the engine RPM via the secondary ignition impulses in the spark plug wires. It features a selection for DIS or conventional systems.

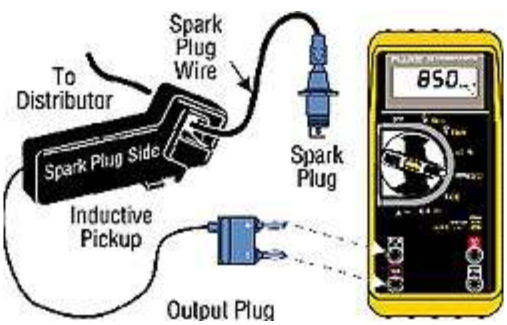


Fig 16 - Measuring RPM with the RPM80 Inductive Pickup
Inductive Pickups converts the magnetic field created by the current in the spark plug wire to a pulse that triggers an RPM measurement. To measure RPM using the pickup, attach the probe to any accessible sparkplug wire and select the normal (1) or DIS (2) setting to read the correct RPM for the engine you are working on.

SPARK PLUG WIRES

Plug wires should be checked if your scope indicates that there may be a problem or if they're more than a couple of years old. Not all wires indicate the date they were manufactured. Due to the heat of the spark plug insulator, a spark plug boot may bond to the spark plug. Pulling a spark plug boot straight off the spark plug can damage the delicate conductor inside the insulated wire. Rotate the boot to free it before pulling it off. If you suspect bad wires, test the resistance of the wire while gently twisting and bending it. Resistance values should be about 10,000 ohms per foot (30,000 ohms per meter), depending on the type of wire being tested; some may be considerably less. You should compare readings to other spark plug wires on the engine to insure the accuracy of the test.

THROTTLE POSITION SENSOR (TPS)

Throttle position sensors (TPSs) are a common source of faults in today's on-board computers. A TPS is simply a variable resistor connected to the throttle shaft. Some people think of it as a replacement for an accelerator pump on throttle body or port fuel injected engines. But it is much more. It tells the on-board computer how far the throttle is open, whether it is opening or closing—and how fast. As its resistance changes, so does the voltage signal returning to the computer. The TPS can be tested by watching either the voltage or resistance change, using the analog pointer on any DMM.

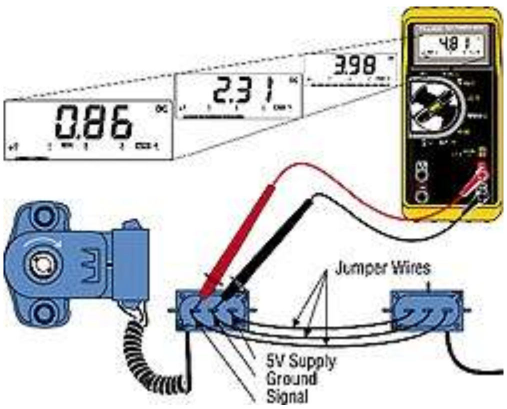


Fig 11 - Testing a Throttle Position Sensor *Use the Min/Max recording feature to check your base TPS setting at idle; to get the maximum reading, depress the accelerator. By comparing these readings to those you get when you open the throttle by hand, you can verify whether the throttle cable and/or linkage is properly adjusted to allow full throttle opening. If it isn't, this may be the source of a problem with poor acceleration.*

SYMTOM RELATED TROUBLESHOOTING:

SLOW OR NO-START:

Begin with a walk-around the vehicle to determine that the tank is at least a third full, batteries are charged, battery terminals are clean and secure, and the radiator is topped off. Check the crankcase and high-pressure pump reservoir oil levels. Ford requires a 15W40 oil that meets SH, CG-4, and Mack E-0L specifications, and recommends that Motorcraft 15W40 “black-lid” be used because of its resistance to aeration. The oil level should come to within one inch of the top of the pump reservoir.

Question the operator to learn as much as possible about the problem and conditions that led up to it. Did it appear suddenly? After repairs to the engine? What parts were replaced? Does the malfunction occur at all engine temperatures or only during cold starts?

Mechanics differ about what checks to make first. But, however you sequence them, the main bases to touch with 7.3L are:

1. Replace the air filter and examine the exhaust system for restrictions. The exhaust butterfly valve, which should cycle closed on cold startups, may stick shut. The back-pressure regulator that controls this valve can also fail.

2. Retrieve active (current) and historical trouble codes. P1111 means that no odes are set and, as far as the ECM knows, things are normal.

3. Drain a sample of fuel from the filter while cranking. If water is present, drain the tank(s) and refill with clean fuel before proceeding. Inspect the water separator for oxidation damage and, if necessary, replace it.

4. Check the glow-plug relay, which is a high-mortality item and especially so in its original oval form. The newer round-case relay interchanges with the older unit. The red cable, connected via fusible links to the starter relay, should have battery voltage at all times. If voltage is not present, check the fusible links and connections for opens. The heavy 10-gauge brown wire going to glow plugs is hot when the relay is energized. One of the 18gauge wires (usually red with a light green tracer) is the signal wire, energized by the lube-oil temperature sensor. This wire must have battery voltage for the relay to function. Depending upon the circuit, the “wait-to start” lamp may signal when the glow plugs energize or merely count off seconds. Individual glow-plugs should have a resistance of about 0.11 to ground when cold and 21 or more after cylinder temperatures normalize.

5. Check fuel pressure while cranking for 15 seconds. If pressure is less than 50 psi, replace the fuel-filter element, remove any debris on the fuel screen and on the screen protecting the IPR deceleration orifice. See the “IPR” section for more information.

6. Check injector-oil pressure during cranking. A pressure of 500 psi must be present to enable the injectors. Expect to see 960–1180 psi at high idle and 2500+ psi during snap acceleration. If the computer senses that the IPR has malfunctioned, it holds idle oil pressure at a constant 725 psi. Trouble code 1280 means low IPR signal voltage, 1281 high signal voltage, and 1212 abnormally high (at least 1160 psi) oil pressure with engine off. See “Low oil pressure” below.

7. While cranking, check for the presence of an rpm signal. A failed CMP can hold oil pressure below the 500-psi injector-enabling threshold. Refer to “Camshaft position sensor” section below.

8. Check power at the injector solenoids with an appropriate scan tool. Zero pulse width on all injectors means a bad CMP sensor or IDM. Failure may trip trouble code 1298. The high power levels—10A at 115 VDC—put severe demands on the injector drive module. In addition, modules on Econoline 7.3L vans built before 4–11–96 have problems with water intrusion.

   WARNING: Injector voltage can be lethal. Do not disconnect or otherwise tamper with the injector wiring while the engine is running or the ignition key is “on.”

9. Finally, check for air in the circuit by inserting a length of transparent tubing in the return fuel line.

ERRATIC IDLE:

A frequent complaint is a rough idle, which can originate from the fuel system or from one or more weak cylinders. Follow this procedure:

1. Verify that the disturbance at idle is not caused by exhaust pipe contact with the vehicle frame, a loose air-conditioner compressor, or other mechanical sources.

2. Scan for trouble codes.

3. Perform steps 1 through 9 in the preceding “Slow or no-start” section.

4. If you have access to a Ford factory tester, make a “buzz” test on the injectors, listening for differences in the sound. A bad injector often buzzes at a lower frequency than the others.

5. Remove the valve covers and, with the engine idling, watch the oil flow out the injector spill ports. Each time a HEUI closes, the oil charge above the plunger drains out the spill port. Thus, amount of oil spilling out of an injector relates to fuel delivery. Replace any injector that passes noticeably less oil than the others.

6. Test engine compression as described in Chap. 4.

7. As a last resort, replace the injectors.

LOW OIL PRESSURE

If you have not already done so, check the oil level in the pump reservoir, which should come to within an inch of the top of the unit. If the engine has been idle for a long period, oil drains back out of the reservoir, making for hard starting.

Verify that there are no leaks at the line connections, around HEUI bodies and into the fuel system. Remove the valve covers and look for cracks in the casting, caused by miss-drilled oil galleries. Small leaks can be detected by pressurizing each gallery with an injector tester or a grease gun and a 3000-psi pressure gauge. Charge the gallery with oil at 2000 psi and wait several hours for any leaks to register on the gauge.

The next step in the search for causes of low oil pressure is to check the IPR (functionally similar to the Caterpillar IAPCV). If the 5V +/- 0.5V reference signal is present and the output circuit is not shorted or open, replace the regulator O-rings with parts available from Ford International or aftermarket sources. The DF6TZ9C977-AN Dipaco repair kit services IPRs used before and after engine SN 187099. If O-rings do not solve the problem, the regulator should be tested by substitution of a known good unit and, if necessary, replaced. Torque to 35 ft. /lb. and do not use sealant that could clog the orifice on the threaded section.

AIR IN LUBE OIL:

Aeration often results in hard or no-starts, erratic idle, shutdowns on deceleration, and loss of rpm. CG4/SH oil helps control the problem. As originally specified, 1994-model engines held 12 quarts of crankcase oil. This specification has been revised to 14 quarts. The dipstick should be recalibrated or replaced with Ford PN F4TZ-6750-E.

Leaks at pump pickup tube O-ring can be detected by jacking the rear wheels 10 in. off the ground and overfilling the crankcase with three quarts of oil. If the idle soothes out, replace the O-ring seal. In addition to its effect on performance, air in the oiling system causes rapid injector wear. Whenever an injector is changed, the associated cylinder bank should be purged:

- Disconnect the CMP to prevent the engine from starting.
- Mechanical fuel pumps (pre-1998 models)—disconnect the return line at the fuel pressure regulator on the fuel filter. Crank the engine in 15-second bursts, allowing ample time for the starter to cool and until a steady stream comes out of the line.
- Electric fuel pumps—crack a vent port on each cylinder head and run the pump until air is purged. If head galleries have been drained, prefill the galleries with pressurized oil as described under “Low oil pressure.”

INJECTOR DRIVE MODULE:

The IDM delivers a low-side signal to control the timing, duration, and sequence of injector opening. The high-side delivers 115 VDC at 10A to the HEUI solenoids.

WARNING: Do not disconnect, attempt to measure or otherwise disturb IDM circuits while the engine is running. Voltages are lethal.

AIR IN FUEL CIRCUIT:

Air leaks can cause rough idle, shutdowns on deceleration, and no-starts. The time required for air intrusion to make itself known depends upon the proximity of the leak to the transfer pump. For example, the engine might start and run several minutes before air entering from a fuel tank connection reaches the pump. Air entry closer to the pump has more immediate effects.

Multiple leak points—Schrader valves, bleed screws, fuel-line connections— make the filter/water separator a prime suspect. Use OEM clamps on hose connections, new seals, and dope screw threads with sealant. Surplus fuel from the injectors recycles back to the filter. The connection at the filter incorporates a check valve that closes when the engine stops. Should the check valve leak, air from the return line will be drawn into the filter as fuel in the canister cools and shrinks.

CAMSHAFT POSITION SENSOR

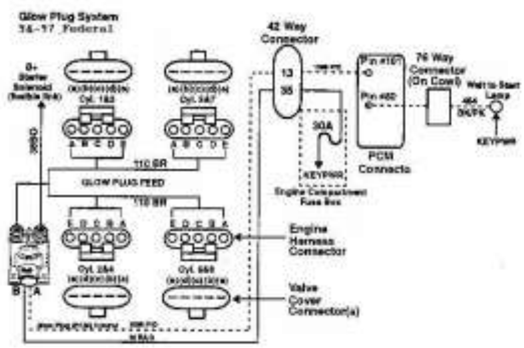
Sensors for mid-1994 to 1996 models are marked C96 or C 97; C-92 sensors were used from late-1997 to the end of production. These OEM units can cause no-start, hard-start, erratic idle, and shutdown on deceleration problems unless shimmed 0.010 in. off their mounting surfaces.

Replacement sensors have been shortened and do not require shimming. The CMP for mid-1994 to 96 models carries International part number C92 F7TZ-12K03-A, and can be recognized by the tin-coated connectors. The latest C98-F7TZ-12K073-A version features gold-plated connectors, which gives one an idea of the problems associated with these units. And while the newer CMP has better reliability than the previous type, its gold connectors present an electrolysis problem when mated with the tin connectors used on early 7.3L production. Replacement sensors cost about $100 from International. It’s good insurance to carry a spare.

The CMP mounts on the front of the engine, adjacent to the camshaft, and is secured by two 10-mm bolts. Trouble code 0344 will be flagged if sensor response is intermittent; 0341 means that enough electrical noise has been detected to affect engine operation. Check connectors for loose, bent, or spread pins and clean grounds. Code 0340 indicates the absence of a sensor signal while cranking. In this case, the engine will not start.

HARD START/LONG CRANK (COLD ONLY):

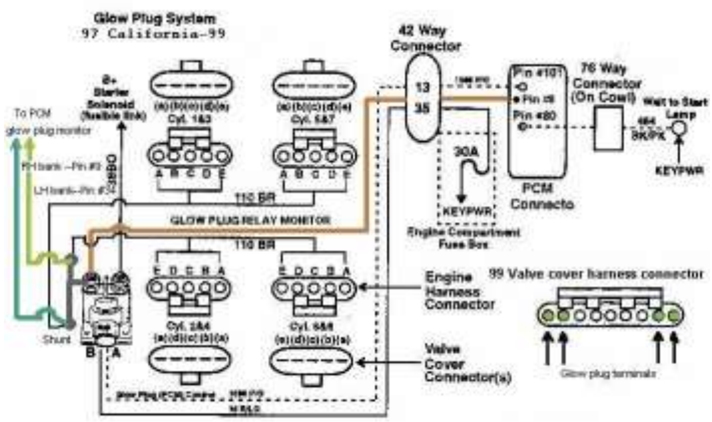
This usually indicates a problem with the glow plug system. Disconnect the Engine Oil Temp (EOT) sensor at the rear of the oil reservoir. This will cause the PCM to energize the glow plug relay for 2 minutes, and set a code. Turn the key to the run position and check for any voltage drop at the outlet side of the glow plug relay. The voltage should be greater than 10 volts during the glow plug cycle.



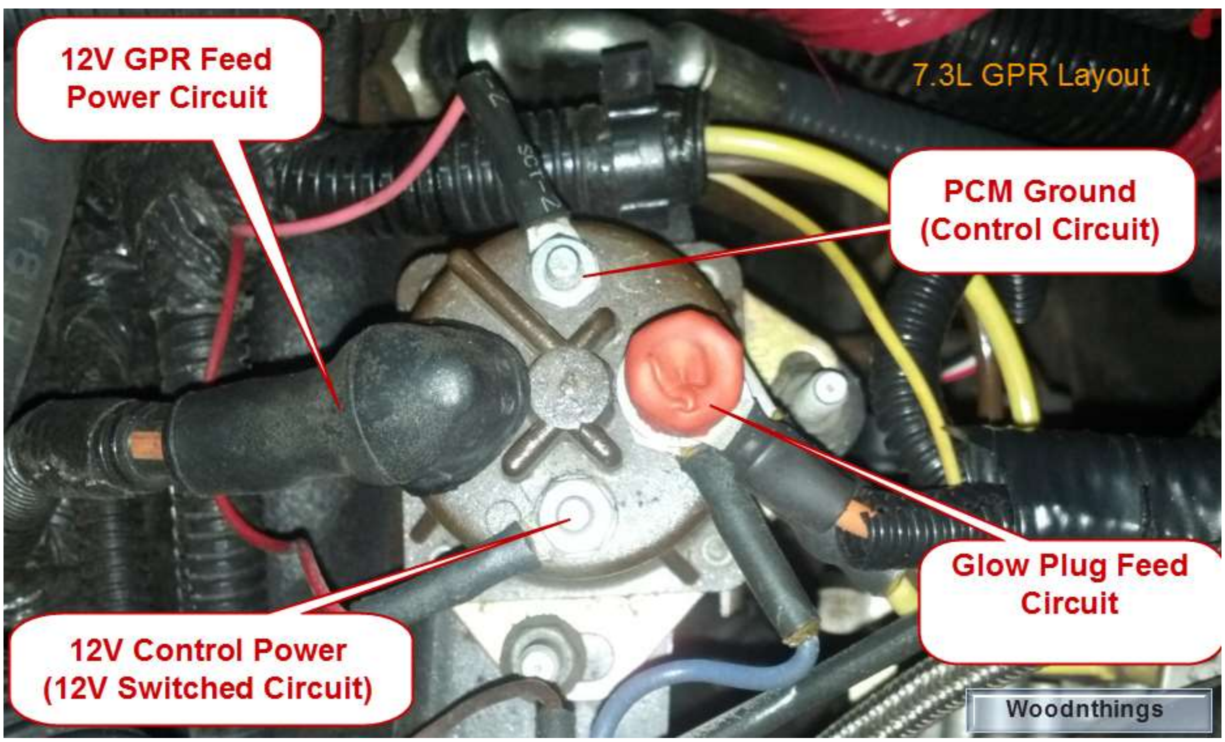
There is a history of burned and melted relay terminals and a couple of updated relays. Most recent part number is F7TZ-12B533-CA and can be identified by a gold-colored base.

If there is no voltage out of the relay, check for voltage in at the main terminal as well as key power and PCM-controlled ground at the two-wire connector. On 97 and newer vehicles inspect the bank circuit divider shunt for damage. If the relay tests fine test the glow plug resistance to ground at the valve cover connectors. The glow plug terminals are the outer two on 94-97, outer four on 98.5/99. Resistance should be 0.1-6 ohms depending on engine temp. A high reading could be the result of a spread or damaged Under Valve Cover harness or damaged valve cover gasket; re-check any high readings at the glow plug itself. Damaged UVC harnesses can be repaired with kits F7TZ-14489-AA for 97 and -BA for 94-96 trucks or replaced with F4TZ-9D930-K for 94-97 trucks or F81Z-9D930-AB on 98.5/99. Resistance from the glow plug relay to the valve cover connectors is 0-1 ohm. If no other faults are found, allow the vehicle to sit overnight. Before starting the engine, set the scan tool to monitor data stream and pick the EOT and Intake Air Temp sensors. The EOT and IAT should be within five degrees of each other. Next, remove the level-check plug from the HP oil pump reservoir and check the oil temperature with a thermometer to verify the EOT reading. If the EOT reading is higher than ambient (IAT) temperature, the PCM may be activating the glow plugs for too short a time, or not at all. If the problem only occurs at high altitude, and there is no glow plug system failures, the BARO sensor is most likely at fault.

Some 97 trucks have experienced a check engine light on after starting with Glow Plug Monitor circuit codes P1391, P1393, P1395 and P1396. After checking the glow plugs and the harnesses as in the above procedure, install a breakout box and check the GPM circuit to the PCM--GPML, LH bank terminal to pin 34; GPMR, RH bank terminal to pin 9; GPMH, relay output terminal to pin 8.

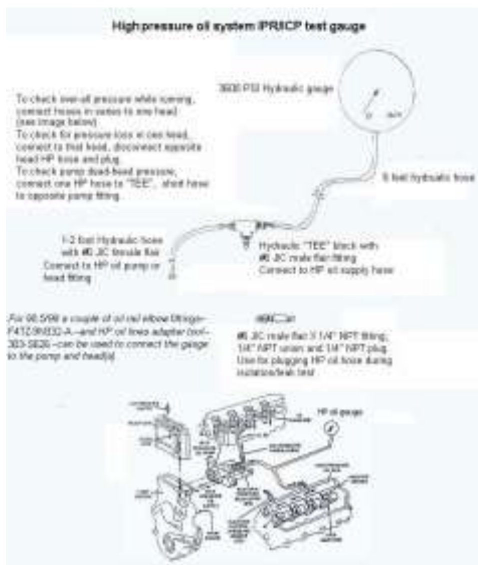


If there are no opens or shorts, re-flash the PCM to a higher calibration level. Also watch for an intermittent no output from the glow plug relay caused by oxidized internal contacts.



NO/HARD START HOT OR AFTER STALLING, USUALLY RE-STARTS AFTER COOL-DOWN; JERKY, ERRATIC IDLE; POSSIBLE DTC#'S P1211, P1212, P1283:

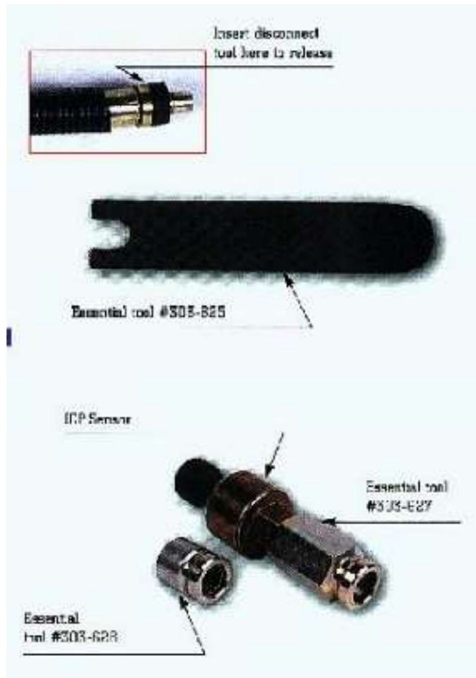
Usually caused by low injection oil pressure or regulator (IPR) valve. High pressure oil is used to pressurize and inject the fuel into the cylinders--each injector is essentially its own injection pump. The IPR is a by-pass valve that controls the high oil pressure depending on demand. The ICP monitors the oil pressure in the LH head. Check for oil in the upper reservoir; it should be within one inch of the top; add oil as necessary. Verify that the correct oil is being used (see my **Powerstroke Page** for oil specs) and that it is not thinned out. For no-start concerns check Injection Control Pressure (ICP) sensor readings with a scan tool or pressure gauge (500 min), or with DVOM at pins 87 to 91 (.83volt min) while cranking.



By using adapter fittings and plugs you can isolate and measure each cylinder bank to see if there is a high pressure oil leak in one head, or connect both HP oil pump hoses to the pressure gauge to measure pump pressure. *NOTE: The 98.5 and later HP oil lines have special couplers requiring special tool 303-625 to disconnect, and tools 303-627 and 303-628 to connect to the coupler along with a pair of F4TZ-9N332-A elbow fittings to adapt to the HP oil gauge hose.*

If isolated pump pressure is low, short break-out-box pin 83 to ground to run IPR valve to full duty-cycle. If the pressure comes up (3600 psi) replace the PCM; if it remains low, remove and inspect the IPR O-rings for damage; a kit is available if they are. If the IPR O-rings are undamaged, replace the IPR valve. If there is still low oil pressure, replace the HP oil pump.

If isolated HP oil pump pressure is 500 psi, or only one bank reads low, remove all the fuel injectors and replace their O-rings using the latest kits P/N F8TZ-9229-AA.



If the concern is a jerky, erratic idle when hot, unplug the ICP sensor (will set a code, causes the PCM to default to a pre-selected IPR duty cycle) to see if it the idle stabilizes. If it does, check the ICP voltage with a scan tool or breakout box at pins 87 to 91 with the sensor plugged in and the key on/engine off. It should be .20-.25 volts. If the base ICP voltage is within specs, replace the IPR; if not, replace the ICP and retest.

NO START AT TIMES; INTERMITTENT STALLING WHILE DRIVING DURING WARM-UP OR WHEN HOT, USUALLY RESTARTS; POWER "HITCH" AT CRUISE OR UNDER LOAD; POSSIBLE DTC#'S P0340, P0341, P0344:

Cam Position (CMP) sensor.

The CMP sensor provides the PCM with cylinder ID and engine RPM. Sometimes hard to detect, even with a scan tool while monitoring the RPM signal. If the PCM does not receive a clear CMP signal, it won't signal the Injector Driver Module (IDM) to energize the injector solenoids.

If this symptom occurs, or if you find one or more of the above codes, check the wiring to the CMP for continuity--BOB pin 90 to CMP pin B; BOB pin 65 to CMP pin A; BOB pin 49 to CMP pin C. **NOTE:** *A code P0344 may be set any time the engine is cranked for an excessive period of time.* Early CMP sensors were @ 1.152" in length, and with the different materials--plastic sensor, aluminum timing cover, steel tone ring) the air gap would change drastically during engine warm-up. There were TSB's published for shimming the sensors 0.010" to cure these problems as well as the drastic repair of replacing the camshaft--something a Navistar tech assist rep recommended *not* doing even if excessive end play was verified. There have been two updates to the CMP. One to decrease the length to 1.142", and also to improve the internal circuitry for less "noise". The CMP designed for engines built after serial number 375549 have gold-plated terminals and cannot be substituted with those designed for previous engines.
94-96 CMP: F6TZ-12K073-A; original Navistar part suffix C-96, C-97; replaced by C-98; replaced by C-99 97 CMP: F7TZ-12K073-A; early suffix C-91; replaced by late suffix C-92; both replaced by C-93.

The suffix is stamped on the connector end of the CMP and can be used to identify the level of the part installed. Replace any CMP's with a suffix of C-96, 97, 91 if these symptoms are experienced. Lube the O-ring and connector with silicone dielectric grease when installing.

HARD START; STALLING; ERRATIC IDLE AND/OR LOSS OF POWER; DTC P1298 ALL MODELS--95-96 ECONOLINE IN WET WEATHER:

Injector Driver Module (IDM).

The IDM converts 12 volt battery power into 110 volts and activates the injectors as directed by the PCM. On some Econolines water may enter the IDM causing the above symptoms. To diagnose, remove the LH battery and the coolant overflow bottle and access the IDM which is mounted behind the coolant bottle. Remove the IDM (both ground strap bolts need to be removed) and shake it, listening for a sloshing sound. Water running off the roof and cowl areas can enter the IDM; there is a service replacement IDM--F6TZ-12B599-AA--that has improved sealing. Also install foam seals (1) F6UZ-13C795-AA and (2)-BA on the back of the IDM.

If the DTC P1298 is alone when performing code retrieval, replace the IDM; if other codes are present, diagnose them first.

A faulty IDM can cause drivability concerns similar to a malfunctioning ignition module in a gas-powered vehicle. Under load it will seem as if the engine is starving for fuel. If you verify good fuel and oil delivery and pressure to the heads, and the Mass Fuel Desired, ICP, IPR and Fuel PW readings climb while the RPM's drop, suspect the IDM.

NO THROTTLE RESPONSE, ENGINE IDLES ONLY, DTC'S P0220 OR P0221; VEHICLE JERKS IN PARKING LOTS, ESPECIALLY MANUAL TRANSMISSION:

Idle Validation Switch.

The IVS tells the PCM that the accelerator pedal has returned to the idle position. Even if the pedal is fully depressed, if the IVS remains off, the engine will only idle. Watching the IVS and AP data stream, the IVS should switch on below 1.41 volts according to Ford. Navistar spec is 0.2-0.3 volts above base AP voltage. If the PCM sees the Accelerator Pedal sensor voltage increase without the IVS switching on, it may set a code. The IVS and AP sensor cannot be replaced without replacing the entire pedal assembly. If the IVS switches on at too high of an AP voltage, it can cause the truck to buck at low speeds as the IVS cycles on and off as the driver tries to control his speed. The only way to correct this is to first loosen and turn the AP sensor to reach the lowest possible voltage reading on the scan tool and retighten. Then bend the IVS stop to adjust the on/off point to 0.2-0.3 volts above the base AP voltage reading.

> *Note*: *There have been cases of lack of throttle response and the above codes which were caused by the PCM not recognizing the IVS "on" signal. Replacing the PCM corrected the problem.*

LACK OF ACCELERATIONERATION WHEN COLD; LIMITED RPM; HISSING NOISE UNDER HOOD; POSSIBLE DTC'S P0470-P0478:

Exhaust (Back) Pressure Regulator valve/servo.

When the engine is cold--EOT less than 140 degrees--and the ambient temperature is less than 37 degrees, the PCM activates the EPR solenoid to divert oil pressure to the EPR servo which closes the EPR valve at the turbo outlet. This causes exhaust backpressure to help the engine warm up more quickly. The PCM monitors the amount of backpressure through the Exhaust Backpressure sensor. On acceleration, the EPR is deactivated, but if the valve sticks, it will cause the above symptoms. You may or may not be able to duplicate the concern, since it normally only occurs on initial start-ups when the PCM activates the EPR for prove-out. If you are able to duplicate it, inspecting the position of the EPR linkage can confirm the problem (the servo linkage will be extended and the bell crank tang will not be on its stop). To repair, replace the turbocharger pedestal.

A similar condition can occur if the EBP sensor tube plugs up with carbon, causing the PCM not to see an increase in exhaust back pressure resulting in the PCM not deactivating the EPR solenoid. Remove the tube and inspect for blockage. Clean as necessary.

ROUGH IDLE, ESPECIALLY HOT:

Could be caused by anti-foaming agent depletion, incorrect oil, or leak at the oil pump pickup tube.

Get the engine and oil hot and run up to 3300 RPM for three minutes. If the ICP reading goes above 1600 within the first thirty seconds of testing there could be a cracked pickup tube or missing seal. The pick-up tube can be checked by adding two quarts of oil to the crankcase and raising the rear of the vehicle approximately ten inches. If the ICP readings at 3300 RPM drop, then the pick-up tube is cracked or leaking.

If at the end of the three minute high RPM test the ICP readings are above 1400 for Federal or 1250 for California and Econoline or 1500 on 99.5, the anti-foaming agents are depleted from the oil or the wrong oil is being used.

LOSS OF POWER, USUALLY AFTER A HARD ACCELERATIONERATION; ROUGH IDLE; CHECK ENGINE LIGHT COMES ON, DTC P1211:

Intermittent high pressure oil leakage.

This condition usually occurs when the vehicle is cold and the oil is thick. When performing a hard acceleration, the truck suddenly loses power, the check engine light comes on, and once returning to idle the engine runs rough and won't accelerate. Cycling the key may correct the concern, clearing the code from the PCM will correct it temporarily. If you can monitor data stream, at idle the ICP pressure normally is 400-700 PSI and the IPR duty cycle is 9-14%; at cruise, ICP is 700-1200 PSIG and IPR is 15-20%; under normal acceleration, ICP is 1200-2000 PSI and IPR is 20-30%; and under WOT acceleration, the ICP is up to 3600 PSI and the IPR is 35% or higher. When the above symptom occurs, typically the idle ICP reading will be normal, but the IPR duty cycle will be high--over 20% and up to the max 50%. A "blow-by" condition has occurred somewhere in the HP oil circuit. If you can get the problem to re-occur with some frequency, the most probable cause is worn or deteriorated injector or IPR O-rings. If the problem is intermittent, it could be a sticking IPR valve. Replace the injector O-rings with the latest-level kits--F8TZ-9229-AA. When replacing the IPR, make sure you get the correct part for the build date/serial number of your engine.

ROUGH IDLE, MANUAL TRANSMISSION TRUCKS; "BEARINGS-IN-A-CAN" RATTLE NOISE:

Dual mass flywheel.

Ford uses a two-pieces flywheel to dampen out the engine vibrations to prevent damage to the ZF 5-speed Trans--99 trucks equipped with the new 6-speed Trans have a standard flywheel. Occasionally either the bearing that supports the rear half of the flywheel fails, or the dampening springs lose their tension. The result is a rougher idle, sometimes described as a miss at idle, often accompanied by a rattling noise. Increasing the RPM usually negates these symptoms. Running the KOER and Cylinder Contribution tests makes the noise worse. Replacing the dual mass flywheel is the only fix for this situation. Use P/N F7TZ-6477-DA.

1996-97 POWERSTROKE STALLING

intermittently after a long deceleration in manual first or second gear in automatic trucks, or in low gears with ZF 5-speed, when shifting back up into a higher gear or depressing the clutch may be corrected by: performing electronic engine control diagnostics; replacing the oil with the recommended SAE weight for the ambient temp (see my **Powerstroke Page**) and API rating; replacing the Injection Control Pressure sensor (ICP, P/N F6TZ-9F838-A) with one that has a date code of 6318 or higher ("C916318A" 6=1996, 318= Julian date Nov. 15); and adding a pint of Lubrizol 888 or Fleetrite CH1824392.

> *Note*: California vehicles with E4OD automatics need to have the calibration of their powertrain computer updated as per TSB # 98-4-14.

Similar condition:

If you have a customer that drives in low gear at idle speed for an extended time then experiences a stall when depressing the clutch, instruct the customer to drive in low range when this condition normally would occur. The stall is most probably caused by the PCM seeing the accelerator pedal in the idle position (IVS "OFF") and a load on the engine and adapts to this mode. Depressing the clutch suddenly removes the load, the PCM over-compensates, and the engine stalls. *There is no repair for this condition*

STALL WHEN ENGAGING TRANSMISSION (AUTOMATIC, USUALLY MANUAL LOW OR REVERSE):

TORQUE CONVERTER CLUTCH.

This may be caused by the TCC being engaged at idle. On trucks built before 9-20-95 the correction is a new transmission front pump and/or torque converter. On trucks built after the above date, it could be cause by a loose transmission filter. In this case, install a flat magnetic strip (from a Tempo ATX or Ranger A4LD transmission) in the trans pan below the filter pick up to retain the filter in place or use an updated filter from Ford that has bumps cast into the plastic to help it stay in place.

SURGE/BUCK/JERK AT CRUISE, 50-60 MPH/1500-2000 RPM, 96 TRUCKS AFTER "CALIFORNIA CACKLE" CALIBRATION UPDATE, 97 AND 99-2000:

There is a revised computer program for 97 California and 99-2000 engines to correct this concern. This is intended to correct the problem if it occurs when the cruise control is on. Broadcast Messages 9817 & 0054; TSB # 00-25-4.

If this condition exists in a 96 model/year truck, if the condition is not completely resolved after this fix, or if it occurs only with the cruise off, try using **synthetic engine oil.** Since most of the synthetic oils on the market are not specifically designed for use in the Powerstroke, a pint of the anti-foaming agent must be included in the oil change--Fleetrite/Navistar CH1824392 or Lubrizol 888 - This may dampen the symptoms to an acceptable level.

REVISED AIR CLEANER AND FILTER, 99-2001 F-SERIES/EXCURSIONS BUILT BEFORE 11-25-00:

This new air cleaner assembly is to correct lack of power concerns caused by a collapsed air filter element. The element now has a 3" pleat, and the air cleaner cover has a post to keep the element in position. May be used to replace any air cleaner from model/year 99 up to 11-25-00, at which time it became production. TSB #01-9-5.
Air Cleaner Assembly: 1C3Z-9600-AA; includes element FA-1710
Trucks built prior to 12-7-98 still with the original air box can use the following older TSB that now includes the newer air filter:

99 F-SERIES LOSS OF POWER;

Snow ingested into air cleaner--trucks built before 12-98. Ford has a new air cleaner box which went into production on 99.5 trucks. This new air cleaner moves the air intake from the fender well to the radiator support and incorporates a LH battery cover. The modification requires removing the LH battery tray and blanket, replacing the P/S return hose from the Hydra-boost and trimming the LH radiator air deflector. TSB# 99-6-4 Air cleaner kit: XC3Z-9K635-AA This may be a more preferable fix to the shortening of the air intake tube as described in TSB#98-16-11 as this condition affects original and shortened air cleaner boxes:

LACK OF POWER; ROUGH RUNNING; CHECK ENGINE LIGHT ON; SUCKING SOUND ON ACCELERATIONERATION--99 F-SERIES:

This could be caused by dirt and water being drawn into the air cleaner. There is a revised air cleaner box that can be installed to correct this--P/N F81Z-9600-BA. If the revised air cleaner box is unavailable, the condition can be resolved by modifying the air cleaner snout: Mark the snout where it enters the fender; remove the air cleaner and cut off the end of the snout 5mm/0.2" from the *fender* side of the mark; reinstall the air cleaner. The end of the snout should stick into the fender slightly. TSB#98-16-11
I have seen this problem show up in very fine dust conditions without *rain.*

1997 F-SERIES (CALIFORNIA) AND 97/98 ECONOLINE CHECK ENGINE LIGHT

Coming on after a cold start and staying on may be due to a programing error in the computer that results in false glow plug monitor circuit trouble codes. The fix, after verifying that no problems exists in the glow plug or monitor circuits, is to clean and torque the glow plug relay terminals and, if the problem persists, re-flash the computer to a higher calibration. TSB# 98-15-1 *Make sure that the U-shaped tin shunt running from the relay output terminal to each of the bank terminals is undamaged.*

1999 F-SERIES AND 1998.5 E-SERIES

With the Powerstroke may experience an engine knock at idle or a whine when the ignition is turned to the run position. There is an up-dated fuel pressure regulator kit available (P/N F81Z-9B249-BB) to correct these conditions. TSB#98-17-16
Vehicles which exhibit an injector cackle--occurs on hot engine; fuel pressure greater than 55 PSI; no other performance concerns; vehicle driven at least 20 miles since last injector removal; no base engine concerns--are candidates for a new fuel injector to be installed **in #8 cylinder only** on E-vans, F-series and Excursion. There is also a revised computer program which must be installed to prevent false trouble codes during a Cylinder Contribution Test. On F650/750 there is a fuel system accumulator to reduce variations in pressure in the fuel rails. This condition is not detrimental to the engine, and is the result of oscillations in the fuel passage causing #8 cylinder to run lean.

Note: Installing the revised injector may result in a more consistent and deeper-sounding knock noise from the engine. 99.5 And up: Broadcast Message #8605/TSB #'s 00-10-1 & 00-22-1. Long-lead injector: XC3Z-9E527-AARM 98.5-99: TSB#'s 01-14-6 & 00-23-5. Long-lead injector: F81Z-9E527-EARM F650/750: TSB # 00-25-3. Fuel line accumulator: YC3Z-9N163-AA

99 F-SERIES LOSS OF POWER OR STALL IN 0°F TEMPS:

May be caused by ice forming in the fuel tank and blocking the pick-up screen. May also cause stalling, no/hard start. A "Top Water Fuel Heater" service kit is available to increase return fuel temperature, which in turn will heat the fuel in the tank.
P/N 1C3Z-9J294-AA. TSB 01-04-04.Using Stanadyne Performance Formula Fuel Conditioner will help prevent this condition.

97-99 E-VANS HARD START/LONG CRANK with aftermarket modifications may be caused by a loss of voltage to the Injector Drive Module during cranking. Run a dedicated circuit to terminal 85 of the IDM relay from the battery terminal of the starter relay using 10 gauge wire and a 30 amp sealed fuse. Secure this new wire, insulate and tape back the original wire as it will still have power for other circuits. TSB#98-26-9.

99 ECONOLINE HARD/NO START:

The computer may be energizing the glow plug relay for too long a time resulting in relay damage. Vans with calibrations 9DTA-AO (tag SZTx) and 9DTA-bg (tag CHKx) should have the computer calibration updated and a new glow plug relay P/N F81Z-12B533-AC. TSB# 99-16-12

99 F-SUPER DUTY IDLES LOW WHEN COLD; TRUCKS W/O CRUISE CONTROL:

Some trucks without cruise control may exhibit a normal idle RPM, but does not have a higher idle at cold temperatures. This may be due to the computer strategy. There is a new calibration to rectify this concern.

99.5/2000 HIGH INJECTION CONTROL PRESSURE READINGS:

Ford has finally released information that engine built after serial number 896812 have a higher ICP reading than earlier engines. This is due to a calibration change and high pressure/low mass poppet injectors. International says it is also due to a higher volume HP oil pump. When performing an oil aeration test, an ICP reading of over 1800 PSI after the engine has been run at 3400 RPM for three minutes indicates the anti-foaming agents may have been depleted. Replace the oil or add de-foaming agents to the oil and retest. TSB# 00-17-4

DAMAGED VALVE TRAIN CONTACT REQUEST:

Some 2000 Powerstroke engine may exhibit bent/out of position pushrods, damaged rocker arms, or damaged valve at low mileage. This may be caused by miss-manufactured rocker arms and/or pedestals. Inspect the suspect rocker pedestal for signs of scraping or breakage. If any rockers are date stamped "LB051" or "LB061", all 16 should be replaced, whether damaged or not, with parts date stamped "LA***". If any rockers are damaged and have an "LA" date stamp, International should be contacted. Have the numbers from the rocker available when calling. SSM #14285, Broadcast Message 1471.

98/99 E-VAN; 99 F-SERIES BUILT THROUGH 4-12-99, CHECK ENGINE LIGHT/DTC P1298:

The Check engine light may illuminate on these trucks with a false trouble code P1298 (IDM failure). This may be due to circuit tolerance inside the Injector Driver Module setting the false code if battery voltage is low. Verify battery voltage is greater than 10 volts. Perform all scan tool code retrieval diagnostic tests. If any codes other than P1298 are retrieved, diagnose and repair these first. If P1298 is the only code retrieved, and the engine cranks good but doesn't start, test the glow plug system and check for voltage drop or PCM reset during cranking. If all of the above is OK, or the P1298 still exists after all repairs are done, clear the code, then cycle the key off and on three times, leaving the key in the on position for five seconds each time. Check KEY ON ENGINE OFF codes and if P1298 is retrieved, or if P1298 returns with no other symptoms or codes, replace the IDM with P/N XC3Z-12B599-AA. TSB #99-13-2

INTERMITTENT COMPUTER RESET 95-01 F- AND E-SERIES:

Check engine and wait to start lamps that cycle while driving with a momentary stumble and the accelerator pedal not responding until it is released may be due to a momentary short in the reference voltage supply to the sensors or a short or open in the battery voltage supply to the computer or IDM, or a short in one of the injector power supply circuits causing the computer to reset. This may not result in any trouble codes. Check TSB 97-15A for more info on this condition.

OIL LEAKAGE FROM CYLINDER HEAD PASSAGE END PLUGS, 94-99:

International has revised the seal on these plugs, replacing the standard O-ring and back-up ring with a thicker oval seal. The port should be cleaned of any debris and burrs, and the threads sealed with Loctite 609 or blue thread locker. Rail plug 1827535-C91. Broadcast Message 9905.

2000 INTERMITTENT MISFIRE:

Some trucks with the Powerstroke engine built between 5-8-00 and 5-30-00 may exhibit a misfire condition which last approximately 15 seconds at either idle, under constant engine load or acceleration. Retrieve and diagnose any trouble codes. If the miss is still present and there are no IDM codes, and the date code on the IDM is between 0E05 and 0E026 (fourth line of the part number tag), replace the IDM. Broadcast message# 9366.

CHARGE AIR COOLER (INTERCOOLER) LEAKS OIL OR HOSE BLOWS OFF, DRIVER'S SIDE:

If excessive oil is leaking from the driver's side intercooler to pipe hose, replace the clamps with spring loaded ones which will better accommodate thermal expansion. If the driver's side hose has blown off, replace the tube assembly along with the clamps.
Clamps: YC3Z-6K786-DA; Tube: YC3Z-6C646-AB. SSM# 13706

99-2001TURBO BOLTS LOOSE/MISSING:

In some cases the bolts attaching the turbine housing to the center section of the turbo may be loose or missing. There are revised bolts available in kit # 1C3Z-9G486-AA. These bolts have locking threads on them to help prevent them from backing out. The bolts should be torqued to 300 in/lbs. in a cross pattern. SSM 15988; Broadcast Message 3226.

7.3 LUBRICATION / FUEL / COOLING / FLUID FILER REQUIREMENTS

ENGINE OIL REQUIREMENTS

The most common problem with Ford's 7.3 Direct Injection Turbo diesel is related to engine oil change interval and type of oil being used. It is critical for proper engine operation that the customer or technician servicing the vehicle check that the correct oil is being used. This engine uses a high pressure oil pump to operate the fuel injectors. Typical system pressures are 500 psi at idle, 1200 at 3300 rpm in neutral, and 3600 psi at full load acceleration. Oil for the Powerstroke requires an anti-foaming agent to prevent the oil from aerating, which would result in poor fuel injector spray patterns and reduced power. Depending on vehicle usage, the anti-foaming agents are depleted in 3000-5000 miles.

The only oil recommended for the Powerstroke by Ford is Motorcraft Super Duty 15W40, 10W30. Each of these has the proper additives in them for use in a diesel engine including the anti-foaming agents. The 15W40 is recommended for normal climates, the 10W30 for temperatures below 20 degrees Fahrenheit. For temperatures below -10 degrees, 5W-30 is recommended. There are other oils, however, that do meet all the requirements for use in the Powerstroke. The specifications the owner needs to look for on the label are the API rating of CF-4/SH or CG-4/SH or higher. Some other oils with the correct ratings are:

• Pennzoil Long-Life 15W40 •Shell Rotella-T 15W40 •Chevron Delo 400 15W40, 10W30
•Mobil Delvac 1300 Super 15W40 •Castrol GTX Diesel 15W40
•Valvoline All-Fleet Plus or Cummins Premium Blue: 15W40
•Union 76 Guardol QLT 15W40 •Wal-Mart's Tech 2000 Universal 15W40
•Texaco Ursa Super Plus 15W40, 10W30 •Quaker State FCI Universal 15W40, 10W30
•Quaker State FCI HDX Plus 15W40 •Kendall Super-D 3 15W40, 10W30
•Kendall SHP Diesel 15W40 •Exxon XD-3 Extra 15W40 •Citgo Mystic Premium Fleet 15W40 •Citgo Mystic JT-8 15W40, 15W50, 10W30

For those of you wishing to use synthetic oil, the only ones I have seen with the correct specs for the Powerstroke engine are:

•Motorcraft Super All Season 0W-30 Semi Synthetic •Amsoil Series 3000 Synthetic 5W30 Heavy Duty Diesel Oil •Amsoil 15W40 Synthetic Heavy Duty Diesel and Marine Oil •Amsoil 10W30/SAE 30 Synthetic Heavy Duty Diesel and Marine Oil •Amsoil 5W-40 and 15W-40 Premium CJ-4 Diesel Oil •Amsoil 15W40 Semi-Synthetic Gasoline and Diesel Oil •Chevron Delo 400 Synthetic 0W-30 or 5W-40 •Mobil 1 Turbo Diesel Truck Oil 5W-40 •Mobil Delvac 1 5W-40 and Delvac 1 ESP 5W-40 •Quaker State 4X4 15W40 Synthetic Blend •Shell Rotella SB (synthetic blend) •Shell Rotella T 5W-40
•Royal Purple Synthetic 15W-40, 10W-30, 20W50 •Schaeffer's Supreme 7000 Synthetic Blend 15W-40

•Conklin Convoy 15W-40, 20W-50 •Valvoline Premium Blue Extreme 5W-40 Synthetic •Petro-Canada Duron XL 15W-40 Synthetic Blend •Citgo Mystic SX-8 15W-40 Synthetic Blend •Advantage Duragard Super HD 15W40

If these are unavailable you can use a multi-grade synthetic designated CF for use in diesel engines along with an anti-foaming additive. Some synthetic oils with this rating are:

•Mobil 1 •Castrol Syntec •Valvoline SynPower •Quaker State Syncron Ultra Performance

Recommended anti-foaming additives are Fleetrite with the Navistar P/N CH1824392 or Lubrizol 888. These are primarily used to counter the effects of silicone sealers on the anti-foaming agents in the oil or if the agents become depleted from use providing the oil is still serviceable and uncontaminated. An anti-foaming additive could also be used between oil changes if an oil-related poor running condition is suspected, especially on a long trip.

Under normal driving conditions the additive could extend the oil change interval to 6000 miles. For vehicles that are used for infrequent towing, using the additive at 3000 miles could extend the oil change interval to no longer than 5000 miles. Vehicles operated in dirty conditions, extreme weather conditions or constantly under heavy loads should stick to the 3000 mile service interval due to the other agents in the oil being depleted, and should only use the anti-foaming additive if performance problems occur between services.

The refill for the crankcase is 14 quarts for 94-97's and 15 quarts for 98.5/99's with filter change. Some early 95 and older engines were equipped with a 12 quart dipstick (Navistar P/N 1820068C1) and need to be filled to just over the word "FULL", or replaced with the correct part (Navistar P/N 1824405C1; Ford P/N F4TZ-6750-E for F-series; F5UZ-6750-A for Econoline). Some later dipstick tubes were not seated properly causing the crankcase to be over-filled in an attempt to bring the level up to the mark.

The oil filter for the Powerstroke (Motorcraft P/N FL1995) is longer than that of the previous Ford/Navistar diesel, and the old-style filter should not be used. Due to its seal design, the oil filter should be hand tightened, then turned an additional quarter-turn--or torqued to 20ft/lbs.--with the oil filter wrench to prevent leaking.

FUEL AND AIR FILTERS

Another problem that arises, usually during wet weather, is the "water in fuel light" staying on. Diesel fuel attracts moisture, and unfortunately water does most of the damage to a diesel's fuel system. Normally the "water in fuel" light only comes on at cold starts when the water has had a chance to separate from the fuel in the filter housing. If the water is not drained regularly, it will mix with the fuel due to the agitation caused by the fuel pump, and if there is enough water in the filter the light stays on. You should drain the fuel filter at least once a month, more if the weather is wet. On early 97 and older F-series the drain is accessed through the opening on the engine trim cover. The yellow drain lever can be seen at the 7 o'clock position on the fuel filter housing. Turn the lever one quarter of a turn clockwise to open it. If the fuel does not drain, you may have to crank the engine over. On the late 97 F-series, the engine trim has been cut down, but the drain lever is in the same position as is the Econoline vans, but the vans need the air filter housing removed to access the drain. On the 99 Powerstroke engines, the drain has been moved to the ten o'clock position and is turned one quarter turn clockwise, and the key turned to the on position to allow the electric fuel pump to expel the fuel. 98.5 And newer Econolines have a cable attached to the filter drain, which is near the transmission dip stick. The fuel drains onto the front cross member, so you may want to install a piece of hose at the end of the drain pipe to prevent messes.

If the fuel becomes very contaminated, you'll want to change the filter. Some aftermarket filters have a square-cut O-ring seal instead of the lip type of the original [IMAGE]. I recommend using the Ford Motorcraft filters FD4595 for the 94-98 and FD4596 for the 98.5-2K or their Racor equivalents: IN F4595 and IN F4596. The WIX 33518/NAPA Gold 3518 used to be identical to these, but recently they changed design (without changing part numbers) to a square cut lid seal and a weak grommet-like lower seal which tends to split. The fuel filter also has a pin in the top which opens a valve inside the filter housing standpipe. Some aftermarket filters have a shorter pin than necessary which results in the valve not opening completely and this can cause lack of power concerns. The fuel filter should be changed at 15,000 mile intervals.

On the 97 and older, the filter housing cover can be removed using a large screwdriver to turn the cover by laying it across the cover and twisting against the ridges on the cover. The 99 fuel filter cover (as well as the earlier design) can be removed with a 4 inch oil filter wrench. On both types of filter housing, the new O-ring needs to be lubed with fuel or oil and installed onto the housing--not the cover--with the lip facing up.

Do not use any fuel additive containing alcohol or ones that would allow water to pass through the fuel system to be burned off in the cylinders. The tolerances of the fuel injectors are so precise that this could cause damage and failure of the injectors from the lack of lubrication. Also using fuel not meant for highway use could cause damage to the injectors or the catalytic converter. Ford does have a fuel additive for use during

break-in periods such as when the injectors are serviced, and is recommended for use any time fuel quality is in question; P/N F8AZ-9C077-AA. In cold weather conditions Stanadyne's Performance/All Season Fuel Conditioner (P/N 29409[pt.]).

Above all, do not mix gasoline in with the diesel fuel. If you have an algae problem, there are fuel conditioners to correct this, too.

The larger F-series air filter (Motorcraft FA-1617) should be good for as long as the fuel filter, depending on dust conditions, but the Econoline (FA-1618), the 99 F-series (FA-1675) and 99.5 F-series (FA-1680) use a smaller filter (the E-van uses two). It would be a good idea to check the air filter(s) on these once a week in dusty conditions and replace them every other oil change, and to keep a spare. Or you could purchase an aftermarket "washable" filter element such as those sold by K&N or Amsoil. When inspecting or replacing the air filter, inspect the filter housing drain and clean it as necessary.

COOLING SYSTEM MAINTENANCE

The cooling system on any diesel has special concerns. It's possible for the coolant to cavitate--produce tiny bubbles--that can with time because pin holes through the cylinder walls from the water jackets. For this there is an additive; Ford P/N FW-15 or FW-16, Fleetguard P/N DCA4; that needs to be maintained in the coolant. Generally this means installing 8 to 10 oz. of the additive to the cooling system every 15000 miles. Another method is to monitor the cooling system with Fleetguard's DCA4 test kit P/N CC2602 or CC2602A. This measures the level of DCA4 in the system, then you add the amount of SCA/DCA as required to reach a nitrite level of 1.2-3.0 PPM. The cooling system should be drained (and flushed if you live in an area with especially alkaline water) and refilled with a fresh 50/50 mix of coolant/distilled or demineralized water and one pint of the additive for every two gallons of coolant/water at 30,000 miles. Use only an ethylene glycol-based coolant, preferably low-silicate.

ANTIFREEZES:

•Ford or Motorcraft Premium Antifreeze •Texaco Antifreeze/Coolant •Texaco Antifreeze/Coolant Pre-diluted 50/50 •Zerex 5/100 (white bottle) Antifreeze/Coolant •Zerex Ready To Use Antifreeze/Coolant (premixed 50/50 with demineralized water) •Zerex Heavy Duty Precharged Formula •Shellzone Premium Quality Antifreeze •Prestone Heavy Duty (black bottle) Antifreeze/Coolant with SCA •Fleetguard Complete EG--precharged at 1.5 units/gallon DCA4

Also available premixed 50/50 with water with the same DCA4 level

•Pyroil Heavy-Duty Antifreeze/Coolant--Low Silicate •Peak Full Force or Advance •Fleet Charge Antifreeze/Coolant--precharged with Pencool •Wal-Mart Super Tech

2002 model year trucks use any of the above if your truck came filled with green coolant. If it came from the factory with yellow coolant, only use Motorcraft Premium Gold Long Life Antifreeze, Zerex G05 (gold bottle), Peak Global Lifetime (gold bottle) or Peak Extended Life CF-EXL (silver bottle). These coolants are fully-formulated using hybrid organic acid technology (HOAT) and do not require SCA/DCA. Recommended service interval with the gold coolant is 5 years or 100,000 miles. Test the gold coolant periodically for pH balance and freeze protection.

Trucks originally filled with Gold coolant: All 2002 F-Series built at the Kentucky Truck Plant (VIN 11th digit "E")

2002 F150-550 built in Cuautitlan (VIN "M") from 2-4-02

2002 F650/750 built in Cuautitlan from 1-28-02

All Econolines built from 7-15-02

Ford has approved using the gold HOAT coolants in their vehicles as far back as the 1999 model year, providing the cooling system has been thoroughly flushed to remove all traces of the green coolant. If regular tap water is used instead of distilled or demineralized water, the recommended service interval is only 50,000 miles.

Ford does not recommend using propylene glycol-based coolants in any of their vehicles, or "universal" coolants that claim to be a replacement for any color antifreeze. They also have not approved the use of any organic acid technology (OAT) extended life coolants (ELC) in the Powerstroke cooling system.

TIPS

Do not use starting fluids for hard starting problems. With the glow plug system, starting fluids can ignite as the key is turned on causing engine damage. Keep your batteries and charging system in good condition, note any problems with the glow plug cycle, and if you experience a hard cold start problem, plug in the block heater, if your truck is equipped with one. This will heat the coolant enough to aid in starting. If you do experience hard starting, get you truck serviced as this condition could cause other system problems if left unrepaired, such as starter failure.

Care should be taken when installing performance enhancing devises or "chips", or modifying any electronic engine component such as configuring the exhaust back pressure valve to act as an engine brake. This can cause drivability problems, "check engine" light to come on, and may affect your warranty.

If you truck has an automatic overdrive transmission and you tow, remember that there is no engine braking in overdrive. It is recommended that the overdrive be cancelled when towing in hilly areas to prevent accelerated brake and transmission wear and transmission overheating.

You may want to pick up some items to carry with you, especially for long trips:

At least 2 quarts of the engine oil that you use. Don't mix two different oils, their chemical additives may not be compatible.

A pint of the Fleetrite CH1824392 or Lubrizol 888 anti-foaming conditioner.

A fuel filter; either a screwdriver or oil filter wrench to open the filter housing; 2 feet of 5/16 hose to attach to the filter drain and something to drain it into (i.e., a coffee can).

At least 2 pints of the F8AZ-9C077-AA fuel lubricity conditioner, or

Stanadye Performance/All Season Fuel Conditioner.

A pint of the FW-15/-16 DCA4 coolant conditioner.

If you own an E-van or 99 F-series, air filter(s).

An accessories drive (serpentine) belt--you may not be able to install it yourself, but at least you won't be stranded for lack of one.

Some other non-essentials: An oil filter, 5 gallons of diesel, jumper cables, a CC2602A test kit for the DCA4, and an extension cord for the block heater.

Chances are, with as many of these engines out there, you'll come across another Powerstroke owner that carries some of these items if you are in need, but it's always good to be prepared when on a trip.

PERIOTIC INSPECTION MAINTENANCE PROCESS

Some engines can be damaged if the wrong SAE rating or "weight" oil is used. There is also an API rating that tells if the oil is suitable for use in a gasoline or a diesel engine:

- •SH or SJ for gasoline engines
- •CF for off-highway IDI diesels
- •CG for on-highway IDI diesels
- •CF-2 for two-stroke diesels
- •CF-4, CG-4 or CH-4 for high-speed four-stroke diesels
- •CI-4 for diesels with cooled EGR systems
- •CJ-4 for diesel with exhaust particulate (soot) filters

Generally, a higher second letter in the API rating supersedes previous ones, so a car requiring SC-rated oil can use SJ.

Once per month: Check all fluid levels under the hood. Automatic transmissions and most power steering fluids need to be checked hot with the engine running, check the coolant in the overflow bottle, do not remove the radiator cap. Note any signs of leaks or abnormal conditions--flapping drive belts, bulging hoses. Check tire pressure and look for abnormal wear. If you own a diesel, drain the water separator, if equipped.

Every 3000-6000 miles: Lubricate, Oil and Filter. Harsh conditions require more frequent service than highway miles. Even if you put very little mileage on a vehicle, it still should be done twice a year. A running engine produces gases in the crankcase that break down the oil, even while the vehicle sits. I do mine on 5000 mile intervals to coincide with:

Every 5000 miles: Tire rotation. Front tires usually wear faster than rears because they get some side slip from cornering and have more up and down movement than the rears. It's best to rotate the tires before abnormal wear becomes apparent. When rotating, cross the tires from one axle left to right while rotating the other two front to back. This ensures that the each tire ends up on a different corner of the vehicle than previously, matching the wear patterns on all four. It is acceptable to have a radial tire rotate in a different direction than before providing its tread is not designed to rotate in one direction only. Some high performance tires are directional, as well as some dress wheels. It's easier to remember to rotate your tires if you have it done with another service. If you feel your vehicle needs the oil changed every 3000 miles, then rotate your tires every other time.

Annually: Have all the lights, the windshield wipers, battery and cables, charging and starting systems, belts and hoses checked and serviced as needed. Have the radiator and air conditioning condenser fins cleaned out. If you can find a shop with a policy of giving credit for any refrigerant recovered from you vehicle's air conditioning system, have the system recovered, evacuated to remove moisture and recharged. Have the entire vehicle inspected for leaks, and the cooling system and radiator cap pressure tested.

Every 15000 miles: Complete vehicle inspection including brakes, chassis fluid levels and steering and suspension components for wear. The wheel bearings, if serviceable, should be cleaned and repacked and the brake caliper slides cleaned and lubed. Have the wheel alignment checked. Have the cooling system ph. checked to prevent leaks due to gasket or hose deterioration from electrolysis. In areas with highly alkaline water have the cooling system chemically treated and flushed. The air and fuel filters should be replaced and if you own a very old car (conventional ignition or carbureted), it's time for a tune-up. Diesel vehicles should have a special conditioner added to their cooling system at this time. The additive prevents deterioration of the cylinder walls. The amount depends on cooling system capacity, but the minimum recommended is 4 oz. per gallon (does not apply to vehicles filled with extended- or long-life antifreeze).

Every 30,000 miles: This should be the first really major service for your vehicle. The services listed above should be done as well as the following. If you have green (non-extended or long life) coolant, it should be drained and replaced, possibly the system flushed. The Trans fluid should be drained and the filter cleaned or replaced. Even if the engine is running fine, at least have the computer system checked for trouble codes and the engine scope analyzed for potential problems. If your vehicle is five years or older, it's probably time for a tune-up including an injector service. If you own a diesel, consider having the injection pump timing and glow plug system checked. Diesels also need to have the conditioner added to their cooling system during the service--4 oz. per gallon total cooling system capacity is the minimum, 9.6 oz. per gallon maximum (does not apply to vehicles filled with extended- or long-life antifreeze).

At 60,000 miles: It's pretty much the same as a 30,000 mile service, except that cars newer than five years old should have the spark plugs changed and the fuel injectors serviced. Most of these vehicles don't have the ignition components of the past, and the spark plugs are the only parts that wear. If the throttle body is not deposit resistant, it and the idle by-pass ports should be cleaned as well. If the hoses and belts are original, it would be a good idea to replace them at this point. If your car has a timing belt, it may be time to have it replaced.

At 100,000 miles you should have the axle lube changed if your vehicle is a rear or four wheel drive, as well as manual transmission fluid drained and replaced. Vehicles with extended- or long-life antifreeze should have the cooling system drained and flushed, and refilled with new antifreeze of the same type and color along with distilled or demineralized water.

DIAGNOSIS PROCEDURES

The easiest way to diagnose the Powerstroke is with an OBD II scan tool that has data stream capabilities. Unfortunately, the 94 vehicles, while equipped with an OBD II data link connector, were actually EEC IV and had no data stream. By manipulating the accelerator pedal during the KOEO test, it was possible to activate an injector actuation (buzz) test, but the best way to fully diagnose these is to replace the computer with a 95 level one. This way not only are you able to retrieve trouble codes, but also run the injector buzz test, cylinder contribution test and monitor data stream and "snap shot" readings during a test drive.

If you are unable to upgrade the computer in a 94 truck, it is still possible to diagnose, just not as easy. By installing a 104-pin Break-out Box and using a DVOM or lab scope you can read most of the inputs and outputs in voltage or duty-cycle.

One thing to understand and remember is the PCM reads only voltage signals from the sensors. All readings which are not displayed in volts are what the PCM calculates those sensor inputs equal. In some cases, the PCM uses one voltage input to calculate a base line for other sensor readings. For example, BARO is used to calculate MAP/MGP base line. At sea level, calculates BARO at 14.7 PSI, so a MAP reading of 14.7 equals 0 PSI MGP. At an elevation of 5000 feet, BARO and MAP would be 12.1 PSI, so the MGP base line would be recalculated to reflect 0 and not -2.6 PSI.

All outputs are functions that the PCM is attempting to perform based on the inputs it is receiving. If there is an output device malfunction, the results may not be what the PCM is trying to achieve, but the output signal may still show normal. Some outputs may not match actual measurements. For example, the displayed duty cycle of the IPR may not match the actual duty cycle as viewed on a scope, or the displayed transmission control pressure output may not match the actual pressure on a test gauge.

Strategic displays like MFDES will change as the PCM detects changes in sensor inputs which may indicate changes in environment, such as altitude, or wear in the engine. This is part of the PCM's adaptive strategy, or "learning" capability. Other tools you may want to make diagnosing this engine easier are a diesel compression gauge and long-reach adapter; an infra-red "no touch" thermometer to find missing cylinders; a 160 psi fuel pressure gauge for testing the lift pump; a standard vacuum/fuel pressure gauge for manifold (turbo-boost) pressure; and a 3600 psi hydraulic oil pressure gauge for diagnosing the high-pressure oil system. There is also a tool available from **InterMotive INC.** to selectively cancel cylinders.

These tests are not in the original order as published by Ford, nor are they necessarily in the order in which I perform them. I modify the order depending upon the concern. While important for a lack of power concern, I wouldn't perform a fuel pressure test for a miss-fire concern.

PRELIMINARY CHECKS

The first thing to do if you have any drivability concern on a Powerstroke is to check the engine oil level. Many problems can be traced to broken down, incorrect or low engine oil. The Powerstroke uses engine oil under high pressure (400-500 psi at idle, up to 3600 under WOT full load) to pressurize and open the fuel injectors. In effect the Powerstroke has eight 110 volt electronically-actuated and controlled injection pumps. The engine oil is therefore critical to engine operation.

Powerstroke injection explained

If the concern is a no-start, remove the pipe plug in the top of the high pressure oil pump reservoir and inspect the oil level, which should be within one inch of the top. If it isn't, top off the oil level.

The next step is to check fuel quality. This is done by draining the fuel filter into a clean container. You'll need to attach a piece of hose to the fuel filter drain to direct the fuel away from the truck frame and into the container. The fuel should be clear or slightly amber, but not red or milky. After you drain the filter housing, remove the filter housing cover and inspect the interior for debris. Excess fuel from the injectors is returned to the filter housing, and if the injector O-rings are deteriorating, you will find pieces of rubber inside the housing.

Next you check the air filter and exhaust system for restrictions. Check the air cleaner "filter minder", look for kinks in the intake hose and exhaust pipes, and make sure that the exhaust back pressure valve on the outlet of the turbo is in the open position--rod retracted, bell crank fully clockwise and the tang against its stop.

Code Retrieval

On the Powerstroke KOEO "hard" faults must be retrieved first because any Injector Driver Module codes will be lost during the Continuous code retrieval and clearing.

After Continuous code retrieval the injector electrical buzz test needs to be performed. This done in two ways: on 94 trucks with the EEC IV connector in the engine compartment and the old PCM, after the fast codes are retrieved for KOEO and Continuous memory, depress the brake pedal to abort slow code retrieval and then depress the accelerator pedal to active the injector buzz test; on trucks with 95 or newer PCM's, after clearing the Continuous memory, select Injector Electrical test from the scan tool menu. Once the buzz test is activated, the PCM will signal the IDM to actuate the injectors. First it will actuate all eight, the each one individually, in order. Listen carefully during the individual actuation sequence as each injector buzzes. Sometimes the injector will pass electrically--that is it will actuate--but the valve that the injector solenoid activates will be stuck, resulting in a muted buzz when compared to the rest of the injectors. When this happens, I usually jump straight to the <u>Cylinder Contribution</u> test to confirm that there is an injector problem.

Fuel Delivery

On 97 and older engines: Fuel pressure is tested at the Schrader valve on the fuel pressure regulator block attached to the LH side of the fuel filter housing. Cranking pressure should be more than 20 PSI and 30-90 PSI at WOT under load, although an idle pressure reading of less than 50 will result in lack of power or hesitation complaints. Note that California vehicles (95 and later) will have a slightly higher and fluctuating pressure readings. If the readings are low, replace the filter and check the pressure regulator for debris. If the pressure is still low, install a vacuum gauge "teed" into the fuel supply line. Run the engine at WOT to check for a restriction. If the reading is above 6 inches of vacuum, the supply line is blocked. If below, replace the lift pump. The last fuel system check on the 97 and older engines is a fuel-aeration check. Install a clear hose on the regulator block outlet, looping it higher than the filter housing. Start and idle the engine and check for air bubbles after the fuel system has stabilized (approximately three minutes). Fuel should be flowing towards the fuel tank--if not, check for a restriction in the regulator block or return line--and have few bubbles. If bubbles are present, check the fuel supply system and filter housing for air leaks.

On 98.5 and newer engines: The newest version of the Powerstroke has an electric fuel supply pump. Pressure readings are taken at the fuel rail plugs at the front of the RH head, the rear of the LH head, and at the fuel pump outlet. The fuel pressure should be over 30 PSI, but anything below 50 PSI will cause an injector knock. If the pressure is low at either head, replace the check valve at that head's fuel rail inlet. If it is low at both heads and the pump outlet, check the pressure regulator at the fuel filter return line for debris or a split O-ring. If the regulator is OK, check for a fuel pump inlet restriction as described above.

Computer Tests

Next the KOER codes are retrieved and then the Cylinder Contribution test is run. On the EEC IV (94) engine the Cylinder Contribution test is run automatically after the KOER trouble codes are displayed. **Note:** *Cylinder Contribution will only run if the EOT is above 170 degrees.*

The PCM will shut off each injector in order and adjusts fuel delivery from the remaining injectors as it attempts to maintain engine RPM. 97 and older engines miss during this test, 98.5 and newer do not. I usually run this test twice to verify which cylinder is missing. If the same cylinder(s) do not appear twice, there may be an oil or fuel aeration problem. If you are unable to run a cylinder contribution test, you can either use an infrared thermometer to check exhaust port temperature or inspect injector performance by removing the valve cover on the suspect injector's bank and comparing the amount of oil being exhausted by one injector to that of the others, or use the tool offered by **InterMotive INC**. An injector problem can be differentiated from a base engine problem by performing a compression test. Compression on the Powerstroke should be more than 400 PSI.

The remaining tests require either an OBD II scan tool or a break-out box and a DVOM. First check Injection Control Pressure stability at idle. The ICP PID reading should be 550-700 on non-California F-series, 97 and older, and 400-600 on all others--or .25 volts KOEO, .75-1 volts at idle, .83 volts require to start at pins 87(ICP sig) to 91(sig ground). Low readings could be caused by poor oil, internal oil leaks, or a high pressure oil pump, ICP or Injection Pressure Regulator malfunction. Isolating the cause can be done by disconnecting the ICP (the PCM will default to an ICP reading of 700 PSI and use other inputs for IPR control) and/or installing a high pressure oil gauge to monitor ICP pressure directly. If the concern is a rough, uneven idle that smooth's out after disconnecting the ICP, The problem is most likely either the ICP malfunctioning or the IPR sticking. The manual says to replace the ICP first, but I have found that it is usually IPR. If you ever encounter an engine that runs with the IPR valve disconnected, the IPR is definitely sticking.

Next, run the engine to 3300 RPM and hold it there for three minutes. ICP pressure should be less than 1400 PSI on 97 and older Federal F-series, 1250 on Econolines and California, and 1800 on built after serial number 896812. On the DVOM at pins 87 to 91 the reading should not exceed 2 volts. And, finally, test drive the vehicle and monitor Exhaust Back Pressure and Manifold Gauge Pressure (turbo boost). On the scan tool select the EBP and MGP PID's, without a scan tool measure voltage at pins 30(EBP sig) to 91(sig ground) and install a vacuum/pressure gauge "teed" into the MAP sensor hose. During the test drive accelerate from 2000-3000 RPM selecting gears to provide the most load on the engine. EBP should be less than 28 PSI (2 volts) on 97 and older, 34 PSI on 98.5 and newer. High reading could be caused by restricted catalytic converter or exhaust. MGP should be at least 13 PSI within 15 seconds. Low readings can be caused by engine condition, intake leaks, inlet restrictions, fuel delivery or a worn turbocharger. One other test that Ford recommends performing is a crankcase pressure or blow-by test. To do this you need a magnetic pressure gauge--reads in inches of water for vacuum or pressure--and a special filler cap adapter with an orifice. If you have access to this equipment, block off the Crankcase Depression Regulator valve, install the adapter in place of the oil filler cap. Attach the adapter to the gauge and run the engine at WOT. The crankcase pressure should be less than two inches of water.

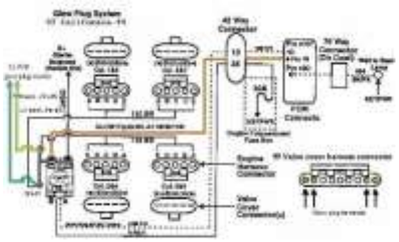
No/Hard Start Diagnosis

As with performance problems, you first have to start with the Preliminary Checks and Code Retrieval. After checking the preliminaries, KOEO and Continuous codes, and the concern happens cold only, check the glow plug system function. Unplug the Engine Oil Temperature sensor and turn the key to the run position. This will cause the PCM to close the glow plug relay for the maximum of two minutes. Check for voltage to and from the glow plug relay. The control voltage is supplied by the ignition switch and the PCM controls the ground based on EOT.

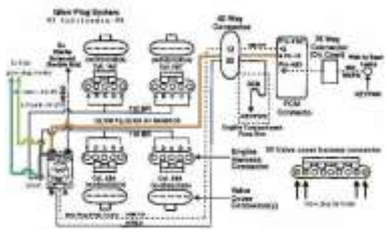
Turn the key off and disconnect each valve cover harness. The two outer-most terminals of each connector are for the glow plugs. Resistance from the glow plug terminal to ground is 1-2 ohms depending on engine temperature, and from the glow plug relay output terminal to the harness connectors 0-1 ohms.

GLOW PLUG CIRCUIT

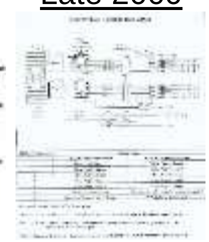
94-97 Fed.



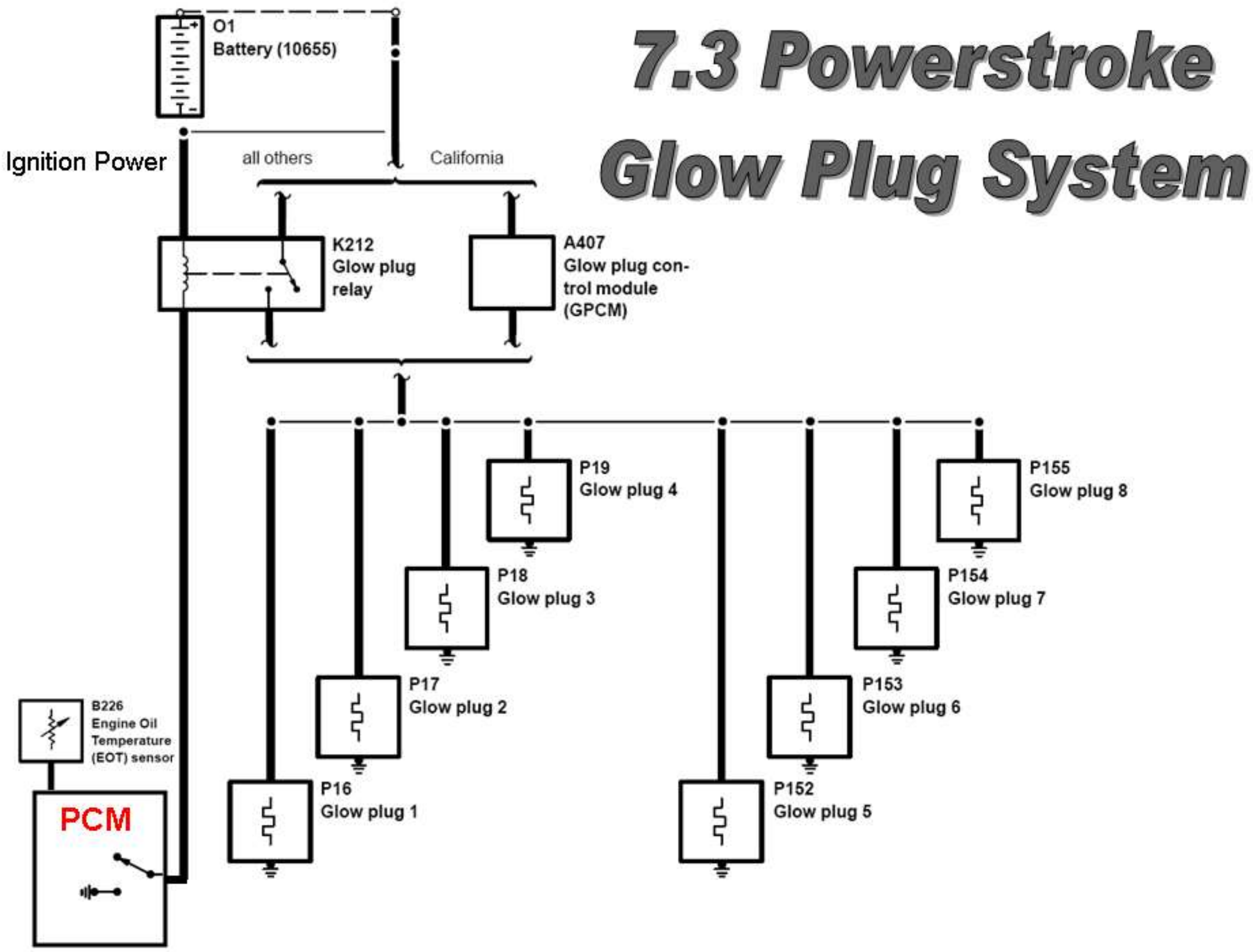
97 Cal-99



Late 2000



If the no/hard start concern happens hot or cold, you need to monitor the computer control inputs/outputs that are associated with starting. On the scan tool select VPWR, RPM, ICP, and FUEL PW PID's. If you have no scan tool you'll have to make do with monitoring VPWR and ICP with DVOM's and a break-out box, ICP with high pressure oil gauge, and CMP with a lab scope, if possible. While cranking the PID's should read 7 or more volts VPWR or VBAT (10 or more on 99 and up), 100 RPM, 500 PSI ICP, and 1-6mS FUEL PW. With the DVOM's measuring pins 97(VPWR) to 51(PWR ground) and 87(ICP sig) to 91(sig ground) the readings should be 7 and .83 volts, respectively. Low VPWR and RPM could be an indication of a starter or battery problem. The IDM will not activate the injectors until a clear RPM signal is received, which would indicate a bad Camshaft Position Sensor or wiring. A low ICP signal indicates a high pressure oil system problem: stuck or leaking IPR, leaking injector O-rings, no oil delivery (engine oil pump), high pressure oil pump or PCM malfunction. All readings normal except FUEL PW indicates a CMP signal sync or count problem, either the gap between the CMP and the sensor ring, a warped ring, or the CMP itself. If the glow plug system and inputs/outputs are within specifications, check fuel delivery. At the fuel pressure regulator block Schrader valve, minimum pressure should be 20 PSI. If it is low, replace the filter and recheck. If it is still low check for a restriction between the fuel tank and pump by installing a vacuum gauge on the fuel supply side of the pump. If the reading is above 6 inches there is a restriction, below replace the fuel pump.


7.3 Powerstroke
Glow Plug System
O1
Battery (10655)
Ignition Power
all others
California
K212
Glow plug relay
A407
Glow plug control module (GPCM)
P19
Glow plug 4
P155
Glow plug 8
P18
Glow plug 3
P154
Glow plug 7
P17
Glow plug 2
P153
Glow plug 6
B226
Engine Oil Temperature (EOT) sensor
PCM
P16
Glow plug 1
P152
Glow plug 5

SMOKE ANALYSIS

White smoke:

Caused by unburned fuel passing through the engine. Some white smoke is normal on cold start-ups.
Excessive white smoke could be an indication of inoperative glow plugs, loose injectors, low compression from worn rings or bent connecting rods, or coolant leak into the cylinders--head gasket or injector well sleeves.

Black smoke:

Caused by excessive fuel for the amount of air drawn into the cylinders. Some black smoke on hard acceleration or at higher altitudes is normal.
Excessive black smoke could result from restricted intake or exhaust, inoperative leaking or weak turbo, intake hose(s) leaks, leaking or worn injectors, fuel return or supply restriction, stuck Exhaust backpressure Regulator valve or solenoid. Also PCM inputs such as BARO MAP ICP or EBP sensors.

Blue or blue/white smoke:

Caused by insufficient fuel or oil consumption. Normal when engine is cold or idling for extended periods.
Excessive smoke could be caused by air in the fuel, contaminated fuel, loose or plugged injectors, worn or leaking injector O-rings, thermostat stuck open, oil consumption, or plugged crankcase depression regulator valve. Also PCM inputs such as MAP or ICP sensors.

REPAIR TIPS:

Most repair procedures on the Powerstroke are pretty straight-forward. However, sometimes after doing certain repairs, everyone comes up with their own way of doing things either to make the job faster or easier. Here are some methods I've developed to perform the most common repairs.

Note: Fuel injectors / Turbocharger / Fuel filter housing (94-97) / Fuel lift pump / Injection Pressure Regulator (IPR) / High pressure oil pump / Glow plugs

INJECTOR REMOVAL/REPLACEMENT:

With re-development of the injector O-rings, early assembly mistakes, as well as problems with fuel contamination, this job is probably one of the most common repairs.

When replacing injector O-rings, it's recommended that all the injectors be resealed using the most recent kits--F8TZ-9229-AA. When replacing injectors, use the correct parts for the given emissions--Federal F7TZ-9E527-ARM; California F8TZ-9E527-ARM.

Any time a valve cover is removed, the injectors hold-down bolts on that bank should checked for torque. Early engines from 94-95 where assembled with the injectors torqued to 106 in/lbs. This caused the potential for the injectors to work loose damaging the O-rings. If any injector hold-down torque is found to be less than 100 in/lbs., then all the injectors should be resealed. The correct torque on the hold-down bolts is 120 in/lbs.

On 94 and early 95 F-series with air conditioning, half the evaporator plenum must be removed to access the #7 injector and to make removing and installing the RH valve cover easier. On 95-97, the A/C vacuum reservoir can be removed instead. 99's only need the intercooler piping removed. To remove the valve covers on the Econoline, the A/C compressor and alternator have to be removed.

The biggest concern on this job is the prevention of internal engine damage caused by oil or fuel entering the cylinders and resulting in a hydraulic lock of the engine. I purge the oil from the rails in the head by removing the oil supply hoses and the two rear 5/8" hex plugs from the tops of the heads (the 99 engine requires a special tool), and gently blowing the rails out with compressed air. There are actually two aluminum plugs inside the valve covers for this purpose, but they are usually frozen and "round off". On the back of each head there is a fuel rail drain that has a 1/4" square drive for a ratchet. If you can access them, unscrew each one full turn. If you can't, don't worry, you can deal with fuel in the cylinder(s) easy enough later.

If you haven't removed the valve covers already, do it; also remove the gaskets and Under Valve Cover harnesses, taking care not to drop the injector connector seals on harnesses with plastic locks (the harnesses with wire flip-locks don't use seals). Remove the spill-spouts from all the injectors you are replacing/servicing. If you don't they will get damaged.

If you are removing more than one injector on either bank, always remove the rear-most injector that is being replaced/serviced first. This will ensure that any oil or fuel in that head is isolated in one cylinder. Example: if you are replacing injectors 1 and 5, remove #5 first.

Remove the first injector by removing its lower/outer hold-down bolt, then sliding the hold-down up towards the center of the engine. Carefully pry under the hold-down with a bar to lift the injector from its well and remove it from the engine. If you are servicing any injectors on the opposite bank, remove the rear most one to be serviced/replaced in the same way.

Remove any fuel or oil that may have entered the cylinders by bumping the engine over by hand or with a remote starter. Use cardboard over the valve train to minimize the amount of spray from the cylinders. Opening the fuel filter drain will prevent any more fuel from entering the heads, and having the supply hoses removed will do the same for the oil.

With the rear most cylinders purged, all the reaming injectors can be removed as required, keeping them in order for installation in the same cylinder.

Inspect each injector well for foreign debris, and clean as required. If any injectors are missing the copper compression ring, retrieve it from the well. Inspect each well for debris and clean as necessary.

When replacing the O-rings, use the latest-level kits--F8TZ-9229-AA --and when installing the blue/black lower oil seal, lube it with clean oil and push it directly onto the injector--don't work it on like a bicycle tire, this will cause it to stretch too much.

Dip each injector into clean oil before installing. Push down on the injector until it seats while holding the hold-down up to clear the upper bolt--do not hammer on the solenoid body. If necessary use a drift and tap on the hold-down to seat the injector. Install the hold-down screws and spill-spouts, torqueing to 120 in/lbs. Install the valve cover gaskets and UVC harnesses, ensure that each glow plug is connected, and connect the engine harness to the gasket. Before installing the valve covers, check the connections by running the Injector Buzz test.

Connect the oil supply hoses, close the fuel filter and rail drains. Add a pint of fuel lubricity conditioner--F8AZ-9C077-AA to whichever tank you will be test driving on. With the rear oil rail plugs still removed, crank the engine over until oil runs from either rail, install that plug and continue to crank until oil runs from the other, then install that plug. Take care not to damage the O-rings (P/N F4TZ-9N693-A) on the rail plugs and torque the plugs to 21 ft. /lbs.

When installing the intercooler piping on the 99 engines, ensure the hoses are positioned correctly and the clamps are tight. Restore the remaining items (A/C plenum, vacuum reservoir, etc.) leaving the engine show cover off, and crank the engine until it starts.

Test drive the vehicle for 20 minutes in fourth gear or with the overdrive cancelled to purge the remaining air from the oil and fuel rails. After the test drive, flush whatever oil is standing in the engine valley with a solvent while the engine is warm (to allow the residue to evaporate) in a well-ventilated area, catching the run-off in a drain pan at the rear of the engine. Reinstall the engine show cover.

TURBOCHARGER REMOVAL:

Most of this procedure was developed for 97 and older F-series trucks. Click here for the procedure on 99 and newer engines. On E-vans the turbo is accessible from the rear. The basic sequence can still be used as an outline.

Start by removing the nuts on the turbo outlet pipe where it connects to the catalytic converter. Remove the Marmon clamp holding the outlet pipe to the turbo--you may have to remove the clamp's nut and bolt, then break the pipe loose by pushing and pulling on it from under the truck. Once the outlet pipe is loose from the turbo, reconnect the cat converter flange with the nuts loose to hold the pipe out of the way. Loosen the bolts and nuts retaining the turbo inlet pipes to the exhaust manifolds. Remove the turbo outlet pipe from the turbine housing and the intake "Y" pipe from the compressor housing. Plug the intake ports to prevent foreign material from entering the engine.

On the left side of the turbo, behind the compressor housing, there is a clamp that holds the EPR solenoid to the turbo pedestal. Remove the bolt and clamp leaving the EPR solenoid in place. Using a stubby 15mm wrench or box-end crow's-foot, loosen the two lower inlet nuts--if using a stubby wrench, you'll have to pry against the wrench with a bar to break the nuts loose. Use a 1/4" 15mm universal socket to remove the nuts. Remove the two upper inlet bolts.

Remove the two front mounting bolts from the pedestal. Remove the two rear mounting bolts, starting with the left one, using a 1/4" drive 10mm universal socket and 6" extension. If the rear bolts are frozen, the LH one may be accessible with a short 3/8" drive 10mm universal socket, but you'll have to remove the EPR valve housing from the turbine to reach the RH one. The collar on the link slides towards the turbo and then the link can be pushed down off the bell crank. The turbo will raise slightly when removing the right rear mounting bolt as the socket contacts the turbocharger housing.

Unplug the EPR harness and roll the turbo forward off the inlet collector and lift it from the engine. The pedestal can be replaced separately from the turbocharger. The new pedestal comes with an adjustable EPR valve link which is shipped clamped in the extended position. Hold the valve closed and screw the link socket in or out until it slips over the bell crank. Tighten the lock nut and remove the clamp holding the EPR linkage. When reassembling/installing use new yellow sealing O-rings (P/N F4TZ-6N653-A and -B) held in place with silicone dielectric grease.

Some replacement turbo chargers are supplied with 13mm-head mounting bolts, and are not accessible in the two rear pedestal holes--use the originals. Insert the two rear pedestal bolts in their holes and wrap a rubber band around the heads to hold them in place while you reposition the turbo. Install in the reverse order of removal, but only start the pedestal bolts until all pedestal and inlet bolts are threaded into their holes before torqueing beginning with the RH rear pedestal bolt--pedestal bolts 18 ft. /lbs.; exhaust flanges and inlet 36 ft. /lbs.

Remember to reinstall the EPR solenoid hold-down clamp. Line up the turbo outlet pipe with the turbo and install/snug the Marmon clamp keeping the flanges aligned, tighten the cat-converter flange, then torque the Marmon clamp to 100 in/lbs. Start the engine and look for oil or exhaust leaks.

The 99 and up turbo should be faster, but it's not. You need to disconnect the two intercooler pipes, disconnect the Y-pipe from the intake and turbo and unplug the Wastagate solenoid, MAT sensor and Manifold air heater (if equipped). Disconnect the waste gate hoses from the Wastagate and air supply duct and move the Y-pipe out of the way. Plug the intake ports to prevent anything from falling into the engine. Disconnect the air supply duct from the turbo and loosen the Marmon clamps from the turbine inlet and outlet. From under the truck, disconnect the exhaust down pipe from the cat or cat delete pipe and push and pull it to break it loose from the turbo, then loosely install the flange nuts at the cat/cat delete pipe. Loosen the bolts retaining the turbo inlet pipes to the exhaust manifolds. Remove the turbo down pipe from the turbine housing. Remove the two bolts which attach the turbo to the pedestal and pivot the turbo up. If equipped with an EPR valve, reach underneath and unhook the rod from the valve by releasing the clip. Wiggle the turbo around to break the inlet flange loose on the turbine; you may have to pry the Marmon clamp off of the flange to separate the turbo from the inlet flange. Slide the turbo forward and remove it from the truck. The pedestal can be removed if necessary. When reinstalling, use silicone dielectric grease to hold the pedestal O-rings in place. Position the turbo onto the inlet flange, aligning the dowel pin and install the Marmon clamp loosely. Keeping the turbo and inlet flange aligned, reconnect the EPR valve and rod and lower the turbo onto the pedestal and torque the bolts to 30 ft. /lbs. Install the exhaust down pipe onto the turbine housing and snug down the Marmon clamp. Under the truck tighten the down pipe and inlet pipes, then torque the two Marmon clamps at the turbine housing to 100 in/lbs. Reinstall the remaining parts ensuring to align the intercooler hoses properly, start the engine and check for exhaust and oil leaks.

FUEL FILTER HOUSING REMOVAL, 97 AND OLDER:

To gain access to the HP oil pump, replace Injection Pressure Regulator valve or lift pump, or to service the filter housing, sometimes it's easiest to get the housing off of the engine. Removal is not that difficult except for the hoses.

Remove the intake Y-pipe and plug the openings into the heads. Open the water separator drain to minimize the amount of fuel dumping into the engine valley. Loosen the hose clamps on the return line at the pressure regulator block, the primary (upper) lift pump hose at the filter housing, and the secondary (lower) lift pump hose at the lift pump. Remove the two head return lines at the pressure regulator block. Disconnect the harness connector at the RH side of the filter housing. Remove the two mounting bolts at the rear of the housing base. Lift up on the LH side of the housing to disengage the return line; pivot the housing forward to disengage the primary pump hose; pivot the housing back to disengage the secondary hose; and turn the housing clockwise to disengage the drain hose. Disconnect the IPR valve wire and remove the housing from the vehicle. Any O-rings or sensors on the housing can be serviced, and removal of the pressure regulator block for service/cleaning can now be done (the regulator can be removed with the housing installed on the vehicle, but with risk of O-ring damage on reassembly). Reverse the procedure for installation, taking care not to damage the hoses when their nipples are inserted in each. Do not over tighten the hose clamps or they will strip.

LIFT PUMP REMOVAL:

This service is not difficult when working on a Federal-emissions F-series. The intake Y-pipe and fuel filter housing need to be removed first. Then, using a 1 1/4" box wrench (having two different wrenches works best because of differing angles on the box ends give you a wider working range) or socket on a flex-head ratchet, loosen the banjo bolt fitting at the rear of the pump. Take care not to drop or damage the steel sealing washers. After removing the banjo bolt, remove the pump mounting bolts and lift the pump straight out of its hole. If the pump seems stuck, use a rolling-head type pry bar (lady-slipper, duck bill, crow's-foot) to pry it up straight. Pulling straight up will prevent the pump push rod from catching and falling back down into the engine requiring engine removal to retrieve the rod. On California-emission vehicles the banjo fitting is too far under the turbo and fuel line damper to reach with a wrench and, access is restricted for using a socket (you may get the bolt out, but good luck getting the back in). In this case and with the Econoline due to its body design, it is necessary to remove the turbocharger to remove the lift pump instead of the fuel filter housing. In all cases, when installing the new lift pump, lube the O-ring on the pump shank with dielectric grease and start the banjo bolt a couple of threads before installing a tightening the mounting bolts. Again, take care not to damage the sealing washers. Once the pump is secured to the block, tighten the banjo bolt to 40 ft. /lbs.

INJECTION PRESSURE REGULATOR VALVE REMOVAL:

To remove the IPR you can remove the fuel filter housing or at least loosen it to allow room for the wrench and to maneuver the valve in and out. The 98.5/99 IPR is accessed easily from behind the fuel filter. Remove the air intake Y pipe and plug openings. Remove the fuel return hoses from the pressure regulator block, remove the filter housing bolts and lean the housing back. Unplug the EOT sensor and IPR valve. Use a 3/4" wrench to remove the solenoid nut, spacer and solenoid coil. Using a 1 1/8" wrench (or a very deep socket--the filter housing will have to be removed for this) remove the IPR valve. Make sure that the replacement IPR is the same level part as the old one. Engines built up to serial number 187099 in early 95 use P/N F4TZ-9C968-C; engine number 187100 and up use F5TZ-9C968-A. Do not use sealer on the IPR threads, it could plug the orifice in the threaded area. Torque the IPR to 35 ft. /lbs. and the solenoid retaining nut to 53 in/lbs. You'll have to drive the truck to purge any air from the HP oil system and clear any codes set during the replacement.

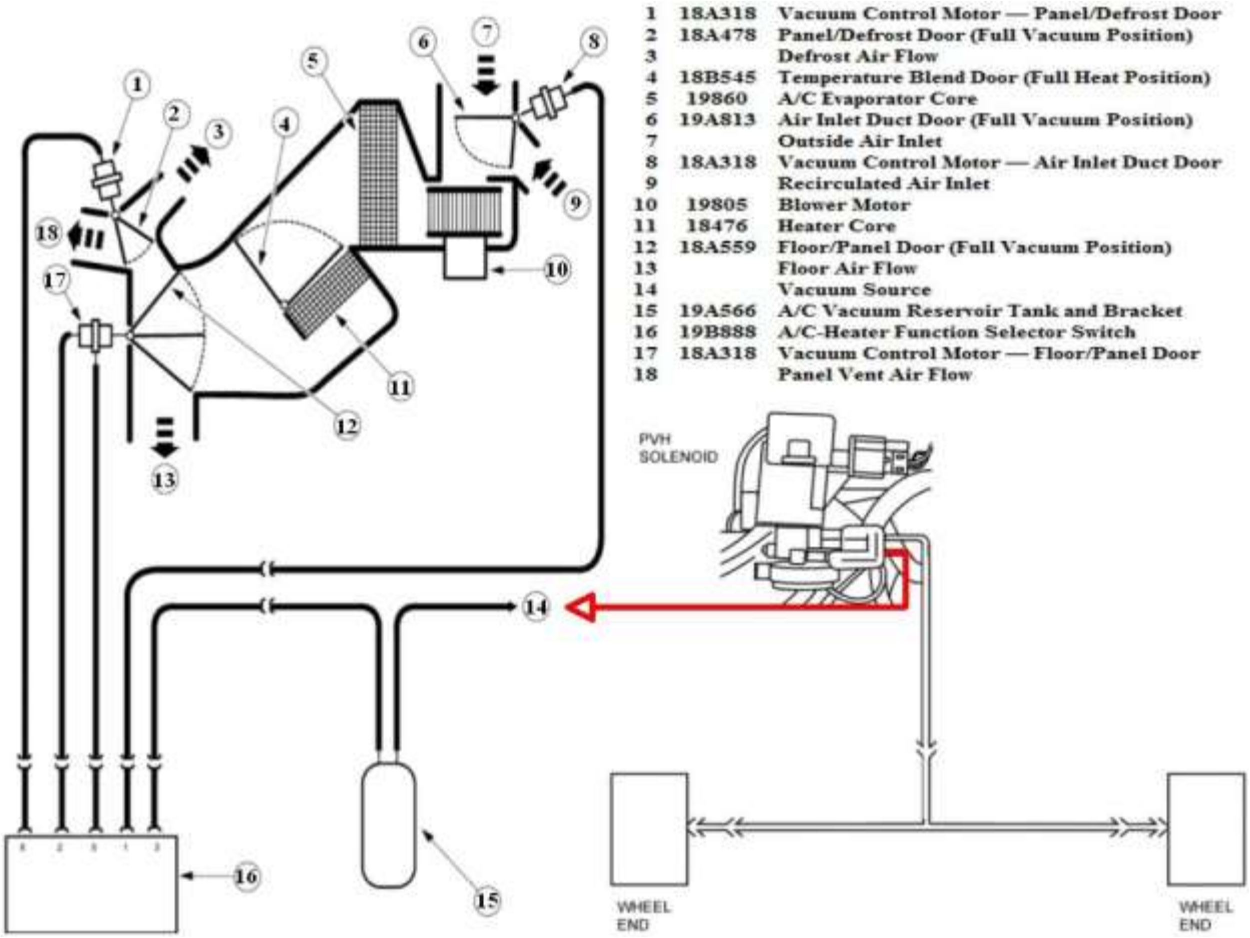
HIGH PRESSURE OIL PUMP REMOVAL:

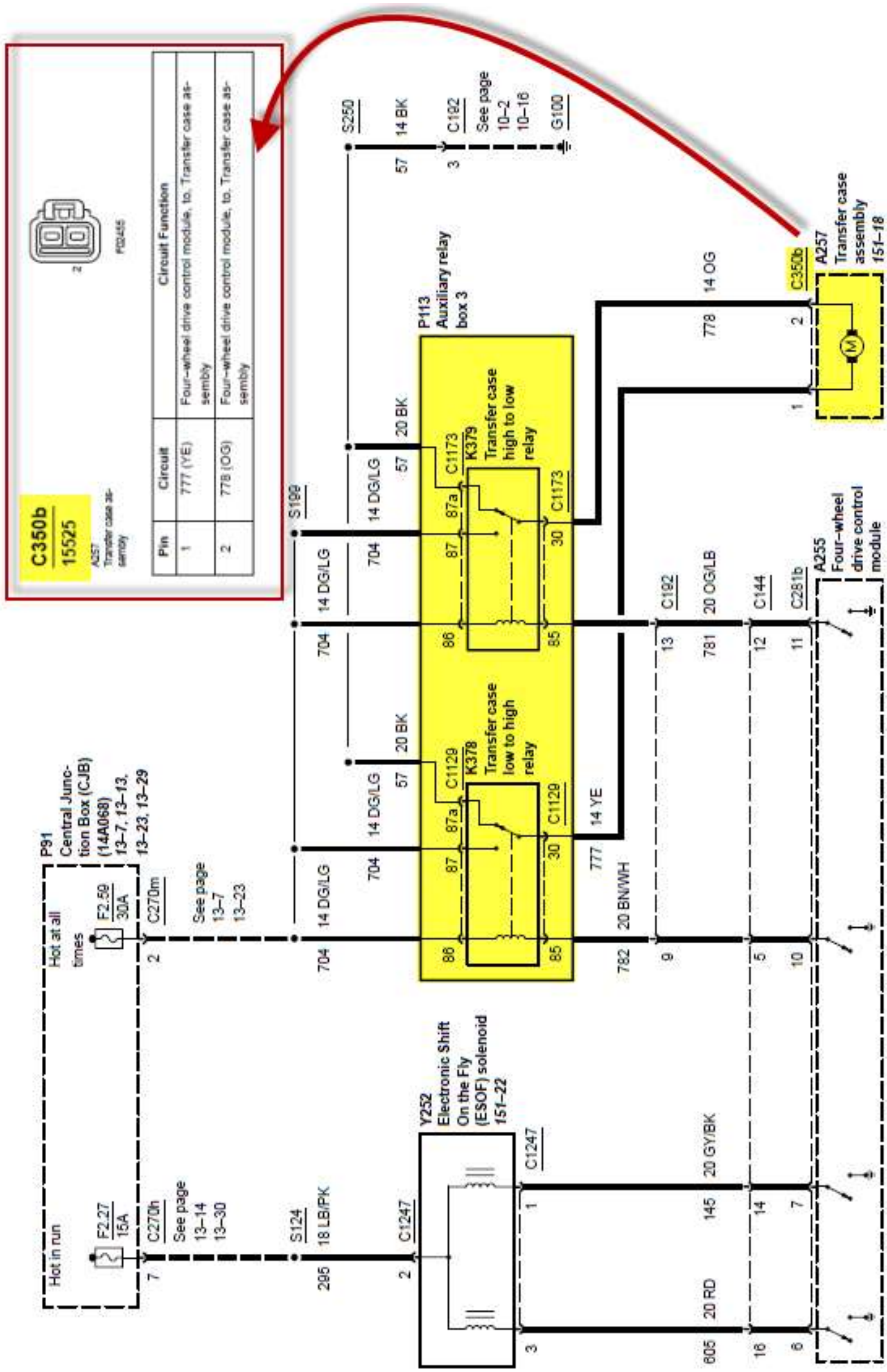
When removing the HP oil pump, remove the fuel filter housing to allow more room to maneuver the pump in and out. Remove the EOT sensor from the reservoir to allow oil to drain, remove the HP oil pump gear access plate from the front of the timing cover. If necessary, remove the heater hose and nipple from the water pump and remove the gear retaining nut. Carefully remove the oil reservoir--it has a partial RTV gasket, so it may adhere to the timing cover. Remove the two oil supply hoses for the HP oil pump and the two retaining bolts and remove the pump from the engine. Inspect the HP oil pump gasket for damage, and both the pump and timing cover surfaces. Clean the timing cover and reservoir mating surfaces. Carefully install the new pump, taking care not to damage the gasket. Seal the top shoulder of the pump bolts with Loctite 515 Gasket Eliminator and torque the pump bolts to 24 ft. /lbs. install the gear retaining bolt and torque to 95 ft. /lbs. Check the pump gear for excessive back-lash. Check the outlet fittings on the pump to make sure they are tight and install the oil lines. Install a new gasket on the oil reservoir and run a bead of Whacker T-95 or Ford F5TZ-19G204-AB gray RTV silicone along the timing cover where the gasket does not seal, install the reservoir and torque the bolts to 24 ft./lbs. Use the same silicone sealer on the gear bolt access plate and install. Finish installing the remaining components. Flush the engine valley with a suitable solvent to remove the oil spilled. The engine will have to crank awhile to resupply the reservoir in order to start. Drive to purge any air from the system and clear any codes.

GLOW PLUG REMOVAL:

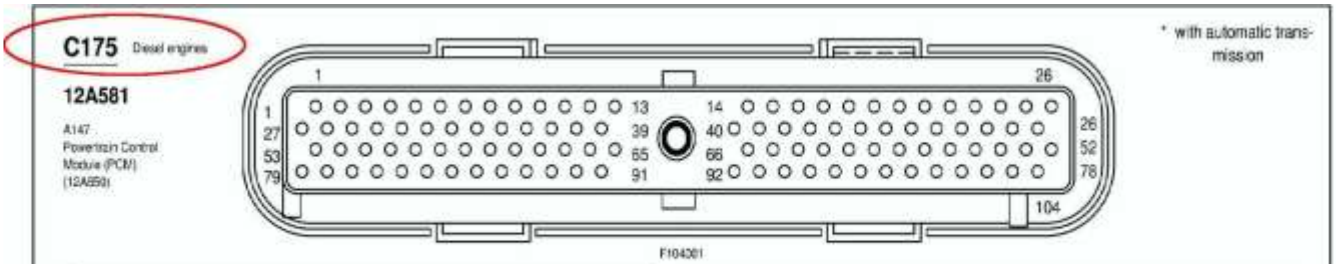
This is a straight-forward service. After removing the valve covers and unplugging the glow plug(s), loosen the glow plug a couple of turns (10mm deep socket, 1/4" drive). Then push a 4-6" piece of vacuum line over the end of the glow plug and use the hose to unscrew and remove it. Use the hose to install and screw in the glow plug, then tighten with the socket. The socket will contact the rocker arms if used to remove the glow plug. If the glow plug is difficult to turn you may be able to loosen it by working it back and forth--turn counter clockwise one turn then clockwise half a turn--until it turns freely enough that it can be loosened with the hose. If the glow plug probe is severely carbon'd up or swollen, the barrel may screw out of the head leaving the probe stuck in the hole. In this instance you may be able to remove the probe by removing the adjacent rocker arm and push rod to gain enough room to get ahold of the probe with a pair of needle-nose pliers. Have someone hold the pliers to prevent the probe from falling into the cylinder and use a long punch to loosen the probe by tapping it down. Once the probe is broken loose, work it up and down in the hole until it can be pulled out--some WD 40 or other solvent may help to loosen any carbon on the probe once it can moved, just remember not to use too much and to remove any residual by cranking over the engine with the glow plug out. You may be able to dislodge the seize probe by cranking over the engine, just remember to reinstall the rocker and pushrod if removed, and place a blanket or fender cover over the glow plug to keep it from shooting out. If the probe falls into the cylinder or cannot be loosened, the head will have to be removed to extract the probe. To prevent damage, remove all the glow plugs on the head to be removed and install them after the head has been reinstalled.

ELECTRONIC SHIFT ON THE FLY (ESOF) VACCUM / ELECTRICAL DIAGRAM:




C350b
15525
A257 Transfer case assembly
Pin | Circuit | Circuit Function
1 | 777 (YE) | Four-wheel drive control module, to, Transfer case assembly
2 | 778 (OG) | Four-wheel drive control module, to, Transfer case assembly
P91 Central Junction Box (CJB) (14A068) 13–7, 13–13, 13–23, 13–29
Hot in run
F2.27 15A
C270h
See page 13–14 13–30
Hot at all times
F2.59 30A
C270m
See page 13–7 13–23
S124
18 LB/PK
295
C1247
Y252 Electronic Shift On the Fly (ESOF) solenoid 151–22
S199
14 DG/LG
704
P113 Auxiliary relay box 3
K378 Transfer case low to high relay
C1129
K379 Transfer case high to low relay
C1173
20 BK
57
S250
14 BK
C192
See page 10–2 10–16
G100
782
20 BN/WH
777
14 YE
781
20 OG/LB
778
14 OG
C144
C281b
145
20 GY/BK
605
20 RD
C350b
A257 Transfer case assembly 151–18
A255 Four-wheel drive control module 151–4

7.3 DIT PCM PIN OUT DIAGRAM:



Pin	Circuit	Circuit function
1	–	not used
2	–	not used
3	3996 (RD/YE)	Manifold intake air heater relay, monitor
4	–	not used
5	162 (LG/RD)	Parking brake switch (15A851)
6	237 (OG/YE)*	Shift solenoid A
7	–	not used
8	1277 (WH/LG)	Glow plug relay, monitor
9	–	not used
10	1285 (RD/LG)	Idle validation switch
11	315 (VT/OG)*	Shift solenoid B
12	911 (WH/LG)*	Transmission Control Indicator Lamp (TCIL)
13	107 (VT)	Module programming signal
14	–	not used
15	915 (PK/LB)	SCP Bus –
16	914 (TN/OG)	SCP Bus +
17	1144 (YE/BK)	Digital Transmission Range (DTR) sensor, TR1
18	331 (PK/YE)	A/C clutch relay, control
19	76 (LG/WH)	Tachometer output
20	924 (BN/OG)*	Powertrain Control Module (PCM) (12A650), to transmission coast clutch solenoid
21	795 (DG)	Camshaft position sensor (6B288)
22	–	not used
23	–	not used

Pin	Circuit	Circuit function
24	357 (YE/WH)	Accelerator pedal position sensor, Ground
25	567 (LB/YE)	Ground
26	–	not used
27	–	not used
28	–	not used
29	224 (TN/WH)	Powertrain Control Module (PCM) (12A650), to transmission overdrive cancel switch – Automatic
	306 (TN/LB)	Clutch switch – Manual
30	553 (VT/LB)	Exhaust Back Pressure (EBP) sensor, monitor
31	307 (BK/YE)	Brake pressure switch (2B264), input
32	–	not used
33	–	not used
34	–	not used
35	1183 (WH/YE)	Generator
36	1280 (GY/RD)	Water–in–fuel sensor
37	923 (OG/BK)	Transmission Fluid Temperature (TFT) sensor, input – Automatic
	923 (OG/BK)	Engine Oil Temperature (EOT) sensor, signal – Manual
38	354 (LG/RD)	Engine Oil Temperature (EOT) sensor, signal
39	743 (GY)	Intake Air Temperature (IAT) sensor (12A697), input
40	787 (PK/BK)	Fuel pump, monitor
41	439 (TN/LG)	A/C high pressure switch (19D594)
42	318 (GY/RD)	Exhaust Pressure Regulator (EPR), control

Pin	Circuit	Circuit function
43	71 (OG/LG)	Powertrain Control Module (PCM) (12A650) – Data cut-put link
44	–	not used
45	203 (OG/LB)	Cruise set, indicator, control
46	–	not used
47	1275 (WH/RD)	Waste gate solenoid, control
48	818 (GY/WH)	Injector Driver Module (IDM)
49	1145 (LB/BK)	Digital Transmission Range (DTR) sensor TR2
50	*1143 (WH/BK)	Digital Transmission Range (DTR) sensor TR4
51	570 (BK/WH)	Ground
52	–	not used
53	–	not used
54	*480 (VT/YE)	Torque Converter Clutch (TCC) solenoid
55	729 (RD/WH)	Voltage supplied at all times (overload protected), keep alive memory
56	–	not used
57	–	not used
58	679 (GY/BK)	Vehicle Speed Sensor (VSS) +
59	136 (DB/YE)*	Powertrain Control Module (PCM) (12A650), – Output Shaft Speed (OSS) sensor (7M101)
60	1165 (YE)	Generator and Regulator
61	151 (LB/BK)	Speed control switch, input
62	1291 (RD/YE)	Air Charge Temperature (ACT) sensor
63	–	not used
64	199 (LB/YE)	TR3A – Automatic Clutch pedal position switch – Manual
65	796 (LB)	Camshaft position sensor (6B288), Signal return
66	322 (LB/YE)	PTO control
67	904 (LG/RD)	Generator/Battery indicator, control
68	–	not used
69	–	not used
70	–	not used
71	361 (RD)	Voltage supplied in Start and Run (overload protected)

Pin	Circuit	Circuit function
72–76	–	not used
77	570 (BK/WH)	Ground
78	–	not used
79	358 (LG/BK)	Manifold Absolute Pressure (MAP) sensor, to, Powertrain Control Module (PCM) (12A650)
80	814 (WH/BK)	Injector Driver Module (IDM) power relay, control
81	*925 (WH/YE)	Electronic Pressure Control (EPC) solenoid
82	–	not used
83	552 (YE/RD)	Injection Pressure Regulator (IPR), control
84	970 (DG/WH)	Turbine Shaft Speed (TSS) sensor
85	–	not used
86	–	not used
87	812 (DB/LG)	Injection pressure sensor, monitor
88	–	not used
89	355 (GY/WH)	Accelerator pedal position sensor, input
90	351 (BN/WH)	Reference voltage
91	359 (GY/RD)	Signal return
92	810 (RD/LG)	Brake pedal position switch (13480), input
93	–	not used
94	926 (LB/OG)	Fuel pump relay, control
95	821 (BN/OG)	fuel delivery command signal output
96	817 (YE/LB)	Injector Driver Module (IDM), cylinder identification
97	361 (RD)	Voltage supplied in Start and Run (overload protected)
98	462 (VT)	Manifold intake air heater relay, control
99	–	not used
100	–	not used
101	1086 (VT/OG)	Glow plugs, control
102	–	not used
103	570 (BK/WH)	Ground
104	–	not used

POWER CONTROL MODULE PIN OUT

Pin #	Name	Circuit #	Wire Color	Key Off	Key On	Low Idle	High Idle	Operating Range	Comments
2 f	Service Engine Soon	658	PK/LG	0v	0v/B+	0v/B+	0v/B+	0v/B+	0v = Light On, B+ = Light Off
3 a b	MIAHM	3996	RD/YE	0v	0v-B+	0v-B+	0v-B+	0v-B+	Manifold Intake Air Heater Monitor — B+ When Heater is Commanded On
5	PBA	162	LG/RD	7v	0v/B+	0v/B+	0v/B+	0v/B+	Parking Brake Applied Switch; B+ = Brake Off, 0v = Brake On
6 b c	SS1	237	OG/YE	0.9v	0v	0v	0v	0v/B+	Shift Solenoid #1 0v = "On," B+ = "Off"
8	GPCOMM	1277	WH/LG	0v	0v/B+	0v/B+	0v/B+	0v/B+	GPCM Communication Circuit, Digital 12V Frequency
10	IVS d , ETC	308, 1285	RD/OG, RD/LG	0v	0v	0v	B+	0v/B+	Idle Validation Signal Circuit; 0v = At Idle, B+ = Off Idle
11 b c	SS2	315	VT/OG	0.9v	B+	B+	B+	0v/B+	Shift Solenoid #2

									0v = "On," B+ = "Off"
12 b c	TCIL	911	WH/LG	0.9v	0v/B+	0v/B+	0v/B+	0v/B+	Trans Control Indicator Light; 0v = Light "On," B+ = Light "Off"
13	FEPS	107	VT	N/A	N/A	N/A	N/A	N/A	Flash EPROM Power Supply
15	BUS (-)	915	PK/LB	N/A	N/A	N/A	N/A	N/A	Data Link Connector
16	BUS (+)	914	TN/OG	N/A	N/A	N/A	N/A	N/A	Data Link Connector
17 b c	TR1	1012 d, 1144	OG/BK, YE/BK	0v	Varies with gear			0v/10.7v	P = 0v, R = 0v, N = 0v, D = 10.7v, MAN2 = 10.7v, MAN1 = 10.7v
18 j	ACCR	331	PK/YE	0v	0v/B+	0v/B+	0v/B+	0v/B+	B+ = A/C Relay Command "Off" 0v = A/C Relay Command "On"
19 f	TAC	648	WH/PK	0v	B+	11.5v / 130 Hz	9v/ 660 Hz	8-12v	Tachometer Signal Reflected CMP Signal
20 c	CCS	924	BN/OG	0.9v	0v	0v	0v	0v/B+	Coast Clutch Solenoid; 0v = "On," B+ = "Off"

21	CMP	795	DG	0.9v	0.8v	7v	7v	100-700 Hz	Camshaft Position Sensor; 650-3600 rpm
24	APGND, ETC GND	837 d , 357	YE/BK, YE/WH	0v	0v	0v	0v	0v	Accelerator Pedal Sensor Ground
25	CASE GND	875 d , 567, 570 j	BK/LB, LB/YE, BK/WH	0v	0v	0v	0v	0v	Case Ground
28 e f	WIFIL	643	RD	0v	B+	B+	B+	B+	Water In Fuel Indicator Lamp; 0v = Light "On", B+ = Light "Off"
29	CPP g (Allison Auto)	329	PK	0v	0v/B+	0v/B+	0v/B+	0v/B+	Allison AT545 B+ in Neutral, 0v Not in Neutral
	CPP (Manual)	306	TN/LB	0v	0v/B+	0v/B+	0v/B+	0v/B+	Clutch Pedal Position Switch (Manual)
	TCS (Auto)	224	TN/WH	0v	0v/B+	0v/B+	0v/B+	0v/B+	Transmission Control Switch (Automatic) B+ Switch Depressed
30 b	EBP	553	VT/LB	0v	1v	1v	2v	0v-4.5v	Exhaust Back Pressure Sensor
31 b	BPA	810 d , 307	RD/LG, BK/YE	0.9v	0v/B+	0v/B+	0v/B+	0v/B+	Brake Pedal Applied Switch; 0v = Brake "On",

									B+ = Brake "Off"
33 h	VSS (-)	676 d	PK/OG	9v	0v	0v	0v	0v	Vehicle Speed Sensor Ground
35 b	ALTI	1183	WH/YE	0.9v	0.5-2v	6-10v	6-10v	6-10v	Alternator #1 (Top) Monitor
36 e	WIF	1280	GY/RD	1v	B+	B+	B+	B+	Water In Fuel
37 b c	TFT, ECT (Manual)	923	OG/BK	0v	0.3v-4.5v	0.3v-4.5v	0.3v-4.5v	0.3v-4.5v	Transmission Fluid Temperature; 4.5v = -40°C, 0.3v = 130°C
38	EOT	354	LG/RD	0v	0.3v-4.7v	0.3v-4.7v	0.3v-4.7v	0.3v-4.7v	Engine Oil Temperature; 4.7v = -40°C, 0.3v = 150°C
39	IAT	743	GY	0v	0.2v-4.5v	0.2v-4.5v	0.2v-4.5v	0.2v-4.5v	Intake Air Temperature; 4.5v =.40°C, 0.2v = 130°C
40 b	FPM	787	PK/BK	0v	0v/B+	0v/B+	0v/B+	0v/B+	Fuel Pump Monitor
40 i	ASMM	175	BK/YE	0v	0v	B+	B+	0v/B+	Automatic Transmission Shift Modulator Monitor (Kickdown Relay)
41	ACC f j	347 d , 439	BK/YE, TN/LG	0v	0v/B+	0v/B+	0v/B+	0v/B+	Air Conditioning Clutch; 0v =

									A/C "Off", B+ = A/C "On"
42 b	EPR	318	GY/RD	0v	0v	0v/B+	0v/B+	0v/B+	Exhaust Back Pressure Regulator; Duty Cycled, 0v = "Off"
47 b	WGC	1275	WH/RD	0v	0v	0v	0v/B+	0v/B+	Waste Gate Control
48	EF	818	GY/WH	0v	3v	1v	0.9v-3v	0.9v-3v	Electronic Feedback line; Digital B+ Frequency
49 b c	TR2	146 d , 1145	WH/PK , LB/BK	0v	Varies with gear			0v/10.7v	P = 0v, R = 0v, N = 11v, D = 11v, MAN2 = 0v, MAN1 = 11v
50 b c	TR4	145 d , 1143	GY/BK, WH/BK	0v	Varies with gear			0v/10.7v	P = 0v, R = 11v, N = 0v, D = 11v, MAN2 = 11v, MAN1 = 0v
43 b	DOL	71	OG/LG	0v	0v	0.1v-0.2v	0.5v-2v	0v-3v	Tripminder Fuel Economy Input
51	PWR GND	570	BK/WH	0v	0v	0v	0v	0v	Power Ground
54 b c	TCC	480	VT/YE	0v	B+	B+	B+	0v/B+	Torque Converter Clutch Solenoid; 0v = "On," B+ = "Off"

55	KAPWR	37 d , 729	YE, RD/WH	B+	B+	B+	B+	B+	Keep Alive Power; B+ = Battery Voltage
58 b	VSS (+)	679	GY/BK	Frequency Signal — Varies with Vehicle Speed					Vehicle Speed Sensor
59 c	OSS k	136	DB/YE	Frequency Signal — Varies with Vehicle Speed					Output Shaft Speed Sensor
60 b	ALT2	1185	YE	0v	0.5-2v	6-10v	6-10v	6-10v	Alternator #2 (Bottom) Control
61	SCCS	151	LB/BK	0v	6.6v	6.6v	6.6v	0v/B+	Cruise Control Command Switch; On = B+, "Off" = 0v, Set = 2.8v, Resume = 4.7v, Coast = 0.8v, Hold = 6.6v
62 l m	MAT	1291	RD/YE	0v	0.3v-4.7v	0.3v-4.7v	0.3v-4.7v	0.3v-4.7v	Manifold Air Temperature
64 b c	TR3	199	LB/YE	0v	Varies with gear			0.7v-4.5v 0v/1.6v	F-Series: P = 4.5v, R = 3.7v, N = 2.9v, D = 2.2v, MAN2 = 1.4v, MAN1 = 0.7v, P=0v, R=1.67v, N=1.67v, D=1.67v, 2=0v, 1=0v

65	CMP GND	796	LB	0v	0v	0v	0v	0v	Camshaft Position Sensor Ground
66 n	PTO	322, 439 d	LB/YE, TN/LG	0v	0/B+	0/B+	0/B+	0/B+	Power Take Off Enable
67 b o	BATTL	904, 905 d	LG/RD, GY/LB	0v	B+	B+	B+	B+	Dual Alternator Battery Lamp Indicator 0v = Lamp "On"
70 f	GPL	464	BK/PK	0v	0v/B +	B+	B+	0v/B+	Glow Plug Lamp, 0v = Light "On", B+ = Light "Off"
71	VPWR	361	RD	0v	B+	B+	B+	B+	Ignition Source Power
76	PWR GND	570	BK/WH	0v	0v	0v	0v	0v	Power Ground
77	PWR GND	570	BK/WH	0v	0v	0v	0v	0v	Power Ground
79	MAP	358	LG/BK	0	1-2v	1-2v	1.5v-3v	1-3v	Manifold Absolute Pressure
80	IDM EN	814	WH/BK	0v	B+->0v	0v	0v	0v/B+	IDM Relay; 0v = Relay "On", B+ = Relay "Off"
81 b	EPC	925	WH/YE	0v	8v	10v	B+	8v-B+	Electronic Pressure Control Solenoid
83	IPR	552	YE/RD	0v	B+	B+	B+	B+	Injection Pressure

									Regulator; Duty Cycle Controlled
84 b c p	TSS	970	DG/WH	0v	0v	0v	0v	0v	Transmission Speed Sensor
87	ICP	812	DB/LG	0v	0.2v-0.4v	1v	2v	0.1v-3v	Injection Control Pressure Sensor (Min 0.83v req. for starting)
89	AP/ETC	355	GY/WH	0v	0.5v-0.7v	0.5v-1.6v	3.4v-4.95v	0.5v-4.95v	Accelerator Pedal Sensor Circuit
90	V REF	351	BN/WH	0.2v-0.5v	5.0 ± 0.5v	5.0 ± 0.5v	5.0 ± 0.5v	5.0 ±0.5v	Voltage Reference
91	SIG GRD	359	GY/RD	0v	0v	0v	0v	0v	Ground for All Sensor Signals
92	BOO	511 d , 810	RD/LG	0v/B+	0v/B+	0v/B+	0v/B+	0v/B+	Brake On/Off Switch; 0v = Brake "Off", B+ = Brake "On"
94	FP	926	LB/OG	0v	0/B+	0v	0v	0v	Fuel Pump Control
94 i	ASM	237	OG/YE	0v	B+	B+	0v	0v/B+	Downshift Relay Control at Over 85% Throttle

95	FDCS	821	BN/OG	0v	0v	1v/49 Hz	4v/200 Hz	40 Hz-240 Hz	Fuel Delivery Control Signal; 650-3600 rpm
96	CI	817	YE/LB	0v	0v	6v/5 Hz	7v/30 Hz	5 Hz-30 Hz	Cylinder Identification
97	VPWR	361	RD	0v	B+	B+	B+	B+	Ignition Source Power
98 b q	MIAH	462	VT	0v	B+	B+	B+	B+	Manifold Intake Air Heater
100 f r	FLI	29	YE/WH	0v	0-4v	0-4v	0-4v	0-4v	Fuel Level Indicator
101	GPC/GP Enable	1086	VT/OG	0v	0v/B+	0v/B+	0v/B+	0v/B+	Glow Plug Control, 0v = Relay "On", B+ = Relay "Off"
103	PWR GND	570	BK/WH	0v	0v	0v	0v	0v	Power Ground

LEGEND:

a. VBAT when heater is on; will cycle from 0 to VBAT to 0 during KOER test.
b. Not used on F650/750.
c. 4R100 transmission only.
d. Econoline only.
e. Voltage goes to 0 when water in fuel activates switch.
f. Pin not used on F-Series or Excursion.
g. Neutral switch — F-Series with AT545 Allison automatic transmission.
h. Not used on F-series.
i . F650/750 only.
j. F-Series 250/550
k. Output is in Hz. and varies with vehicle speed; zero Hz when stopped; 450 to 750 Hz. at 50 mph.
l. Not used on Econoline.
m. Voltage increases as manifold air temperature increases.

n. Voltage normally 0, goes to VBAT when PTO switch is turned on and ignition is on.
o . Will momentarily go to VBAT during lamp check.
p. Voltage goes to VBAT if engine is not running and key is on for over 20 seconds.
q. Grounded when heater is on; will cycle from VBAT to 0 to VBAT during KOER test.
r. Voltage increases as fuel level increases.

Fault Code	Condition Description	Probable Causes
P0107	Barometric pressure sensor circuit low input	PCM's internal barometric sensor
P0108	Barometric pressure sensor circuit high input	PCM's internal barometric sensor
P0112	Intake air temp. sensor circuit low input	Grounded circuit, biased sensor, PCM
P0113	Intake air temp. sensor circuit high input	Open circuit, biased sensor, PCM, short to 5v
P0122	Accelerator pedal sensor circuit low input	Grounded circuit, biased sensor, PCM
P0123	Accelerator pedal sensor circuit high input	Open circuit, biased sensor, PCM, short to 5v
P0197	Engine oil temp. sensor circuit low input	Grounded circuit, biased sensor, PCM
P0198	Engine oil temp. sensor circuit high input	Open circuit, biased sensor, PCM, short to 5v
P0220	Throttle switch B circuit malfunction	Short/open circuit, switch failure, operator, PCM
P0221	Throttle switch B circuit performance	Failed pedal assembly
P0230	Fuel pump relay driver failure	Open FP relay, blown fuse, open/grounded circuit
P0231	Fuel pump circuit failure	Fuse, relay, inertia switch, fuel pump, open/short circuit
P0232	Fuel pump circuit failure	Relay failure, short circuit, pump failure
P0236	Turbo boost sensor A circuit performance	Restricted inlet/exhaust/supply hose, missing hose
P0237	Turbo boost sensor A circuit low input	Circuit open, short to ground, MAP sensor
P0238	Turbo boost sensor A circuit low high	Circuit short to power, MAP sensor
P0261	Injector circuit low Cylinder 1	Harness short to ground
P0262	Injector circuit high Cylinder 1	Miswired connector or harness
P0263	Cylinder 1 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0264	Injector circuit low Cylinder 2	Harness short to ground
P0265	Injector circuit high Cylinder 2	Miswired connector or harness
P0266	Cylinder 2 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0267	Injector circuit low Cylinder 3	Harness short to ground
P0268	Injector circuit high Cylinder 3	Miswired connector or harness

P0269	Cylinder 3 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0270	Injector circuit low Cylinder 4	Harness short to ground
P0271	Injector circuit high Cylinder 4	Miswired connector or harness
P0272	Cylinder 4 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0273	Injector circuit low Cylinder 5	Harness short to ground
P0274	Injector circuit high Cylinder 5	Miswired connector or harness
Fault Code	**Condition Description**	**Probable Causes**
P0275	Cylinder 5 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0276	Injector circuit low Cylinder 6	Harness short to ground
P0277	Injector circuit high Cylinder 6	Miswired connector or harness
P0278	Cylinder 6 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0279	Injector circuit low Cylinder 7	Harness short to ground
P0280	Injector circuit high Cylinder 7	Miswired connector or harness
P0281	Cylinder 7 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0282	Injector circuit low Cylinder 8	Harness short to ground
P0283	Injector circuit high Cylinder 8	Miswired connector or harness
P0284	Cylinder 8 contribution/balance fault	Power cylinder, valve train or injector problem, circuit
P0301	Fault cylinder 1 Misfire detected	Mechanical engine failure
P0302	Fault cylinder 2 Misfire detected	Mechanical engine failure
P0303	Fault cylinder 3 Misfire detected	Mechanical engine failure
P0304	Fault cylinder 4 Misfire detected	Mechanical engine failure
P0305	Fault cylinder 5 Misfire detected	Mechanical engine failure
P0306	Fault cylinder 6 Misfire detected	Mechanical engine failure
P0307	Fault cylinder 7 Misfire detected	Mechanical engine failure
P0308	Fault cylinder 8 Misfire detected	Mechanical engine failure
P0340	Camshaft position sensor ckt. malfunction	Open/grounded circuit, sensor fault, short to power
P0341	Camshaft position sensor ckt. performance	Harness routing, charging circuit, sensor
P0344	Camshaft position sensor ckt. intermittent	Harness routing, charging ckt., sensor, int. ckt., improper gap

P0380	Glow plug circuit malfunction	Open/grounded ckt., solenoid open/shorted, failed PCM
P0381	Glow plug indicator circuit malfunction	Open/grounded circuit, lamp open, failed PCM
P0460	Fuel level sensor circuit malfunction	Open/short circuit, cluster, tank unit, open case GND
P0470	Exhaust back pressure sensor circuit malfunction	Biased sensor, open signal return
P0471	Exhaust back pressure sensor circuit performance	Plugged, stuck or leaking hose
P0472	Exhaust back pressure sensor circuit low input	Open/grounded circuit, biased sensor, PCM
Fault Code	**Condition Description**	**Probable Causes**
P0473	Exhaust back pressure sensor circuit high input	Circuit shorted to 5v, biased sensor, PCM
P0475	Exhaust pressure control valve malfunction	Open/grounded ckt., solenoid open/shorted, failed PCM
P0476	Exhaust pressure control valve performance	Failed/stuck EPR control, EBP fault, EPR circuit
P0478	Exhaust pressure control valve high input	Plugged sensor line, stuck butterfly, restricted exhaust
P0500	Vehicle speed sensor malfunction	Sensor, circuit, PCM, PSOM, TR failure, low trans. fluid
P0503	Vehicle speed sensor noisy	Harness routing, sensor
P0541	Manifold intake air heater...	Open/short circuit
P0542	Manifold intake air heater...	Grounded circuit
P0560	System voltage malfunction	Charging system problem/load, glow plugs still enabled
P0562	System voltage low	Low sys. voltage, charging sys., internal PCM failure
P0563	System voltage high	High sys., voltage, charging sys., internal PCM failure
P0565	Cruise "On" signal malfunction	Open or short circuit, switch failure, PCM failure or failed to activate switch during KOER switch test
P0566	Cruise "Off" signal malfunction	Open or short circuit, switch failure, PCM failure or failed to activate switch during KOER switch test

P0567	Cruise "Resume" signal malfunction	Open or short circuit, switch failure, PCM failure or failed to activate switch during KOER switch test
P0568	Cruise "Set" signal malfunction	Open or short circuit, switch failure, PCM failure or failed to activate switch during KOER switch test
P0569	Cruise "Coast" signal malfunction	Open or short circuit, switch failure, PCM failure or failed to activate switch during KOER switch test
P0571	Brake switch A circuit malfunction	Cruise control codes will be set on every switch test on vehicles not equipped with cruise control
P0603	Internal control module KAM error	Open PCM pin, disconnect B+, faulty PCM
P0605	Internal control module ROM error	Internal PCM failure
P0606	PCM processor fault	Internal PCM failure
Fault Code	**Condition Description**	**Probable Causes**
P0640	Manifold intake air heater...	Circuit open or shorted to ground
P0670	Glow plug control circuit malfunction	Open/grounded circuit, failed GPCM, failed PCM
P0671	Glow plug #1 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0672	Glow plug #2 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0673	Glow plug #3 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0674	Glow plug #4 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0675	Glow plug #5 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0676	Glow plug #6 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0677	Glow plug #7 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0678	Glow plug #8 circuit failure	Circuit/connector failure, failed glow plug, failed GPCM, PCM
P0683	Glow plug diagnostic signal communication fault	Circuit/connector failure, failed GPCM, PCM
P0703	Brake switch B circuit malfunction	Open/short circuit, switch, PCM, failed to activate switch during KOER switch test

P0704	Clutch switch input circuit malfunction; F650-F750 with Allison AT545: neutral switch	Open/short circuit, switch, PCM, failed to activate switch during KOER switch test
P0705	TR sensor circuit malfunction	Resistance in circuit, faulty sensor, PCM
P0707	TR sensor circuit low input	Open in circuit, biased sensor, PCM
P0708	TR sensor circuit high input	Open in circuit, biased sensor, PCM, short to power
P0712	Trans. fluid temp. Sensor ckt. low input	Short to ground, biased sensor, PCM
P0713	Trans. fluid temp. Sensor ckt. high input	Open in circuit, biased sensor, PCM, short to power
P0715	TSS sensor circuit malfunction	Short/open circuit, sensor, PCM
P0717	TSS intermittent failure	Short/open circuit, sensor, PCM
P0718	Noisy TSS	Erratic signal, sensor, intermittent circuit
P0720	OSS sensor circuit malfunction	Short/open circuit, sensor, PCM
P0721	Noisy OSS	Erratic signal, sensor, intermittent circuit
P0722	OSS intermittent failure	Short/open circuit, sensor, PCM
P0732	Gear 2 incorrect ratio	Mechanical/hydraulic failure, 4x4 switch failure
Fault Code	**Condition Description**	**Probable Causes**
P0733	Gear 3 incorrect ratio	Mechanical/hydraulic failure, 4x4 switch failure
P0741	Torque converter clutch ckt. performance	Circuit failure, faulty solenoid, PCM
P0743	Torque converter clutch system electrical	Faulty solenoid, circuit, PCM
P0750	Shift solenoid A malfunction	Circuit failure, faulty solenoid, PCM
P0755	Shift solenoid B malfunction	Circuit failure, faulty solenoid, PCM
P0781	1-2 Shift malfunction	Circuit failure, faulty solenoid, faulty clutch, PCM
P0782	2-3 Shift malfunction	Circuit failure, faulty solenoid, faulty clutch, PCM
P0783	3-4 Shift malfunction	Circuit failure, faulty solenoid, faulty clutch, PCM
P1000	OBDII monitor status	OBDII monitors/drive cycle incomplete
P1105	Dual alternator upper fault (monitor)	Circuit failure, alternator failure, PCM
P1106	Dual alternator lower fault (control)	Circuit failure, alternator failure, PCM
P1107	Dual alternator lower circuit malf. (control)	Circuit failure, alternator failure, PCM
P1108	Dual alternator BATT lamp ckt. malf.	Open/short circuit, lamp, fuse, PCM
P1118	Manifold air temp sensor out of range low	Short to GND MAT circuit, MAT sensor
P1119	Manifold air temp sensor out of range high	Open/short to PWR circuit, MAT sensor

P1139	Water in fuel lamp circuit malfunction	WIF lamp, circuit failure, fuse, PCM
P1140	Water in fuel condition	Water in fuel, grounded circuit, shorted sensor, PCM
P1184	Engine oil temp out of self-test range	Engine too cold/hot, leaking thermostat, ckt., sensor
P1209	ICP system fault	IPR valve stuck
P1210	ICP above expected level	ICP sensor, open signal return
P1211	ICP pressure above/below desired	IPR valve failed, stuck, or shorted to ground
P1212	ICP voltage not at expected level	Biased sensor or ckt., open signal return, low oil in reservoir
P1218	CID stuck high	CID circuit open, probably intermittent
P1219	CID stuck low	CID circuit short to ground, probably intermittent
P1247	Turbo boost pressure low	MAP hose, sensor, EBP sys, intake leaks, turbo
P1248	Turbo boost pressure not detected	MAP hose, sensor, EBP sys, intake leaks, turbo
P1249	Waste gate steady state failure	GND short, plugged hose/port, solenoid, actuator
P1260	Electronic positive anti-theft system failure	Refer to appropriate workshop manual.
Fault Code	**Condition Description**	**Probable Causes**
P1261-P1268	High to low side short cyl. # 1-8	Short circuit, shorted injector, failed IDM
P1271-P1278	High to low side open cyl. # 1-8	Open circuit, open injector, failed IDM
P1280	ICP circuit out of range low	Open/grounded circuit, biased sensor, PCM
P1281	ICP circuit out of range high	Circuit shorted to 5v, biased sensor, PCM
P1282	Excessive ICP pressure	Faulty IPR regulator (sticking), IPR short to ground
P1283	IPR circuit failure	Open/grounded circuit, stuck IPR, loose connection
P1284	ICP failure aborts KOER CCT test	See codes P1280, P1281, P1282, P1283, P1211
P1291	High side # 1 (right) short to grd. or B+	Short circuit, faulty IDM
P1292	High side # 2 (left) short to grd. or B+	Short circuit, faulty IDM
P1293	High side open bank No. 1 (right)	Open circuit, faulty IDM

P1294	High side open bank No. 2 (left)	Open circuit, faulty IDM
P1295	Multiple faults on bank No. 1 (right)	Miswired connector or harness, short to ground
P1296	Multiple faults on bank No. 2 (left)	Miswired connector or harness, short to ground
P1297	High sides shorted together	Shorted wires, faulty IDM
P1298	IDM failure	Internal IDM failure
P1316	Injector circuit/IDM codes detected	Injector circuit failure/IDM codes detected
P1391	Glow plug circuit low input, bank #1 (right)	Open/short/miswired circuit, faulty relay, glow plugs
P1393	Glow plug circuit low input, bank #2 (left)	Open/short/miswired circuit, faulty relay, glow plugs
P1395	Glow plug monitor fault, bank #1	One or more glow plugs failed or circuit fault
P1396	Glow plug monitor fault, bank #2	One or more glow plugs failed or circuit fault
P1397	System voltage out of self-test range	Voltage too high or low for glow plug monitor test
P1464	A/C on during KOER CCT test	Operator error, A/C circuit shorted to power
P1501	Vehicle moved during testing	Operator error
P1502	Invalid test APCM functioning	APCM active while KOER test is running
P1531	Invalid test accelerator pedal movement	Accelerator moved during KOER on-demand or CCT test
P1536	Parking brake applied fail	Circuit, switch, PCM, failed to activate switch KOER
P1660	OCC signal high	High system voltage, internal PCM fault
Fault Code	**Condition Description**	**Probable Causes**
P1661	OCC signal low	Low system voltage, internal PCM fault
P1662	IDM EN circuit failure	Open relay, blown fuse, open/grounded circuit
P1663	FDCS circuit failure	Open/grounded circuit, faulty IDM
P1667	CID circuit failure	Open/grounded circuit, faulty IDM
P1668	PCM/IDM diag. communication error	Open/shorted EF or FDCS wire, open IDM grd.
P1670	EF signal not detected	Open/shorted EF circuit
P1690	Waste gate failure	WGC circuit or solenoid, PCM

P1702	TRS sensor intermittent circuit malfunction	Sensor, wiring, PCM, mechanical alignment
P1704	Digital TRS failed to transition state	Sensor, wiring, PCM, mechanical alignment
P1705	TR sensor out of self-test range	Operator error, circuit failure, faulty sensor, PCM
P1711	TFT sensor out of self-test range	Circuit failure, faulty sensor, PCM
P1713	TFT stuck in range low below 50F	Sensor, circuit, PCM
P1714	Shift solenoid 1 inductive	Circuit, solenoid, PCM
P1715	Shift solenoid 2 inductive	Circuit, solenoid, PCM
P1718	TFT stuck in range high above 250F	Sensor, circuit, PCM
P1728	Transmission slip error	Solenoid failure or mechanical failure
P1729	4x4L low switch error	Circuit failure, faulty switch, PCM
P1744	Converter not functioning	Converter solenoid/hydraulic/mechanical failure
P1746	EPC solenoid open circuit	Open circuit, faulty solenoid, PCM
P1747	EPC solenoid short circuit	Short circuit, faulty solenoid, PCM shorted to ground
P1754	Coast clutch solenoid ckt. malfunction	Circuit failure, faulty solenoid, PCM
P1760	EPC solenoid short intermittent	Switch not detected during self-test, circuit, switch
P1780	TCS circuit of out self-test range	Circuit, switch, PCM, failed to activate switch KOER
P1781	4x4L circuit out of self-test range	Operator error, short to ground, PCM
P1783	Transmission over temperature condition	Internal trans. failure, circuit failure, sensor, PCM
P1902	Kickdown solenoid relay control circuit failure	Blown fuse, failed relay, open control circuit, faulty PCM, faulty wiring
P1903	Kickdown solenoid circuit low voltage	Blown fuse, failed relay, open control circuit, faulty PCM
P1904	Kickdown solenoid circuit high voltage	Blown fuse, failed relay, open control circuit, faulty PCM, open in ASMM (circuit #175)

Diagnostic Trouble Code Chart E4OD- 4R100

Five Digit DTC	Component	Description	Condition	Symptom	Action

P0102 P0103 P1100 P1101	MAF	MAF concerns	MAF system has a malfunction which may cause a transmission concern.	High or low EPC pressure, incorrect shift schedule. Incorrect torque converter clutch engagement scheduling. Symptoms similar to a throttle position (TP) failure.	WIRING OR MAP SENSOR
P0117	ECT	ECT indicates 125°C (257°F)	Voltage drop across ECT exceeds scale set for temperature 125°C (257°F) (grounded).	Torque converter clutch will always be off, resulting in reduced fuel economy.	WIRING OR ECT SENSOR
P0118	ECT	ECT indicates -40°C (-40°F)	Voltage drop across ECT exceeds scale set for temperature -40°C (-40°F) (open circuit).	Torque converter clutch will always be off, resulting in reduced fuel economy.	WIRING OR ECT SENSOR
P0122 P0123 P1120	TP	TP concern	PCM has detected an error that may cause a transmission concern.	Harsh engagements, firm shift feel, abnormal shift schedule, torque converter clutch does	WIRING OR TP SENSOR

				not engage, torque converter clutch cycling.	
P1702	Digital TR	Intermittent DTC codes P0705 or P0708	Refer to DTC codes P0705 or P0708 condition.	Refer to DTC codes P0705 or P0708 symptom.	WIRING OR DIGITAL TR SENSOR
P1704	Digital TR	Digital TR circuit reading in between gear position during KOEO/KOER	Digital TR sensor or shift cable incorrectly adjusted; or digital TR circuit failure.	Wrong commanded EPC pressure. Digital TR reading the wrong gear position.	WIRING OR DIGITAL TR SENSOR
P0705	Digital TR	Digital TR circuit failure	Digital TR circuits, indicating an invalid pattern in TR_D. Condition caused by a short to ground or an open in TR4, TR3A, TR2 and or TR1 circuits. This DTC cannot be set by an incorrectly adjusted digital TR sensor.	Increase in EPC pressure (harsh shifts). Defaults to (D) or D for all gear positions. In (D) position trans, stuck in D or manual 2.	WIRING OR DIGITAL TR SENSOR
P0708	Digital TR	Digital TR sensor circuit TR3A open	Digital TR sensor circuit TR3A reading 2.6v - 5.0v (open circuit). This DTC cannot be set by an incorrectly adjusted digital TR sensor.	Increase in EPC pressure. Defaults to (D) or D for all gear ranges.	WIRING OR DIGITAL TR SENSOR

P1705	Digital TR	Digital TR self-test was not carried out in PARK or NEUTRAL	Vehicle not in PARK or NEUTRAL during onboard diagnostic.	Rerun on-board diagnostic in PARK or NEUTRAL.	WIRING OR DIGITAL TR SENSOR
P0715	TSS	Insufficient input from turbine shaft speed sensor	PCM detected a loss of TSS signal during operation.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR TSS SENSOR
P0717	TSS	Turbine shaft speed sensor signal intermittent	PCM has detected an intermittent TSS signal.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR TSS SENSOR
P0718	TSS	Turbine shaft speed sensor signal noisy	PCM has detected a noisy TSS signal.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR TSS SENSOR
P0720	OSS	Insufficient input from output shaft speed sensor	PCM detected a loss of OSS signal during operation.	Harsh shifts, abnormal shift schedule, no torque converter clutch activation.	WIRING OR OSS SENSOR
P0721	OSS	OSS sensor signal noisy	PCM has detected an erratic OSS signal.	Harsh shifts, abnormal shift schedule, no torque	WIRING OR OSS SENSOR

				converter clutch engagement.	
P0722	OSS wiring	Insufficient input from OSS	PCM has detected a loss of OSS signal.	Harsh shifts, abnormal shift schedule, no torque converter clutch engagement.	WIRING OR OSS SENSOR
P0731	SSA, SSB or internal parts	1st gear error	No 1st gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER
P0732	SSA, SSB or internal parts	2nd gear error	No 2nd gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER

P0733	SSA, SSB or internal parts	3rd gear error	No 3rd gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER
P0734	SSA, SSB or internal parts	4th gear error	No 4th gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER
P0741**	TCC, internal components	TCC slippage detected	The PCM picked up an excessive amount of slippage during normal vehicle operation.	TCC slippage/erratic or no torque converter clutch operation. Flashing Transmission Control Indicator Lamp (TCIL).	PTS BILLET TORQUE CONVERTOR AND PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT

P0743*	TCC, wiring, PCM	TCC solenoid circuit failure during onboard diagnostic	TCC solenoid circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Short circuit: engine stalls in second (OD, 2 range) at low idle speeds with brake applied. Open circuit: torque converter clutch never engages. May flash TCIL.	WIRING OR PTS HYDROSYSTEM
P0750*	SSA, wiring, PCM	SSA solenoid circuit failure	SSA circuit failed to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Incorrect gear selection depending on condition mode and manual lever position. See Solenoid On/Off Chart.	WIRING OR PTS HYDROSYSTEM

P0753	SSA, wiring, PCM	SSA electrical failure	SSA circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver ıring on-board c.	Incorrect gear depending on condition mode and manual lever position. See Solenoid On/Off Chart. May flash TCIL.	WIRING OR PTS HYDROSYSTEM
P0755*	SSB, wiring, PCM	SSB solenoid circuit failure	SSB circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during	Incorrect gear selection depending on condition mode and manual lever position. See Solenoid On/Off Chart.	WIRING OR PTS HYDROSYSTEM

			on-board diagnostic.		
P0758*	SSB, wiring, PCM	SSB electrical circuit failure	SSB circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Incorrect gear depending on condition mode and manual lever position. See Solenoid On/Off Chart. May flash TCIL.	WIRING OR PTS HYDROSYSTEM
P1714	SSA, internal components	SSA malfunction	Mechanical failure of the solenoid detected.	Incorrect gear selection depending on condition, mode and manual lever position. See Solenoid Operation Chart.	PTS HYDROSYSTEM
P1715	SSB	SSB malfunction	Mechanical failure of the solenoid detected.	Incorrect gear selection depending on condition, mode and manual lever position. See Solenoid Operation Chart.	PTS HYDROSYSTEM
P0781**	SSA or internal parts	1-2 shift error	Engine rpm drop not detected when 1-2 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material).	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER

P0782**	SSA, SSB or internal parts	2-3 shift error	Engine rpm drop not detected when 2-3 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material).	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER
P0783**	SSA, SSB or internal parts	3-4 shift error	Engine rpm drop not detected when 3-4 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material).	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER
P1703	BPP	BPP switch circuit failed	Brake ON/OFF circuit failure.	Failed on or not connected “torque converter clutch will not engage at less than 1/3 throttle. Failed off or not connected “torque converter clutch will not disengage when brake is applied.	WIRING OR BPP SWITCH
P1703	BPP	Brake not actuated during on-board diagnostic	Brake not cycled during KOER.	Failed off or not connected “torque converter clutch will not engage at less than 1/3 throttle. Failed off or not connected “torque	WIRING OR BPP SWITCH

				converter clutch will not disengage when brake is applied.	
P0713	TFT, wiring, PCM	-40°C (-40°F) indicated TFT sensor circuit open	Voltage drop across TFT sensor exceeds scale set for temperature -40°C (-40°F).	Firm shift feel.	WIRING OR TFT SENSOR
P1711	TFT	TFT out of on-board diagnostic range	Transmission not at operating temperature during on-board diagnostic.	Warm vehicle to normal operating temperature.	

P0712	TFT, wiring, PCM	157°C (315°F) indicated TFT sensor circuit grounded	Voltage drop across TFT sensor exceeds scale set for temperature of 157°C (315°F).	Firm shift feel.	WIRING OR TFT SENSOR
P1713	TFT wiring PCM	TFT continually reading cold	TFT sensor in range low failure.	Firm shift feel. Substitute ECT for TFT	WIRING OR TFT SENSOR
P1783	TFT	Transmission over temperature condition indicated	Transmission fluid temperature exceeded °C (270°F).	Increase in EPC pressure.	WIRING OR TFT SENSOR CLOGGED COOLER
P1718	TFT, wiring, PCM	TFT continually reading hot	TFT sensor in range high failure.	Firm shift feel. Substitute ECT for TFT.	WIRING OR TFT SENSOR

P0740	TCC, wiring, PCM	TCC electrical failure	TCC circuit fails to provide voltage drop across solenoid. Circuit open, shorted or PCM driver failure during on-board diagnostics.	Short circuit, engine stalls in 2nd ((D), 2 range) at low speeds with brake applied. Open circuit, torque converter clutch never engages. May flash TCIL.	
P1740	TCC	TCC malfunction	Mechanical failure of the solenoid detected.	Failed on “Engine stalls in 2nd (O/D, Manual 2 ranges) at low idle speeds with brake applied. Failed off “Torque converter never applies.	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER
P1741**	TCC, internal components	Excessive torque converter clutch engagement error	Excessive variations in slip (engine speed surge) across the torque converter clutch.	Engine rpm oscillation is present in 3rd gear.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTOR. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1742	TCC, internal components	TCC solenoid failed on	TCC solenoid has failed on by electric, mechanical or hydraulic concern.	Harsh shifts.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTOR. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1743	TCC, internal components	TCC solenoid failed on	TCC solenoid has failed on by electric, mechanical or	Harsh shifts.	PTS HYDROSYSTEM,BILLET TORQUE

			hydraulic concern.		CONVERTOR. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1744	TCC	TCC	The PCM picked up an excessive amount of TCC slippage during normal vehicle operation.	TCC slippage/erratic or no torque converter clutch operation.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTOR. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1746* P0960	EPC, wiring, PCM	EPC solenoid open circuit	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Open circuit causes maximum EPC pressure, harsh engagements and shifts.	WIRING OR SUPER SOLENOID
P1747* P0962	EPC, wiring, PCM	EPC solenoid circuit failure, shorted circuit or output driver	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Short circuit causes minimum EPC pressure (minimum capacity) and limits engine torque (alternate firm).	WIRING OR SUPER SOLENOID

P1760	EPC, wiring, PCM	EPC solenoid circuit failure, shorted circuit or output driver	PCM detected a loss of EPC during operation.	Unexpected reduction in engine torque.	WIRING OR SUPER SOLENOID.

P1781 1	4x4 Low switch	4x4 Low switch closed	4x4 Low switch closed or 4x4 Low indicator lamp circuit open.	Failed on “early shift schedules in 4x2 and 4x4 HI range. Failed off " shifts delayed in 4x4 Low.1	WIRING OR 4X4 SWITCH
P0748* *	EPC solenoid	EPC solenoid circuit failure	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Short circuit results in minimum EPC pressure (minimum capacity) and limits engine torque (Alternate firm). Not all gears present. Open circuit: maximum PC A pressure, harsh engagements and shifts.	WIRING OR SUPER SOLENOID.
P1729	4x4 Low	4x4 Low switch failure	4x4 Low switch failure during normal vehicle operation.	Early shifts, harsh shifts, increase in electronic pressure control valve.	WIRING OR 4X4 SWITCH
P1728	Trans	Transmis sion slip error	The PCM has detected an excessive amount of slippage during normal operation.	Transmission slippage erratic or no torque converter clutch operation.	COMPLETE TRANSMISSION FAILIER

Diagnostic Trouble Code Chart 4R70-75W

Five Digit DTC	**Componen t**	**Descripti on**	**Condition**	**Symptom**	**Action**

P0102 P0103 P1100 P1101	MAF	MAF concerns	MAF system has a malfunction which may cause a transmission concern.	High or low EPC pressure, incorrect shift schedule. Incorrect torque converter clutch engagement scheduling. Symptoms similar to a throttle position (TP) failure.	WIRING OR MAP SENSOR
P0117	ECT	ECT indicates 125°C (257°F)	Voltage drop across ECT exceeds scale set for temperature 125°C (257°F) (grounded).	Torque converter clutch will always be off, resulting in reduced fuel economy.	WIRING OR ECT SENSOR
P0118	ECT	ECT indicates -40°C (-40°F)	Voltage drop across ECT exceeds scale set for temperature -40°C (-40°F) (open circuit).	Torque converter clutch will always be off, resulting in reduced fuel economy.	WIRING OR ECT SENSOR
P0122 P0123 P1120	TP	TP concern	PCM has detected an error that may cause a transmission concern.	Harsh engagements, firm shift feel, abnormal shift schedule, torque converter clutch does not engage, torque converter clutch cycling.	WIRING OR TP SENSOR
P1702	Digital TR	Intermittent DTC codes	Refer to DTC codes P0705 or P0708 condition.	Refer to DTC codes P0705 or P0708 symptom.	WIRING OR DIGITAL TR SENSOR

		P0705 or P0708			
P1704	Digital TR	Digital TR circuit reading in between gear position during KOEO/KOER	Digital TR sensor or shift cable incorrectly adjusted; or digital TR circuit failure.	Wrong commanded EPC pressure. Digital TR reading the wrong gear position.	WIRING OR DIGITAL TR SENSOR
P0705	Digital TR	Digital TR circuit failure	Digital TR circuits, indicating an invalid pattern in TR_D. Condition caused by a short to ground or an open in TR4, TR3A, TR2 and or TR1 circuits. This DTC cannot be set by an incorrectly adjusted digital TR sensor.	Increase in EPC pressure (harsh shifts). Defaults to (D) or D for all gear positions. In (D) position trans, stuck in D or manual 2.	WIRING OR DIGITAL TR SENSOR

P0708	Digital TR	Digital TR sensor circuit TR3A open	Digital TR sensor circuit TR3A reading 2.6v - 5.0v (open circuit). This DTC cannot be set by an incorrectly	Increase in EPC pressure. Defaults to (D) or D for all gear ranges.	

			adjusted digital TR sensor.		
P1705	Digital TR	Digital TR self-test was not carried out in PARK or NEUTRAL	Vehicle not in PARK or NEUTRAL during onboard diagnostic.	Rerun on-board diagnostic in PARK or NEUTRAL.	WIRING OR DIGITAL TR SENSOR
P0715	TSS	Insufficient input from turbine shaft speed sensor	PCM detected a loss of TSS signal during operation.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR DIGITAL TR SENSOR
P0717	TSS	Turbine shaft speed sensor signal intermittent	PCM has detected an intermittent TSS signal.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR TSS SENSOR
P0718	TSS	Turbine shaft speed sensor signal noisy	PCM has detected a noisy TSS signal.	Harsh shifts, harsh torque converter clutch activation and harsh engagements.	WIRING OR TSS SENSOR
P0720	OSS	Insufficient input from output shaft speed sensor	PCM detected a loss of OSS signal during operation.	Harsh shifts, abnormal shift schedule, no torque converter clutch activation.	WIRING OR TSS SENSOR
P0721	OSS	OSS sensor	PCM has detected an	Harsh shifts, abnormal shift schedule, no torque	WIRING OR OSS SENSOR

		signal noisy	erratic OSS signal.	converter clutch engagement.	
P0722	OSS wiring	Insufficient input from OSS	PCM has detected a loss of OSS signal.	Harsh shifts, abnormal shift schedule, no torque converter clutch engagement.	WIRING OR OSS SENSOR
P0731	SSA, SSB or internal parts	1st gear error	No 1st gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	WIRING OR OSS SENSOR
P0732	SSA, SSB or internal parts	2nd gear error	No 2nd gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER

P0733	SSA, SSB or internal parts	3rd gear error	No 3rd gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER
P0734	SSA, SSB or internal parts	4th gear error	No 4th gear.	Incorrect gear selection, depending on failure or mode and manual lever position. Shift errors may	PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND PTS BILLET TORQUE CONVERTER
					PTS HYDROSYSTEM IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED

				Also be due to other internal transmission concerns (stuck valves, damaged friction material). Engine rpm could be higher or lower than expected.	PTS KIT AND PTS BILLET TORQUE CONVERTER

P0741**	TCC, internal components	TCC slippage detected	The PCM picked up an excessive amount of slippage during normal vehicle operation.	TCC slippage/erratic or no torque converter clutch operation. Flashing Transmission Control Indicator Lamp (TCIL).	PTS BILLET TORQUE CONVERTER AND PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P0743*	TCC, wiring, PCM	TCC solenoid circuit failure during onboard diagnostic	TCC solenoid circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Short circuit: engine stalls in second (OD, 2 range) at low idle speeds with brake applied. Open circuit: torque converter clutch never engages. May flash TCIL.	WIRING OR PTS HYDROSYSTEM
P0750*	SSA, wiring, PCM	SSA solenoid circuit failure	SSA circuit failed to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Incorrect gear selection depending on condition mode and manual lever position. See Solenoid On/Off Chart.	WIRING OR PTS HYDROSYSTEM
P0753	SSA, wiring, PCM	SSA electrical failure	SSA circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during	Incorrect gear depending on condition mode and manual lever position. See Solenoid On/Off Chart. May flash TCIL.	WIRING OR PTS HYDROSYSTEM

			on-board diagnostic.		
P0755*	SSB, wiring, PCM	SSB solenoid circuit failure	SSB circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Incorrect gear selection depending on condition mode and manual lever position. See Solenoid On/Off Chart.	WIRING OR PTS HYDROSYSTEM
P0758*	SSB, wiring, PCM	SSB electrical circuit failure	SSB circuit fails to provide voltage drop across solenoid. Circuit open or shorted or PCM driver failure during on-board diagnostic.	Incorrect gear depending on condition mode and manual lever position. See Solenoid On/Off Chart. May flash TCIL.	WIRING OR PTS HYDROSYSTEM
P1714	SSA, internal components	SSA malfunction	Mechanical failure of the solenoid detected.	Incorrect gear selection depending on condition, mode and manual lever position. See Solenoid Operation Chart.	PTS HYDROSYSTEM
P1715	SSB	SSB malfunction	Mechanical failure of the solenoid detected.	Incorrect gear selection depending on condition, mode and manual lever position. See	PTS HYDROSYSTEM

				Solenoid Operation Chart.	
P0781**	SSA or internal parts	1-2 shift error	Engine rpm drop not detected when 1-2 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material).	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER
P0782**	SSA, SSB or internal parts	2-3 shift error<;/td>	Engine rpm drop not detected when 2-3 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material).	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT AND BILLET TORQUE CONVERTER
P0783**	SSA, SSB or internal parts	3-4 shift error	Engine rpm drop not detected when 3-4 shift was commanded by PCM.	Incorrect gear selection depending on failure or mode and manual lever position. Shift errors may also be due to other internal transmission concerns (stuck valves, damaged friction material	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED

P1703	BPP	BPP switch circuit failed	Brake ON/OFF circuit failure.	Failed on or not connected “torque converter clutch will not engage at less than 1/3 throttle. Failed off or not connected “torque converter clutch will not disengage when brake is applied.	WIRING OR BPP SWITCH
P1703	BPP	Brake not actuated during on-board diagnostic	Brake not cycled during KOER.	Failed off or not connected “torque converter clutch will not engage at less than 1/3 throttle. Failed off or not connected “torque converter clutch will not disengage when brake is applied.	WIRING OR BPP SWITCH
P0713	TFT, wiring, PCM	-40°C (-40°F) indicated TFT sensor circuit open	Voltage drop across TFT sensor exceeds scale set for temperature -40°C (-40°F).	Firm shift feel.	WIRING OR TFT SENSOR
P1711	TFT	TFT out of on-board diagnostic range	Transmission not at operating temperature during on-board diagnostic.	Warm vehicle to normal operating temperature.	

P0712	TFT, wiring, PCM	157°C (315°F) indicated TFT sensor circuit grounded	Voltage drop across TFT sensor exceeds scale set for temperature of 157°C (315°F).	Firm shift feel.	WIRING OR TFT SENSOR
P1713	TFT wiring PCM	TFT continually reading cold	TFT sensor in range low failure.	Firm shift feel. Substitute ECT for TFT	WIRING OR TFT SENSOR
P1783	TFT	Transmission over temperature condition indicated	Transmission fluid temperature exceeded °C (270°F).	Increase in EPC pressure.	WIRING OR TFT SENSOR CLOGGED COOLER
P1718	TFT, wiring, PCM	TFT continually reading hot	TFT sensor in range high failure.	Firm shift feel. Substitute ECT for TFT.	WIRING OR TFT SENSOR
P0740	TCC, wiring, PCM	TCC electrical failure	TCC circuit fails to provide voltage drop across solenoid. Circuit open, shorted or PCM driver failure during on-board diagnostics.	Short circuit, engine stalls in 2nd ((D), 2 range) at low speeds with brake applied. Open circuit, torque converter clutch never engages. May flash TCIL.	
P1740	TCC	TCC malfunction	Mechanical failure of the solenoid detected.	Failed on “Engine stalls in 2nd (O/D, Manual 2 ranges) at low idle speeds with brake applied. Failed off “Torque	PTS HYDROSYSTEM. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED

				converter never applies.	PTS KIT AND BILLET TORQUE CONVERTER
P1741**	TCC, internal components	Excessive torque converter clutch engagement error	Excessive variations in slip (engine speed surge) across the torque converter clutch.	Engine rpm oscillation is present in 3rd gear.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTER. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1742	TCC, internal components	TCC solenoid failed on	TCC solenoid has failed on by electric, mechanical or hydraulic concern.	Harsh shifts.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTER. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1743	TCC, internal components	TCC solenoid failed on	TCC solenoid has failed on by electric, mechanical or hydraulic concern.	Harsh shifts.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTER. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT
P1744	TCC	TCC	The PCM picked up an excessive amount of TCC slippage during normal vehicle operation.	TCC slippage/erratic or no torque converter clutch operation.	PTS HYDROSYSTEM,BILLET TORQUE CONVERTER. IF THERE IS LOTS OF DEBRIS IN PAN YOU WILL NEED PTS KIT

P1746* P0960	EPC, wiring, PCM	EPC solenoid open circuit	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Open circuit causes maximum EPC pressure, harsh engagements and shifts.	WIRING OR SUPER SOLENOID
P1747* P0962	EPC, wiring, PCM	EPC solenoid circuit failure, shorted circuit or output driver	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Short circuit causes minimum EPC pressure (minimum capacity) and limits engine torque (alternate firm).	WIRING OR SUPER SOLENOID
P1760	EPC, wiring, PCM	EPC solenoid circuit failure, shorted circuit or output driver	PCM detected a loss of EPC during operation.	Unexpected reduction in engine torque.	WIRING OR SUPER SOLENOID
P17811	4x4 Low switch	4x4 Low switch closed	4x4 Low switch closed or 4x4 Low indicator lamp circuit open.	Failed on “early shift schedules in 4x2 and 4x4 HI range. Failed off " shifts delayed in 4x4 Low.1	WIRING OR 4X4 SWITCH
P0748**	EPC solenoid	EPC solenoid circuit failure	Voltage through EPC solenoid is checked. An error will be noted if tolerance is exceeded.	Short circuit results in minimum EPC pressure (minimum capacity) and limits engine torque (alternate firm). Not all gears	WIRING OR SUPER SOLENOID

				present. Open circuit: maximum PC A pressure, harsh engagements and shifts.	
P1729	4x4 Low	4x4 Low switch failure	4x4 Low switch failure during normal vehicle operation.	Early shifts, harsh shifts, increase in electronic pressure control valve.	WIRING OR 4X4 SWITCH
P1728	Trans	Transmission slip error	The PCM has detected an excessive amount of slippage during normal operation.	Transmission slippage erratic or no torque converter clutch operation.	COMPLETE TRANSMISSION FAILURE

E4OD/4R100 TECHNICAL INFORMATION

Both the E4OD (introduced in 1989) and the 4R100 (1998 and up) transmissions are basically one and the same and we shall group technical information together as it's the same.

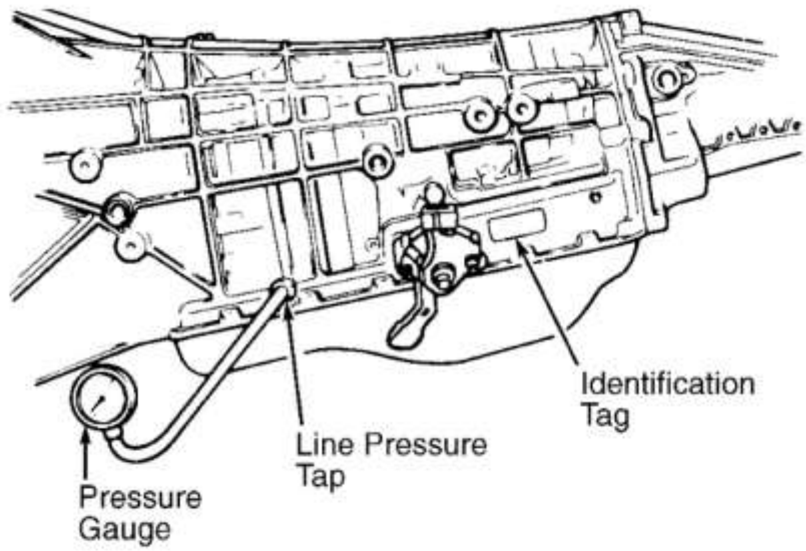
Ratios:

1st Gear: 2:71 to 1
2nd Gear: 1:54 to 1
3rd Gear: 1 to 1
4th Gear: .71 to 1
Reverse: 2:18 to 1
Lock up is either on/off or PWM controlled depending on year/model.

Clutches	1st	2nd	3rd	4th	Rev	Man 1	Man2
Forward	X	X	X	X		X	
Int.		X	X	X			
Direct			X	X	X		
O/D				X			
O/R					X	X	X
L/Rev.					X	X	
2nd band							X
Low Sprague	hold					hold	
o/r Sprague	hold	hold	hold			hold	hold
Int sprague		hold					hold

Ove run clutches are applied with overdrive button off in forward gears. Limp mode or total power failure will give you 4th gear and reverse only in these transmissions. Some trouble codes will result in limp mode of 1-3rd gears with high line pressure and no 4th or lock up.

Pressure Tests

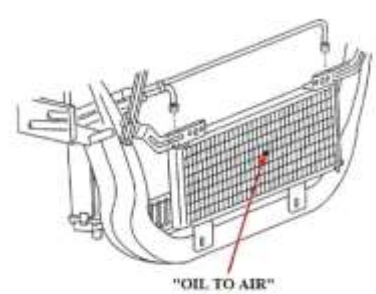


LINE PRESSURE SPECIFICATIONS

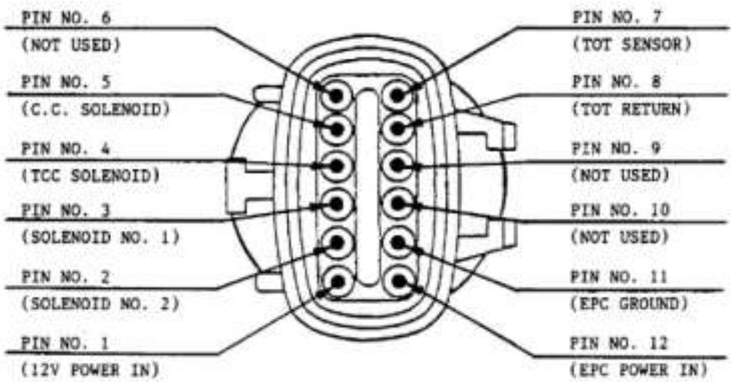
Selector Lever Position	Idle psi (kg/cm^2)	WOT Stall psi (kg/cm^2)
"P" & "N"	50-65 (3.5-4.6)	(Not Applicable)
"R"	70-100 (4.9-7.0)	245-290 (17.2-20.3)
"OD" & "2"	50-65 (3.5-4.6)	165-185 (11.6-13.0)
"1"	(1) 70-100 (4.9-7.0)	175-210 (12.3-14.7)
(1) On Expedition/Navigator models, 145-175 (10.2-12.3).		

Use a 0-300 P.S.I. gauge for pressure testing. Do not maintain wide open throttle test for more than 5 seconds at a time or transmission damage can result. Apply parking brake at all times and use wheel blocks. Apply service brake during all tests. Do no drive vehicle during tests.

Cooler flushing: If you have a 1998 and newer truck with an auxiliary cooler like the one pictured to the right and you're rebuilding or replacing the transmission you must replace the cooler with new from Ford or aftermarket replacement. This will not flush debris out with flushing machine due to its internal construction. Reuse can result in debris getting back into your new transmission from this cooler.



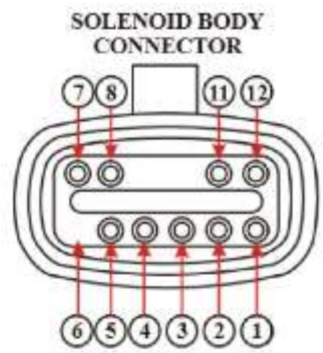
Wiring Terminal pin-outs



1989-1994 E4OD case connector E4OD and 98 and up

1995 and up

4R100 case connector



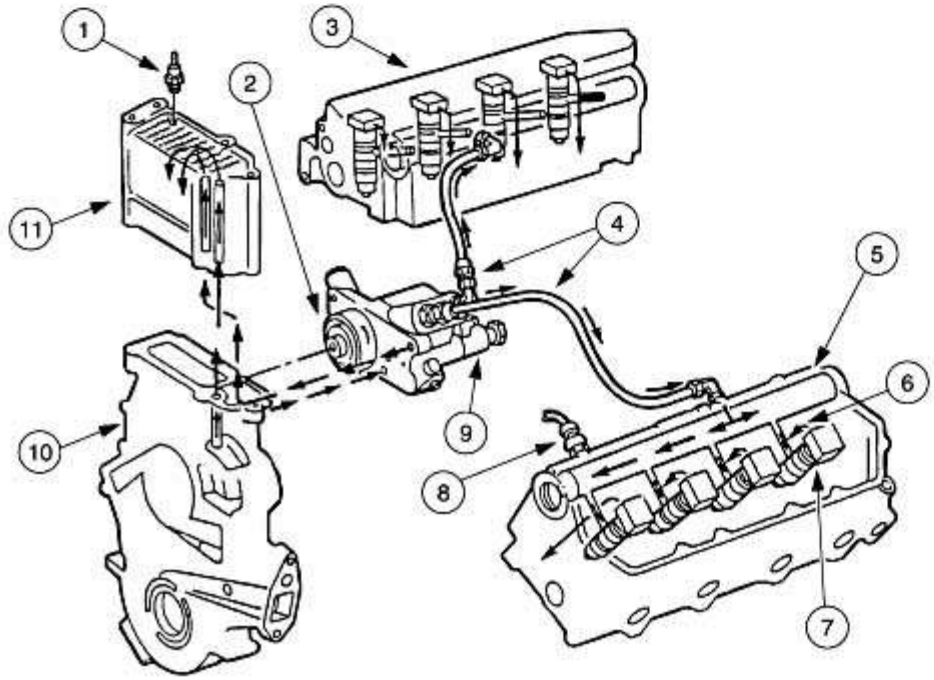
Solenoid Resistance Chart		
Solenoid	Solenoid Body Pin Numbers	Resistance
Shift Solenoid "B" (2)	1 and 2	20-30 Ohms
Shift Solenoid "A" (1)	1 and 3	20-30 Ohms
TCC Solenoid, Gasoline (On-Off)	1 and 4	20-30 Ohms
TCC Solenoid, Diesel (PWM)	1 and 4	10-20 Ohms
Coast Clutch Solenoid	1 and 5	20-30 Ohms
Electronic Pressure Control Solenoid	11 and 12	3.0-5.0 Ohms
Transmission Fluid Temp Sensor	7 and 8	See Chart Below

Transmission Fluid Temperature		
°C	°F	Resistance
-40 to -20	-40 to -4	1062k - 284k W
-19 to -1	-3 to 31	284k - 100k W
0 - 20	32-68	100k - 37k W
21-40	69-104	37k - 16k W
41-70	105-158	16k - 5k W
71-90	159-194	5k - 2.7k W
91-110	195-230	2.7k - 1.5k W
111-130	231-266	1.5k - 0.8k W
131-150	267-302	0.8k - 0.54k W

1995 and up vehicles used either PWM or on-off TCC solenoid. To identify which you have look at the internal plastic solenoid cover: Black color is on-off and grey color is PWM.

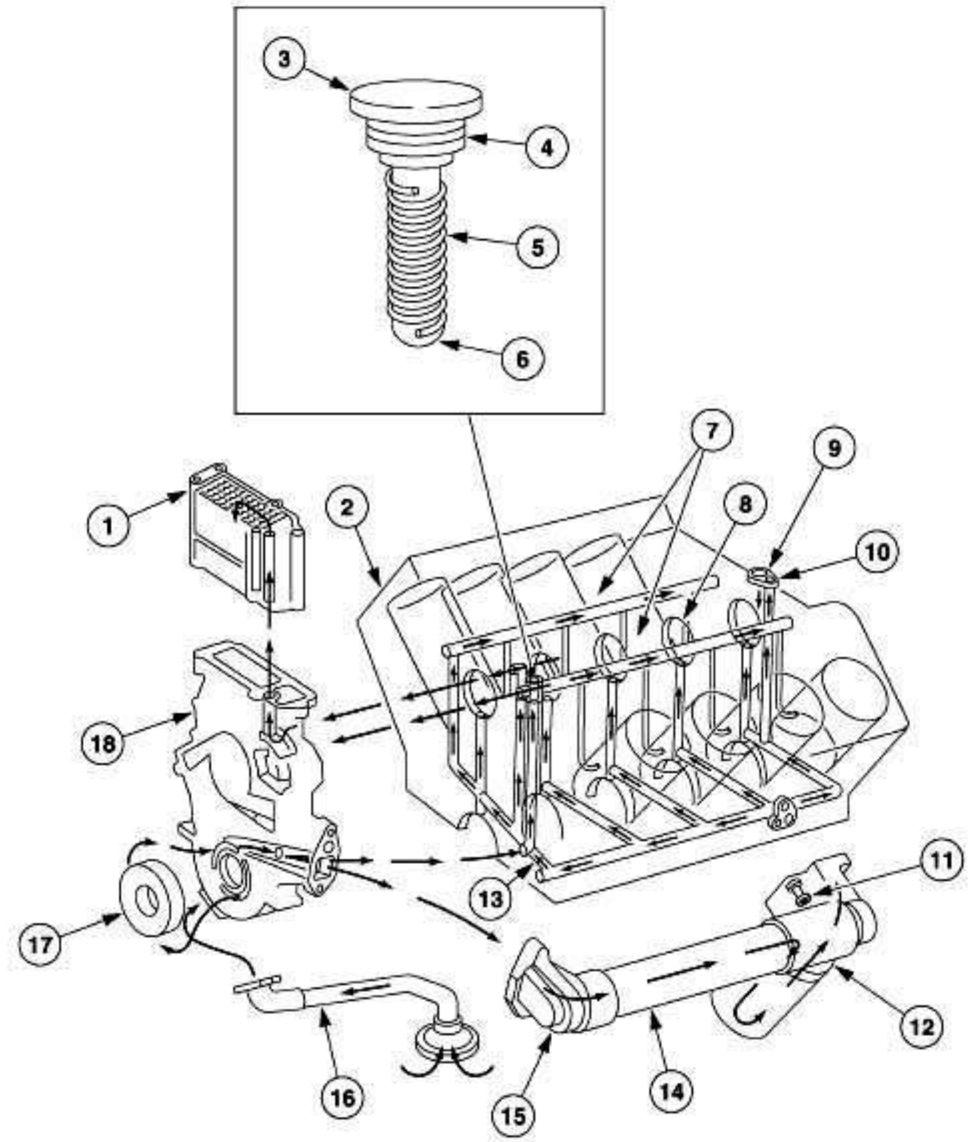
(All diesels are PWM after 1995 and most gas are on-off however some gas engine vehicles are also PWM thru 2001.)

HIGH FLOW OIL SYSTEM FLOW



Item	Part Number	Description
1	9278	Low Pressure Oil Sensor (EOP)
2	6600	**H**igh **P**ressure **O**il **P**ump (HPOP)
3	6049	Cylinder head
4	9A332	High-pressure oil feed hoses
5	—	High-pressure oil rail
6	—	Injector oil feed galleries
7	9F593	Fuel injectors (8 required)
8	9F838	**I**njection **C**ontrol **P**ressure Sensor (ICP)
9	7A139	**I**njection **P**ressure **R**egulator (IPR)
10	6019	Engine front cover
11	6658	**H**igh **P**ressure **O**il **P**ump Reservoir

LOW FLOW OIL SYSTEM



Item Part Number Description

1 6658 High-pressure oil pump reservoir
2 6010 Cylinder block
3 — Anti-drain check ball cap (part of 6658)
4 — O-ring seal (part of 6658)
5 — Spring (part of 6658)
6 — Check ball (part of 6658)
7 — Valve lifter oil galleries (part of 6010)
8 6C327 Piston cooling oil jet
9 — Turbocharger oil return gallery (part of 6010)
10 — Turbocharger oil supply gallery (part of 6010)
11 — Pressure relief/regulator valve (part of 9155)
12 — Oil filter bypass drain (part of 6881)
13 — Main oil gallery (part of 6010)
14 6A642 Oil cooler
15 6881 Oil cooler header
16 6622 Oil pump screen cover and tube
17 6608 Gerotor oil pump
18 6019 Engine front cover