RELATED DIAGNOSIS/SERVICE PROCEDURES

Fuel Injection System Diagnosis

Diagnosis of the fuel injection system includes the following diagnostic steps.

INJECTION PUMP

To check the fuel supply to the injection pump (figure 4-9):

1. Check that the output of the lift pump is correct:
   - Volume of at least 0.24 liter (1/2 pint) in 15 seconds
   - Pressure of 40 to 60 kPa (5.8 to 8.7 psi)
2. Check that the restriction of the fuel filter is not excessive:
   - Lift pump volume and pressure should be present at the inlet of the injection pump.
3. Check the fuel entering the injection pump for the presence of air, using a transparent hose:
   - If air bubbles appear, check the lift pump suction line for air leakage under a vacuum.
4. Check the quality of the fuel:
   - If necessary, use a fuel with a known cetane rating.

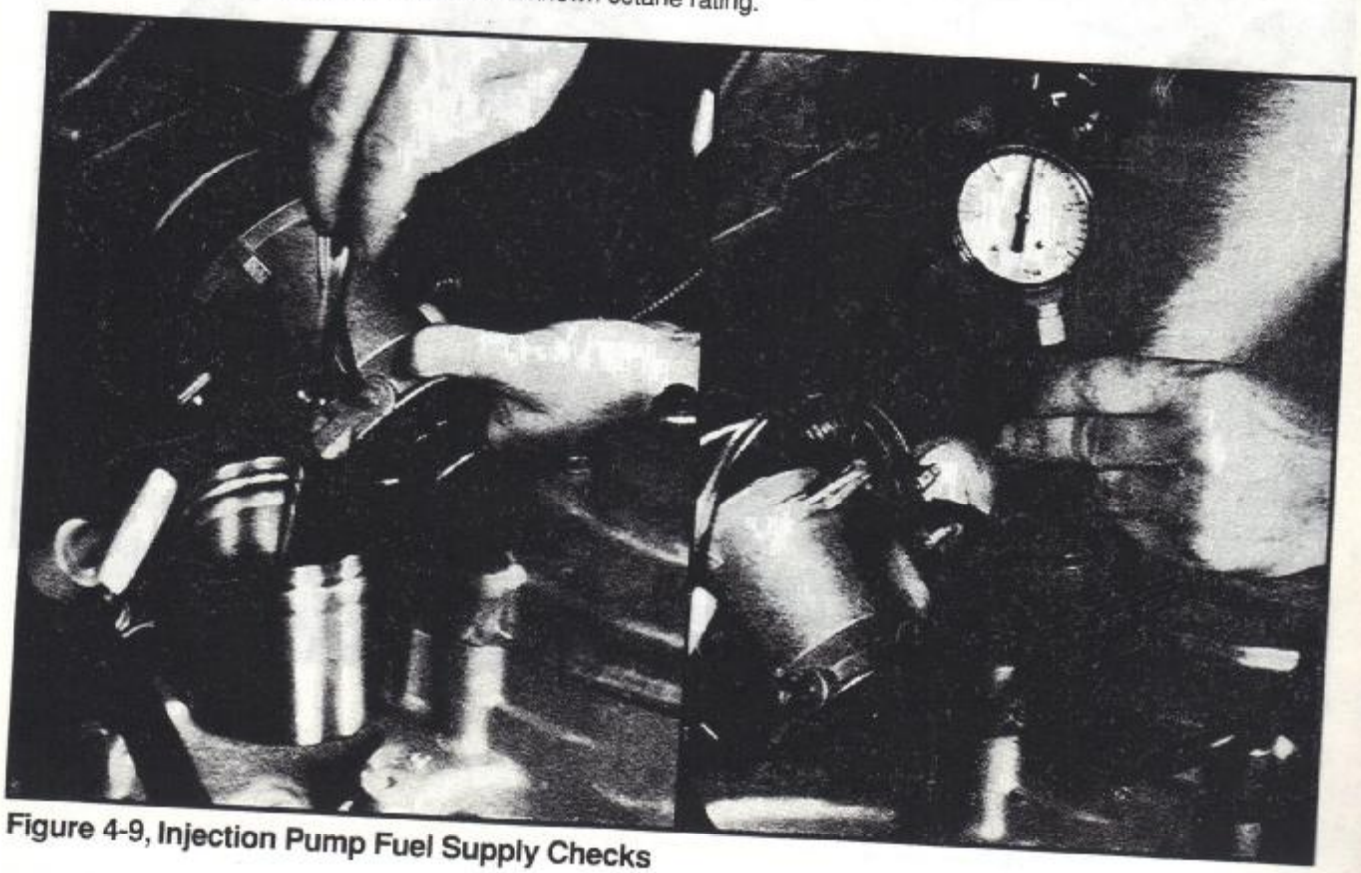

Figure 4-9, Injection Pump Fuel Supply Checks

INJECTION PUMP

The 6.5L diesel engine uses the Stanadyne model DS rotary distributor fuel pump consisting of the following components (figure 4-5):

- A fuel solenoid driver that determines fuel metering by controlling the fuel solenoid
- An optical/fuel temperature sensor that supplies the PCM with pump speed, rotor position, cam ring position and fuel temperature information
- An engine shutoff (ESO) solenoid located on top of the pump
- An injection timing stepper (ITS) motor that controls injection timing advance and retard
- A fuel solenoid that opens and closes a control valve for pump fill and spill activity
- Inlet and outlet ports for fuel to and from the pump

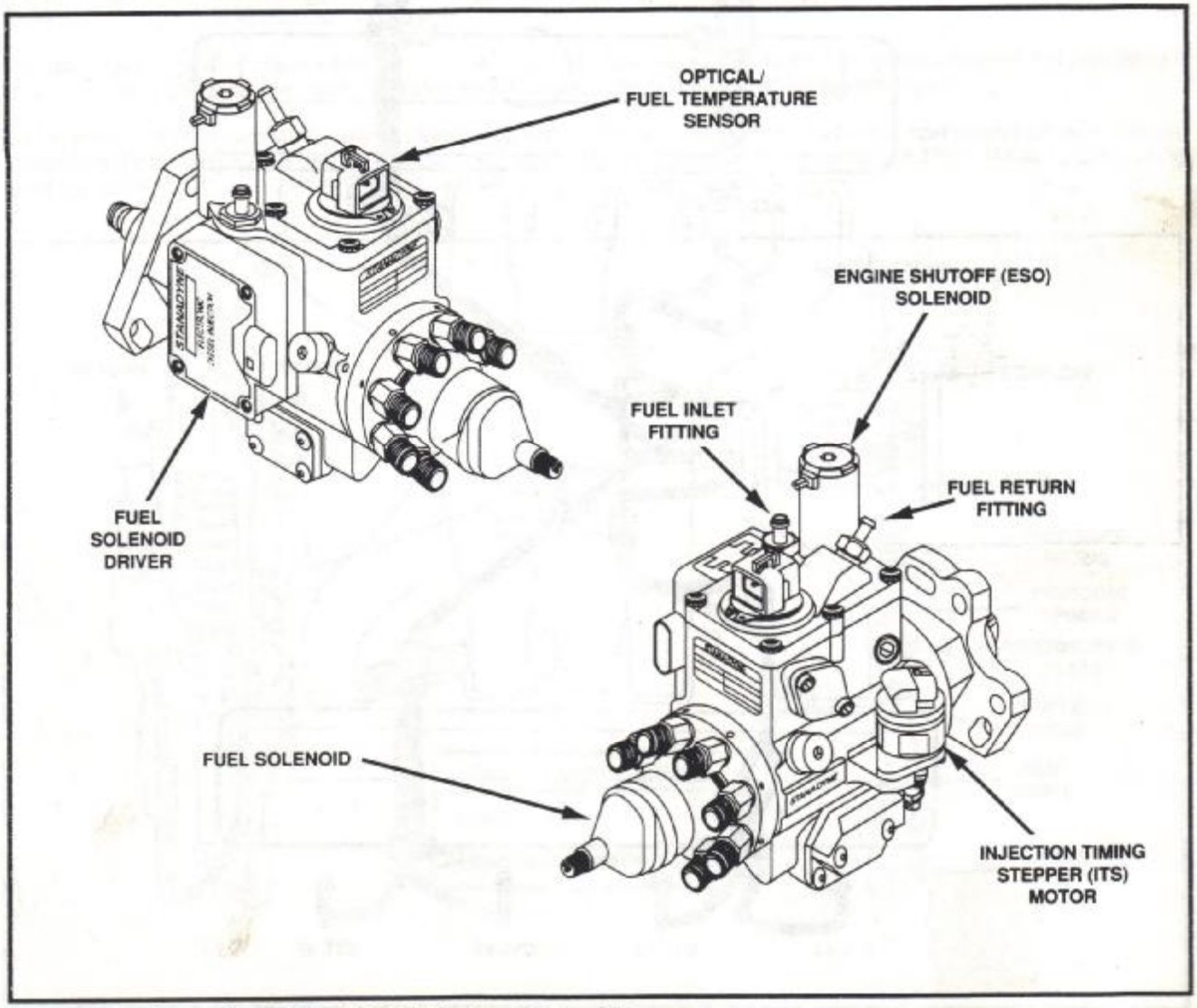

Figure 4-5, Stanadyne Model DS Electronic Fuel Pump

Fuel Contamination Inspection and Cleaning

— IMPORTANT —
The following procedure checks for the presence of water and gasoline in diesel fuel that may cause injection pump and nozzle damage.

1. Remove the fuel filter element and inspect it:
   - If water, gasoline or fungi/bacteria are not present, end the inspection.
   - If water or fungi/bacteria are present, go to step 2.
   - If gasoline is present, go to step 3.
2. Clean water from the fuel system in these steps:
   A. Disconnect the batteries.
   B. Drain the fuel tank.
   C. Remove the fuel tank.
   D. Remove the fuel sender unit.
   E. Inspect the fuel tank and fuel sender for rust, fungi or bacteria:
      - If no rust is present, clean the inside of the fuel tank and fuel sender with hot water, then dry them with compressed air.
      - If rust is present, replace affected parts.
   F. Disconnect the ends of the following lines:
      - Lift pump suction
      - Lift pump feed
      - Fuel filter outlet
      - Fuel filter drain
      - Fuel return
   G. Inspect each of the lines and replace any rusted pipes.
   H. Dry the inside of each line with low-pressure air.
   I. Clean the inside of the fuel filter housing and dry it with compressed air.
   J. Disconnect the electrical connector for the engine shutoff (ESO) solenoid in the injection pump.
   K. Install a new fuel filter element.
   L. Install the fuel pick-up/sending unit and fuel tank (add clean diesel fuel to one-quarter full).

— CAUTION —
The 6.5L EFI diesel engine could start momentarily even with the ESO solenoid disconnected.

2. *Cleaning water from the fuel system, continued...*

M. Connect the following lines:

- Lift pump suction (both ends)
- Lift pump feed (both ends)
- Fuel filter drain
- Fuel return (at injection pump)

N. Connect the fuel filter outlet and the fuel return line at the pick-up/sending unit to hoses that flow to metal containers.

O. Connect the batteries and crank the engine until clean fuel flows from the fuel filter outlet into a metal container (figure 4-11):

- Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.

P. Connect the hose from the fuel filter outlet to the injection pump inlet.

Q. Open each injection line at its nozzle end and crank the engine until clean fuel flows from it:

- Use two wrenches when loosening the injection line fittings.
- Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.

R. Tighten each injection line fitting at its nozzle:

- Use two wrenches when tightening the injection line fittings.

S. Connect the electrical connector for the ESO solenoid in the injection pump.

Figure 4-11, **Fuel System Cleaning (1 of 2)**

2. *Cleaning water from the fuel system, continued...*
   T. Start and run the engine for 15 minutes while fuel flows from the fuel return line into a metal container (figure 4-12).
   U. Stop the engine.
   V. Connect the fuel return hose to the fuel sender.
   W. Clean the engine of fuel spillage.
   X. Fill the fuel tank and add a biocide, if needed.

3. Clean gasoline from the fuel system in these steps:
   A. Determine a procedure:
      - If the engine runs, follow steps B, C, and I.
      - If the engine does not run, begin at step B.
   B. Drain the fuel tank.
   C. Fill the fuel tank.
   D. Disconnect the electrical connector for the ESO solenoid in the injection pump.
   E. Remove the fuel filter outlet and connect it to a hose that flows to a metal container.
   F. Crank the engine until clean fuel flows from the fuel filter outlet into a metal container:
      - Allow a maximum of 15 seconds cranking time, followed by 1 minute of cranking motor cooling time.
   G. Connect the hose from the fuel filter outlet to the injection pump inlet.
   H. Connect the electrical connector for the ESO solenoid in the injection pump.
   I. Start and run the engine for 15 minutes.
   J. Stop the engine.
   K. Clean the engine of fuel spillage.

Figure 4-12, Fuel System Cleaning (2 of 2)

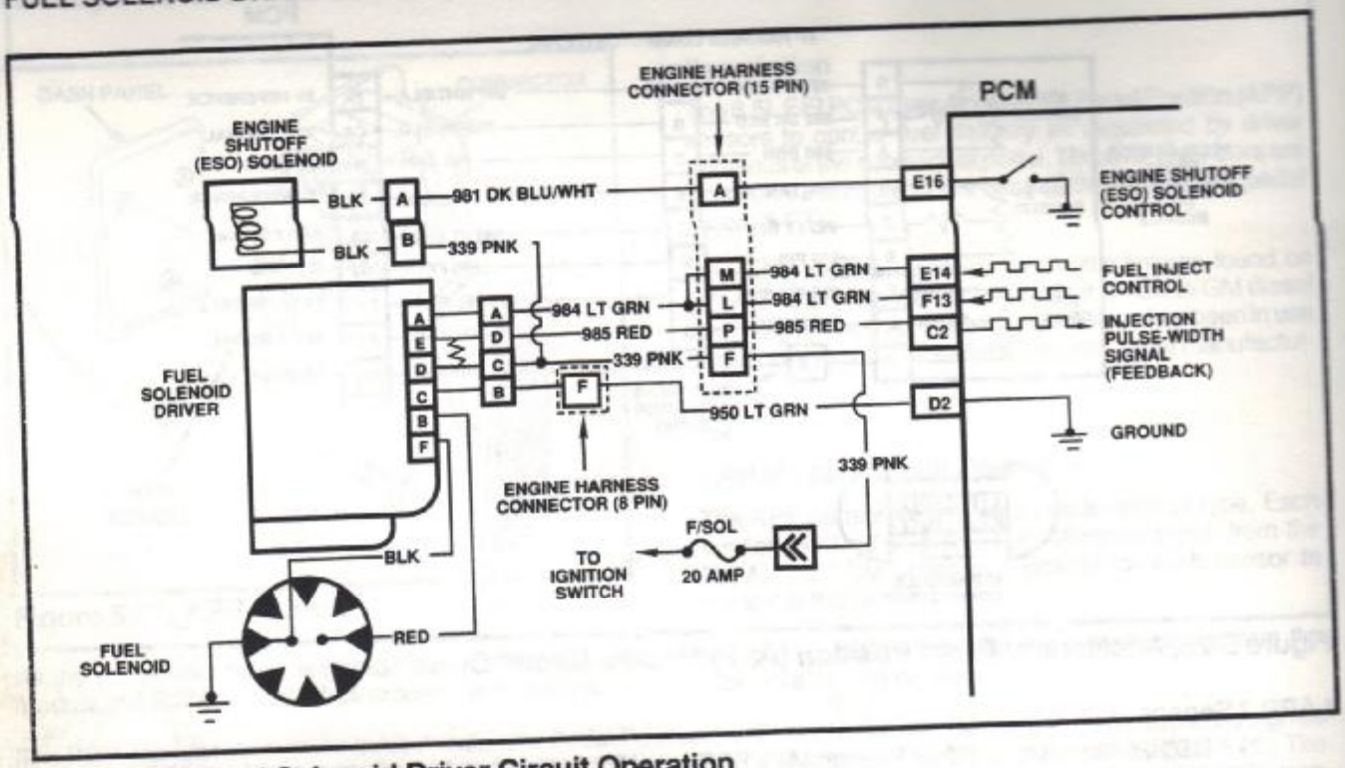

Figure 5-29, Fuel Solenoid Driver Circuit Operation

Fuel Solenoid Driver Circuit Operation

The fuel solenoid driver receives an inject-command signal from the PCM on CKT 984 (figure 5-29). The driver provides current-regulated output to the fuel solenoid that controls fuel pump metering injection. The driver also returns an injection pulse-width modulated (PWM) signal back to the PCM on CKT 985. This signal tells the PCM when the fuel solenoid plunger seats. The PCM uses a calibrated injection pump-mounted resistor to determine fuel rates. The resistor value of the pump is stored in PCM memory. If PCM memory has been disturbed or the PCM has been replaced, the PCM will relearn the resistor value on the next ignition cycle and store this value.

DTC 35 — "Injection Pulse Width Error (Response Time Short)"

DTC 35 sets when battery voltage is greater than 10 volts, coolant temperature is at or above 20°C (68°F), and response time of the fuel injection solenoid is less than 1.5 milliseconds as indicated by the voltage signal on CKT 985.

DTC 36 — "Injection Pulse Width Error (Response Time Long)"

DTC 36 sets when battery voltage is greater than 10 volts, coolant temperature is at or above 20°C (68°F), and response time of the fuel injection solenoid is greater than 2.5 milliseconds as indicated by the voltage signal on CKT 985.

DTC 56 — "Injection Pump Calibration Resistor Error"

DTC 56 sets when the injection pump resistor value is not present. This could be caused by the PCM having lost its memory or the PCM being unable to read a resistor value on CKT 985 on the next ignition cycle. When DTC 56 is set, a current and history DTC will store and the "Service Engine Soon" malfunction indicator lamp will illuminate. The PCM will default to the lowest fuel table, and possible poor engine performance will be noticed.The current DTC 56 will clear on the next ignition cycle. However, the history DTC 56 will remain in the PCM.

Component Operation

OPTICAL SENSOR

Description

The optical sensor is located in the fuel injection pump (figure 5-36) and includes the fuel temperature sensor. The optical sensor counts the pulses emitted by a disc in the fuel pump. The disc is a silver-colored, film-like ring notched with two sets of notches.

- The outer diameters consists of 512 notches that provide the PCM with pump speed information.
- The inner diameter uses eight notches, one for each cylinder, to send pump cam reference information.

The optical sensor transmits pulses from these notches to the PCM as a voltage signal known as the high resolution signal (small notches) or pump cam signal (large notches). The PCM relies on the optical sensor to identify pump position. The high resolution signal is one of the most important PCM inputs for determining fuel control and timing.

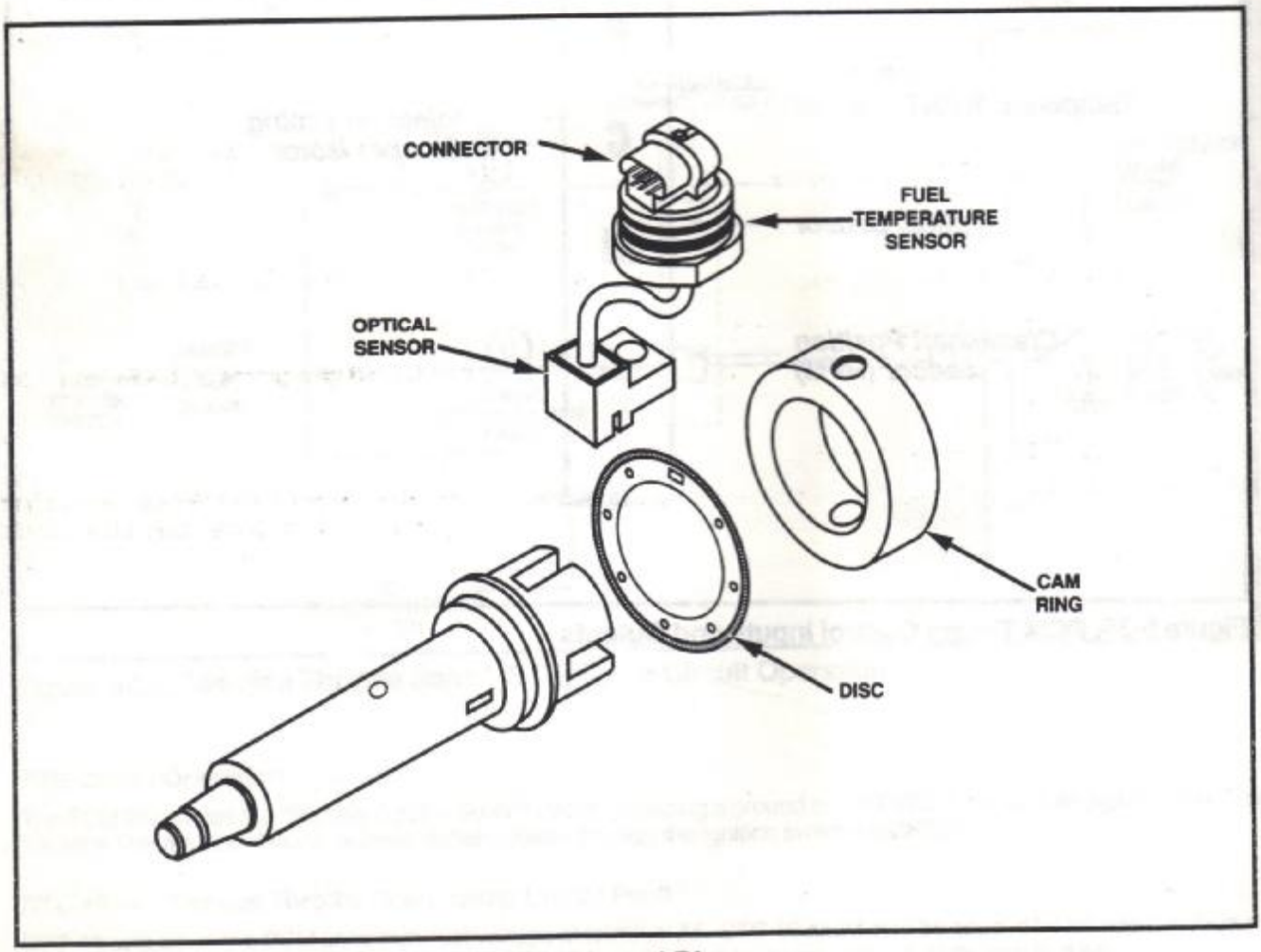

Figure 5-36, **Optical/Fuel Temperature Sensor and Disc**

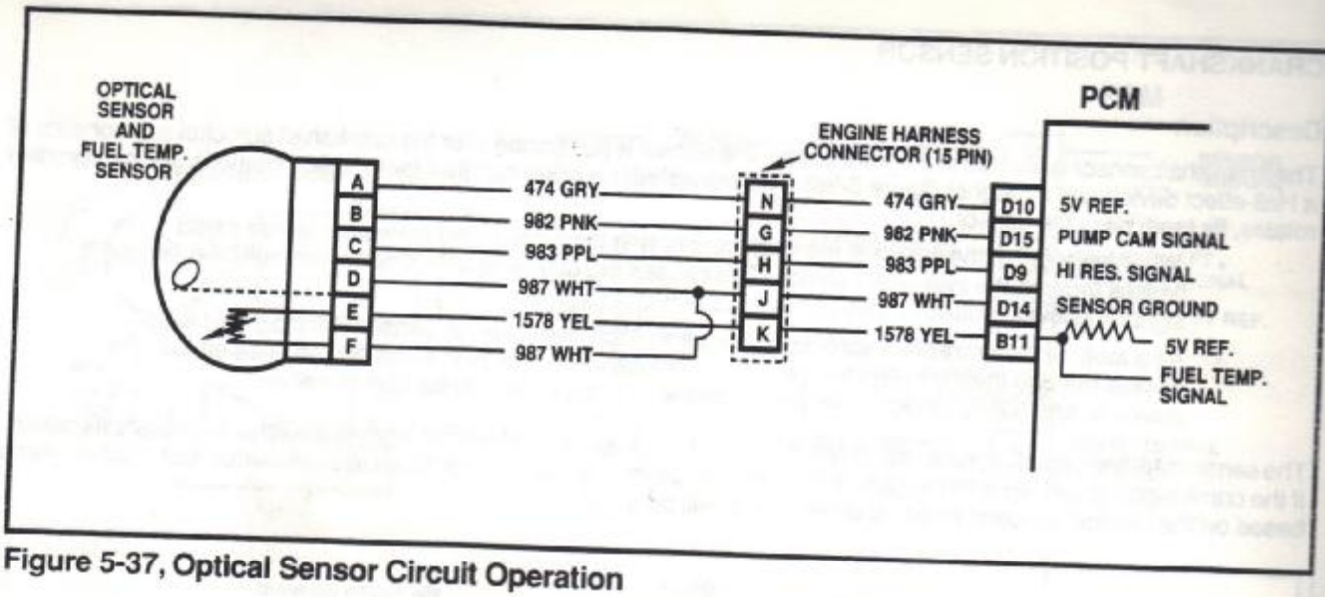

Figure 5-37, Optical Sensor Circuit Operation

Optical Sensor Circuit Operation

The PCM sends a 5 volt reference signal to the optical sensor on CKT 474 (figure 5-37). The sensor returns two signals to the PCM: a high resolution signal on CKT 983 and a cam signal on CKT 982. Both are regulated-current signals read by the PCM. The high resolution signal pulses 512 times per one revolution of the injection pump. The cam signal pulses 8 times per one revolution of the pump.

When the signal on either circuit to the PCM is out of calibration, the PCM sets a Diagnostic Trouble Code (DTC).

DTC 17 — "High Resolution Circuit Fault"

DTC 17 identifies a missing high resolution signal. It sets when the PCM receives 8 cam pulses on CKT 982 without receiving a corresponding high resolution signal on CKT 983.

DTC 18 — "Cam Reference Pulse Error"

DTC 18 identifies a missing cam pulse. It sets when the PCM detects 8 missing cam pulses on CKT 982 for every crankshaft position pulse received on CKT 643 (see crankshaft position sensor/DTC 19). If DTC 17 and 18 are both stored, it could indicate a problem with CKTs 474 or 987.

SECTION 4

DIAGNOSTIC TROUBLE CODES (DTC's) FOR THE 6.5L DIESEL ENGINE

For the 1996 model year, a new set of standardized diagnostic trouble codes has been established as part of the new On Board Diagnostics System known as OBD II. A cross reference listing of the old and the new DTC codes are provided below with the pump related items shown in boldface type to help assist you with your DS pump servicing. Following the cross reference listing is an explanation of the parameters which trigger the pump related DTC's to be set.

Code Description	'96 OBD II DTC	'94/'95 OBD DTC
PROM Error		51
PCM Fuel Circuit Error		54
Intake Air Temperature Sensor Circuit Low (High Temperature)	P0112	47
Intake Air Temperature Sensor Circuit High (Low Temperature)	P0113	48
Engine Coolant Temperature Sensor Circuit Low (High Temperature)	P0117	14
Engine Coolant Temperature Sensor Circuit High (Low Temperature)	P0118	15
Accelerator Pedal Position 1 Circuit Range Fault	P0121	23
Accelerator Pedal Position 1 Circuit Low	P0122	22
Accelerator Pedal Position 1 Circuit High	P0123	21
Fuel Temperature Circuit Low (High Temperature)	**P0182**	**42**
Fuel Temperature Circuit Low (Low Temperature)	**P0183**	**43**
Engine Shutoff Solenoid Circuit Fault	**P0215**	**13**
Injection Timing Stepper Motor Fault	**P0216**	**34**
Engine Overspeed Condition	P0219	
Accelerator Pedal Position 2 (5 Volt Reference Fault)	P0220	99
Accelerator Pedal Position 2 Circuit Range Fault	P0221	27
Accelerator Pedal Position 2 Circuit Low	P0222	26
Accelerator Pedal Position 2 Circuit High	P0223	25
Accelerator Pedal Position 3 (5 Volt Reference Fault)	P0225	
Accelerator Pedal Position 3 Circuit Range Fault	P0226	65
Accelerator Pedal Position 3 Circuit Low	P0227	64
Accelerator Pedal Position 3 Circuit High	P0228	63
Lift Pump Secondary Circuit Low Voltage	P0231	
Wastegate Solenoid Fault	P0236	78
Turbo Boost Sensor Circuit Low	P0237	62
Turbo Boost Sensor Circuit High	P0238	61
Pump Cam Reference Pulse Error	**P0251**	**18**
Cylinder Balance Fault #8 Cylinder	**P0263**	**98**
Cylinder Balance Fault #7 Cylinder	**P0266**	**97**
Cylinder Balance Fault #2 Cylinder	**P0269**	**92**
Cylinder Balance Fault #6 Cylinder	**P0272**	**96**
Cylinder Balance Fault #5 Cylinder	**P0275**	**95**
Cylinder Balance Fault #4 Cylinder	**P0278**	**94**
Cylinder Balance Fault #3 Cylinder	**P0281**	**93**
Cylinder Balance Fault #1 Cylinder	**P0284**	**91**
Crankshaft Position Reference Error	**P0335**	**19**
High Resolution Circuit Fault	**P0370**	**17**
Glow Plug Relay Fault	P0380	29
EGR Circuit Error	P0404	32
EGR Control Pressure/Barometric Sensor Circuit Low (High Vacuum)	P0405	31
EGR Control Pressure/Barometric Sensor CircuitHigh (Low Vacuum)	P0406	33

DIAGNOSTIC TROUBLE CODES (DTC's) FOR THE 6.5L DIESEL ENGINE (Cont'd)

Code Description	'96 OBD II DTC	'94/'95 OBD DTC
Vehicle Speed Sensor Buffer Fault	P0501	16
Resume/Accel Switch Fault	P0567	76
Set/Coast Switch Fault	P0568	71
PCM Memory	P0601	
PCM Not Programmed	P0602	
PCM Internal Communication Interrupted	P0606	
Accelerator Pedal Position Circuit Fault	P1125	84
TDC Offset Error	**P1214**	**88**
Fuel Solenoid Response Time Too Short	**P1216**	**35**
Fuel Solenoid Response Time Too Long	**P1217**	**36**
Injection Pump Calibration Resistor Error	**P1218**	**56**
A/D Performance	P1627	
PCM 5 Volt Shorted	P1635	57
Malfunction Indicator Lamp Circuit Fault	P1641	46
EGR Vent Error	P1653	45
Service Throttle Soon Lamp Circuit Fault	P1654	49
EGR Pulse Width Error	P1655	44
Wastegate Solenoid Control Circuit	P1656	

NOTE: The following DTC parameters are those used on the engine. Calibration specification parameters may be different - refer to the individual specification.

DTC 13 (P0215) - Electric Shutoff Solenoid Circuit Fault (ESO).
The injection pump fuel supply line has a solenoid controlled shutoff valve. When the solenoid is energized (key in run position), the valve is open and fuel is supplied to the injection pump.

DTC 13 (P0215) becomes active (set) when Powertrain Control Module (PCM) has:

1. Attempted to energize the engine shutoff solenoid (open valve, turn on fuel supply) AND

   voltage at ESO terminal of the PCM connector is greater than zero volts. This indicates the voltage drop across the solenoid, required to energize the coil, did not occur and the solenoid valve is closed.

2. Attempted to de-energize the engine shutoff solenoid (close valve, turn off fuel supply) AND

   voltage at ESO terminal of the PCM connector equals zero volts. This indicates a voltage drop across the solenoid coil did occur, the coil remains energized and the solenoid valve is open.

DTC 17 (P0370) - Encoder Sensor High Resolution Signal Malfunction
This test monitors the number of high resolution pulses which have been missed (not detected). It is based on a comparison between the number of pulses that were detected since the last cam pulse (low resolution) and the number of pulses that should have occurred.

DTC 17 (P0370) becomes active (set) when:

1. Eight cam pulses have occured since the last high resolution pulse was detected.

DIAGNOSTIC TROUBLE CODES (DTC's) FOR THE 6.5L DIESEL ENGINE (Cont'd)

DTC 18 (P0216) - Encoder Sensor Low Resolution Malfunction (Cam Reference Pulse).
This test monitors the number of cam pulses which have been missed (not detected). It is based on the number of crankshaft position sensor pulses (TDC) that have occurred since the last cam pulse was detected. The physical one to one correspondence between the cam and crankshafts implies if more crank pulses are detected than cam pulses, cam pulses have been missed.

DTC 18 (P0216) becomes active (set) when:

1. Eight crankshaft position sensor pulses have occurred since the last cam pulse was detected. This implies eight cam pulses have been missed.

DTC 34 (P0216) - Fuel Injection Timing Control Circuit Malfunction
Timing of the combustion event is accomplished by delivering a pulse of fuel into the combustion chamber at a desired degree of cylinder travel. This desired degree (desired timing) defines the current position of the cylinder in relationship to Top Dead Center. This test compares desired timing to measured timing when certain conditions have been met.

DTC 34 (P0216) becomes active (set) when:

1. Engine speed has not changed more than 56 RPM for 20.8 seconds AND the absolute value of the timing error exceeds 8 degrees. (The difference between desired timing and measured timing is greater than 5 degrees for both DTC 34 and DTC P0216.)

DTC 35 (P1216) - Fuel Control Solenoid Response Time Too Short (Closure Time).
The injection pump delivers fuel to individual cylinders by opening and closing a solenoid controlled fuel valve. The PCM monitors the amount of time it takes for the fuel solenoid valve to physically close after being commanded to close. Closure time out of range is seen as a fault.

DTC 35 (P1216) becomes active (set) when:

1. Battery voltage is greater than 10 volts but less than 16 volts AND
   engine coolant temperature is greater than 20°C (68°F) AND
   engine speed is greater than 506 RPM AND
   requested fuel is greater than 0.0mm^3 AND
   closure time is less than 1.2 milliseconds for DTC 35 (0.75 milliseconds for DTC P1216).

DTC 36 (P1217) - Fuel Control Solenoid Response Time Too Long (Closure Time).
The injection pump delivers fuel to individual cylinders by opening and closing a solenoid controlled fuel valve. The PCM monitors the amount of time it takes for the fuel solenoid valve to physically close after being commanded to close. Closure time out of range is seen as a fault.

DTC 36 (P1217) becomes active (set) when:

1. Battery voltage is greater than 10 volts but less than 16 volts AND
   engine coolant temperature is greater than -20°C(68°F) AND
   engine speed is greater than 506 RPM AND
   requested fuel is greater than 0.0mm^3 AND
   closure time greater than 2.45 milliseconds.

DIAGNOSTIC TROUBLE CODES (DTC's) FOR THE 6.5L DIESEL ENGINE (Cont'd)

DTC 42 (P0182) - Fuel Temperature Sensor Circuit Low Input (Unreasonably High Temperature Measured).

The thermistor sensing the fuel temperature is a NTC (negative temperature coefficient), therefore as temperature increases the resistance of the thermistor decreases. The voltage measured across the thermistor is interpreted as a temperature.

DTC 42 (P0182) becomes active (set) when:

1. The fuel temperature is greater than 102°C (215°F).

DTC 43 (P0183) - Fuel Temperature Sensor Circuit High Input (Unreasonably Low Temperature Measured).

The thermistor sensing the fuel temperature is a NTC (negative temperature coefficient), therefore as temperature increases the resistance of the thermistor decreases. The voltage measured across the thermistor is interpreted as a temperature.

DTC 43 (P0183) becomes active (set) when:

1. The engine has been running longer than 2 minutes AND

   the sensor indicates a temperature below -14°C (6°F) for DTC 43 or 8 minutes and 17°C (63°F) for DTC P0183.

DTC 56 (P1218) - Injection Pump Calibration Resistor Fault.

Each injection pump has a calibration resistor installed in the pump mounted driver connector housing. The value of the calibration resistor, measured by the PCM, determines which of eight possible correction tables will be used in providing the correct fuel for injection. This test reports if a valid calibration resistor has been detected.

DTC 56 (P1218) becomes active (set) when:

1. PCM currently does not have a valid resistor value AND

   PCM is unable to read a valid resistor value.

DTC 88 (P1214) - TDC Offset Error

If the PCM is replaced or other components affecting timing are removed or replaced, TDC Offset must be reprogrammed into the PCM. Failure to Program TDC will result in DTC 88 (P1214).

DTC 88 (P1214) becomes active (set) when:

The TDC Offset is greater than ± 2.0° for DTC 88 and ± 2.5° for DTC P1214.

NOTE: DTC 88 (P1214) along with DTC 34 (P0216) may mean that the drive hub has slipped on the pump drive shaft, the advance piston is stuck in its bore or the engine crankshaft key is sheared.