ISUZU

Engine Diagnostic and Drivability Training

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Preface

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This *Participant's Manual* is designed to support the training course for applicable vehicles and vehicle systems. Refer to service information for complete repair procedures and diagnostics. Procedures are subject to change, with or without notice. Refer to the Service Bulletins for applicable vehicles for updates and current vehicle information.

In order to reduce the chance of personal and/or property damage, carefully observe the instructions that follow.

Service information provided by Isuzu Commercial Truck of America is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could result in injury to you or to others. Failure to observe the procedures can also lead to vehicle damage or cause improper vehicle operation.

Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If replacement parts are to be used, always use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and present in this workbook, as well as in the in-class guide, are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes. Do not use tools which are not designed for any specific task.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by Isuzu Commercial Truck of America must first establish that there is no jeopardy to personal safety or the safe operation of any motor vehicle.

This workbook may contain Cautions that you must observe carefully in order to reduce the risk of injury to yourself or others. This workbook also contains Notices that must be carefully followed in order to properly service the vehicle, and to avoid damage to the vehicle, tools, or equipment.

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Caution

Caution

In order to reduce the risk of personal injury or property damage, carefully observe the following information:

The service information of Isuzu Commercial Truck of America is intended for use by professional, qualified technicians. Attempting service procedures without the appropriate training, tools, and equipment could cause personal injury, vehicle damage, or improper vehicle operation. Proper vehicle service is important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If a replacement part is needed, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service information contains effective methods for performing service procedures. Some of the procedures require the use of tools that are designed for specific purposes.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by Isuzu Commercial Truck of America, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

The service information contains Cautions and Notices that must be observed carefully in order to reduce the risk of personal injury. Improper service may cause vehicle damage or render the vehicle unsafe. The Cautions and Notices are not all-inclusive. Isuzu Commercial Truck of America can not possibly warn of all the potentially hazardous consequences that may result by not following the proper service procedures.

The service information covers service procedures for vehicles that are equipped with Supplemental Inflatable Restraints (SIR). Failure to observe all SIR Cautions and Notices could cause air bag deployment, personal injury, or otherwise unneeded SIR repairs. Refer to the SIR component and wiring location views in Restraints before performing a service on or around SIR components or wiring.

If multiple vehicle systems are in need of repair, including SIR, repair the SIR system first to reduce the risk of accidental air bag deployment and personal injury

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Course Objectives

- To provide an overview of what is expected of students in the course, to understand the basic operation of the engine and specific features of the 4HK and 6HK engines, and to be able to identify components on the vehicle.
- To provide an overview of the 4HK and 6HK series fuel and engine management systems, including inputs and outputs of the ECM, along with sensor operation.
- To learn how to properly diagnose the engine and where to find procedures.
- To provide a basic understanding of the VNT turbocharger on both the 4HK and 6HK engines.
- To provide a basic understanding of cam timing, valve adjustment and fuel injection pump timing procedures.

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Table of Contents

2005 – 2007 4HK1-TC Engine

On the 2005 - 2007 model year NPR/NQR truck, the 4HK1-TC in-line 4-cylinder engine replaces the 4HE1-TC engine. The newly-developed 4HK1-TC engine, based on the previous 4HE1-TC engine, has additional features including the use of a four valve mechanism per cylinder operated via a single camshaft, a common rail fuel injection system, a water-cooled exhaust gas re-circulation (EGR) system, and the change of combustion chamber form. The larger engine displacement and the common rail fuel injection system have resulted in an increase in both maximum output and torque, and meets emission regulation standard..

2007i – 2010 4HK1-TC Engine with DPF

From the 2007i model year, the 4Hk1 engine meets a new emission regulation (EPA 07) by adopting an exhaust gas after treatment device, etc. The main items changed are listed below:

- Electrically controlled intake throttle valve
- Two laminated corrugated type water cooled EGR coolers
- Variable nozzle turbocharger
- Diesel particulate filter (DPF) assembly
- Cold weather fuel heating system
- Gear driven vacuum pump
- Closed crankcase ventilation system
- ECM controlled engine shutdown warning system

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Horsepower and Torque Ratings

	Horsepower	Torque
4HE1	179hp @ 2700rpm	347lb ft @ 2000-2200rpm
4HK1 (‘05 to ’07)	190hp @ 2500rpm	387lb ft @ 1500-2200rpm
4HK1 (’07i to 2010)	200hp @ 2400rpm	441lb ft @ 1850-2350rpm

On-board Computer Controlled Components

On-board Diagnostics

- On-board diagnostic capabilities are incorporated into the
  - Hardware
  - Software

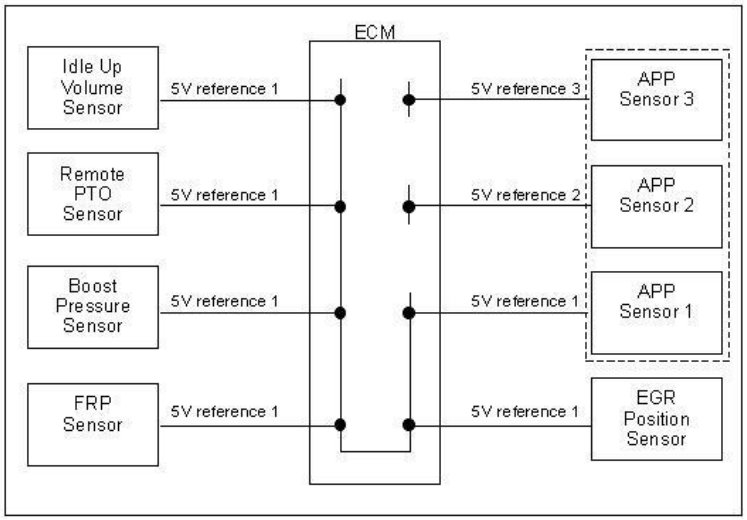
  of the vehicles on-board computer to
  - Monitor
  - Detect
  - Report

  Emission performance malfunctions, component malfunctions and system malfunctions

- The central focus of an OBD compliant emission control system is the operation of supported monitors
- All systems and components that play a significant role in the vehicle's emissions output must be monitored using one or more of the following:
  - Electrical Tests:
    - Testing sensors and actuators for continuity, short circuits, signal out-of-range
  - Rationality Tests:
    - Determining whether the data provided for the sensor is logical when considering other data input
  - Functional Tests:
    - Analyzing whether a device is responding properly to computer commands. Functional tests can be active or passive.

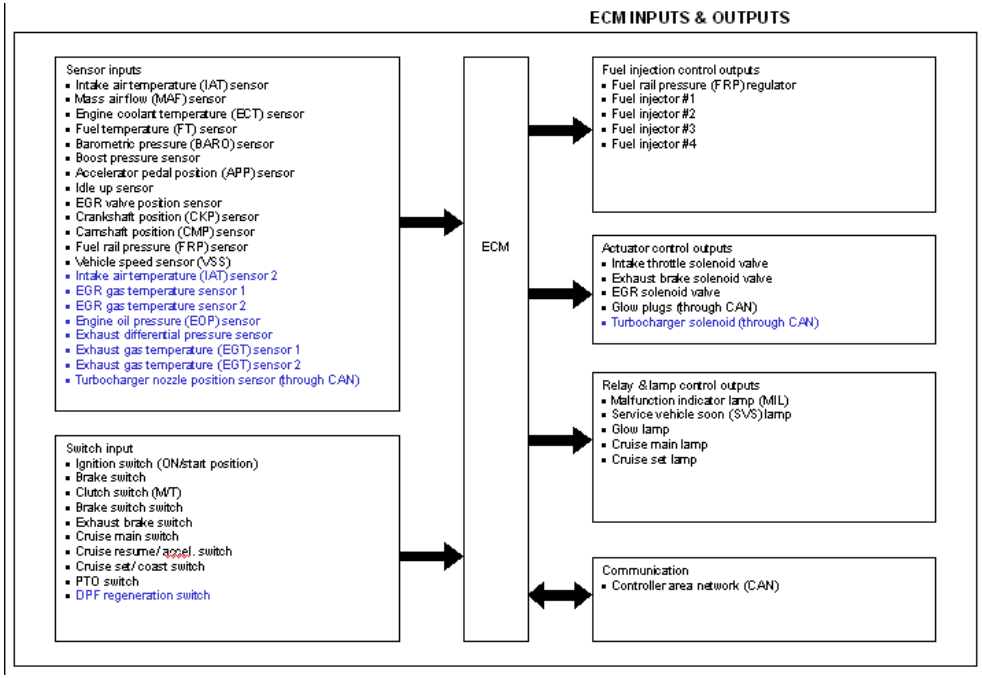
ECM/PCM

- Description
  - Provides 5 Volt Reference to various sensors
  - Observes information from various sensors
  - Controls the systems that affect performance
    - The fuel system control
    - The exhaust gas recirculation (EGR) system control
    - The preheating (glow) system control
    - Exhaust brake system control
    - Power take off (PTO) system control
    - On-board diagnostics for engine control
    - Diesel Particulate Filter (DPF)
  - Performs diagnostic functions
  - Recognizes operational problems
  - Alerts the driver through the Malfunction Indicator Light (MIL)
  - Stores Diagnostic Trouble Codes (DTCs) that identify system faults to aid the technician in making repairs



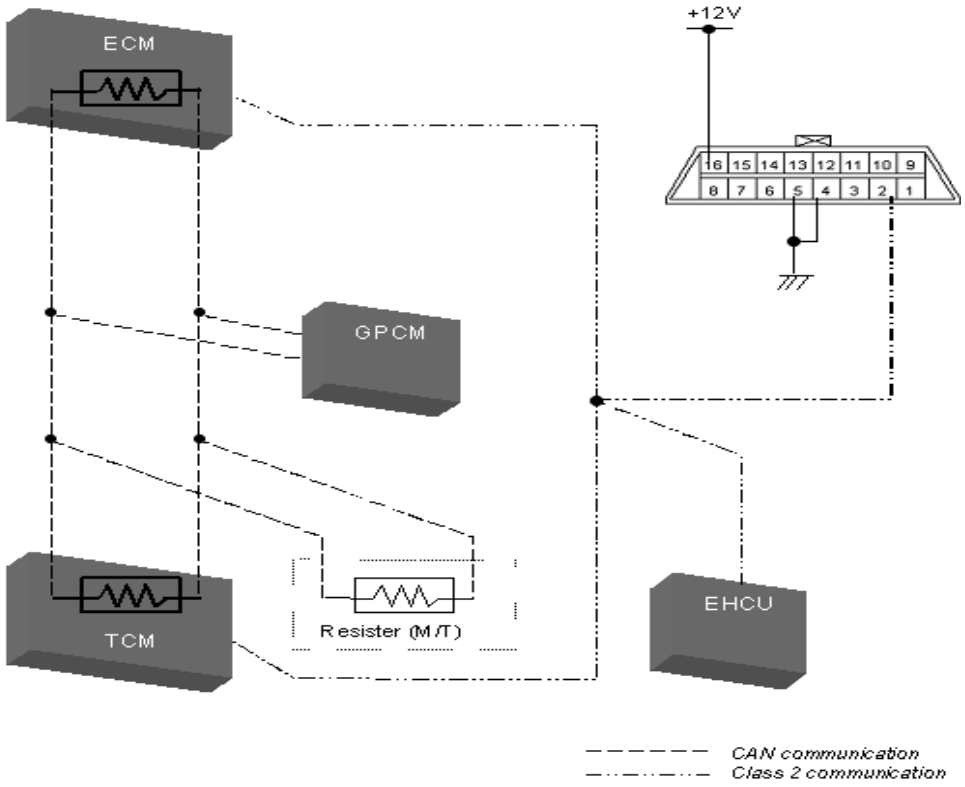
ECM/PCM Inputs & Outputs

- Input components may include:
  - Crank angle sensor
  - Throttle position sensor
  - Cam position sensor
  - Intake air temperature sensor
  - Boost pressure sensor
  - Manifold pressure sensor
  - Mass air flow sensor
  - Exhaust temperature sensor
  - Exhaust pressure sensor
  - Fuel pressure sensor
- Output components may include:
  - Idle speed control system
  - Glow plug system
  - Variable vane turbo control
  - Wait to start lamp
  - MIL
  - Electronic Fuel Pressure Regulator
  - Electronic Fuel Injectors

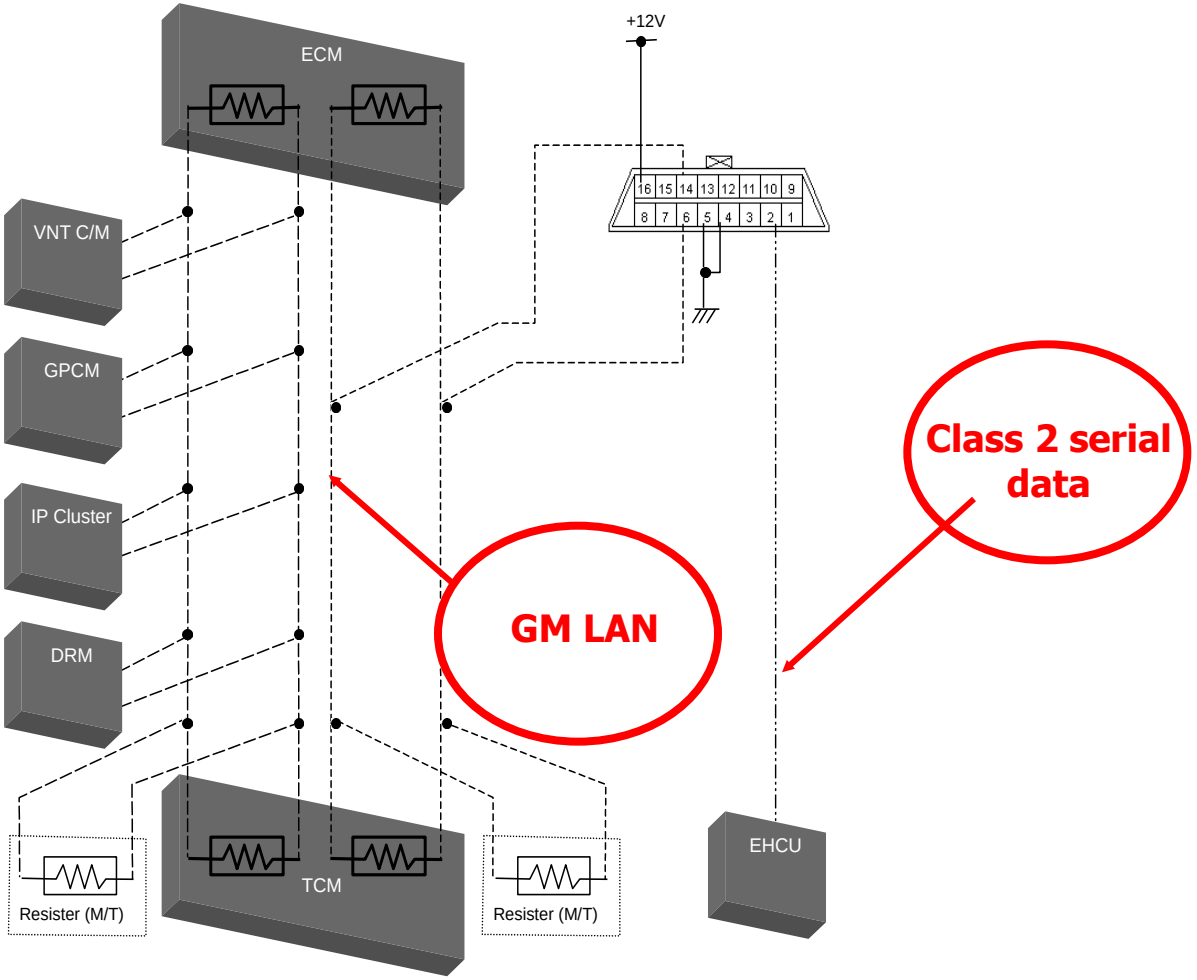


ECM/TCM/EHCU Communication
NON-DPF

- Communication
  - Communicates with other modules over the controller area network (CAN) communication bus
  - Monitors CAN operational status and will set a DTC if communication is lost
  - Communicates with IDSS over the Class 2 serial data link or GMLAN



ECM/TCM/EHCU Communication with DPF

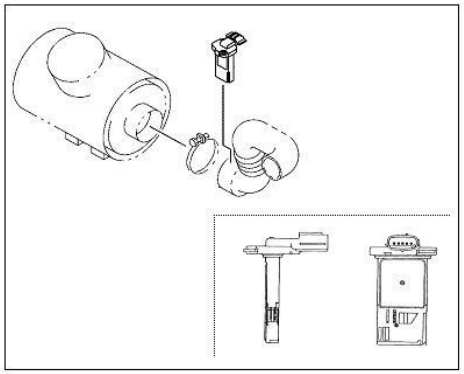


Electrical Components

- Mass Air Flow (MAF) Sensor
- Intake Air Temperature (IAT) Sensor
- Engine Coolant Temperature (ECT) Sensor
- Fuel Temperature (FT) Sensor
- Barometric Pressure (BARO) Sensor
- Boost Pressure Sensor
- Accelerator Pedal Position (APP) Sensor
- Idle Up Sensor
- Crankshaft Position (CKP) Sensor
- Camshaft Position (CMP) Sensor
- Vehicle Speed Sensor
- EGR Exhaust Gas Temperature Sensors 1 and 2

MAF (Mass Air Flow) Sensor

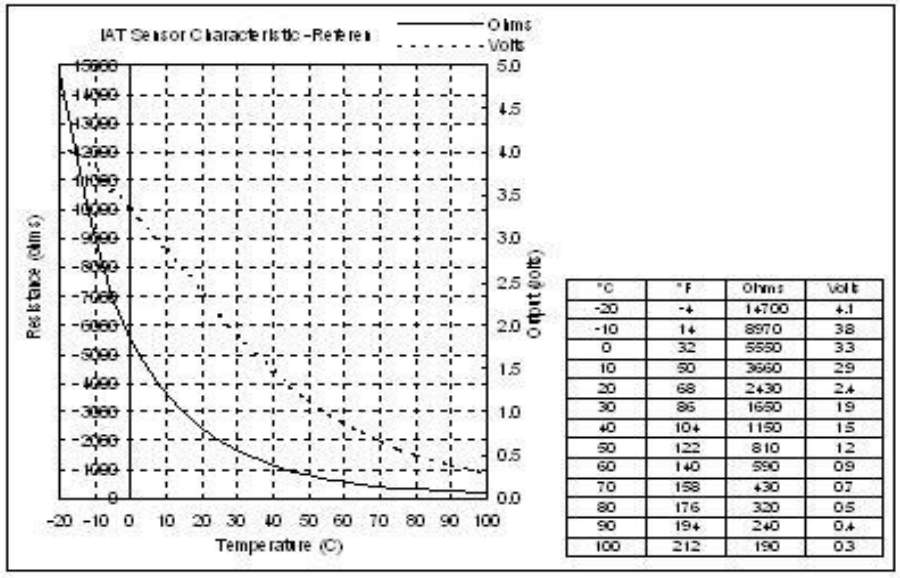
- Description
  - The MAF Sensor element measures the partial air mass through a measurement duct on the sensor housing. The ECM/PCM uses the MAF signal to calculate an EGR gas flow rate into the combustion chamber.



- Location
  - Located between the air cleaner and turbocharger.
- Operation
  - The hot wire type sensor operates at a range of 170 to 300 C (338 to 572 ° F)
  - Decreased air measurement indicates deceleration or idle speed
  - Increased air measurement indicates acceleration or high load condition
- Diagnostics
  - Associated DTCs - 4HK1 Ref
    - P0101 Circuit Performance
    - P0102 Circuit Low Voltage
    - P0103 Circuit High Voltage
  - For specific DTC criteria refer to the workshop manual

IAT (Intake Air Temperature) Sensor

- Description
  - Variable resistor that measures the temperature of the air entering the engine
- Location
  - Located between the air cleaner and turbocharger internal to the MAF
- Operation
  - Has a signal circuit and a low reference circuit. The ECM/PCM supplies 5 volts to the signal circuit.
  - As air temperature ↓ the sensor resistance ↑.
  - As air temperature ↑ the sensor resistance ↓.
  - The ECM/PCM detects a high voltage on the signal circuit as the sensor resistance ↑ and a low voltage as the sensor resistance ↓. The ECM/PCM uses the IAT signal to calculate fuel injection, quantity injection timing and EGR control.



°C	°F	Ohms	Volt
-20	-4	14700	4.1
-10	14	8970	3.8
0	32	5550	3.3
10	50	3660	2.9
20	68	2430	2.4
30	86	1650	1.9
40	104	1150	1.5
50	122	810	1.2
60	140	590	0.9
70	158	430	0.7
80	176	320	0.5
90	194	240	0.4
100	212	190	0.3

Tech Tip:

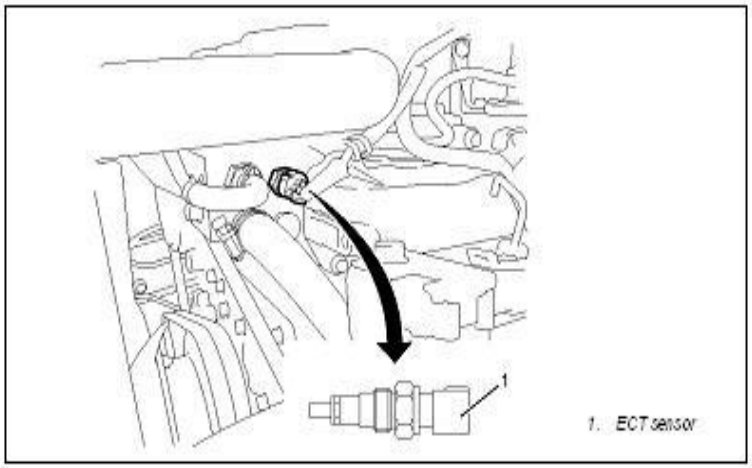
If the key is left on with the engine not running, the heating element of the MAF will skew the IAT temperatures readings high.

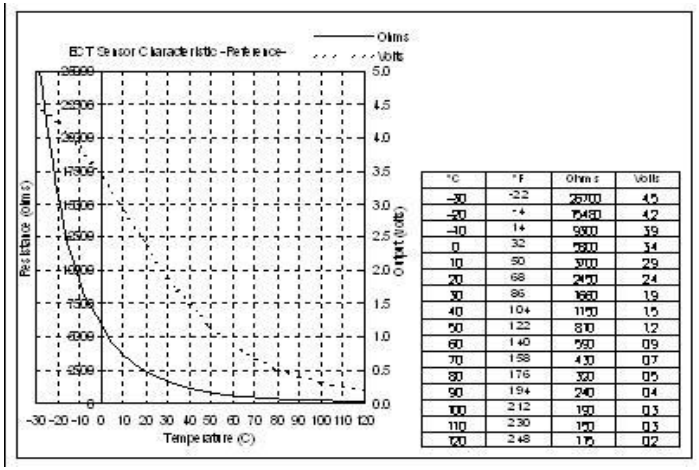
IAT (Intake Air Temperature) Sensor (cont'd)

- Diagnostics
  - The MAF sensor is heated and as a result the IAT sensor may indicate a higher than normal intake air temperature if the ignition switch is ON
  - Associated DTCs - 4HK1 Ref
    - P0097 Circuit 2 Low Voltage
    - P0098 Circuit 2 High Voltage
    - P0112 Circuit 1 Low Voltage
    - P0113 Circuit 1 High Voltage
    - P02E2 Control Circuit Low
    - P02E3 Control Circuit High
    - P02E7 Position Sensor Performance
    - P02E8 Position Sensor Circuit Low
    - P02E9 Position Sensor Circuit High
    - P2199 Sensor 1-2 Correlation
  - For specific DTC criteria refer to the workshop manual

ECT (Engine Coolant Temperature) Sensor

- Description
  - Variable resistor that measures the temperature of the engine coolant
- Location
  - Located in a coolant passage
- Operation
  - The sensor has a signal circuit and a low reference circuit. The ECM/PCM supplies 5 volts to the signal circuit.
  - As coolant temperature ↓, the sensor resistance ↑.
  - As coolant temperature ↑, the sensor resistance ↓.
  - The ECM/PCM detects a high voltage on the signal circuit as the sensor resistance ↑ and a low voltage as the sensor resistance ↓. The ECM/PCM uses the ECT signal to calculate fuel injection quantity, injection timing, EGR control and preheating control.





°C	°F	Ohms	Volts
-30	-22	25700	4.5
-20	-4	15450	4.2
-10	14	9600	3.9
0	32	6200	3.4
10	50	3700	2.9
20	68	2450	2.4
30	86	1660	1.9
40	104	1150	1.5
50	122	810	1.2
60	140	590	0.9
70	158	430	0.7
80	176	320	0.5
90	194	240	0.4
100	212	190	0.3
110	230	150	0.3
120	248	115	0.2

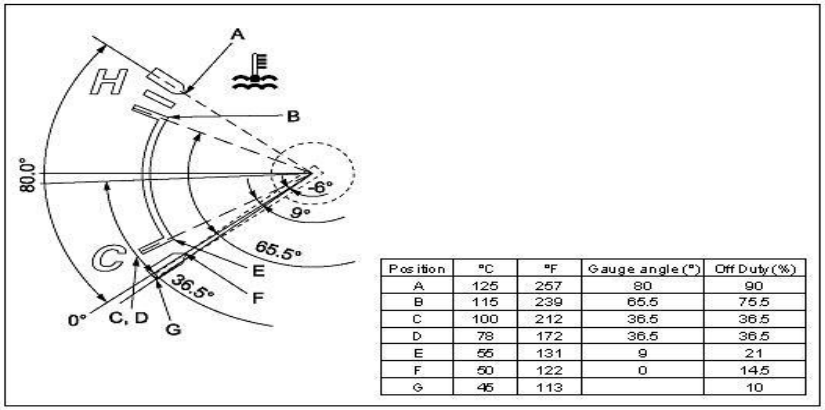
ECT (Engine Coolant Temperature) Sensor (cont'd)

- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P0116 Sensor Performance
    - P0117 Sensor Circuit Low
    - P0118 Sensor Circuit High
    - P0126 Insufficient for Stable Operation
    - P0128 Below Thermostat Regulating Temperature
  - For specific DTC criteria refer to the workshop manual

Tech Tip:

With the key on and engine not running, disconnect the ECT sensor, the scan tool data should read -40F (0C)

- Additional Function
  - The Engine Coolant Temperature Gauge signal for the instrument panel cluster is sent from the ECM/PCM. An analog ECT sensor signal is converted by the ECM/PCM into a pulse wave signal (64 Hz duty signal).
  - When engine coolant temperature is between 172-212 °F (78-100 °C), the gage needle indicates slightly lower than middle range C and D.

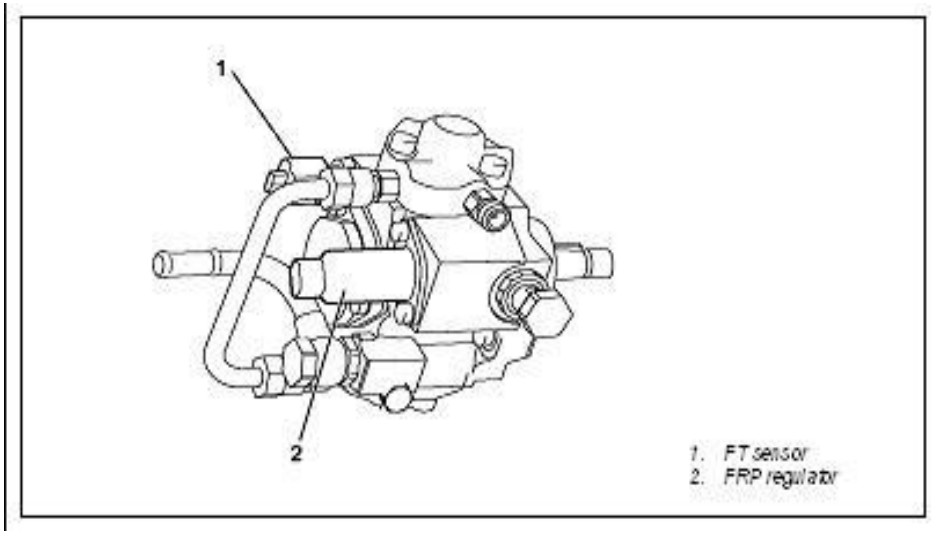


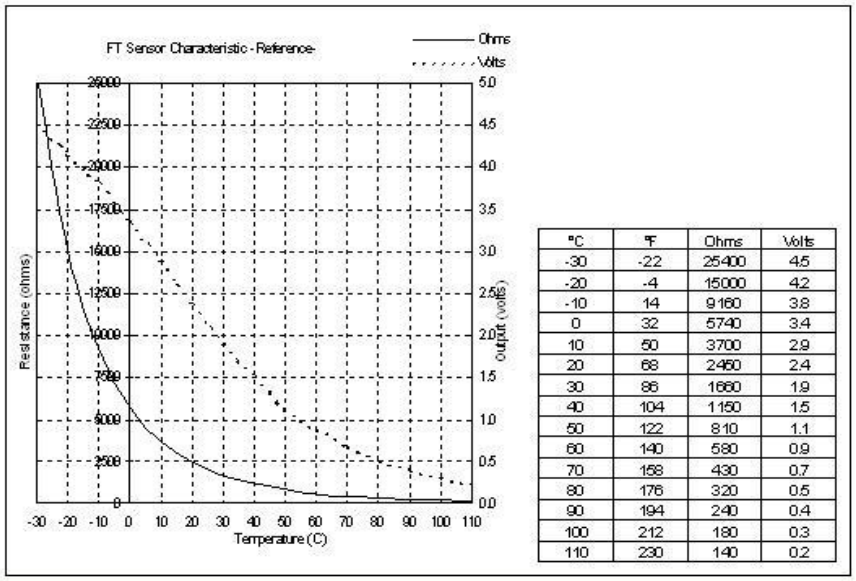
Position	°C	°F	Gauge angle (°)	Off Duty (%)
A	125	257	80	90
B	115	239	65.5	75.5
C	100	212	36.5	36.5
D	78	172	36.5	36.5
E	55	131	9	21
F	50	122	0	14.5
G	45	113		10

FT (Fuel Temperature) Sensor

- Description
  - Variable resistor that measures the temperature of the fuel entering the fuel supply pump
- Location
  - Installed on the fuel supply pump
  - The sensor has a signal circuit and a low reference circuit. The ECM/PCM supplies 5 volts to the signal circuit
- Operation
  - The sensor has a signal circuit and a low reference circuit. The ECM/PCM supplies 5 volts to the signal circuit.
  - As fuel temperature ↑ the sensor resistance ↓.
  - As fuel temperature ↓ the sensor resistance ↑.
  - The ECM/PCM detects a high voltage on the signal circuit as the resistance ↑ and a low voltage as the resistance ↓. The ECM/PCM uses the FT signal to adjust fuel injection quantity and injection timing.

FT (Fuel Temperature) Sensor (cont'd)



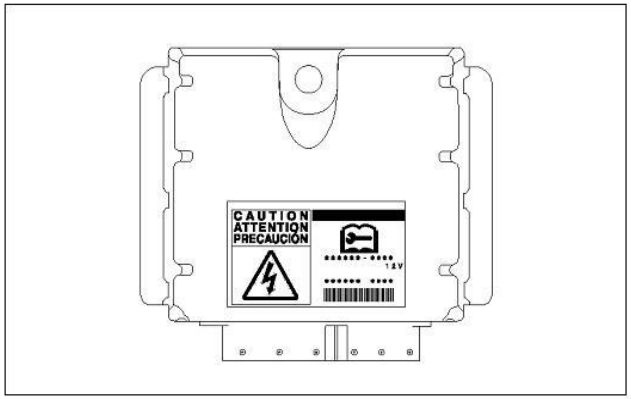


°C	°F	Ohms	Volts
-30	-22	25400	4.5
-20	-4	15000	4.2
-10	14	9160	3.8
0	32	5740	3.4
10	50	3700	2.9
20	68	2450	2.4
30	86	1660	1.9
40	104	1150	1.5
50	122	810	1.1
60	140	580	0.9
70	158	430	0.7
80	176	320	0.5
90	194	240	0.4
100	212	180	0.3
110	230	140	0.2

- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P0181 Circuit Performance
    - P0182 Circuit Low Voltage
    - P0183 Circuit High Voltage
  - For specific DTC criteria refer to the workshop manual

BARO (Barometer) Sensor

- Description
  - Converts the BARO reading into a voltage signal
- Location
  - The BARO sensor is located inside of the ECM/PCM
- Operation
  - The ECM/PCM uses the BARO signal to calculate fuel injection quantity and injection timing for altitude compensation
  - Converts the BARO reading into a voltage signal



Tech Tip:

With the key on and engine not running, the Baro Sensor and Boost Pressure Sensor should read the same in kPa (+/- 3)

- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P2227 Sensor Performance
    - P2228 Sensor Circuit Low Voltage
    - P2229 Sensor Circuit High Voltage
  - For specific DTC criteria refer to the workshop manual

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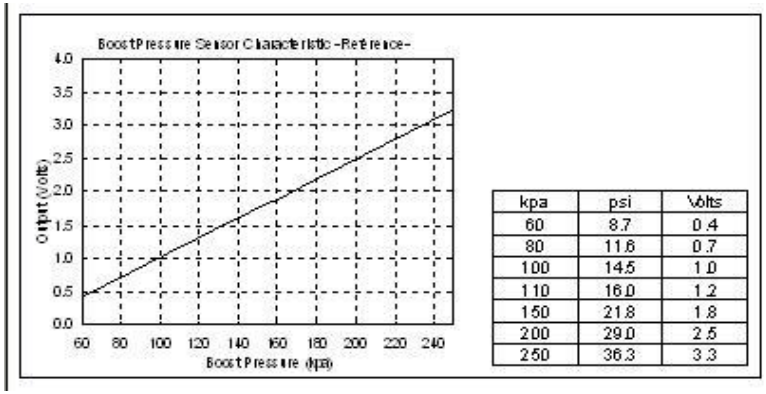
Boost Sensor

Description – Measures the amount of boost pressure being made by the turbo, and then converts it into a voltage signal.

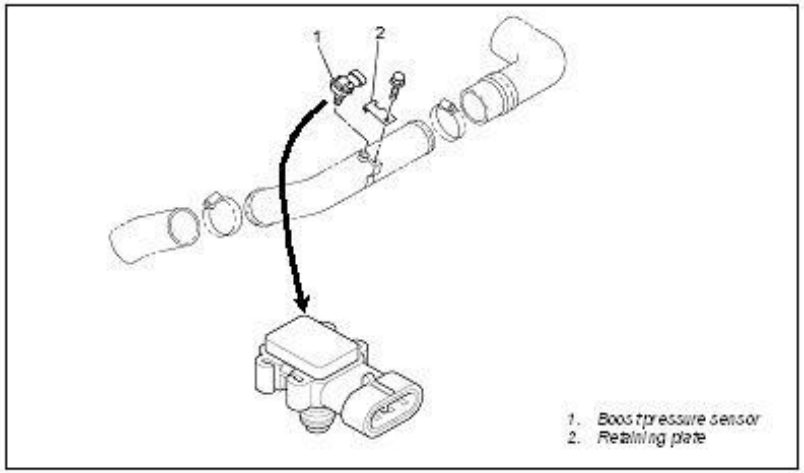
Location – In the intake pipe between the Charge Air Cooler and the Intake Air Throttle.

Diagnostics – DTC P0237 Boost sensor circuit low voltage

DTC P0238 Boost sensor circuit high voltage

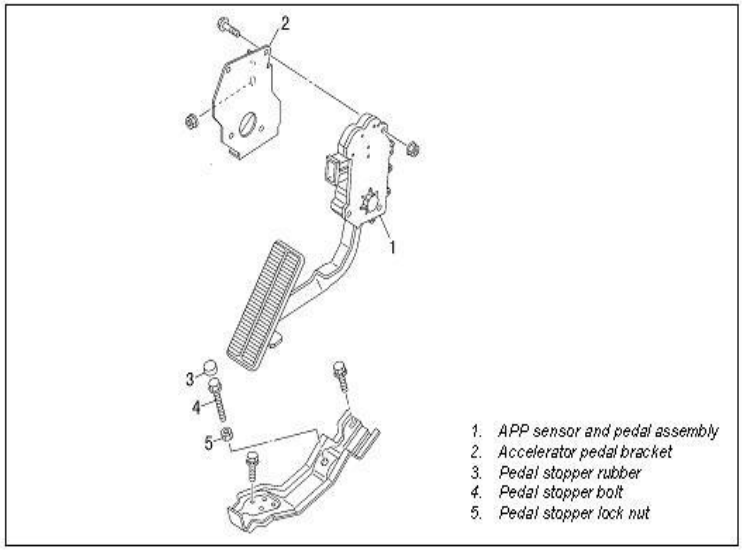


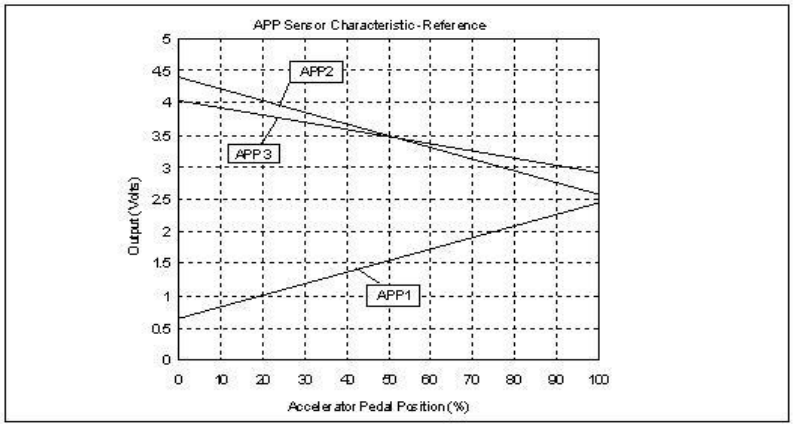
kpa	psi	Volts
60	8.7	0.4
80	11.6	0.7
100	14.5	1.0
110	16.0	1.2
150	21.8	1.8
200	29.0	2.5
250	36.3	3.3



APP (Accelerator Pedal Position) Sensor

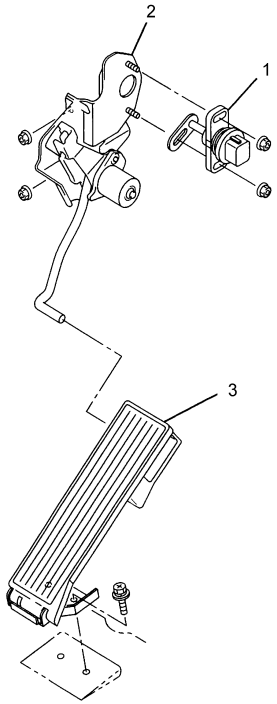
- Description
  - The 2005-2007 APP sensors are potentiometer type sensors. The 2008 -2010 sensors are Hall Effect Sensors
- Location
  - Mounted on the accelerator pedal control assembly. The 2005-2007 sensor is comprised of three individual sensors within one housing. The 2008-2010 sensors are comprise of two individual sensors within one housing
- Operation
  - The ECM uses the APP signals to determine the amount of acceleration or deceleration that is desired. If the correlation between two sensors is out of range ,this indicates a skewed sensor.
  - Each APP sensor provides a signal to the ECM relative to the position changes of the accelerator pedal angle.
    - APP sensor 1 signal voltage is low at rest and increases as the pedal is depressed.
    - APP sensor 2 and APP sensor 3 signal voltages are high at rest and decrease as the pedal is depressed.

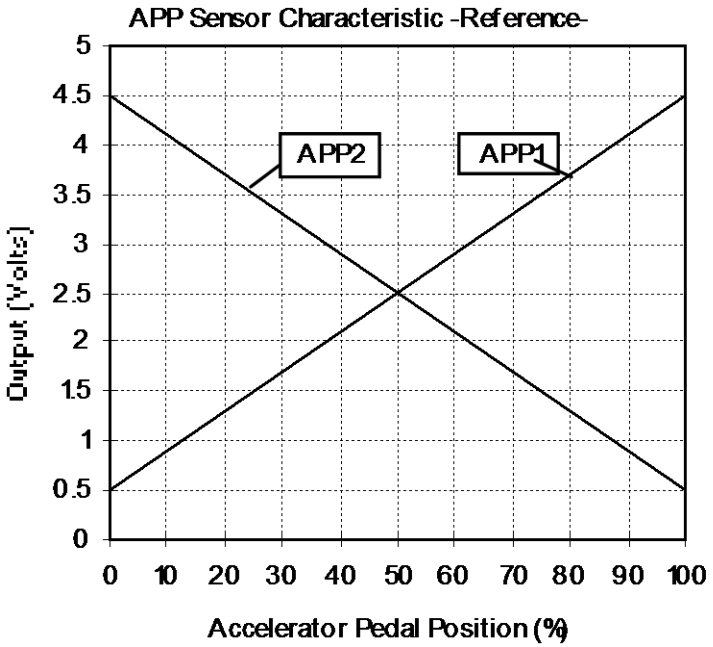




APP (Accelerator Pedal Position) Sensor

- Accelerator Pedal Position Sensor (APP) - 2 Sensor 2007I - 2010





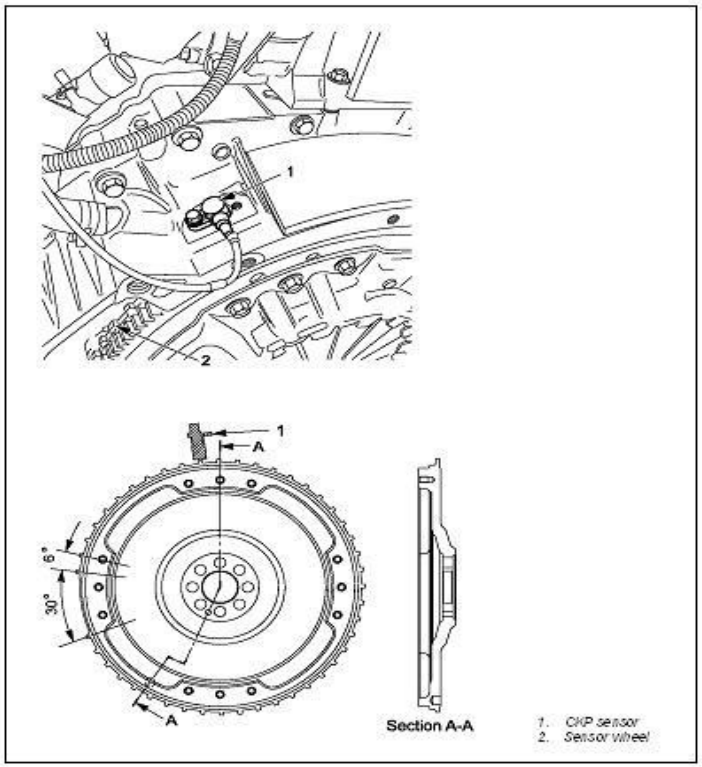
APP (Accelerator Pedal Position) Sensor (cont'd)

- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P2122 Sensor 1 Circuit Low Voltage
    - P2123 Sensor 1 Circuit High Voltage
    - P2127 Sensor 2 Circuit Low Voltage
    - P2128 Sensor 2 Circuit High Voltage
    - P2132 Sensor 3 Circuit Low Voltage (6HK1)
    - P2133 Sensor 3 Circuit High Voltage (6HK1)
    - P2138 Sensor 1-2 Correlation
    - P2139 Sensor 1-3 Correlation (6HK1)
    - P2140 Sensor 2-3 Correlation (6HK1)
  - For specific DTC criteria refer to the workshop manual

CKP (Crankshaft Position) Sensor

- Description
  - Magnetic coil type sensor [coil resistance is 105-145Ω at °F (20 °C)] which generates an AC signal voltage based on the crankshaft rotational speed.
  - There are 56 notches spaced 6 apart and a 30 section that is an open span. The open span portion allows for the detection of cylinder #1 at top dead center (TDC).
- Location
  - Located on top of the flywheel housing.
- Operation
  - ECM/PCM monitors both the CKP sensor and CMP sensor signals to ensure they correlate with each other
  - If the CKP sensor signal is lost while the vehicle is running, the CMP sensor signal will substitute for the CKP sensor signal

CKP (Crankshaft Position) Sensor (cont'd)

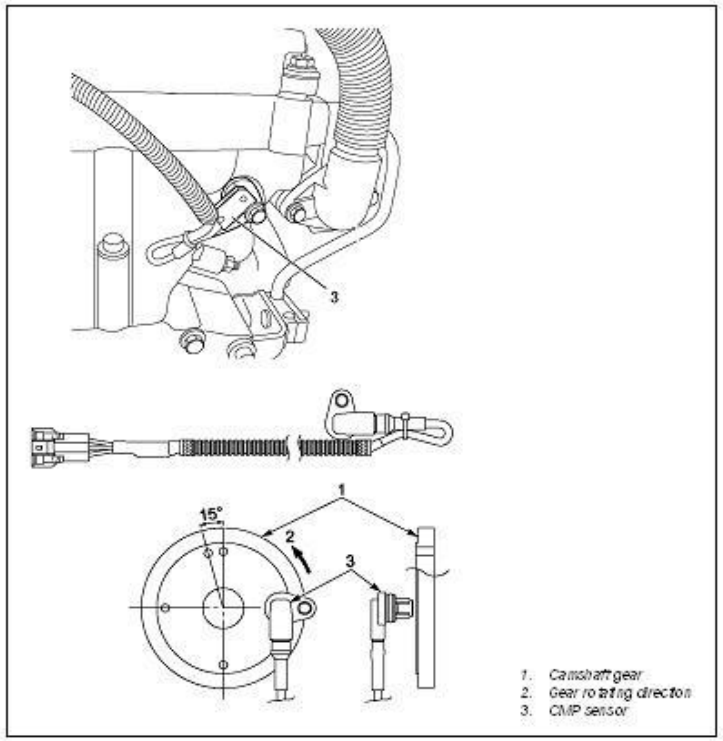


- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P0016 CKP/CMP Correlation
    - P0335 CKP Sensor Circuit
    - P0336 CKP Sensor Performance
  - For specific DTC criteria refer to the workshop manual

CMP (Camshaft Position) Sensor

- Description
  - Detects a total of five through holes (four holes are arranged equally every 90° on the face of the cam gear and one 5° reference hole on the camshaft gear flange surface – this indicates TDC on #1 cylinder)
- Location
  - Installed on the cylinder head at the rear of the camshaft gear
- Operation
  - ECM/PCM uses the CMP signal to synchronize fuel injection
  - If the CMP sensor signal is lost while the vehicle is running, the CKP sensor signal will substitute for the CMP sensor signal

CMP (Camshaft Position) Sensor (cont'd)



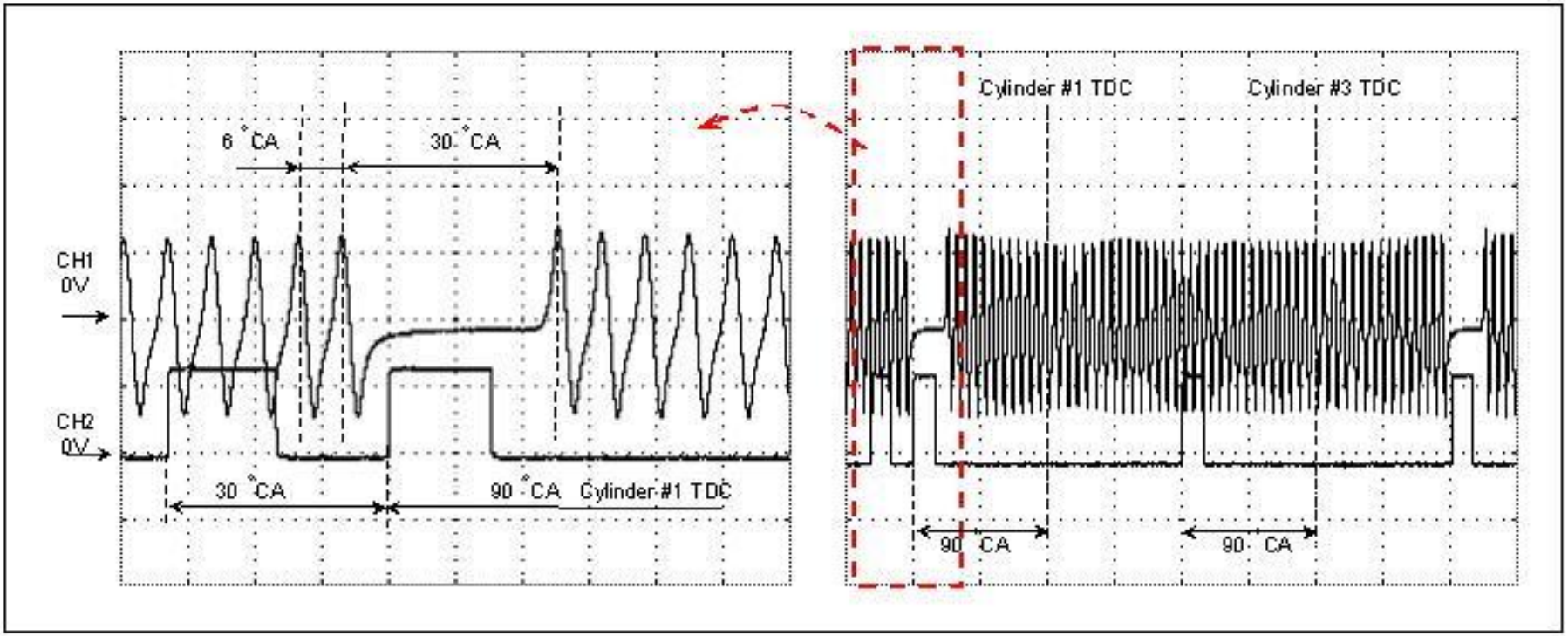
Tech Tip:

2007i – 2010 engines will not start if the CMP signal is lost

- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P0016 CKP/CMP Correlation
    - P0340 CMP Sensor Circuit
    - P0341 CMP Sensor Performance
  - For specific DTC criteria refer to the workshop manual

CKP/CMP Relationship

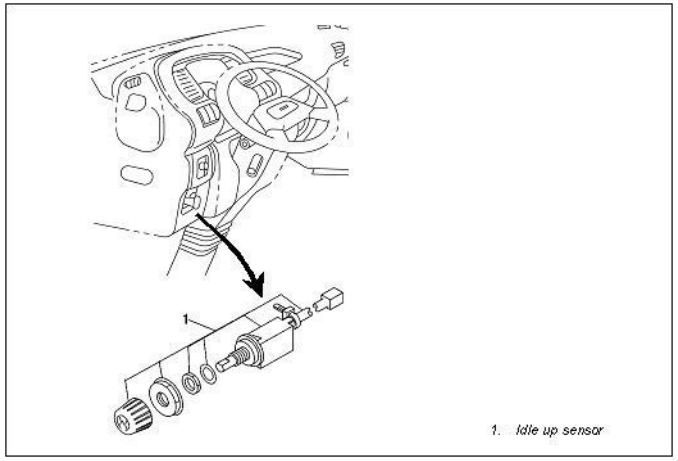
- The ECM/PCM detects 112 CKP sensor pulses (56 x 2) and 5 CMP sensor pulses per 2 crankshaft rotations
  (720 °CA)
- The CKP and CMP sensor wheels mechanically engage with each other
- The relationship of each pulse is always constant

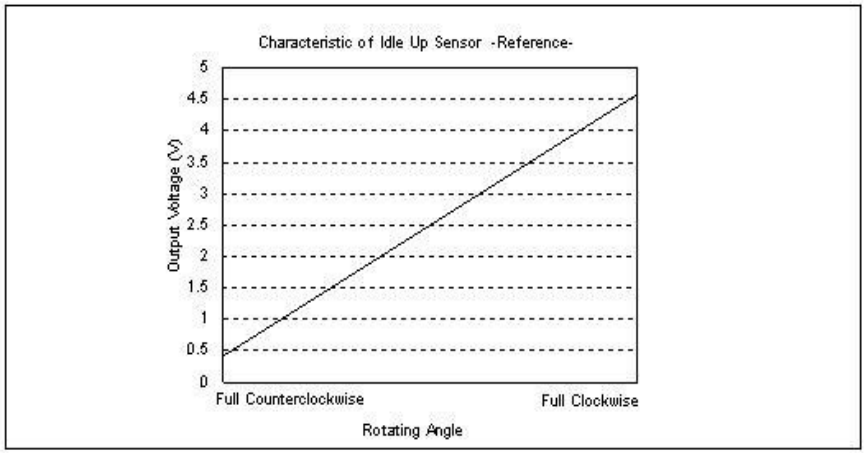


Idle Up Sensor

- Description

  Controls the idle speed during warm-up
- Location
  - Installed on the driver's side instrument panel
- Operation
  - Sensor is active only when the gear position is in neutral. Turn the sensor knob clockwise to ↑ idle and counter clockwise to ↓ idle.
  - As the gear selector lever is moved to a position other than neutral the sensor is canceled.
  - The ECM/PCM uses the Idle Up signal to control fuel injection quantity.





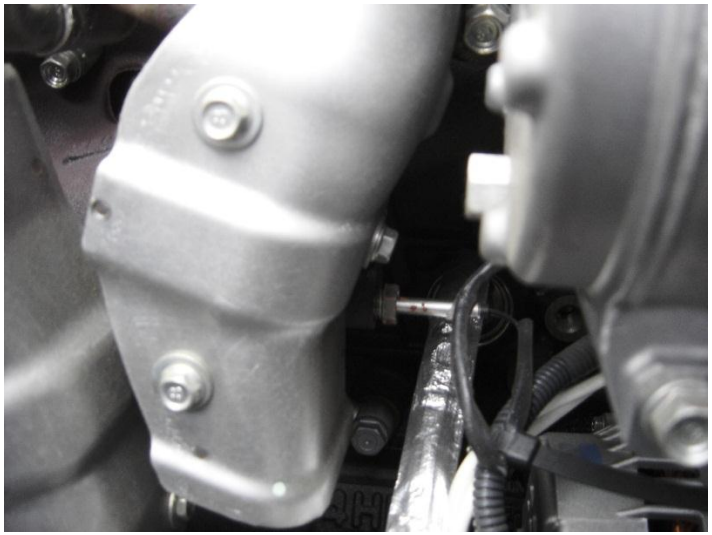
- Diagnostics
  - No associated DTCs for Idle Up Sensor

VSS (Vehicle Speed Sensor)

- Description
  - Generates a speed signal from the transmission output shaft rotational speed or transfer output shaft rotational speed.
  - Used by the ECM/PCM, speedometer, TCM and ABS.
- Operation
  - Generates a speed signal from the transmission output shaft rotational speed or transfer output shaft rotational speed
  - Uses a hall effect element
  - Interacts with the magnetic field created by the rotating magnet and outputs a square wave pulse signal
  - The ECM/PCM uses the VSS signal to calculate the vehicle speed
- Diagnostics
  - Associated DTCs – 4HK1 Ref
    - P0500 VSS Circuit
  - For specific DTC criteria refer to the workshop manual

EGR Exhaust Gas Temperature 1 & 2

EGR Exhaust Gas Temperature Sensor 1



EGR Exhaust Gas Temperature Sensor 2

The EGR exhaust gas temperature sensor 1 measures the exhaust gas temperature at the entrance of the coolers, and sensor 2 measures the exhaust gas temperature as it exits the coolers. The ECM compares the data to ensure the exhaust gasses have been cooled sufficiently before the EGR valve allows it to enter the combustion chambers.

On-board Diagnostic (OBD) Overview

OBD Overview

- OBD for Heavy-Duty (HD) Vehicles
  - Ensures emission control components are working and vehicle maintains low emissions in-use
  - Assists technicians in diagnosis & repair
- Why Wasn't OBD Required Before Now?
  - Heavy-duty engines have traditionally lagged behind in the use of electronic engine controls and advanced emission controls including aftertreatment
  - More stringent emission standards starting in 2007-2010 are instituting change
- ODB Regulation for HD
  - Establish emission standards for OBD systems installed on 2007i and subsequent model-year engines certified for sale in heavy-duty applications
  - Using an on-board computer, OBD will monitor and detect malfunctions of all emission control systems/components in-use for the actual operational life of the engine
  - Requirement for 2010-2012 MY:
    - Detect malfunctions that increase emissions to parts per million (PPM) std + 0.02 or 2.5 times the std for NMHC, CO, or NOx
  - Requirement for 2013 MY:
    - Detect malfunctions that increase emissions to PPM std + 0.02 or 2.0 times the std for NMHC, CO, or NOx

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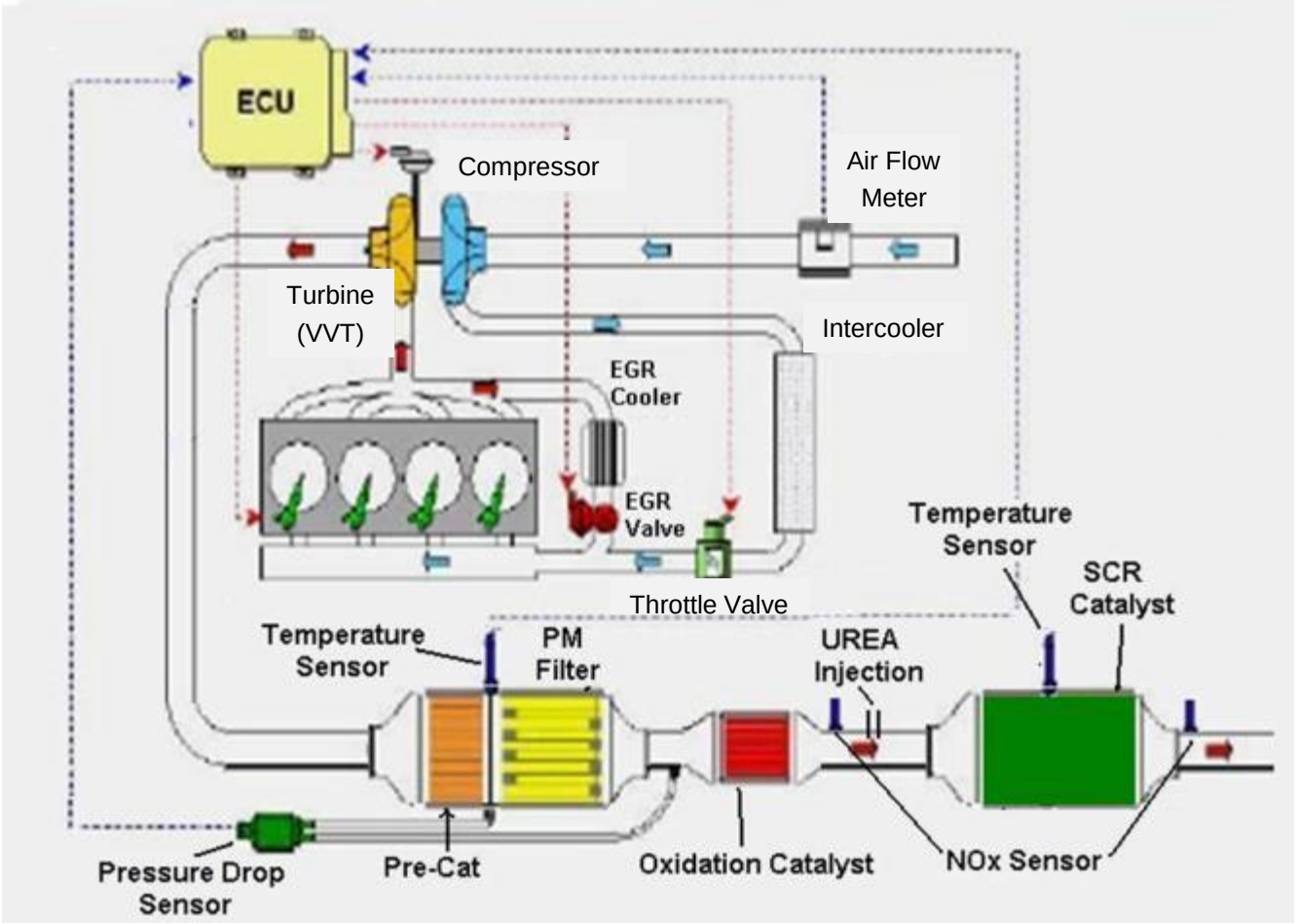
HD Diesel Technology



Malfunction Indicator Light (MIL)

- The MIL is labeled with the International Standard Organization (ISO) engine symbol
- Amber in color
- Located in clear view on the driver side instrument console
- Before the MIL illuminates
  - Engine Control Module (ECM)/Powertrain Control Module (PCM) determines that a malfunction has occurred within the OBD monitored system
  - ECM/PCM generates and stores
    - Pending Diagnostic Trouble Code (DTC)
    - Freeze Frame of engine data
- When the MIL illuminates
  - ECM/PCM determines that the malfunction has been detected again before the next monitored drive cycle
  - ECM/PCM generates and stores
    - Confirmed Diagnostic Trouble Code (DTC)
    - Freeze Frame of engine data
- MIL is extinguished
  - If the malfunction is not detected in the next 3 drive cycles (except for misfire and fuel system faults)
  - By a technician with a scan tool
- Confirmed Codes
  - The Diagnostic Fault Code (DTC) is stored for a least 40 engine warm-up cycles

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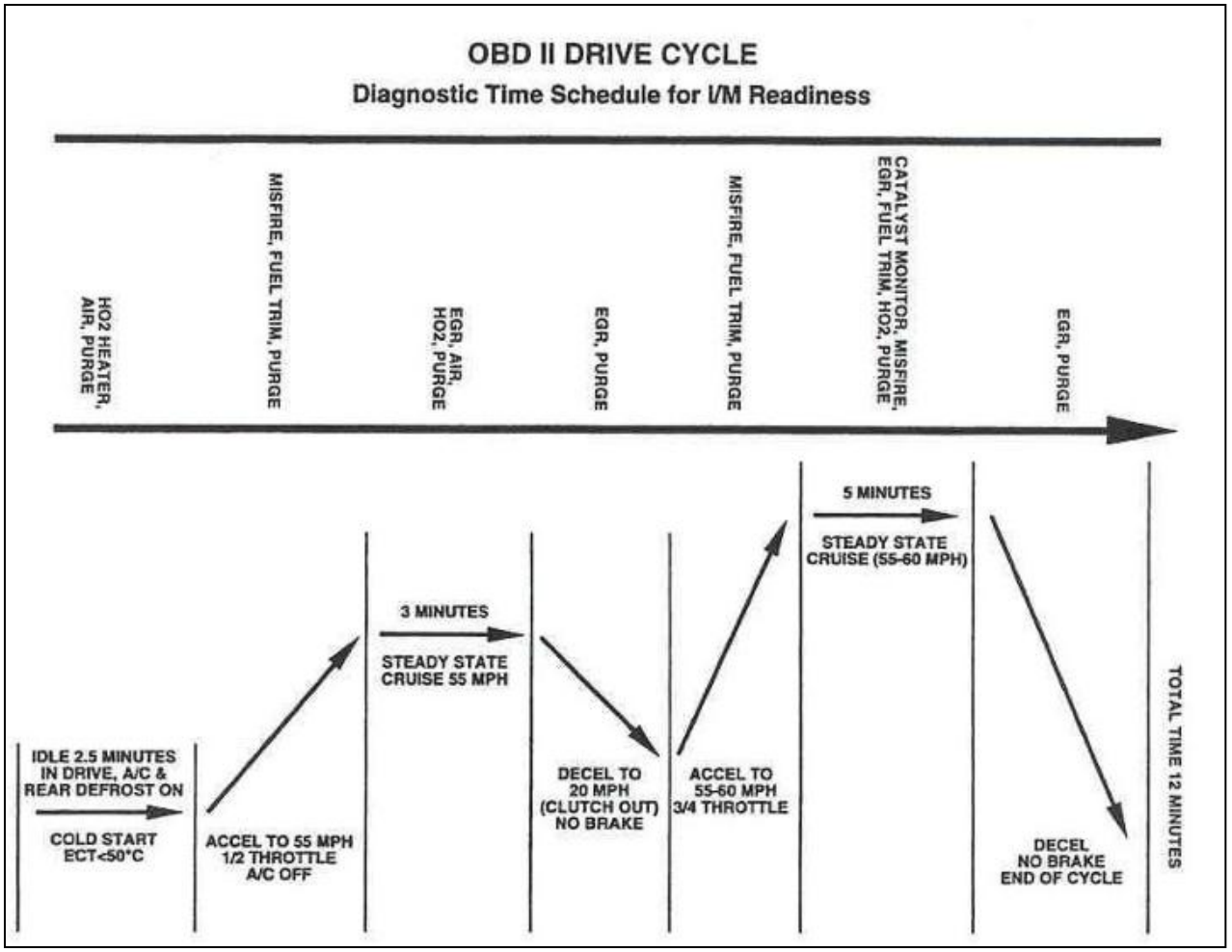
Drive Cycle

- What is a Drive Cycle?
  - Ordered set of instructions under a variety of conditions through which the vehicle must be driven
- Why is a Drive Cycle needed?.
  - To run all of the on-board diagnostics and satisfy enable criteria for the System Status to display the Inspection Maintenance (I/M) Readiness flags
  - The System Status (I/M) Readiness flags are an indication if the diagnostics of certain critical emission-related systems have run
  - System Status flags must be set in the following cases:
    - The battery or ECM/PCM has been disconnected from the wiring harness
    - The vehicle is new from the factory and has not been through an OBD drive cycle
    - The ECM/PCM DTCs have been erased after completion of repairs
  - EVAP currently only for gasoline engines, possible future use in diesel applications

System Status I/M Readiness Flags

TEST	COMPLETE
Catalyst	Y
HO2S	N
HO2S Heater	Y
EGR System	N
EVAP	N

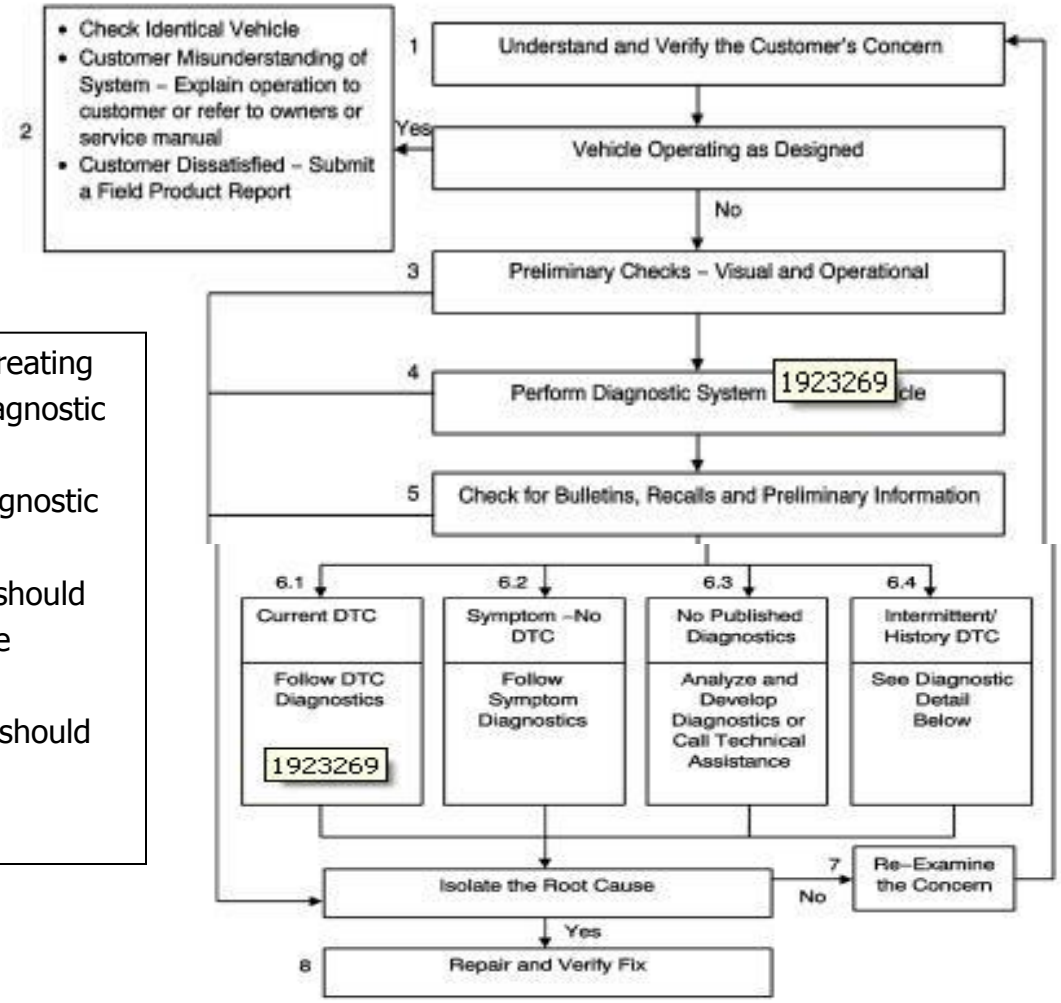
Drive Cycle Illustration



Diagnosing The Vehicle

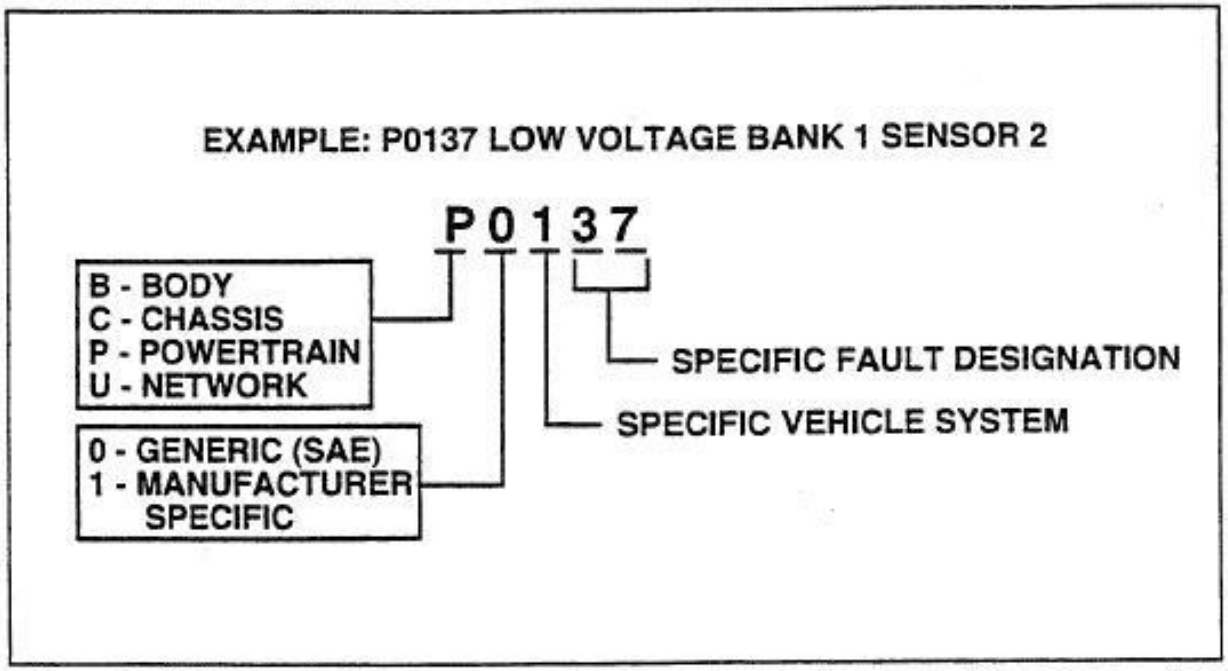
Strategy Based Diagnostic Flow

- The goal is to provide guidance in creating a plan of action for each specific diagnostic situation.
- Following a similar plan for each diagnostic situation, maximizes efficiency.
- First step of the diagnostic process should always be understand and verify the customers concern.
- Final step of the diagnostic process should be repair and verify the fix.



Diagnostic Trouble Codes (DTCs)

- DTCs are defined by four basic malfunction categories
  - General Circuit Malfunction
  - Range/Performance Problem
  - Low Circuit Input
  - High Circuit Input
- OBD provides a five-digit alphanumeric trouble code for detected malfunctions



DTCs (cont'd)

- The letter identifies the function of the monitored component that has failed
  - P0137
    - P – Indicates a Powertrain device
    - C – Indicates a Chassis device
    - B – Indicates a Body device
    - U – Indicates a Network or Data Link code
- The first number identifies that the code is either a generic or manufacturer specific code
  - P0137
    - 0 – Indicates generic
    - 1 – Indicates manufacturer
- The second number identifies the system that is affected
  - P0137
    - 1 – Indicates Fuel and Air Metering
    - 2 – Indicates Fuel and Air Metering (injector circuit malfunctions only)
    - 3 – Indicates Ignition System or Misfire
    - 4 – Indicates Auxiliary Emission Controls
    - 5 – Indicates Vehicle Speed Control and Idle Control System
    - 6 – Indicates Computer Output Circuits
    - 7 – Indicates Transmission
    - 8 – Indicates Transmission
- The last two numbers identify the component or system area which is experiencing the fault
  - P0137
    - In this example the 37 indicates HO2S Circuit Low Voltage Bank 1 Sensor 2

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DTCs (cont'd)

- Type A
  - Emissions related.
  - Turns ON the MIL after one failed drive cycle
  - Sets a DTC
  - Stores a Freeze Frame (if empty) after one failed drive cycle
  - Stores and updates a Failure Record every time the diagnosis fails
- Type B
  - Emissions related
  - Turns ON the MIL after two consecutive failed driving cycles
  - Sets a DTC
  - Armed after one drive cycle with a failure
  - Disarmed after one drive cycle with a pass
  - Stores a Freeze Frame (if empty) after two consecutive failed driving cycles
  - Stores a Failure Record after one failed drive cycle
  - Updates Failure Record each time the diagnostic fails

DTCs (cont'd)

- Type C
  - Non-emissions related
  - Turns ON an Auxiliary MIL and sets a DTC after one failed drive cycle
  - Does not store a Freeze Frame
  - Stores a Failure Record after one failed drive cycle
  - Updates the Failure Record each time the diagnostic fails
- Type D
  - Non-emissions related
  - Does not turn ON the MIL
  - Sets a DTC
  - Does not store a Freeze Frame
  - Stores a Failure Record after one failed drive cycle and updates each time the diagnostic fails

Freeze Frame/Failure Records

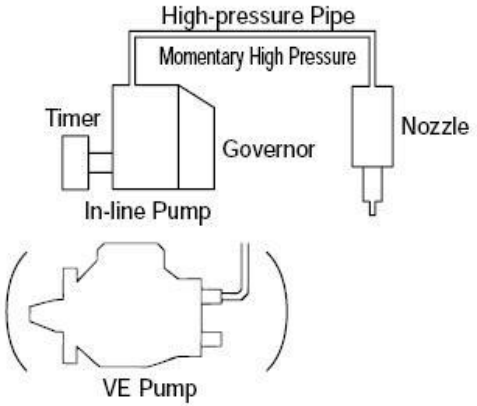
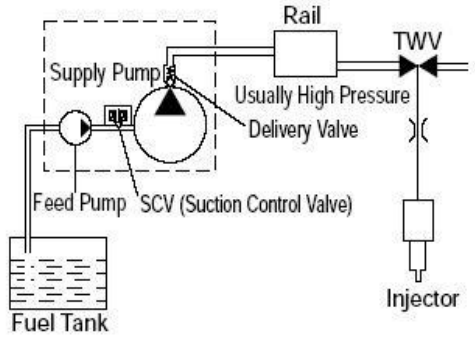
- The first time a fault occurs, the on-board computer will store conditions and data which were present when the fault was detected. This information is stored in Freeze Frame/Failure Records which include:
  - Fuel mode (open or closed loop)
  - Engine load
  - Fuel trim value / injection quantities
  - Intake manifold pressure
  - Engine and vehicle speed
  - Mileage covered since fault was detected
- If the failure is emission related the ECM/PCM may adopt a Limited Operation Strategy (LOS or limp home mode)
  - Value substitution
  - Circuit substitution
  - Ignore the signal

Diesel Monitored Systems

- Fuel
- Misfire
- EGR
- Turbocharger
- DPF
- Cooling

Conventional VS Common Rail

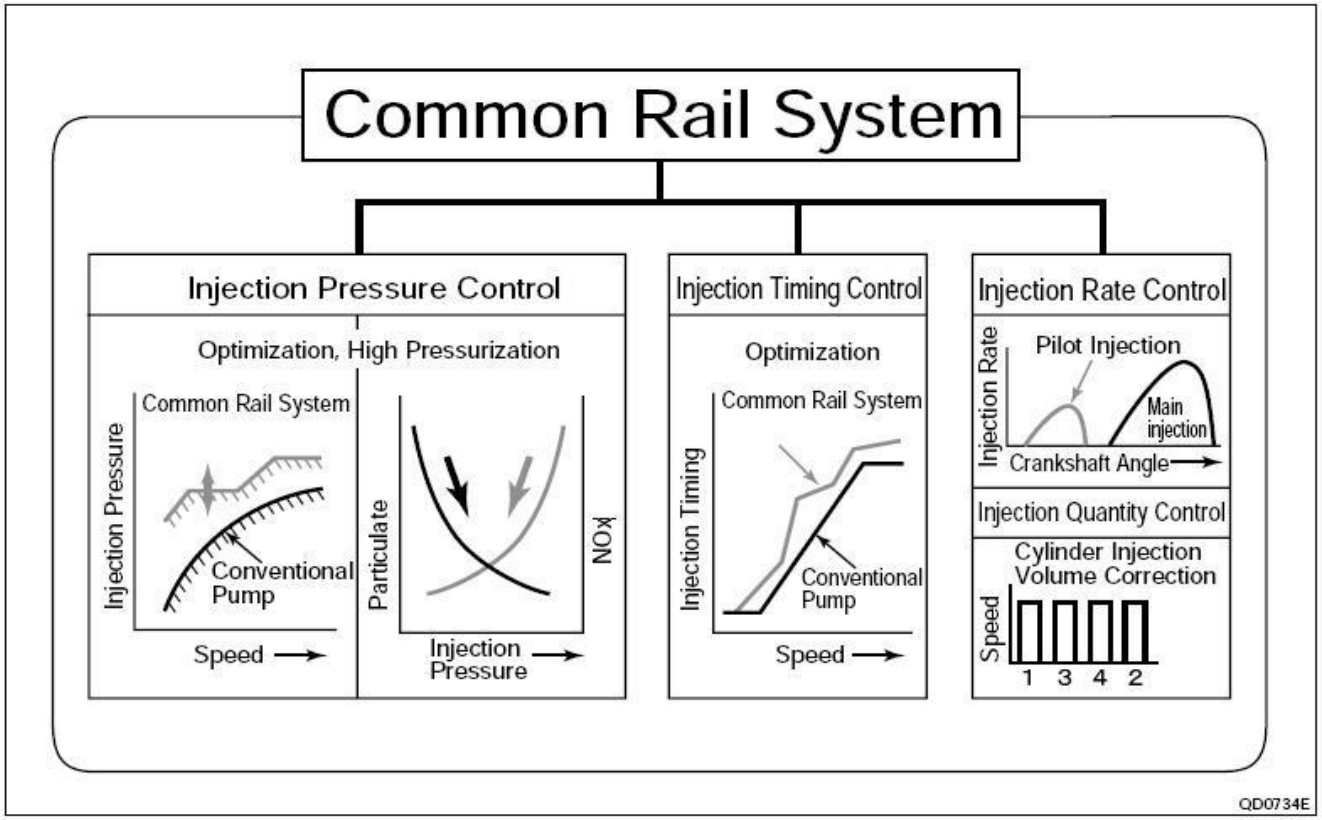
- Overview
  - Advanced electronic control technology
  - Developed to meet high pressurization requirements for cleaner exhaust gas regulations on diesel engines
  - Improved fuel economy
  - Increased power output
  - Reduced noise

System	In-line, VE Pump	Common Rail System
		
Injection Quantity Control	Pump (Governor)	Engine ECU, Injector (TWV)*1
Injection Timing Control	Pump (Timer)	Engine ECU, Injector (TWV)*1
Rising Pressure	Pump	Engine ECU, Supply Pump
Distributor	Pump	Engine ECU, Rail
Injection Pressure Control	Dependent upon Speed and Injection Quantity	Engine ECU, Supply Pump (SCV)*2

*1 TWV: Two Way Valve *2 SCV: Suction Control Valve QD2341E

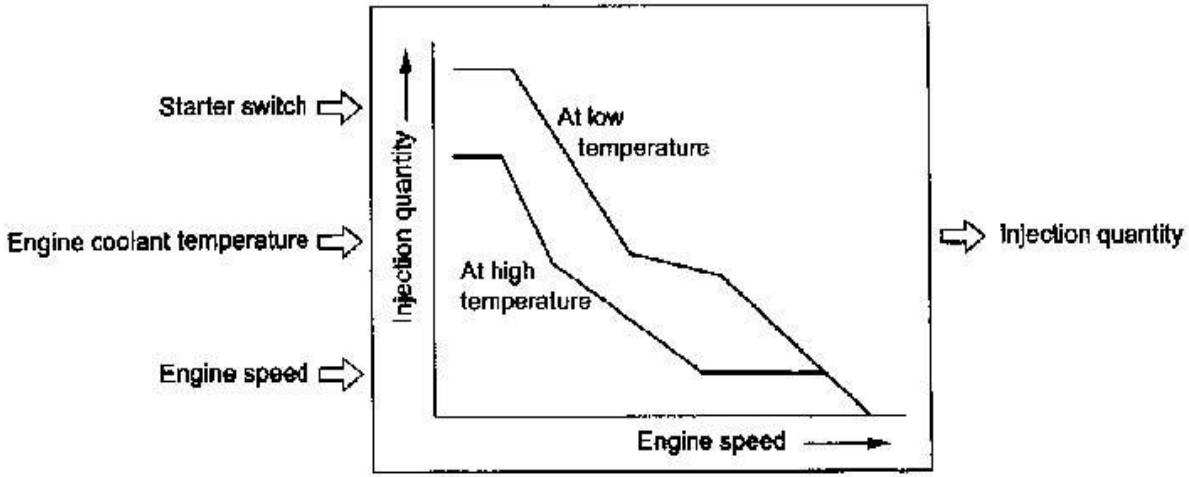
Fuel Injection Control

- Control
  - Injection Pressure Control
  - Injection Timing Control
  - Injection Rate Control



Fuel Injection Control

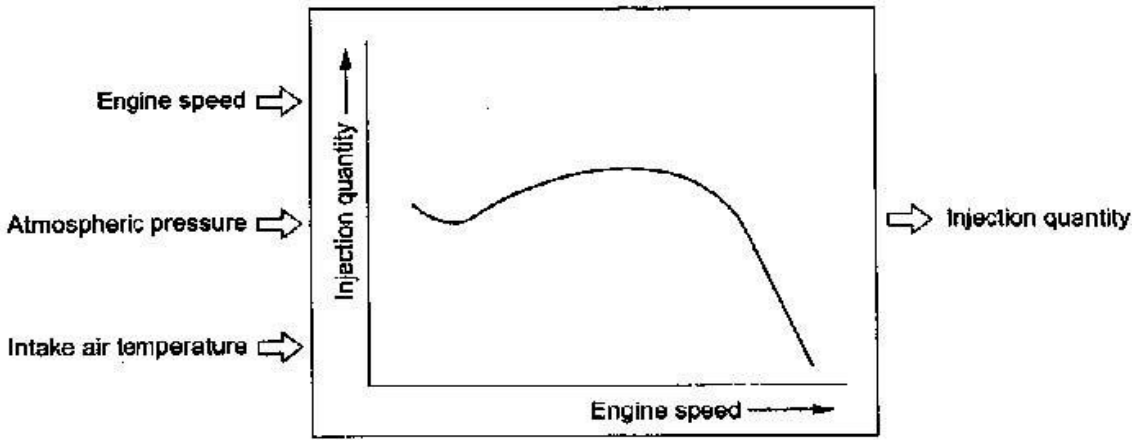
Boosted Quantity Control at Starting



At engine start (after the key switch is turned to the START position to start the engine, and until the return of the key switch to the ON position), optimum fuel injection quantity is controlled based on information from the starter switch, engine speed, and ECT. At low temperature, the fuel injection quantity increases. When the engine starts completely, this boosted quantity mode at starting is cancelled and normal running mode is restored

Fuel Injection Control

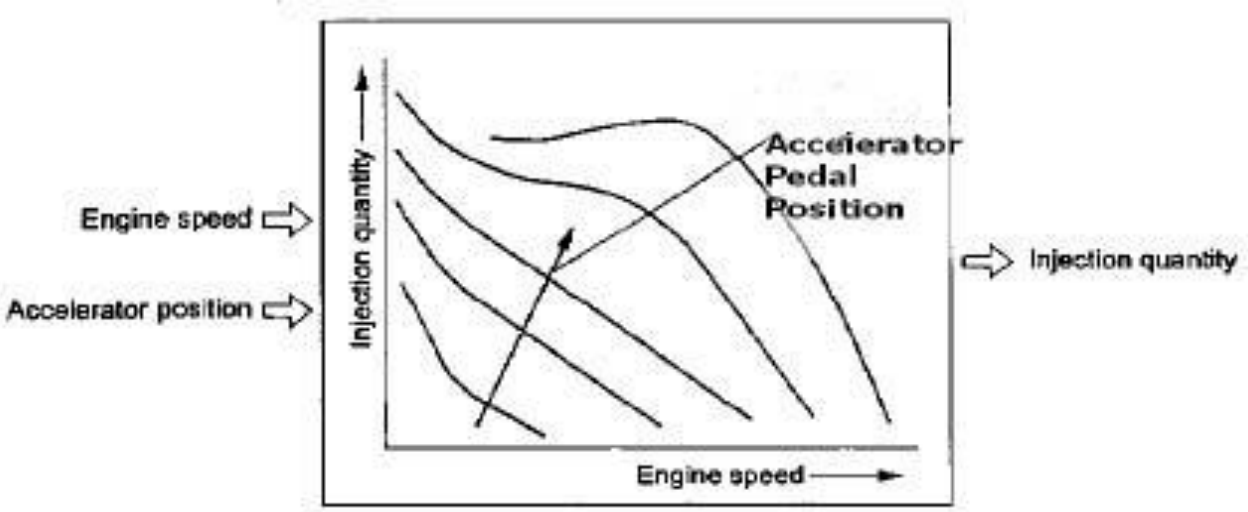
Maximum Fuel Injection Quantity Control



During normal running, the maximum fuel injection quantity is controlled according to the engine speed, ensuring the maximum torque according to the engine characteristics. In any running conditions, the fuel injection quantity is controlled within these characteristics to reduce the smoke and also to prevent overload on the engine..

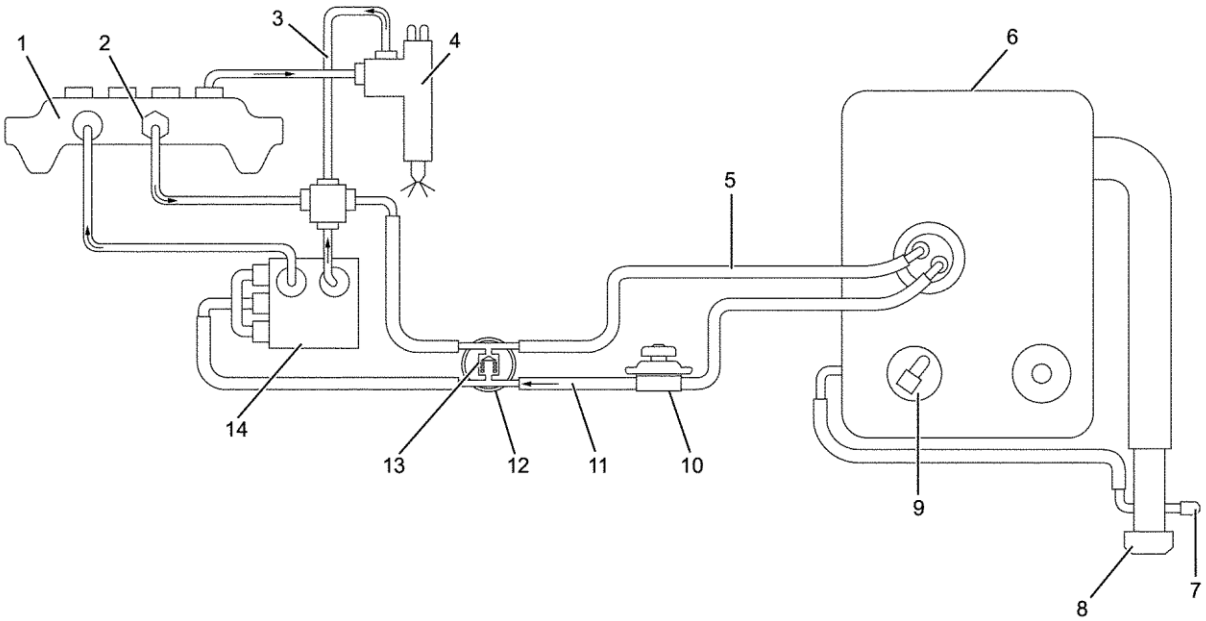
Fuel Injection Control

Normal Running Control



During normal running, optimum fuel injection quantity is controlled according to the engine speed and accelerator pedal pressure. Combined with high pressure injection of atomized fuel, this control improves exhaust gas and ensures proper fuel consumption.

Fuel System



1. Fuel Rail
2. Pressure Limiter
3. Leak Off Pipe
4. Fuel Injector
5. Fuel Return Pipe
6. Fuel Tank
7. Ventilation Valve
8. Fuel Filler Cap
9. Fuel Level Sensor
10. Priming Pump
11. Fuel Feed Pipe
12. Fuel Filter With Water Separator
13. Return Fuel Flow Back Valve
14. Fuel Supply Pump

Fuel System – Common Rail

- Description
  - The common rail fuel system is comprised of two fuel pressure sections:
    - A suction side between the fuel tank and the fuel supply pump.
    - A high-pressure side between the fuel supply pump and the fuel injectors.
  - Uses a type of accumulator chamber, the fuel rail, to store pressurized fuel.
  - Injectors contain electronically controlled solenoid valves to spray the pressurized fuel in the combustion chambers.
  - Injection system, injection pressure, injection rate and injection timing are controlled by the ECM/PCM.
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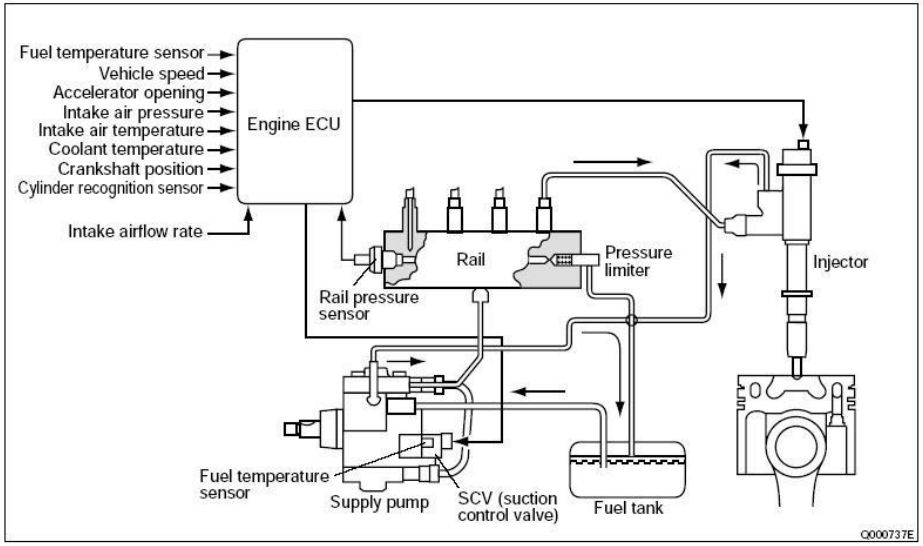
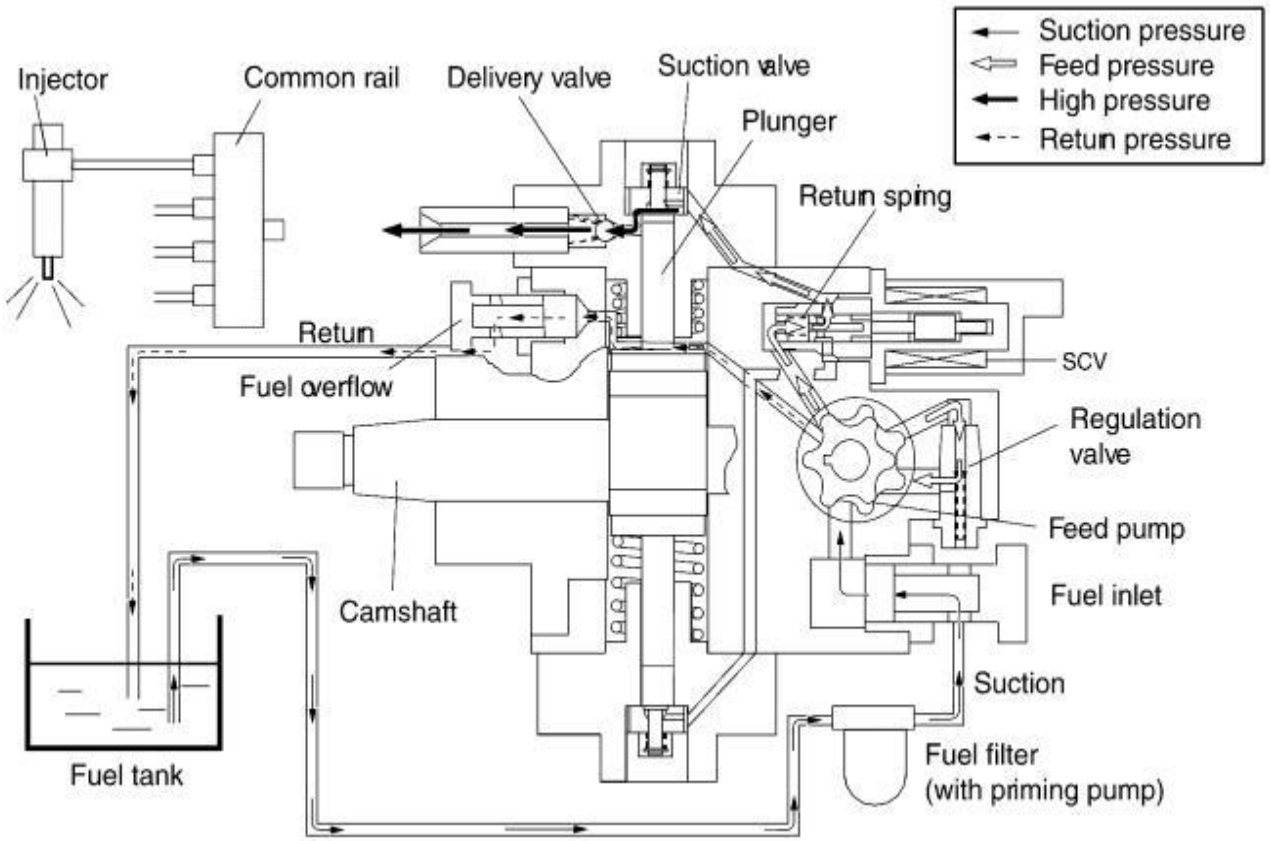
  - Injection system, injection pressure, injection rate and injection timing are controlled by the ECM/PCM.



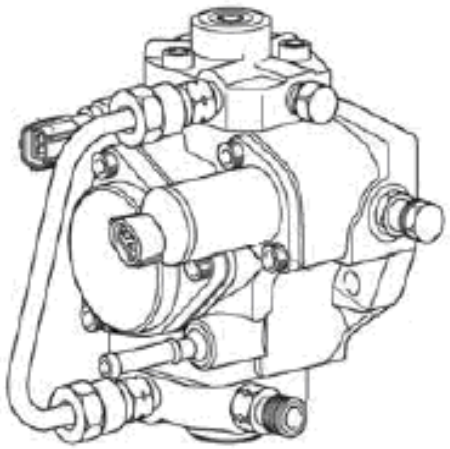
Fuel System – Common Rail (cont'd)

- Characteristics
  - ECM/PCM management allows for
    - Independent control free from the influence of engine speed and load
    - Stable injection pressure at all times – particularly in the low engine speed range
    - Reduced exhaust gas emissions
    - Higher output
- Operation
  - Fuel is drawn from the fuel tank via a feed pump and then pumped into the fuel rail by two plungers (4HK1) or three plungers (6HK1), all of which are internal to the fuel supply pump.
  - High pressure is regulated by the ECM/PCM using the fuel rail pressure (FRP) regulator dependant upon values from the FRP sensor attached to the fuel rail.
  - In case of fuel rail overpressure, a pressure limiter valve threaded into the fuel rail will open to release overpressure and return fuel back to the fuel tank.

Common Rail System Operation



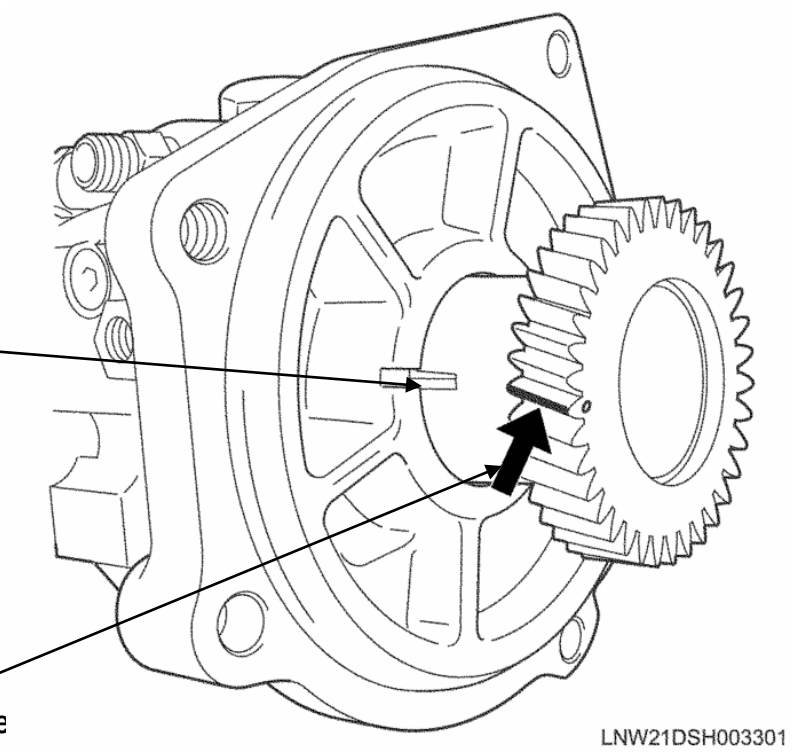
Fuel Injection (Supply) Pump



The supply pump draws fuel from the fuel tank, and pumps the high pressure fuel to the fuel rail. The quantity of the fuel discharged from the supply pump controls the pressure in the fuel rail. The fuel rail pressure regulator in the fuel supply pump affects this control in accordance with the command received from the engine control module (ECM).

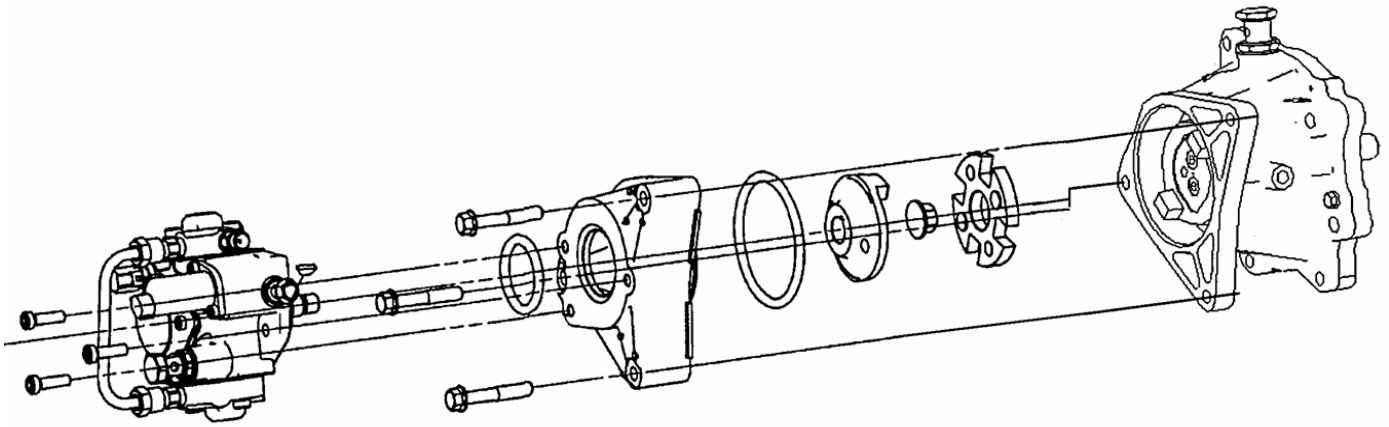
Fuel Injection (Supply) Pump

- **Fuel Injection Supply Pump Timing for 2005 thru 2007**

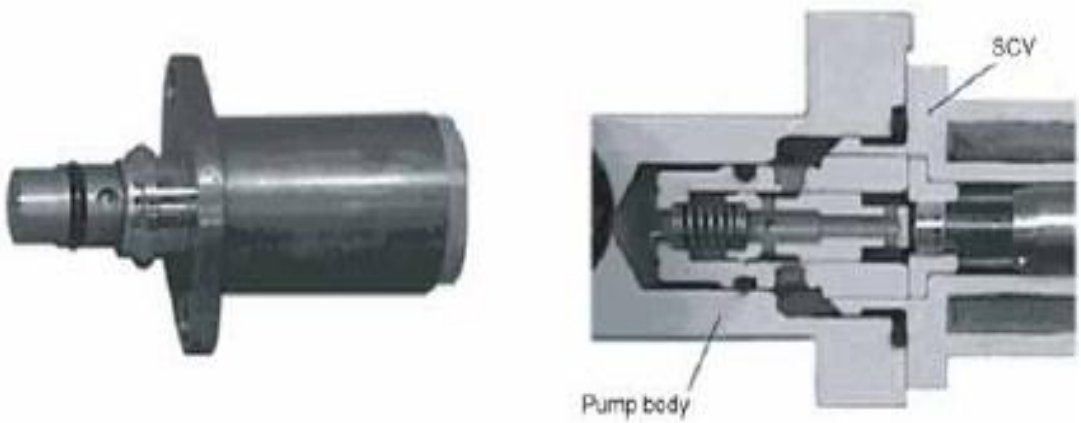


Fuel Injection (Supply) Pump

- **Fuel Injection Supply Pump Timing for 2007I thru 2010**



SCV (Suction Control Valve) or FRP (Fuel Rail Pressure) Regulator

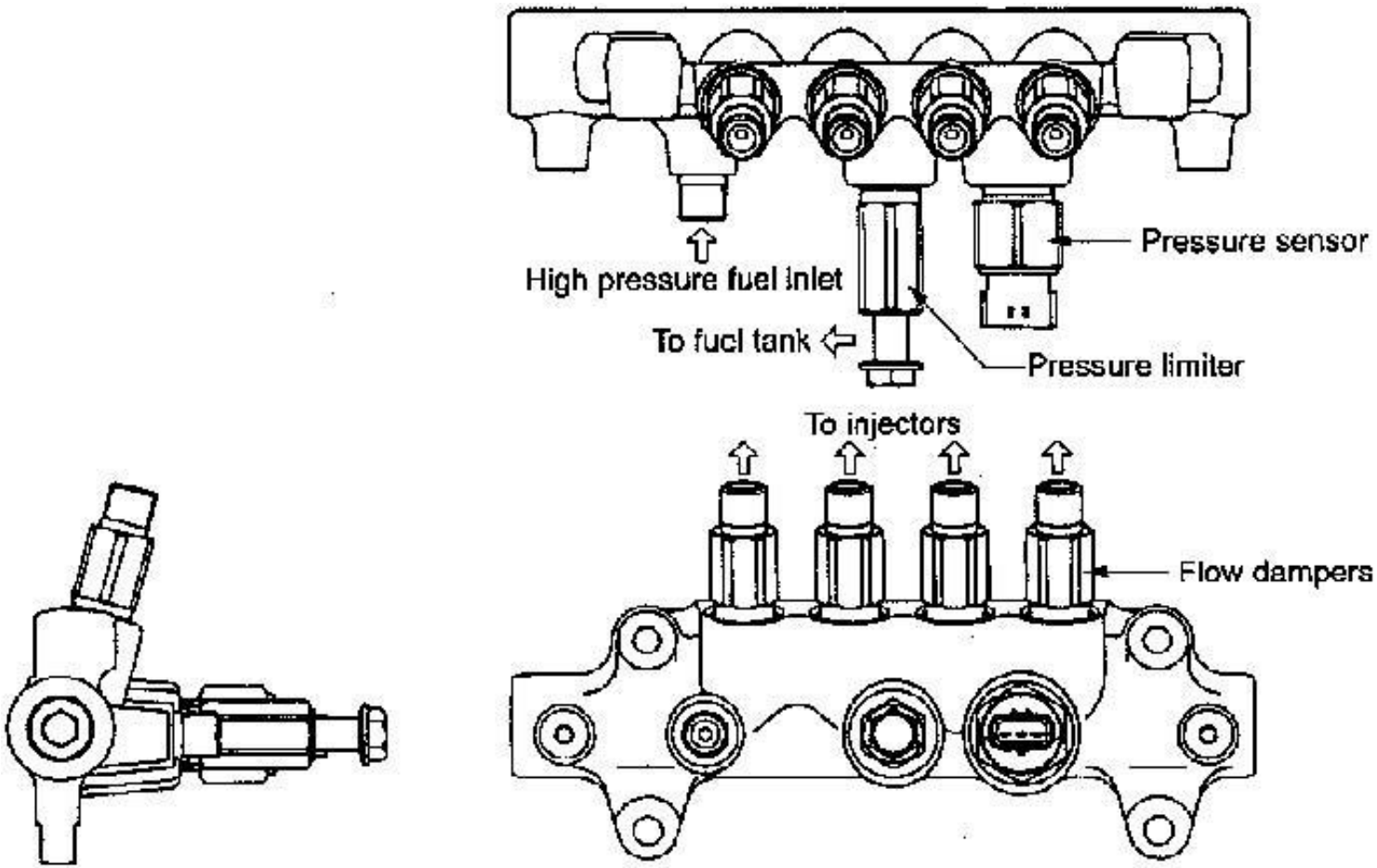


Previously called the Suction Control Valve (SCV), the fuel rail pressure regulator is a linear solenoid type. The ECU controls the duty ratio (the length of time that the current is applied to the fuel rail pressure regulator), in order to control the quantity of fuel that is supplied to the high-pressure plunger. Because only the quantity of fuel that is required for achieving the target rail pressure is drawn in, the drive load of the supply pumps decreases.

SCV (Suction Control Valve) or FRP (Fuel Rail Pressure) Regulator

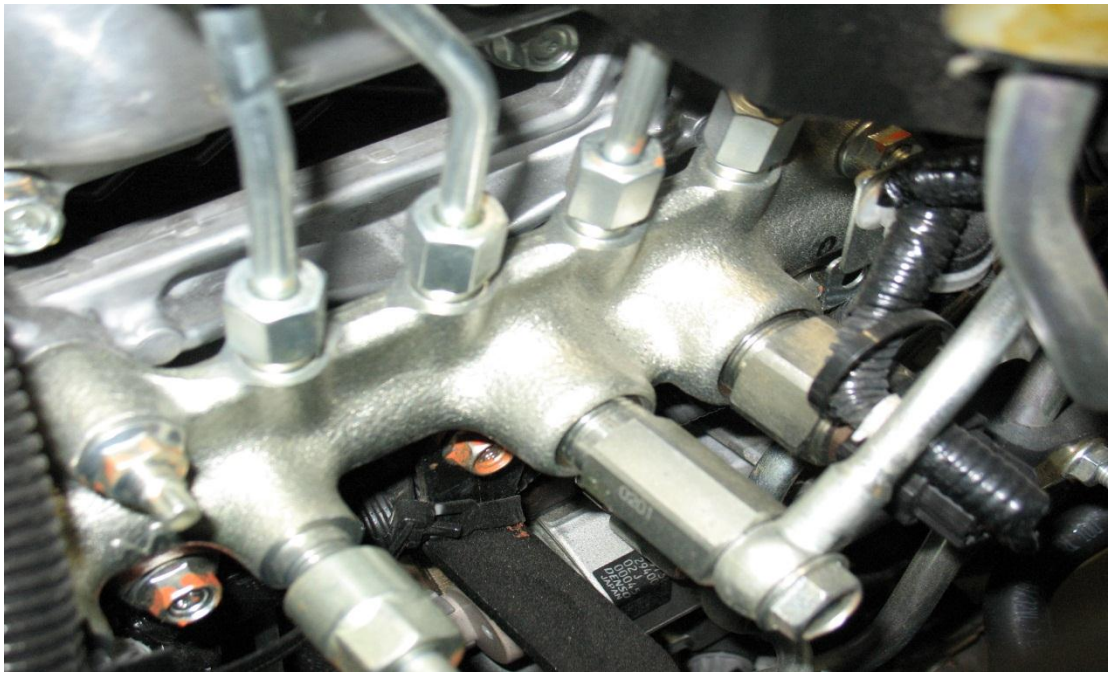
- When current flows to the fuel rail pressure regulator, variable electromotive force results in accordance with the duty ratio, moving the armature to the left side. The armature moves the cylinder to the left side, changing the opening of the fuel passage and thus regulating the fuel quantity.
- With the fuel rail pressure regulator OFF, the return spring contracts, completely opening the fuel passage and supplying fuel to the plungers. (Full quantity intake and full quantity discharge)
- When the fuel rail pressure regulator is ON, the force of the return spring moves the cylinder to the right, closing the fuel passage (normally opened).
- By turning the fuel rail pressure regulator ON/OFF, fuel is supplied in an amount corresponding to the actuation duty ratio, and the plungers discharge the fuel.

2005 to 2007 Common Rail

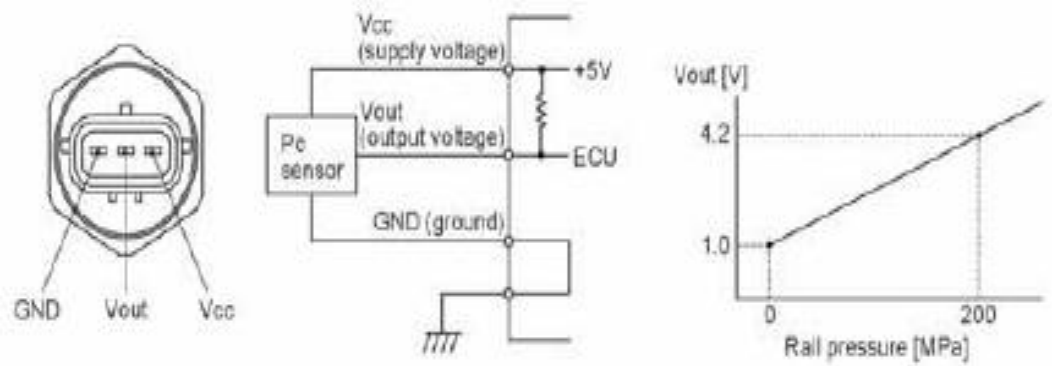


2007i to 2010 Common Rail

Beginning with the 2007i model year, the flow dampers have been eliminated from the common rail



Common Rail Pressure Sensor



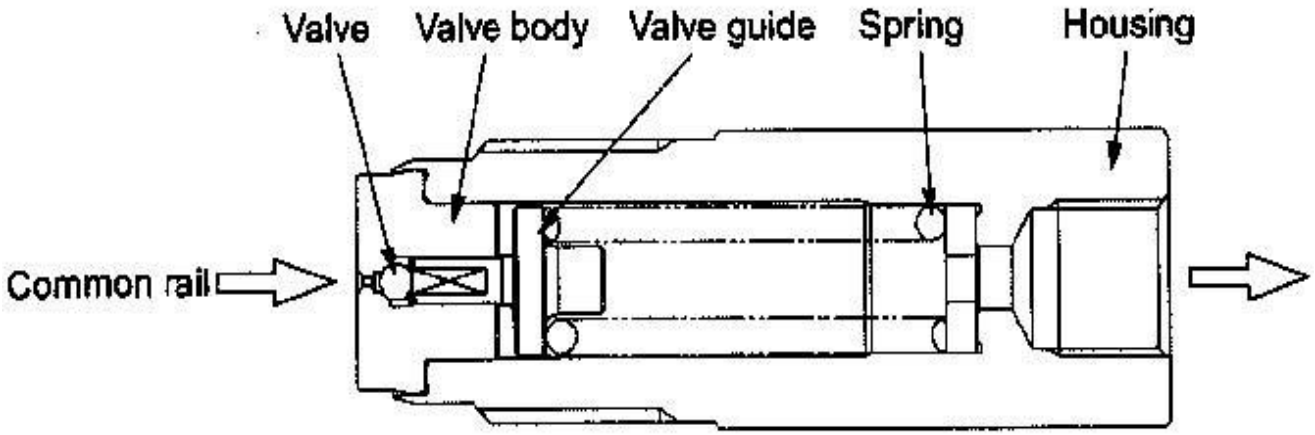
Tech Tip:

With the key on and engine not running, disconnect the Pressure Sensor and the scan tool data should read as follows:

'05 36205 psi '06-'07 27000 psi '08-'10 35722 psi

The common rail pressure sensor is located on the common rail. This sensor detects the fuel pressure in the common rail, converts the pressure into a voltage signal, and sends the signal to the ECM. The ECM supplies 5 volts to the fuel rail pressure sensor on the 5V reference circuit. The ECM also provides a ground on the low circuit. Higher common rail pressure provides higher fuel pressure sensor voltage while lower pressure provides lower fuel pressure sensor voltage.

Pressure Limiter



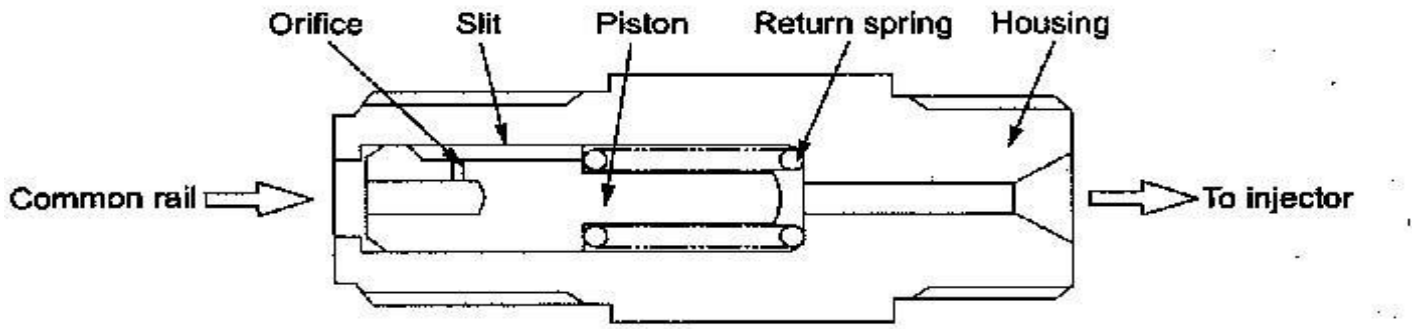
The pressure limiter is located on the common rail. The pressure limiter opens mechanically for pressure relief when the fuel pressure inside the common rail increases extremely.

Specification

Pressure Limiter Opening Pressure: 230 MPa
(33,358.68 psi)

Closes at 29 Mpa (4250 psi)

Flow Dampers



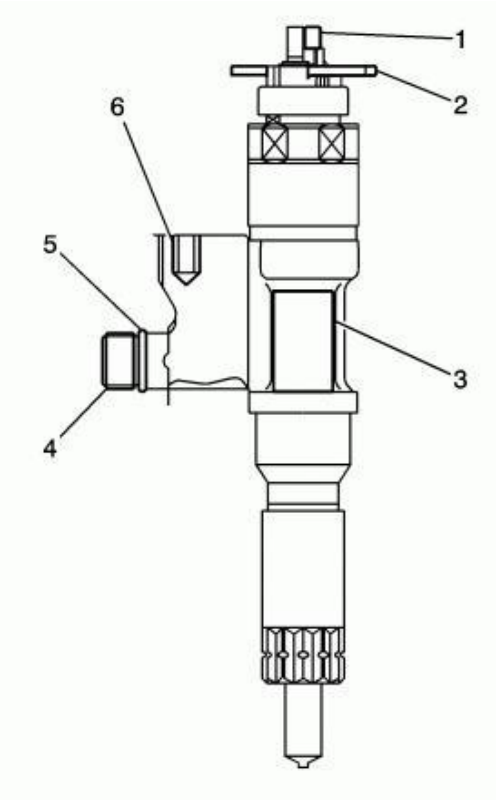
The flow dampers are located at the outlet of the common rail to damp a pulsation of fuel pressure inside the common rail. The flow dampers also cut off the fuel supply if there is a fuel leak downstream of the flow damper.

An orifice drilled into the side of the piston located inside of the flow damper (Figure 1-19) supplies fuel to the injector under normal operation. The resistive force of the return spring allows slight piston movement which dampens the pulsation of the fuel as it enters the injector pipe. Should an injector pipe fracture, the return spring and orifice flow cannot hold the piston open and the flow damper will close to prevent fuel leakage.

The piston returns when the fuel pressure inside the common rail goes below 0.6 MPa (87 psi).

Fuel System – Common Rail (cont'd)

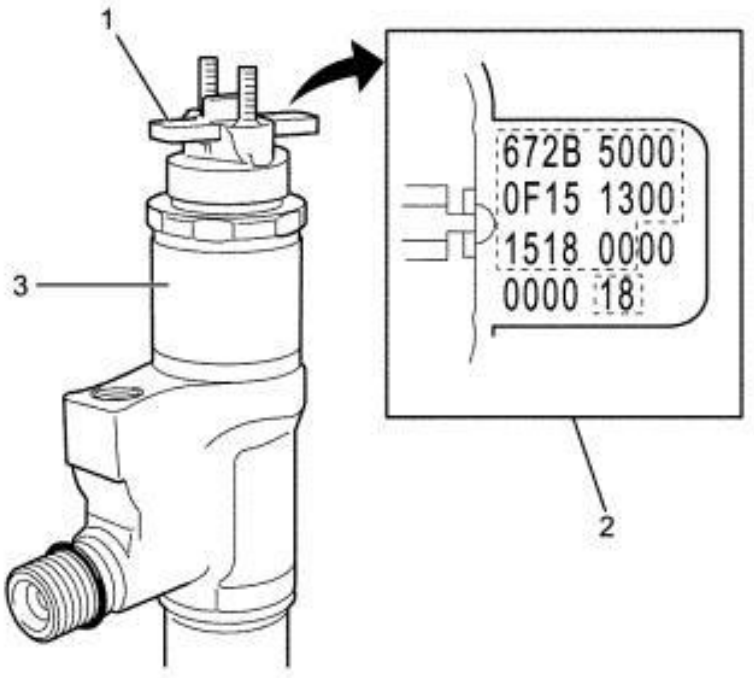
- Fuel Injectors
  - Overview
    - Controlled by the ECM/PCM
    - Uses Injector flow rate code information to optimize injection quantity control



1.	Terminal Stud
2.	ID Plate
3.	Injector Parts Number Marking
4.	Fuel Inlet Port
5.	O-ring
6.	Fuel Leak Off Port

Fuel System – Common Rail (cont'd)

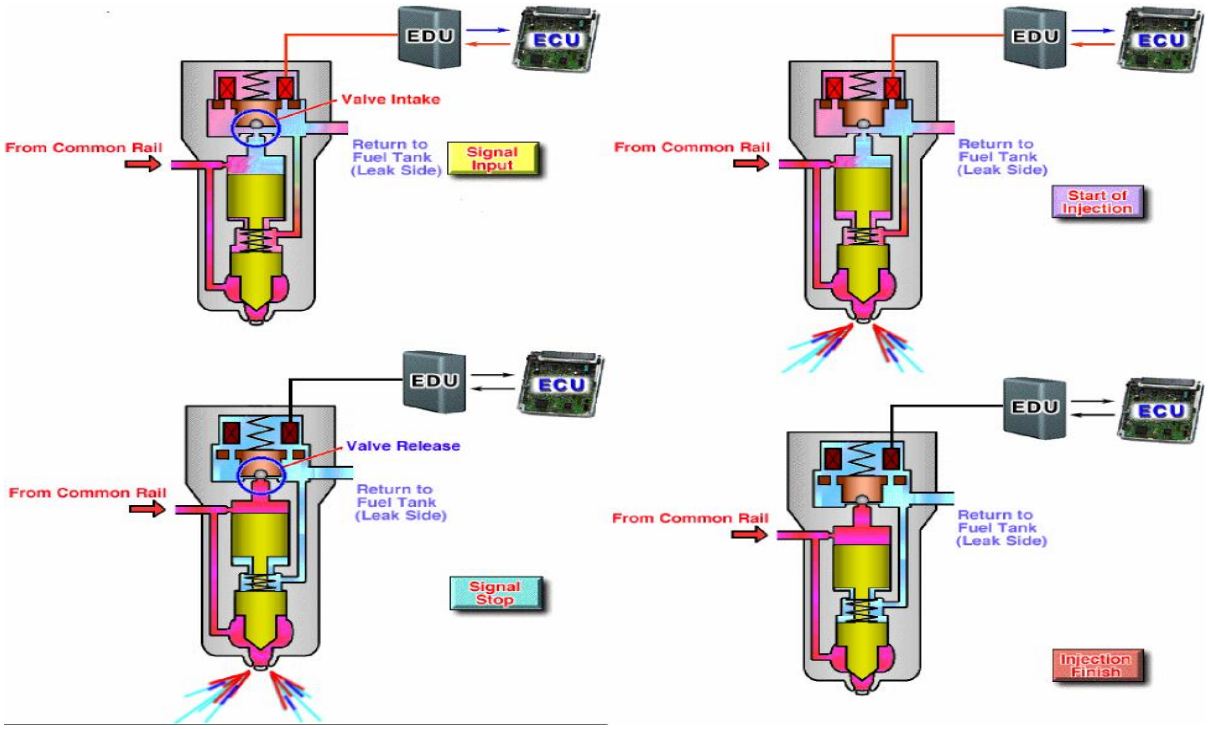
- Injector Flow Rate Code Information
  - 30 digit alphanumeric code is laser marked on the injector
  - First two digit define engine code
  - Ten sets of two digits define fuel injector flow rate information to optimize injection quantity control
  - Last two figures are the checksum
  - Sticker on valve cover contains flow rate information for all fuel injectors



1. ID Plate
2. Flow Rate
3. Fuel Injector

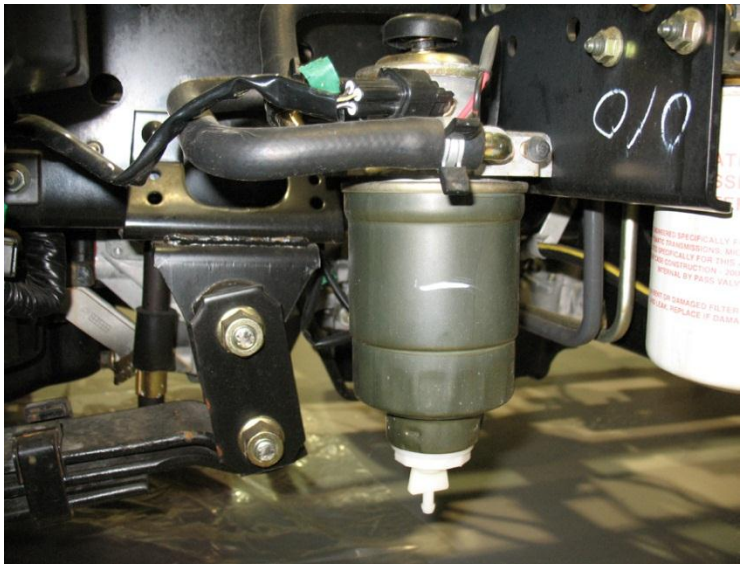
Fuel System – Common Rail (cont'd)

- Fuel Injectors (cont'd)
  - Operation
    - Non-injection state
    - Injection start
    - Injection end



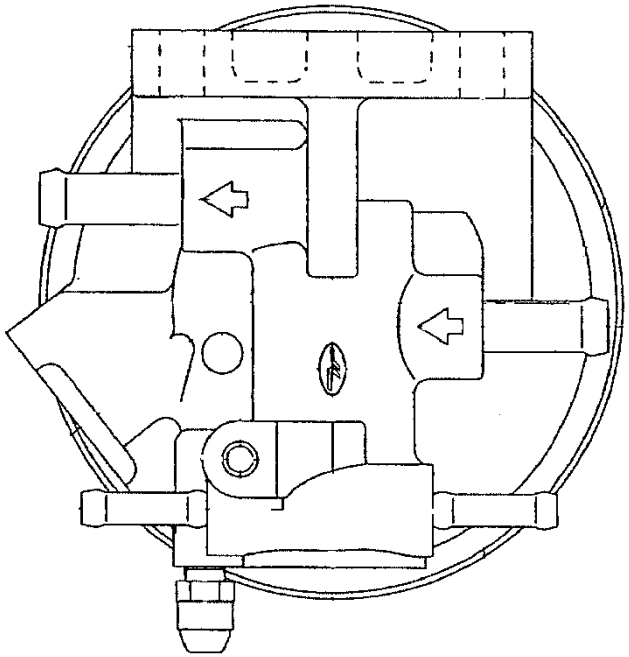
Fuel Filters

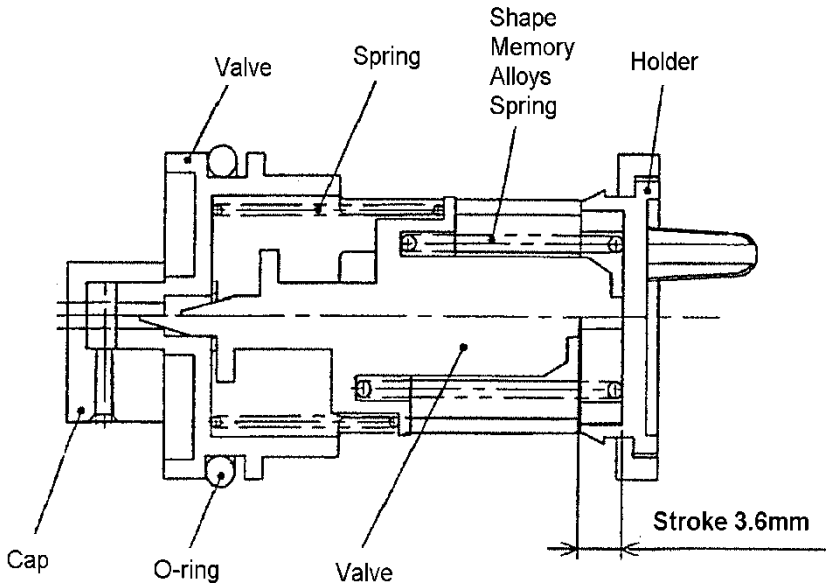
2007i-2010 4HK1 w/DPF



2005-2007 4HK1

Anti-gel Fuel Return System





Tech Tip:

The fuel system return must be bypassed when performing a fuel system vacuum test.

Diesel Fuel Testing

Specific Gravity Testing

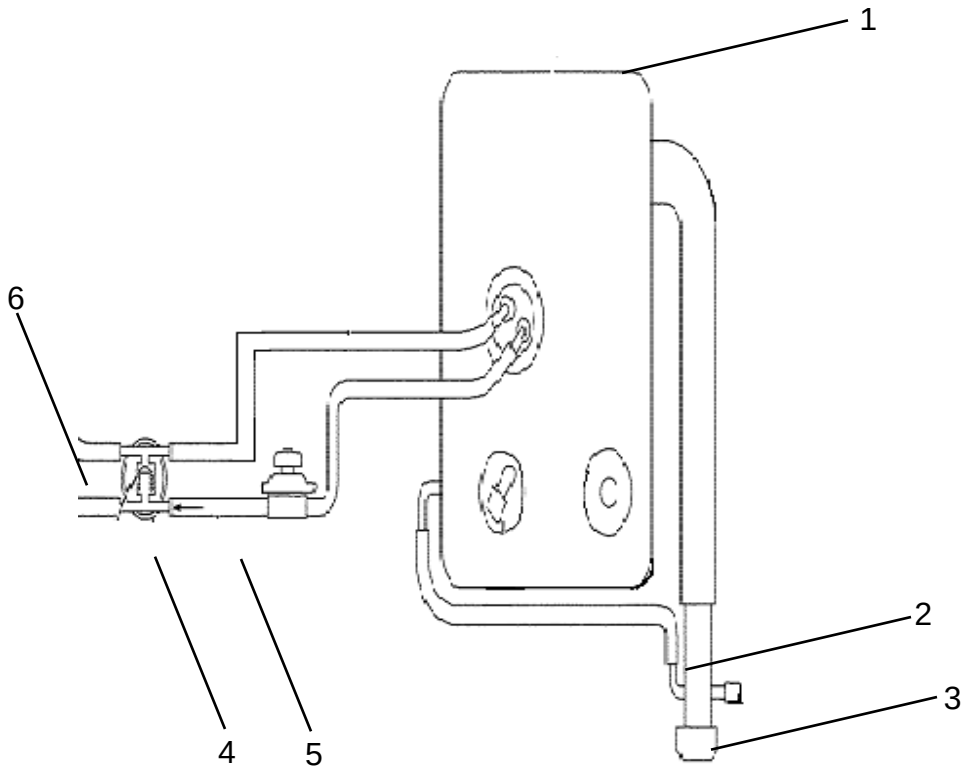
Specific Gravity Requirements	Number 2 Diesel	Number 1 Diesel	Tool
API Gravity	30-39	39-44	J-38641-B

Refer to the Fuel Oil Specific Gravity Requirements table. If the correct fuel is being used in the conditions listed in Fuel Quality, and meets number 1-Diesel or number 2-Diesel fuel oil specific gravity requirements, fuel is OK. If not, the fuel should be replaced.

These Service Bulletins can also be helpful when diagnosing fuel related issues:

- IB09-J-003A Symptom Diagnosis – Engine Fuel System
- SB10-J-09 Fuel Injector Failure – Contaminated Diesel Fuel, Secondary Fuel Filter Kit

Fuel System Suction Side Diagnosis



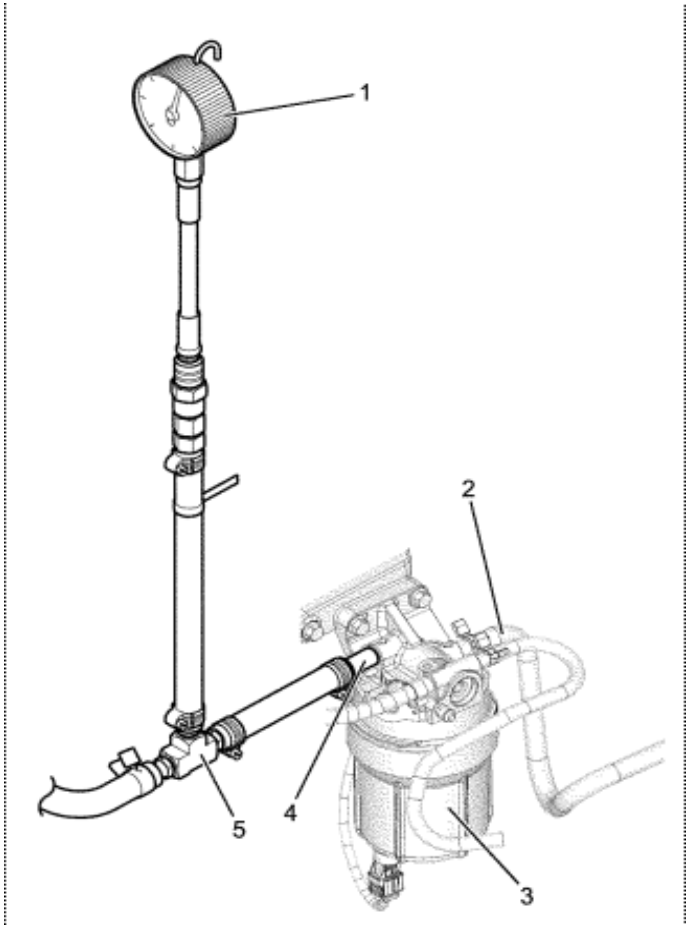
1. Fuel Tank
2. Fuel Filler Neck
3. Tank Vent
4. Fuel Feed Lines
5. Fuel Primer Pump
6. Fuel Filter & Backflow Valve

Fuel System Suction Side Diagnosis (cont'd)

- Customer complaint
  - Vehicle surges at steady speeds. What Parameters should you be looking at from the list below?
- Related Symptoms
  - Hard Starting
  - Low Power
  - Poor fuel economy
- Related DTCs
  - P0087, P0088, P0093, P0300, P1093
- Related Data

Actual Fuel Rail Pressure	psi
Desired Fuel Rail Pressure	psi
Fuel Rail Pressure (FRP) Sensor	Volts
Fuel Temperature	°F
Start Up Fuel Temperature	°F
Actual Fuel Rail Pressure (FRP) Regulator	mA
Desired Fuel Rail Pressure (FRP) Regulator	mA
Fuel Rail Pressure (FRP) Regulator Command	%
Fuel Rail Pressure (FRP) Regulator Commanded Fuel Flow	mm3/stroke
Turbocharger Boost Pressure	psi
Supply Pump Status	-
Supply Pump Adjustment	mA

Fuel System Suction Side Diagnosis (cont'd)



1. Fuel Pressure/Vacuum Gauge Assembly
2. Fuel Pipe (Intake Side)
3. Fuel Filter
4. Fuel Pipe (Discharge Side)
5. Fuel Pressure/Vacuum Gauge Adapter

Tech Tip:

To test the Feed Pump assembly of the Supply Pump, connect a vacuum gauge directly to the inlet of the Supply Pump. The pump should pull aprox. 15" of vacuum after a 15 sec. crank time

Fuel System Check

- The Fuel System Check diagnostic table directs the service technician to the appropriate section for fuel system diagnosis. The diagnostic table assumes the following conditions are met:
  - The battery is completely charged and terminals are cleaned and tight
  - The engine cranking speed is normal
  - There is adequate fuel in the fuel tank
  - There is no air in the fuel line
  - Fuse and fuse links are ok
- The fuel system from the fuel tank(s) to the fuel supply pump is under a slight vacuum with the engine running. As a result, air can enter the fuel system if these connections are not tight. Air in the fuel system will cause fuel rail pressure fluctuations especially at high engine speed and load.
- If the fuel tank is empty or near empty, air might be allowed to go into the fuel system. With air in the fuel system, smooth flow of fuel into the supply pump is interrupted and may cause a DTC to set. If it is suspected that air is present, perform bleeding of fuel system after refilling.
  - Refer to the workshop manual for specific Fuel System Check criteria

Fuel System Vacuum Check

- Use this procedure to measure the vacuum (negative pressure) discharge side of the fuel system.

  Notice: The fuel pressure/vacuum gauge assembly (gauge (1)) and the fuel pressure/vacuum gauge adapter (adapter (5)) must be cleaned before connect to the fuel line. Otherwise, foreign material adherent to the tools may damage the fuel supply pump.

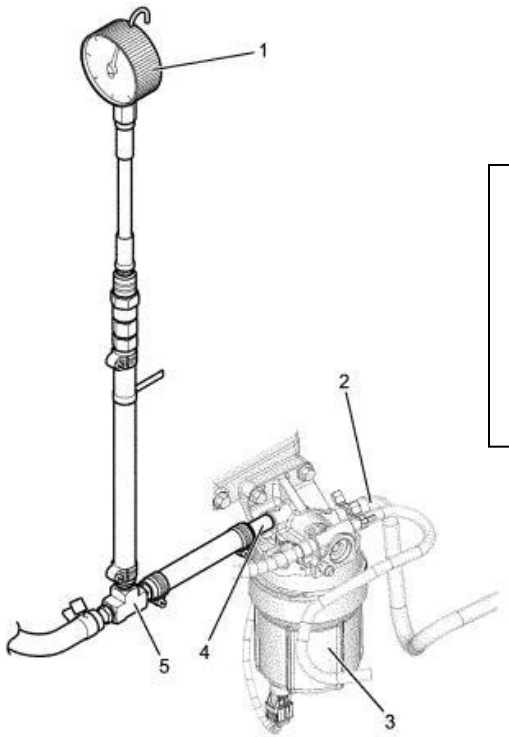
  - 1. Disconnect the fuel hose from the fuel filter housing. (fuel supply pump side).
  - 2. Install the adapter. Special tool Fuel pressure/vacuum gauge adapter: EN-47667
  - 3. Connect the gauge (1) with hose to the adapter (5). Special tool Fuel pressure/vacuum gauge assembly: J-44638
  - 4. Loosen the air bleeding plug on the fuel filter.
  - 5. Operate the priming pump until all the air has been bled from the system.
  - 6. Tighten the air bleeding plug on the fuel filter.
  - 7. Start the engine and allow it to idle.
  - 8. Note the gauge (1) reading. If the reading is normal, go to Step 9. If the fuel vacuum is greater than the specified value of - standard fuel vacuum less than 5 in Hg - there is a problem in the fuel system. Perform the procedures outlined below.
    - Replace the fuel filter element.
    - Check the fuel delivery pipe. If it is clogged, it must be replaced.
    - Remove the fuel pipe at the fuel filter inlet. Use high-pressure air forced through the fuel pipe to clean the fuel system.

    Notice:

    - Remove the fuel filler cap before applying high-pressure air.
    - Do not perform this procedure if the fuel tank is nearly full (fuel approaching or flowing into the fuel filler neck). The forced air will spray fuel from the fuel filler neck.

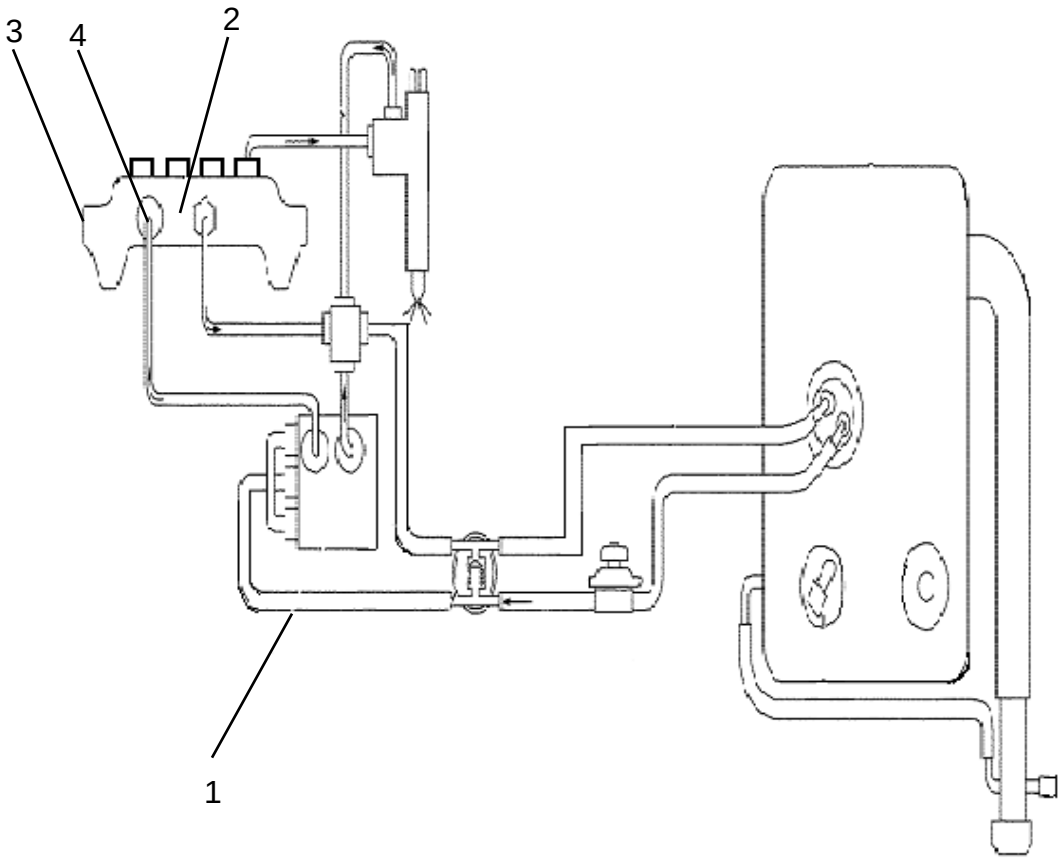
Fuel System Vacuum Check (cont'd)

- 9.Remove the gauge (1) and hose from the adapter (5).
- 10. Remove the adapter (5).
- 11. Connect the fuel hose.
- 12. Use your hand to operate the fuel filter priming pump. Operate the pump until all the air has been bled from the system.
- 13. Start the engine and allow it to idle.
- 14. Inspect the fuel system for fuel leakage.



(1) Fuel Pressure/Vacuum Gauge Assembly
(2) Fuel Pipe (Intake Side)
(3) Fuel Filter
(4) Fuel Pipe (Discharge Side)
(5) Fuel Pressure/Vacuum Gauge Adapter

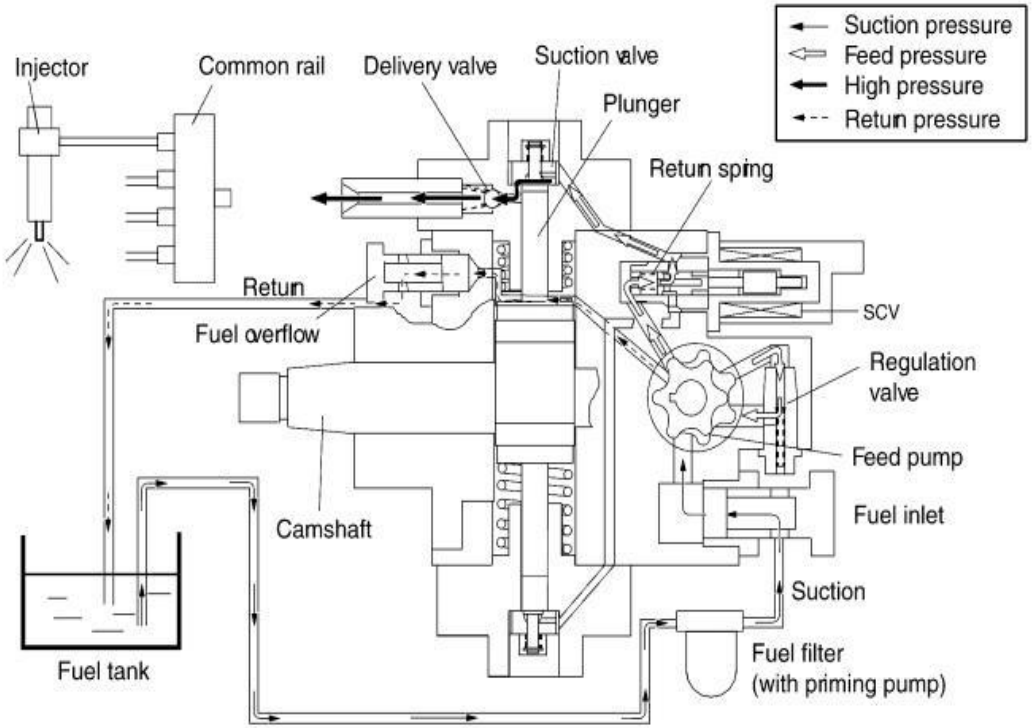
Fuel System High Pressure Side Diagnosis



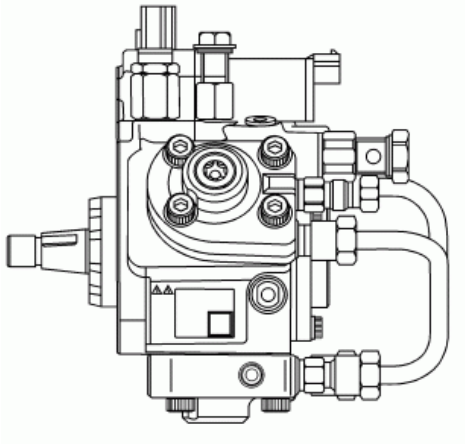
1. High Pressure Supply Pump
2. Common Rail Fuel Rail
3. Fuel Pressure Sensor
4. Fuel Pressure Limiter Valve

Fuel System High Pressure Side Diagnosis

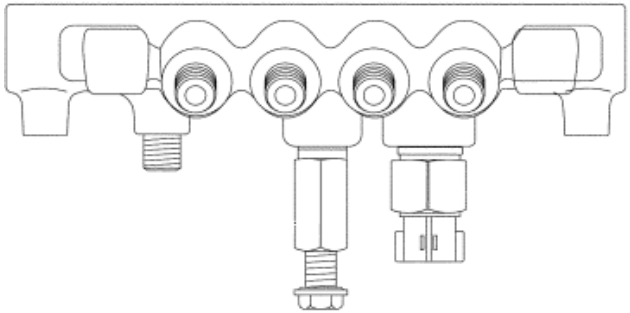
Common Rail System Operation



Fuel Pressure Supply Pump



Common Rail



Fuel System Drivability Diagnosis

- Starting Point
  - Review Customer's Complaint
  - Prior repair History for the vehicle
  - Review Customer's Complaint
  - Careful visual inspection of the vehicle and systems
  - Perform a Diagnostic Circuit Check
  - Review Engine/Fuel data with IDSS
  - Perform a DTCs that were found during the Diagnostic Circuit Check
- Symptom
  - Hard Starting-No Start
  - Low Power
  - Engine run rough
  - Cuts out, hesitates
- Vehicle Diagnosis
  - Fuel System Check
  - Scan Tool Data Comparison
  - On-Vehicle Testing

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Fuel System Diagnostic Review

Question:

Customer states the vehicle is low on power and does not pull well when carrying a load. What parameters from the data list below would you use to diagnose the complaint??

Parameter	Unit
Balancing Rate Cylinder 1	mm3/stroke
Balancing Rate Cylinder 2	mm3/stroke
Balancing Rate Cylinder 3	mm3/stroke
Balancing Rate Cylinder 4	mm3/stroke
Actual Fuel Rail Pressure	psi
Desired Fuel Rail Pressure	psi
Fuel Rail Pressure (FRP) Sensor	Volts
Fuel Temperature	°F
Start Up Fuel Temperature	°F
Actual Fuel Rail Pressure (FRP) Regulator	mA
Desired Fuel Rail Pressure (FRP) Regulator	mA
Fuel Rail Pressure (FRP) Regulator Command	%
Fuel Rail Pressure (FRP) Regulator Commanded Fuel Flow	mm3/stroke
Turbocharger Boost Pressure	psi
Supply Pump Status	-
Supply Pump Adjustment	mA
Engine Speed	RPM
Vehicle Speed	mph
Engine Load	%
Barometric Pressure	kPa
Engine Coolant Temperature (ECT)	°F
Start Up Engine Coolant Temperature (ECT)	°F

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Low Power Demo IDSS datalist

- Actual rail pressure
- Fuel temperature
- Coolant temperature
- Barometric pressure
- Boost pressure
- Main Injection timing
- Mass Air Flow
- APP Percentage

Fuel System – Common Rail (cont'd)

- Diagnostics
  - Symptoms
    - Problems with starting

Condition	Possible Cause	Correction
Problems with starting	Fuel tank is empty	Fill the tank.
	Air has entered the fuel system.	Bleed the air.
	Fuel line is clogged or damaged. Connection to the fuel line is loose.	Repair or replace the fuel line. Re-tighten the connection.
	Fuel filter element is clogged.	Replace the element.
	Fault in the feed pump	Replace the fuel supply pump.
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

    - Hunting during idling

Condition	Possible Cause	Correction
Hunting during idling	Air has entered the fuel system.	Bleed air from the fuel system.
	Leakage or clogging of the fuel system	Repair or replace the fuel system.
	Drops of water have entered the fuel system.	Replace the fuel.
	Fuel filter element is clogged.	Replace the fuel filter element.
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

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Fuel System – Common Rail (cont'd)

- Symptoms (cont'd)
  - Insufficient horsepower

Condition	Possible Cause	Correction
Insufficient horsepower	Air has entered the fuel system.	Bleed air from the fuel system.
	Leakage or clogging of the fuel system	Repair or replace the fuel system.
	Water mixes in the fuel system	Replace the fuel.
	Fuel filter element is clogged.	Replace the element.
	Sticking of the fuel injector nozzle	Replace the fuel injector.
	Defective engine control system	Diagnose the engine control system.

  - Maximum engine speed is too low

Condition	Possible Cause	Correction
Maximum engine speed is too low	Fuel line is clogged or damaged.	Repair or replace the fuel line.
	Defective engine control system	Diagnose the engine control system.

Fuel System – Common Rail (cont'd)

- Symptoms (cont'd)
  - Exhaust gas is blue or black

Condition	Possible Cause	Correction
Exhaust gas is blue or black.	Reduction in injection-valve opening pressure or defective atomizing status	Replace the fuel injector.
	Engine control system malfunction	System diagnosis.

  - Engine does not stop

Condition	Possible Cause	Correction
Engine does not stop	Defective engine control system	Diagnose the engine control system.

Fuel System – Common Rail (cont'd)

- Diagnostics (cont'd)
  - Associated DTC's – 4HK1 Ref
    - P0087 Fuel Rail Pressure Too Low
    - P0088 Fuel Rail Pressure Too High
    - P0089 Fuel Pressure Regulator Performance
    - P0091 Fuel Pressure Regulator Solenoid 1 Control Circuit Low Voltage
    - P0092 Fuel Pressure Regulator Solenoid 1 Control Circuit High Voltage
    - P0093 Large Leak Detected
    - P0181 Fuel Temperature Sensor Performance
    - P0182 Fuel Temperature Sensor Circuit Low Voltage
    - P0183 Fuel Temperature Sensor Circuit High Voltage
    - P0191 Fuel Rail Pressure Sensor Performance
    - P0192 Fuel Rail Pressure Sensor Circuit Low Voltage
    - P0193 Fuel Rail Pressure Sensor Circuit High Voltage
  - For specific DTC criteria refer to the workshop manual

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Misfire Drivability Diagnosis

- Starting Point
  - Verify customers complaint.
  - Review repair history.
  - Road test to duplicate the concern.
  - Review Scan tool data parameters for abnormal data.
  - Check for DTCs
- Symptom
  - Engine runs rough.
  - Lacks power.
  - Surges at steady speeds.
  - Excessive fuel consumption.
- Vehicle Diagnosis
  - Scan Tool Data
  - Engine Compression Test

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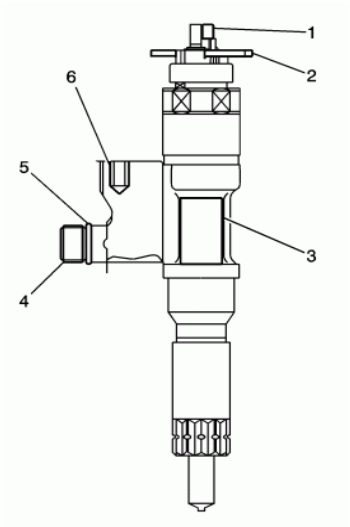
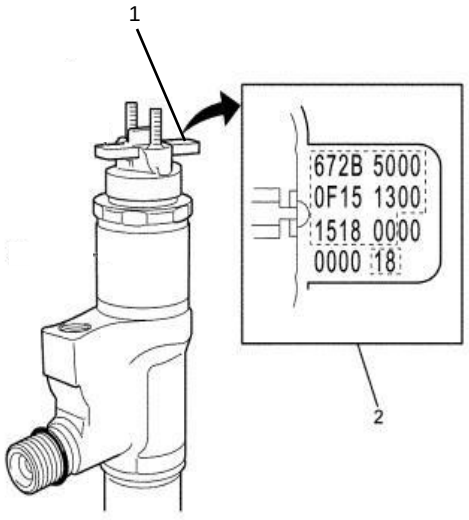
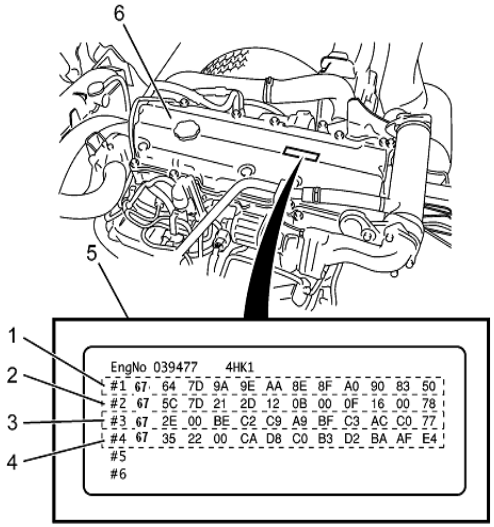
Fuel System High Pressure Side Diagnosis



1. Terminal Stud
2. QR Plate
3. Injector Parts Number Marking
4. Fuel Inlet Port
5. O-ring
6. Fuel Leak Off Port

1. ID Plate
2. Flow Rate





1. Cylinder #1 ID code
2. Cylinder #2 ID code
3. Cylinder #3 ID code
4. Cylinder #4 ID code
5. Injector ID code label
6. Cylinder head cove

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Misfire

Description:

- Rough or Unstable Idle
- Hesitation or Lag when accelerating
- Surging & Vary vehicle speed at steady throttle.

Causes:

Mechanical:

- Valve Train
- Piston Rings
- Fuel Injectors

Electrical:

- Fuel Pressure Regulator
- Engine Wiring

Diagnostics:

- Compression & Cylinder Leakage Test
- Scan Tool

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Misfire

- Diagnostics
  - Full-range, intermittent misfire monitoring necessary.
  - Monitor the CKP and CMP sensors for smooth output.
  - Sufficient variance in the signals received can indicate a misfire.
  - Some vehicles have problems with misfire monitoring during some driving conditions, such as driving over railroad tracks, that can cause sufficiently rapid changes in load.
  - Other Components that can cause misfire
    - Fuel Injector (see bulletin IB09-J-003A)
      - Pressure
      - Timing
      - Rate
    - Mechanical Gear Lash
  - Associated DTCs – 4HK1 Ref
    - P0300 Engine Misfire Detected
    - P0301, P0302, P0303, P0304 Cylinder 1, 2, 3, 4, Misfire Detected
  - For specific DTC criteria refer to the workshop manual

Misfire Diagnostic Review

Question:

Customer states the vehicle has no power and is very hard to start after it has been driven for a period of time. Customer also advises the vehicle has blue smoke on start up. What is the first thing you should do as part of the diagnosis of this complaint?

- Perform a compression test on the engine.
- Check for DTCs and review engine data.
- Verify customer's complaint.
- Check the operation of the turbocharger.

Misfire Drivability Diagnosis (cont'd)

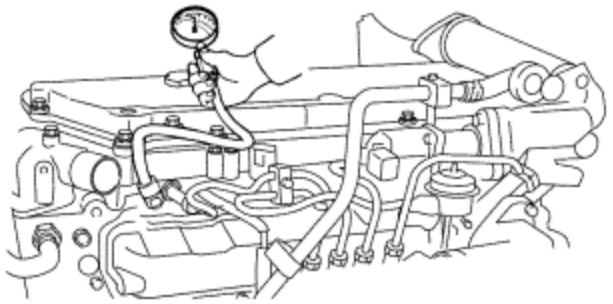
- Fuel System Data
  - Injector Balance Rates
  - Desired Fuel Pressure
  - Actual Fuel Pressure
  - FRP Commanded Fuel Flow

Fuel System Data 1

Parameter	Unit
Balancing Rate Cylinder 1	mm3/stroke
Balancing Rate Cylinder 2	mm3/stroke
Balancing Rate Cylinder 3	mm3/stroke
Balancing Rate Cylinder 4	mm3/stroke
Actual Fuel Rail Pressure	psi
Desired Fuel Rail Pressure	psi
Fuel Rail Pressure (FRP) Sensor	Volts
Fuel Temperature	°F
Start Up Fuel Temperature	°F
Actual Fuel Rail Pressure (FRP) Regulator	mA
Desired Fuel Rail Pressure (FRP) Regulator	mA
Fuel Rail Pressure (FRP) Regulator Command	%
Fuel Rail Pressure (FRP) Regulator Commanded Fuel Flow	mm3/stroke

Fuel System Data 2

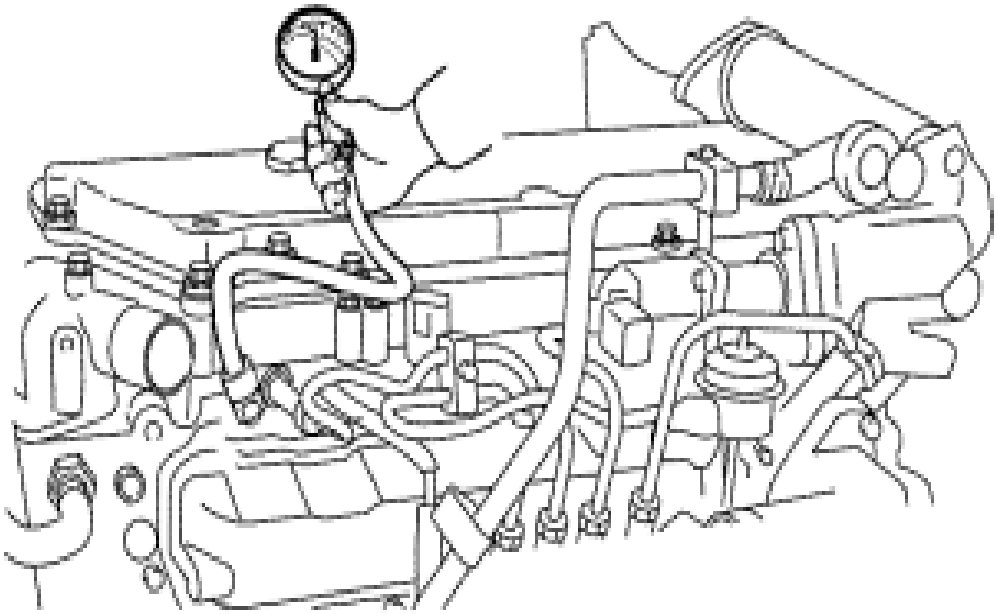
Pilot Injection Fuel Rate	mm3/stroke
Main Injection Fuel Rate	mm3/stroke
Basic Fuel Rate	mm3/stroke
Final Fuel Rate	mm3/stroke
Final Fuel Rate Correction	mm3/stroke
Pilot Injection Pulse Width	ms
Main Injection Pulse Width	ms
Main Injection Timing	°CA
Engine Speed	RPM
Vehicle Speed	mph
Engine Load	%



Compression pressure	MPa (psi)	/rpm
Standard	2.4 – 2.7 (348 – 391) 2.5 – 2.8 (363 – 406) 2.6 – 2.9 (377 – 421)	/ 150 / 185 / 220
Limit	2.16 (316)	
Differences among the cylinders	294 kPa (43)	

- **Notice: To keep engine speed at 200 RPM or more, use fully charged batteries**

Cylinder Leakage Tester



Cylinder Leakage Test

- Remove All Glow plugs.
- Start with cylinder that had Low Compression.
- Verify both Intake & Exhaust valves Are in the "CLOSED" position.
- Install the Leak-Down Tester per tools instruction guide.
- Record your reading. If > 15% list for air escaping into the crank case, exhaust system, check cooling system for air bubbles.

- Question: Customer reports the vehicle runs rough at idle, sometimes will crank but not start. This concern occurs both at idle and throughout the RPM range. What data parameters would you use to determine the cause of this complaint?

Fuel System Data 1

Parameter	Unit
Balancing Rate Cylinder 1	mm3/stroke
Balancing Rate Cylinder 2	mm3/stroke
Balancing Rate Cylinder 3	mm3/stroke
Balancing Rate Cylinder 4	mm3/stroke
Actual Fuel Rail Pressure	psi
Desired Fuel Rail Pressure	psi
Fuel Rail Pressure (FRP) Sensor	Volts
Fuel Temperature	°F
Start Up Fuel Temperature	°F
Actual Fuel Rail Pressure (FRP) Regulator	mA
Desired Fuel Rail Pressure (FRP) Regulator	mA
Fuel Rail Pressure (FRP) Regulator Command	%
Fuel Rail Pressure (FRP) Regulator Commanded Fuel Flow	mm3/stroke

Misfire Data List

- Injector Balance Rates ALL Cylinders
- APP Percentage
- Actual Rail Pressure
- Desired Rail Pressure

Exhaust Gas Recirculation System (EGR)

EGR Purpose

The oxygen and nitrogen that make up the engine's intake air normally exist as a mixture of separate elements. However, under some operating conditions, engine combustion temperature can become high enough to cause nitrogen atoms and oxygen atoms to chemically combine and form a compound called nitrogen oxide (NOx), an undesireable air pollutant. This unwanted chemical reaction can be prevented by reducing the peak combustion temperature. The easiest way to accomplish this is to introduce an inert gas (a gas that is not combustible, nor does it support combustion) into the combustion chamber along with the intake air. This inert gas acts like a "heat sink" during the combustion process, lowering the peak temperature to an acceptable level. Since the engine's exhaust gas is inert, and readily available, it offers a perfect solution to the NOx problem.

Exhaust Gas Recirculation System (EGR)

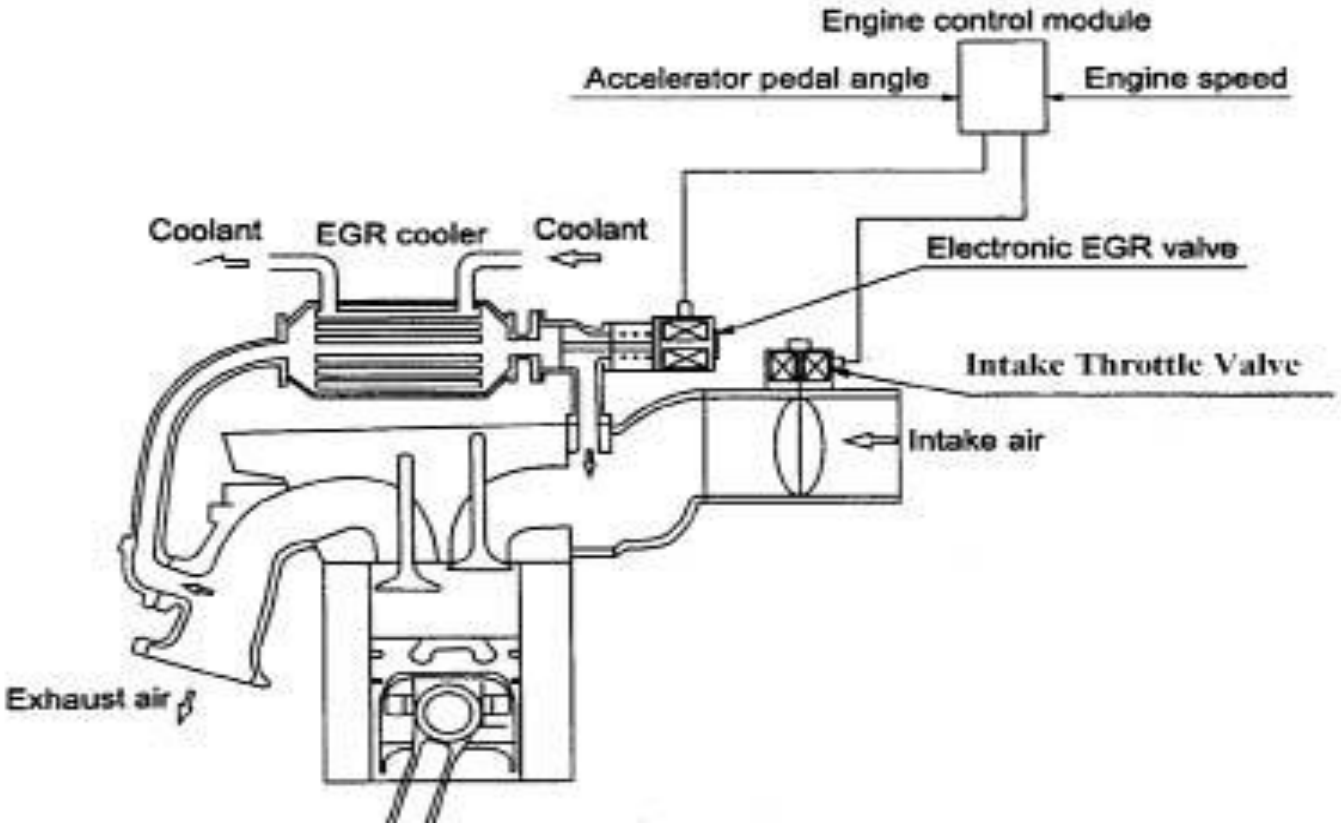
EGR Operation

The EGR system recirculates an appropriate portion of the exhaust gas into the intake manifold with an ECM controlled pulse width modulated (PWM) valve. The control current from the ECM operates the DC motor to control the lift amount of the EGR valve. The EGR control starts when the appropriate operating conditions are satisfied, including engine speed, coolant temperature, accelerator pedal angle, atmospheric pressure, and system voltage. The valve opening is then calculated based on coolant temperature, engine speed, and target fuel injection quantity. Based on this valve opening, the ECM adjusts the pulse width (duty cycle) of DC motor in order to achieve the appropriate EGR valve lift. A valve position sensor (potentiometer) at the rear of the motor feeds actual valve lift amount back to the ECM for more precise control.

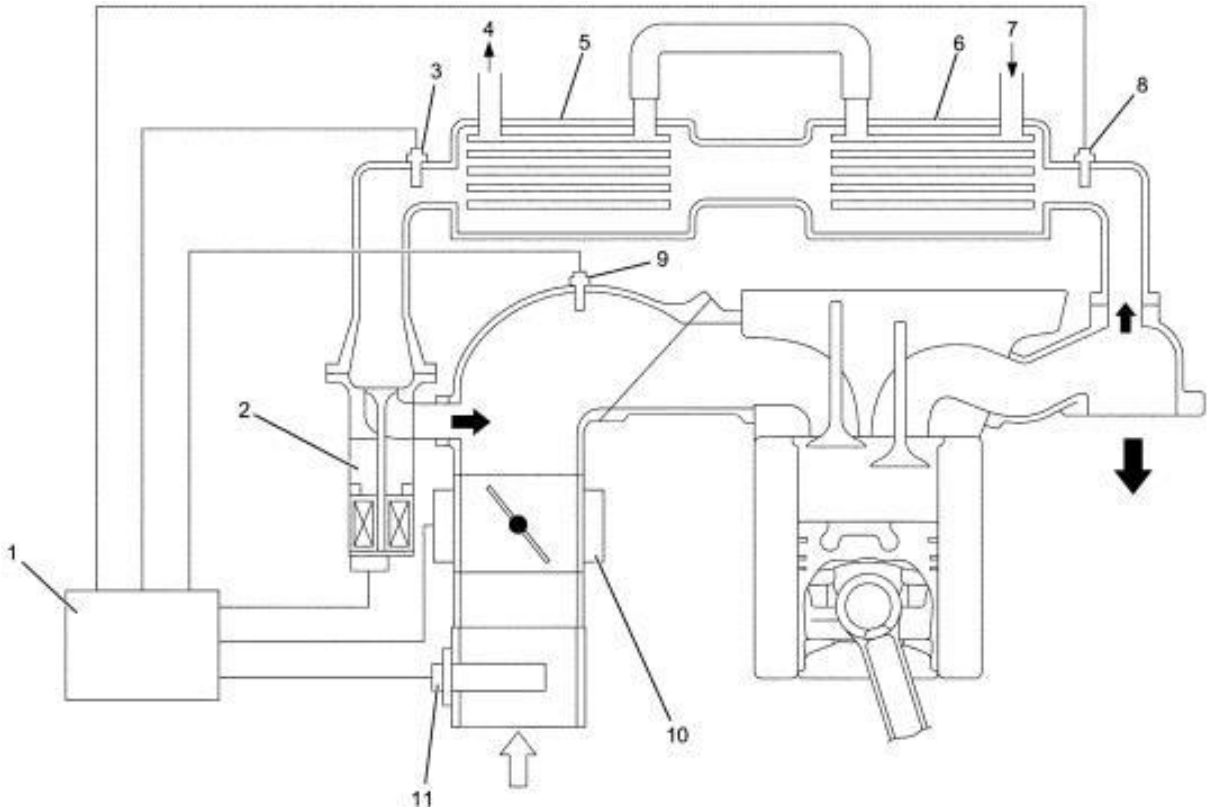
At the same time, the ECM regulates intake airflow with a DC motor operated intake throttle valve. An intake throttle position sensor at the intake throttle feeds the actual throttle valve position back to the ECM for more exact control. This electronic control system strategy ensures both driveability and low emissions.

The ECM will discontinue EGR when the exhaust brake operates, the PTO operates, the AP sensor is faulty, the ECT sensor is faulty, or the EGR system is faulty. EGR operation will also stop whenever coolant temperature is low to ensure driveability and startability.

4HK1 EGR System (without DPF)

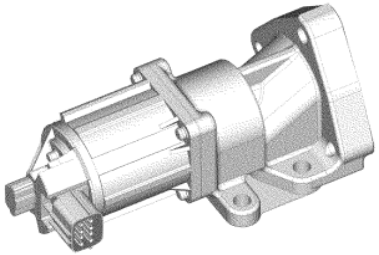


4HK1 EGR System (with DPF)



1. ECM
2. EGR Valve
3. EGR Gas Temperature Sensor 2
4. Engine Coolant outlet
5. Secondary EGR cooler
6. Primary EGR cooler
7. Engine coolant inlet
8. EGR Gas Temperature Sensor 1
9. Intake Air Temperature (IAT) Sensor
10. Intake Air Flow (IAF) valve
11. Mass Air Flow (MAF) sensor

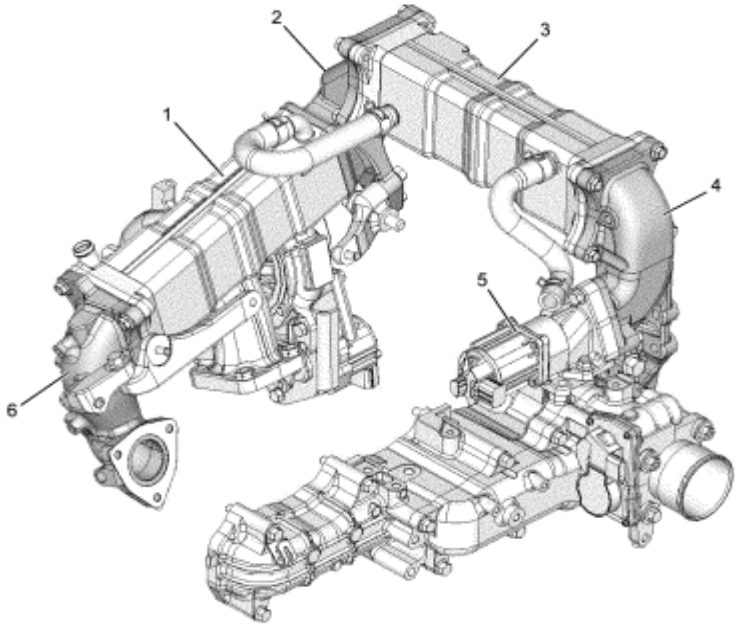
EGR System Drivability Diagnosis (cont'd)



Electronically Controlled Solenoid Valve

EGR DATA

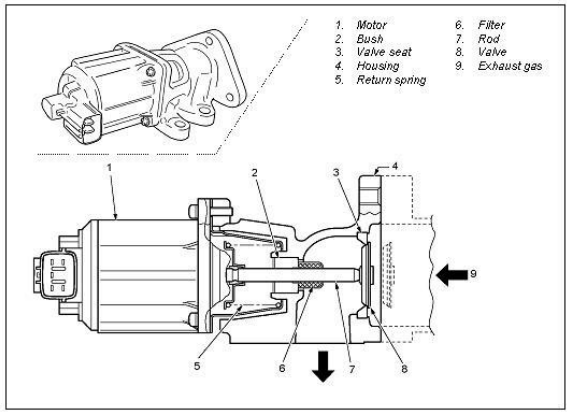
Parameter	Unit
Exhaust Gas Recirculation (EGR) Valve Position	%
Desired Exhaust Gas Recirculation (EGR) Valve Position	%
Exhaust Gas Recirculation (EGR) Valve Position Sensor	Volts
Exhaust Gas Recirculation (EGR) Solenoid Command	%
Exhaust Gas Recirculation (EGR) Valve Position Variance	%
Exhaust Gas Recirculation (EGR) Valve Learned Minimum Position	mm
Exhaust Gas Recirculation (EGR) Valve Position Error	%
Exhaust Gas Recirculation (EGR) Gas Temperature 1	°F
Exhaust Gas Recirculation (EGR) Gas Temperature 2	°F

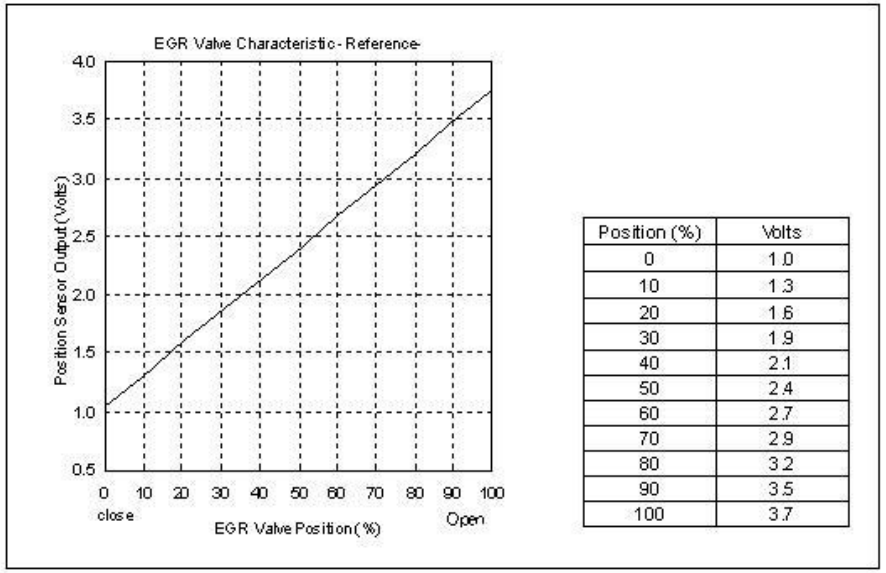


1. EGR Cooler 1st
2. EGR Cooler Duct 1st to 2nd
3. EGR Cooler 2nd
4. EGR Duct 2nd to EGR Valve
5. EGR Valve
6. EGR Cooler Duct Exhaust

EGR System (cont'd)

- Description
  - Part of the exhaust gas recirculates to the intake side, and inert gases are mixed with intake air to reduce combustion temperature, so nitrogen oxide (NOx) generation is reduced.
  - EGR Control begins when the conditions for engine speed, engine coolant temperature, intake air temperature and barometric pressure are satisfied.
  - An electronic control system is used to balance the requirements of operability and low emissions. A DC motor is operated using a control current from the ECM/PCM to control the EGR valve. The intake airflow (IAF) allows for adequate intake manifold depression to ensure EGR gas flow.
- Components
  - EGR Valve
  - Intake Air Temperature Sensor
  - Intake Air Flow (IAF) Valve
  - EGR Gas Temperature Sensor 1
  - EGR Gas Temperature Sensor 2

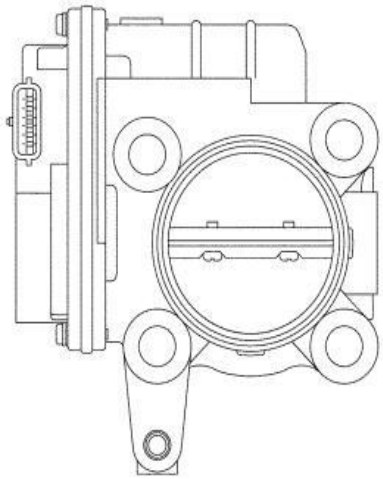




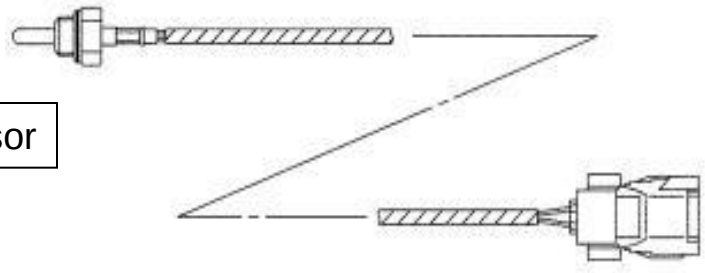
Position (%)	Volts
0	1.0
10	1.3
20	1.6
30	1.9
40	2.1
50	2.4
60	2.7
70	2.9
80	3.2
90	3.5
100	3.7

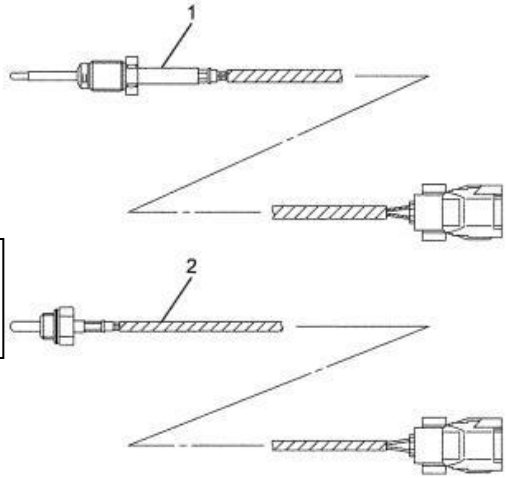
EGR Components

IAF Valve



IAT Sensor





1. EGR Gas Temperature Sensor 1
2. EGR Gas Temperature Sensor 2

EGR System Drivability Diagnosis

- Starting Point
  - Verify customers complaint.
  - Review repair history.
  - Road test to duplicate the concern.
  - Review Scan tool data parameters for abnormal data.
  - Check for DTCs
- Symptom
  - There are really no symptoms for the EGR System.
  - White smoke out the exhaust with no misfires or other drivability complaints could be the EGR Cooler leaking into the EGR System.
- Vehicle Diagnosis
  - Use IDSS to check for DTCs.
  - EGR system usually set Diagnostic Trouble Codes for most failures in the system. Use the workshop manual DTC flow charts to correctly repair the vehicle.

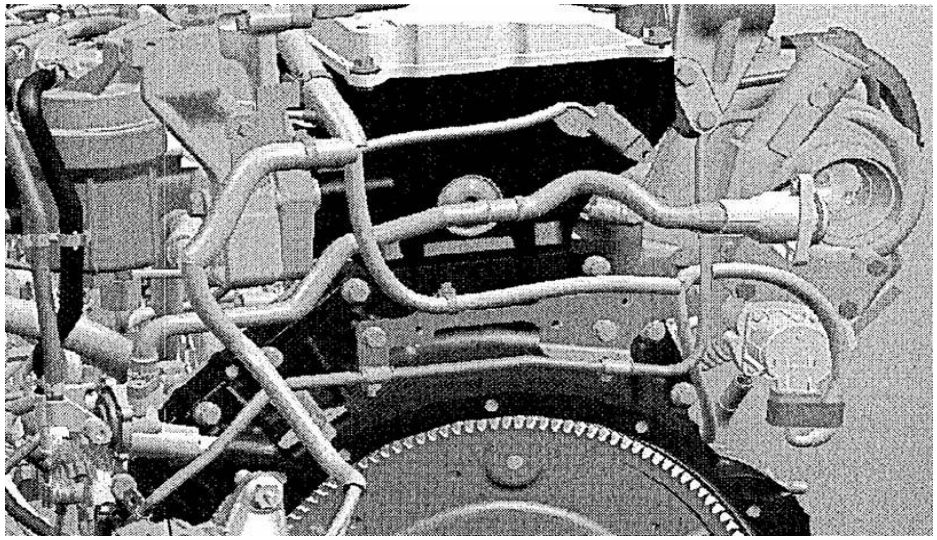
EGR System (cont'd)

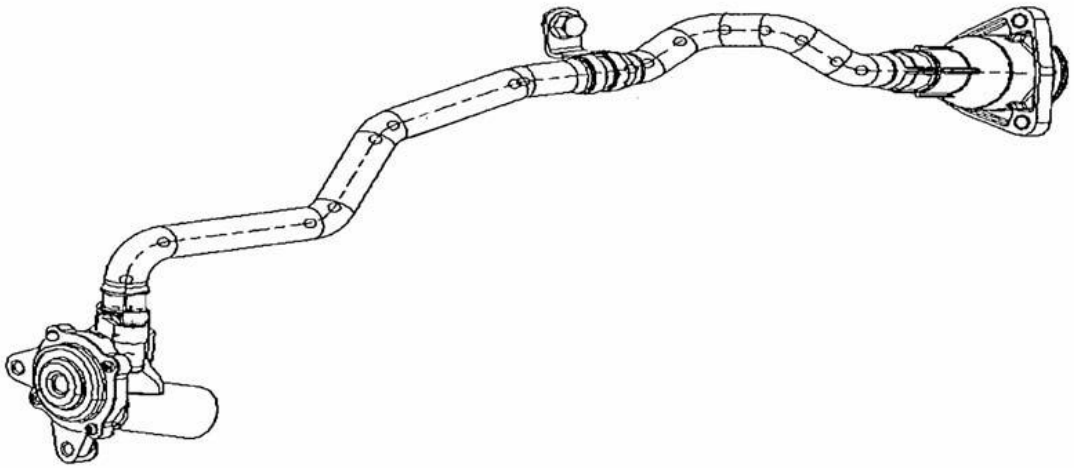
- Diagnostics
  - Symptoms
    - Insufficient Flow
    - Excessive Flow
    - Solenoid Operation
    - EGR Performance
  - Associated DTCs - 4HK1 Ref
    - P0401 EGR Flow Insufficient
    - P0402 EGR Flow Excessive
    - P0403 EGR Solenoid Control Circuit
    - P0404 EGR Open Position Performance
    - P0405 EGR Position Sensor Circuit Low Voltage
    - P0406 EGR Position Sensor Circuit High Voltage
    - P040B EGR Temperature Sensor 1 Circuit Performance
    - P040C EGR Temperature Sensor 1 Circuit Low Voltage
    - P040D EGR Temperature Sensor 1 Circuit High Voltage
    - P041B EGR Temperature Sensor 2 Circuit Performance
    - P041C EGR Temperature Sensor 2 Circuit Low Voltage
    - P041D EGR Temperature Sensor 2 Circuit High Voltage

EGR System (cont'd)

- Associated DTCs - 4HK1 Ref (cont'd)
  - P042E EGR Closed Position Performance
  - P0545 EGT Sensor 1 Low Voltage
  - P0546 EGR Sensor 1 High Voltage
  - P2032 EGT Sensor 2 Low Voltage
  - P2033 EGT Sensor 2 High Voltage
  - P2080 EGT Sensor 1 Performance
  - P2084 EGT Sensor 2 Performance
  - P20E2 EGT Sensor 1-2 Correlation
  - P2457 EGR Cooling System Performance
- For specific DTC criteria refer to the workshop manual

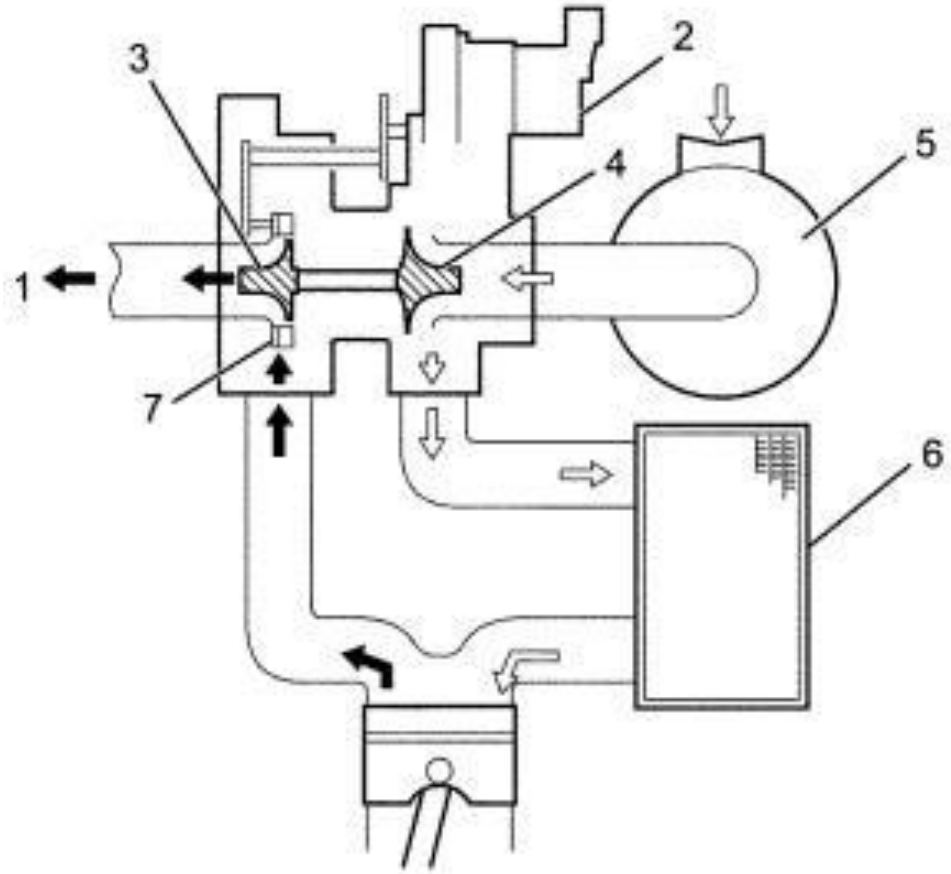
2007i-2010 4HK1 Closed Loop PCV System





The new PCV system is a closed design. Previous models used a system that vented pressures out to the atmosphere though a road draft tube out of the engine. The EPA Required that the system now be closed or diverted back into the engine. The new system shown on this 4HK vents the crankcase pressure back into the turbocharger inlet so it gets re-burned. Note that there are special "tamper resistant" bolts that secure the system to the engine as mandated by the EPA whenever a passive (not controlled by the ECM) system is used.

Turbocharger System Illustration



1. Exhaust Gas
2. VNT Actuator & Sensor
3. Turbine Wheel
4. Compressor Wheel
5. Air Cleaner
6. Charge Air Cooler
7. Nozzles

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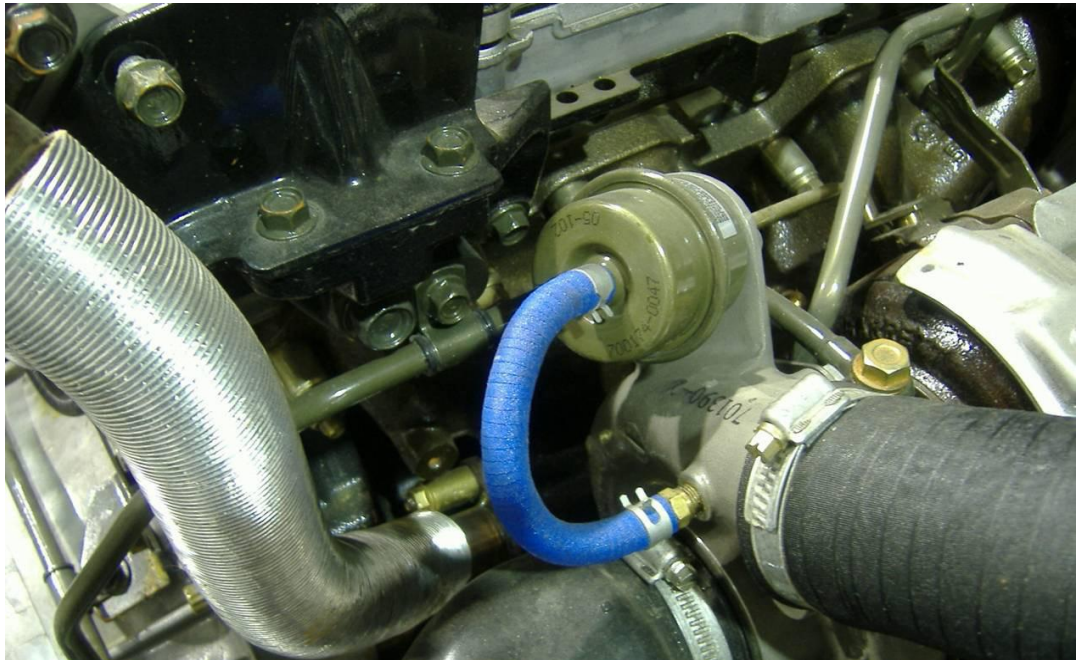
Turbocharger 2005 to 2007

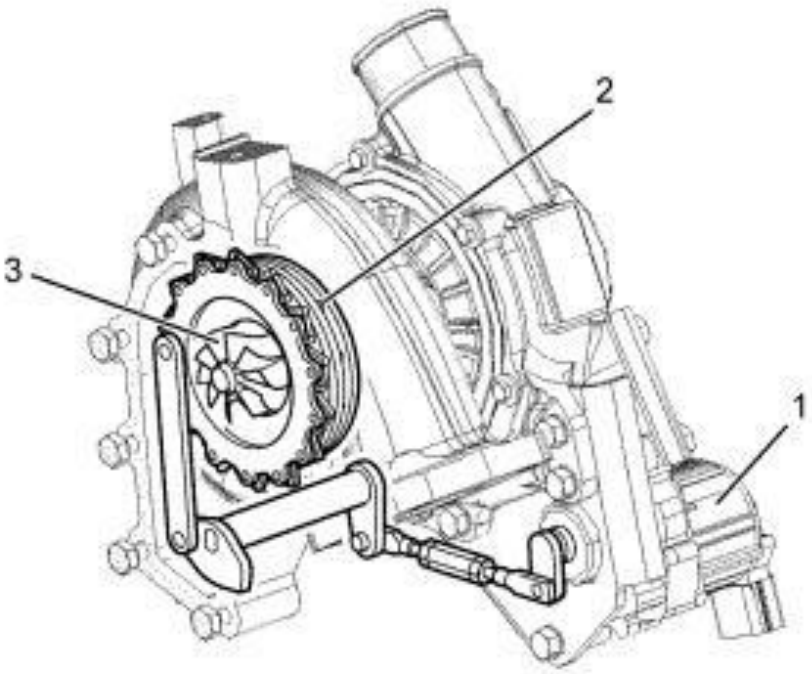
- The turbocharger increases the amount of air that enters the engine cylinders. This allows a proportional increase of fuel to be injected into the cylinders, resulting in increased power output, more complete combustion of fuel, and increased cooling of the cylinder heads, pistons, valves, and exhaust gas. This cooling effect helps extend engine life.
- Heat energy and pressures in the engine exhaust gas drive the turbine. Exhaust gas moves on to the turbine housing. The turbine housing acts as a nozzle to direct the shaft wheel assembly. Since the compressor wheel attaches directly to the shaft, the compressor wheel rotates at the same speed as the turbine wheel. Clean air from the air cleaner is drawn into the compressor housing and wheel. The air is compressed and delivered through a crossover pipe to the engine air intake manifold, then into the cylinders. A waste gate valve in the exhaust housing regulates the amount of air pressure rise and air volume delivered to the engine from the compressor outlet. The amount of pressure built up on the intake side of the turbocharger controls the position of the waste gate valve. The diaphragm on the inside of the waste gate is pressure sensitive, and controls the position of the valve inside the turbocharger. The position of the valve will increase or decrease the amount of boost to the turbocharger.
- The charge air cooler also helps the performance of the diesel. Intake air is drawn through the air cleaner and into the turbocharger compressor housing. Pressurized air from the turbocharger then flows forward through the charge air cooler located in the front of the radiator. From the charge air cooler, the air flows back into the intake manifold.
- The charge air cooler is a heat exchanger that uses air flow to dissipate heat from the intake air. As the turbocharger increases air pressure, the air temperature increases. Lowering the intake air temperature increases the engine efficiency and power.

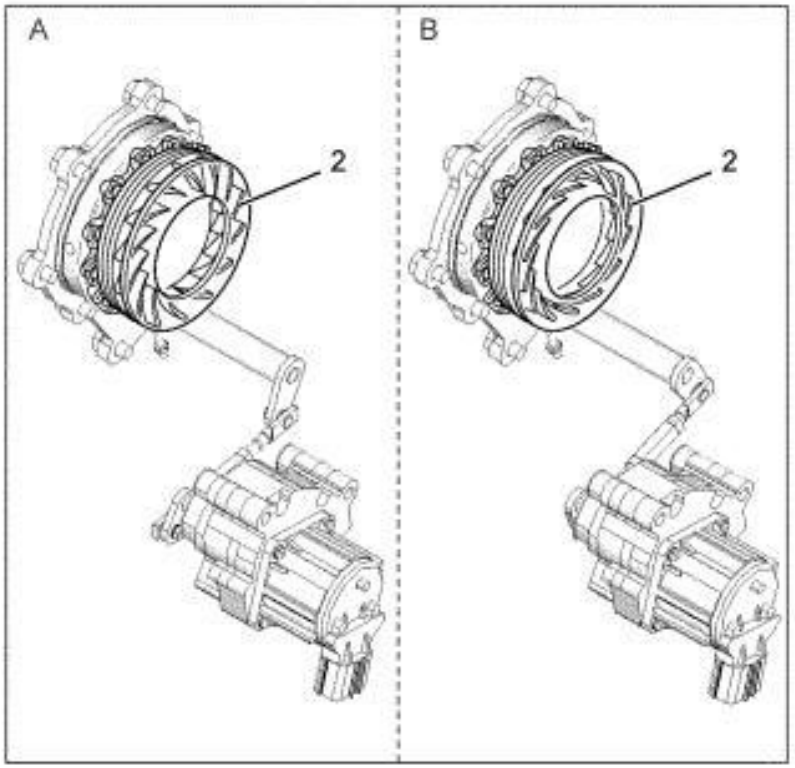
Turbocharger 2005 to 2007



Tech Tip:
To manually test boost pressure,
insert a "T" into the waste gate hose,
and attach a pressure gauge.

Turbocharger 2007i to 2010





1. VNT actuator & sensor
2. Nozzle
3. Turbine Wheel

1. VNT actuator & sensor
2. Nozzle
3. Turbine Wheel

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Turbocharger System

- Description
  - The turbocharger is used to increase the amount of air that enters the engine cylinders. This allows a proportional increase of fuel to be injected into the cylinders.
  - Heat energy and pressures in the engine exhaust gas are utilized to drive the turbine.
  - Clean air from the air cleaner is drawn into the compressor housing and wheel. The air is compressed and delivered through a crossover pipe to the engine air intake manifold, then into the cylinders.
  - The position of the turbocharger nozzle is controlled by the variable nozzle turbocharger (VNT) control module based on the command from the ECM.
  - When the engine load is low, the turbocharger nozzles are moved to the open direction (A). When the engine load is high, the VNT control module commands the control solenoid to close the turbocharger nozzles (B), thus increasing the boost.
  - The ECM will vary the desired boost target dependant upon requirements of the engine power output.
  - Pressurized air from the turbocharger has a higher temperature than intake air, and the charge air cooler cools the pressurized air.
- Diagnostics
  - Associated DTCs
    - P0234 Engine Overboost
    - P0237 Sensor Circuit Low Voltage
    - P0238 Sensor Circuit High Voltage
    - P0299 Engine Underboost
    - P2564 Boost Control Position Sensor Low Voltage
    - P2565 Boost Control Position Sensor High Voltage
    - U010C Turbocharger CAN Communication
  - For specific DTC criteria refer to the workshop manual

Turbocharger System Drivability Diagnosis

- Starting Point
  - Verify customers complaint.
  - Review repair history.
  - Road test to duplicate the concern.
  - Perform a careful visual inspection of the engine.
  - Review Scan tool data parameters for abnormal data.
  - Check for DTCs
- Symptom
  - Low Horse power
  - Slow to accelerate
  - Transmission short shifts or feels like it is starting out wrong gear.
- Vehicle Diagnosis
  - Physical Inspection of all related components for the turbocharger system.
  - Check for DTCs, perform DTC flow charts first.
  - System check.

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Turbocharger System Diagnostic Review

Turbocharger (TC) Vane Position	%
Desired Turbocharger (TC) Vane Position	%
Turbocharger (TC) Vane Position Control Solenoid Command	%
Turbocharger Boost Pressure	psi
Turbocharger (TC) Control Enable Status	-
Turbocharger (TC) Vane Position Learned Operational Angle	°
Turbocharger (TC) Vane Position Learned Angle Error	-
Turbocharger (TC) Vane Position Sensor Low Voltage	-
Turbocharger (TC) Vane Postion Sensor High Voltage	-
Turbocharger (TC) Vane Position Control Solenoid Circuit Shorted	-
Turbocharger (TC) Vane Position Control Solenoid Error	-
Turbocharger (TC) Vane Position Control Module Memory Error	-
Turbocharger (TC) Vane Position Control Module Supply Voltage Low	-
Turbocharger (TC) Vane Position Control Module Supply Voltage Higl	-
Turbocharger (TC) Vane Position Control Module Supply Voltage	Volts
Engine Speed	RPM
Vehicle Speed	mph
Accelerator Pedal Position (APP) Indicated Angle	%
Engine Load	%
Engine Coolant Temperature (ECT)	°F
Intake Air Temperature (IAT) 1	°F
Mass Air Flow (MAF)	g/s

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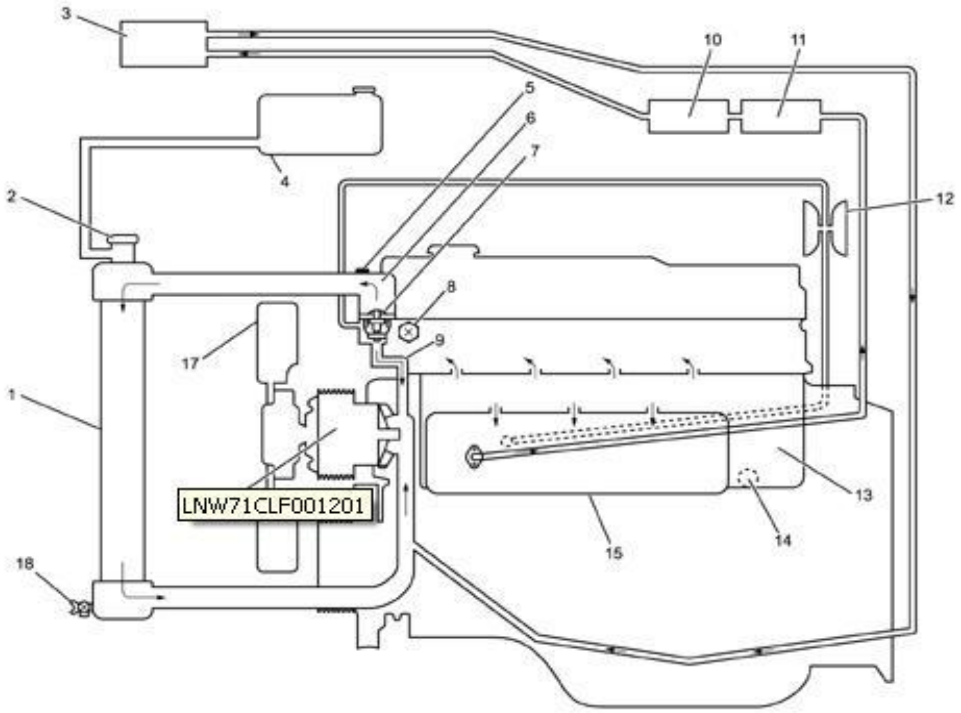
Cooling System



1. Radiator
2. Radiator Cap
3. Heater Core
4. Reserve Tank
5. Air Bleeding Plug
6. Water Outlet Pipe
7. Thermostat (2 nos.)
8. Thermometer Unit
9. Bypass Route
10. EGR Cooler 2nd
11. EGR Cooler 1st
12. Turbocharger
13. Water Jacket
14. Drain Plug
15. Oil Cooler
16. Water Pump
17. Cooling Fan
18. Drain Plug

Cooling System Drivability Diagnosis

- Starting Point
  - Verify customers complaint.
  - Review repairs history.
  - Road test to duplicate the concern.
  - Perform a careful visual inspection of the engine.
  - Review Scan tool data parameters for abnormal data.
  - Check for DTCs.
- Symptom
  - Engine overheats.
  - Cab heater blows cool air.
  - Engine never warms up (under cools).

Vehicle Diagnosis

- Physical Inspection of all related components for the Cooling system.
- Check for DTCs, perform DTC flow charts first.
- Perform Coolant System Functional check.

Cooling System (cont'd)

- Description
  - The coolant system is a forced circulation system.
  - Consists of a water pump, thermostat, automatic transmission fluid cooler and radiator as its main components.
  - Circulates from top of the radiator to the bottom of the radiator.
- Diagnostics
  - Symptoms
    - Engine overheats

Condition	Possible Cause	Correction
Engine overheats	Cooling water volume is deficit.	Replenish.
	Thermometer unit is defective.	Replace.
	Thermostat is defective.	Replace.
	Radiator pump is defective.	Replace.
	Radiator is clogging.	Clean or replace.
	Radiator cap is defective.	Replace.
	Engine oil volume is deficient or incorrect engine oil is used.	Replenish or change the engine oil.
	Cylinder head gasket is defective.	Replace.
	The fan belt is loose.	Adjust.
	Exhaust system is clogging.	Clean or replace.
	The fuel injection quantity is in surplus.	Diagnose the engine control system.
	Fuel injection timing is incorrect.	Diagnose the engine control system.
	Starting pressure of fuel injection is low.	Diagnose the engine control system.

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Cooling System (cont'd)

- Symptoms
  - Engine overcools

Condition	Possible Cause	Correction
Engine overcools	Thermostat is defective.	Replace.

- Associated DTCs – 4HK1 Ref
  - P0116 ECT Sensor Performance
  - P0117 ECT Sensor Circuit Low Voltage
  - P0118 ECT Sensor Circuit High Voltage
  - P0126 Insufficient for Stable Operation
  - P0128 Below Thermostat Regulating Temperature
- For specific DTC criteria refer to the workshop manual

Cooling System Diagnostic Review

Question:

Customer reports the vehicle's temperature gauge never moves off cold. What data parameters would you monitor from the list below to diagnose this complaint?

Engine Data 1

Engine Speed	RPM
Desired Idle Speed	RPM
Vehicle Speed	mph
Engine Load	%
Engine Coolant Temperature (ECT)	°F
Intake Air Temperature (IAT) 1	°F
Intake Air Temperature (IAT) 2	°F
Fuel Temperature	°F
Mass Air Flow (MAF)	g/s
Mass Air Flow (MAF) Sensor	Volts

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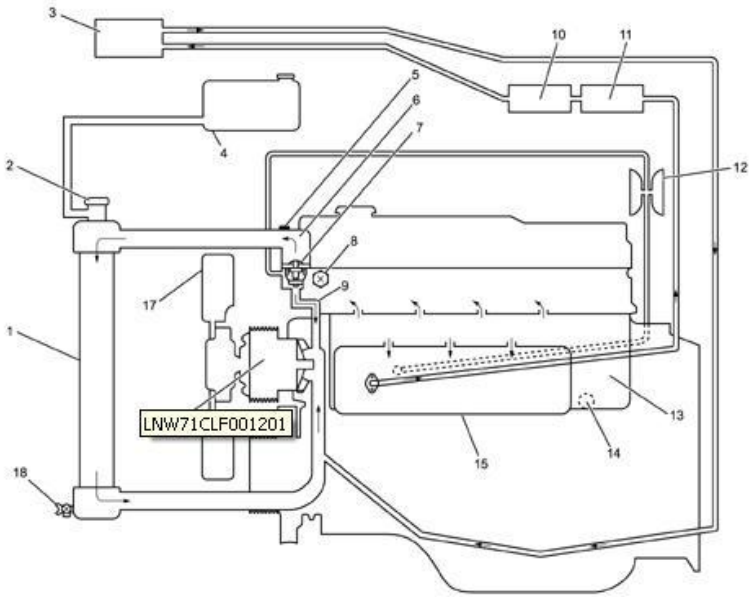
Cooling System Drivability Diagnosis (cont'd)

1. Radiator
2. Radiator Cap
3. Heater Core
4. Reserve Tank
5. Air Bleeding Plug
6. Water Outlet Pipe
7. Thermostat (2 nos.)
8. Thermometer Unit
9. Bypass Route
10. EGR Cooler 2nd
11. EGR Cooler 1st
12. Turbocharger
13. Water Jacket
14. Drain Plug
15. Oil Cooler
16. Water Pump
17. Cooling Fan
18. Drain Plug



Engine Data 1

Engine Speed	RPM
Desired Idle Speed	RPM
Vehicle Speed	mph
Engine Load	%
Engine Coolant Temperature (ECT)	°F
Intake Air Temperature (IAT) 1	°F
Intake Air Temperature (IAT) 2	°F
Fuel Temperature	°F
Mass Air Flow (MAF)	g/s
Mass Air Flow (MAF) Sensor	Volts

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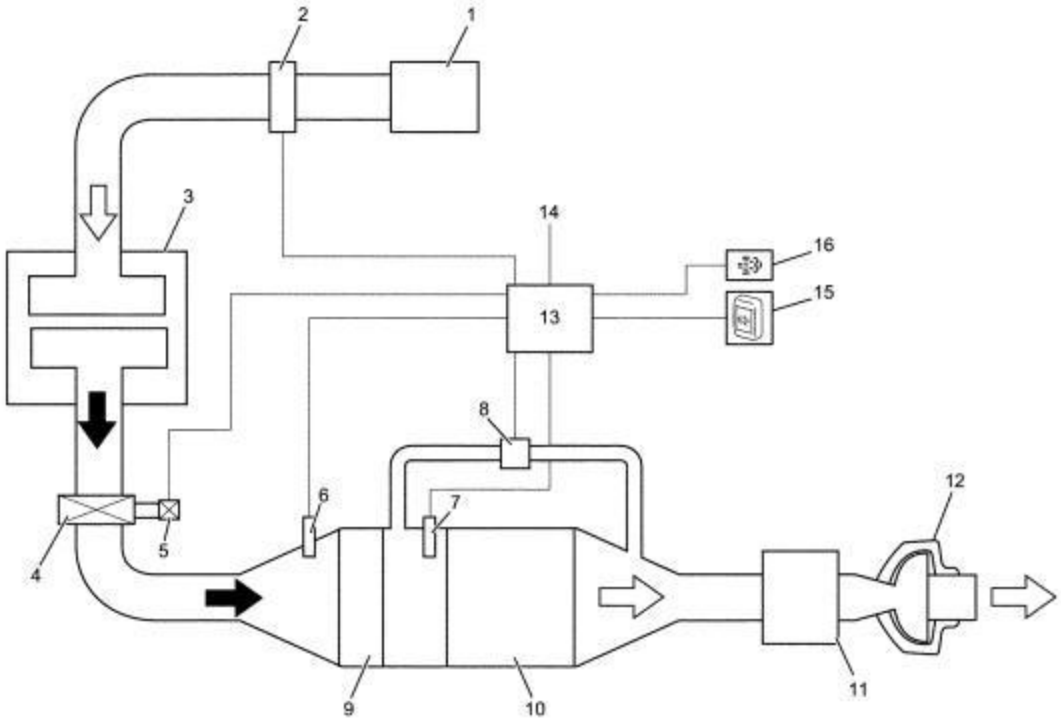
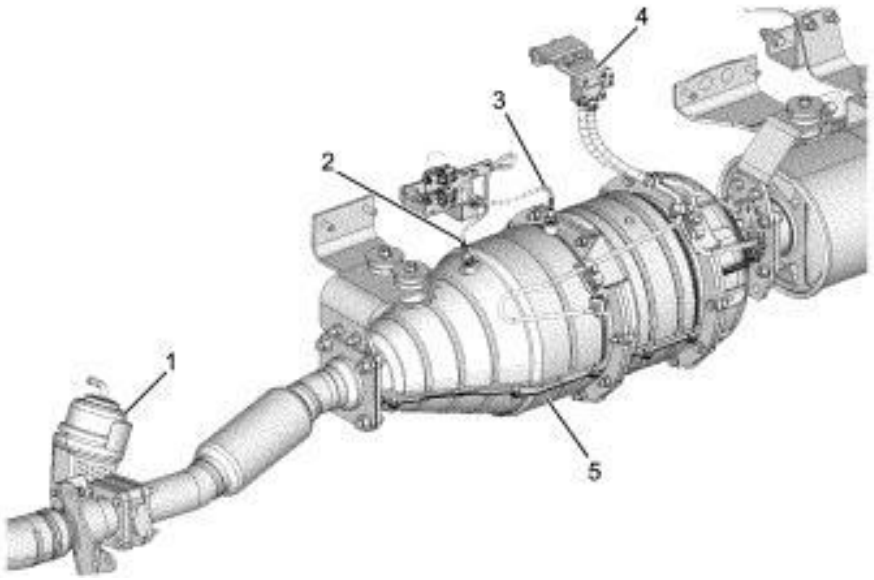
Diesel Particulate Filter (DPF) System Diagram



1. Air Cleaner
2. MAF Sensor
3. Engine Assembly
4. Exhaust Brake valve
5. Exhaust Brake solenoid
6. EGT Sensor 1
7. EGR Sensor 2
8. Exhaust Differential Pressure Sensor
9. Oxidation catalyst
10. Filter
11. Exhaust Silencer
12. Exhaust Cooler
13. ECM
14. Other Inputs
15. DPF Regeneration Switch
16. DPF Green, Amber, Red Lamp

DPF System

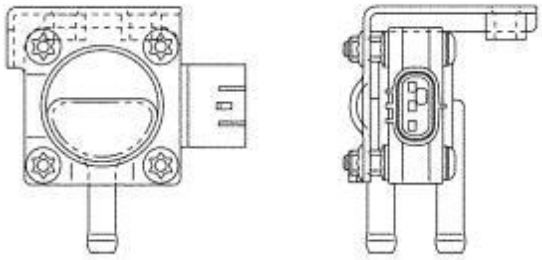
- Description
  - The DPF system uses an oxidation catalyst to clean the CO and HC, and a filter to collect PM discharged from the engine.
  - The ECM detects the threshold amount of PM accumulation from the exhaust differential pressure sensor or from mileage and automatic regeneration starts.
  - The ECM detects exhaust temperature and raises the temperature by controlling fuel injections and the exhaust brake valve to begin regeneration burn off the accumulated PM.
  - Once the regeneration starts, it must be finished within a certain time. After regeneration is finished, a purification of the filter is judged by monitoring the exhaust differential pressure.



1. Exhaust Brake Valve
2. EGT 1 (in front of oxidation catalyst)
3. EGT 2 (in front of filter)
4. Exhaust Differential Pressure Sensor
5. DPF Assembly

DPF Components

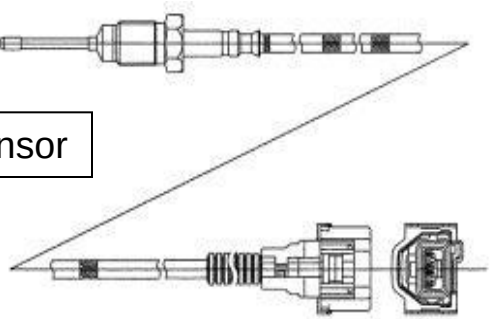
Exhaust Differential Pressure Sensor

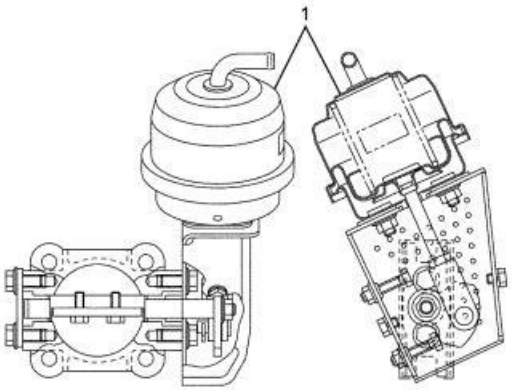


Tech Tip:

The Exhaust Differential Pressure Sensor can be damaged by vibration. Avoid using an impact wrench near the sensor location

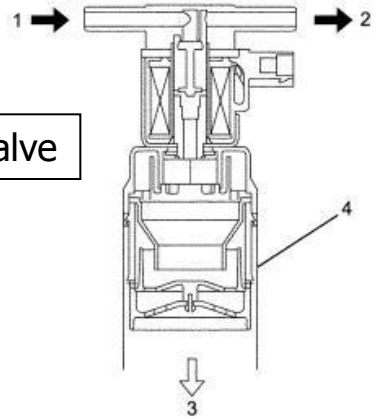
Exhaust Gas Temperature Sensor





1. Exhaust Brake Valve

Exhaust Brake Valve



1. Vacuum Inlet
2. Vacuum Outletr Cap
3. Vacuum Exhaust
4. Solenoid Valve

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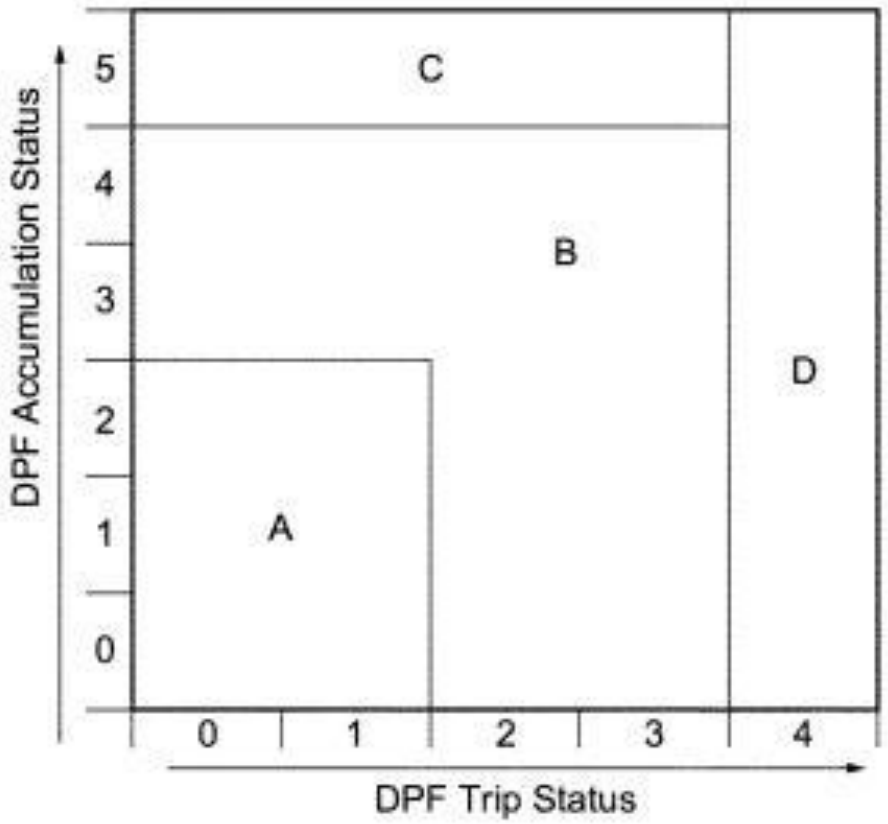
DPF Status Table



Range A: Normal Range

Range B: DPF lamp illuminates but regeneration is possible

Range C: Exhaust differential pressure is excessive high range and emergency regeneration is inhibited

Range D: Trip status is abnormal range and emergency regeneration is inhibited

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DPF System (cont'd)

- Operation
  - DPF Regeneration Modes
    - Automatic
    - Manual
      - Emergency
      - Selectable
  - DPF Green Lamp
    - Turns ON during
      - Automatic DPF regeneration
      - Emergency (manual) DPF regeneration
      - Selectable (manual) DPF regeneration
    - Turns OFF
      - When DPF regeneration is complete
      - When manual DPF regeneration is interrupted
  - DPF Yellow/Red Lamp
    - Turns ON when emergency DPF regeneration is required
    - Color determined by quantity of PM accumulation in DPF
    - Remains ON if manual DPF regeneration is interrupted
    - Turns OFF when DPF regeneration is complete
  - Chime
    - Rings when Yellow/Red lamp turns ON
    - Rings when manual DPF regeneration is impossible

DPF System (cont'd)

- Operation (cont'd)
  - Emergency DPF regeneration
    - Drive the vehicle above 30 mph (50 km/h) for approximately 20 minutes or until the Green and Yellow/Red Lamps turn OFF

      or
    - Stop the vehicle and idle in park. With the parking brake ON, press the DPF switch and continue idling for approximately 20 minutes or until the Green and Yellow/Red Lamps turn OFF
  - Manual DPF regeneration
    - Is interrupted by the following conditions:
      - Parking brake OFF (F-series only)
      - Accelerator pedal ON
      - Engine speed increases
      - Neutral switch OFF (automatic transmission only)
      - DPF switch OFF (N-series only)
    - When manual DPF regeneration is interrupted
      - DPF Green Lamp turns OFF
      - DPT Yellow/Red Lamp remains ON
- Components
  - Exhaust Differential Pressure Sensor
  - EGT Sensor 1
  - EGT Sensor 2
  - Exhaust Brake Valve

DPF System (cont'd)

- Diagnostics
  - Symptoms
    - DPF Yellow/Red Lamp turns on frequently
      - Driving conditions
      - Other components
      - Differential Pressure
      - Engine exhaust gas has too much smoke
  - Associated DTCs – 4HK1 Ref
    - P1471 DPF Regeneration Insufficient
    - P2002 Filter Low Efficiency
    - P244B DPF Pressure Too High
    - P244C Regeneration Duration
    - P2453 DPF Differential Pressure Sensor Performance
    - P2454 DPF Differential Pressure Sensor Circuit Low Voltage
    - P2455 DPF Differential Pressure Sensor Circuit High Voltage
    - P2463 DPF Soot Accumulation
  - For specific DTC criteria refer to the workshop manual
  - DPF Control System Check
    - Diagnostic Procedure - for specific criteria refer to the workshop manual
    - DPF Status Table

DPF System Drivability Diagnosis

- Starting Point
  - Verify customers complaint.
  - Review repairs history.
  - Road test to duplicate the concern.
  - Perform a careful visual inspection of the engine.
  - Review Scan tool data parameters for abnormal data.
  - Check for DTCs
- Symptom
  - Slow engine throttle response
  - DPF lights “ON”
- Vehicle Diagnosis
  - Physical Inspection of all related components for the DPF system.
  - Check for DTCs, perform DTC flow charts first.
  - System check.

DPF System Diagnostic Review

Question:

Customer states the DPF Regeneration lamps are “flashing” on the meter assembly while driving and then they stopped. What data parameters below would you use to determine why the lamp are flashing?

DPF Data

Diesel Particulate Filter (DPF) Regeneration Switch	-
Diesel Particulate Filter (DPF) Mode Status	-
Exhaust Gas Temperature (EGT) 1	°F
Exhaust Gas Temperature (EGT) 2	°F
Exhaust Differential Pressure	kPa
Diesel Particulate Filter (DPF) Accumulation Status	-
Diesel Particulate Filter (DPF) Trip Status	-
Diesel Particulate Filter (DPF) Insufficient Regeneration Status	-
Diesel Particulate Filter (DPF) Incomplete Regeneration Status	-
Diesel Particulate Filter (DPF) Manual Regeneration Time	hr:min:sec

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DPF Differential Pressure Test

- Observe Exhaust Gas Temperature Sensor #2 (in front of the filter). When 4HK engine reaches 302º F (150º C) or 6HK engine reaches 266º F (130º C) accelerate engine to WOT (wide open throttle) until the Exhaust Temperature Sensor 2 reads 4HK 392º F (200º C) or 6HK 302º F (150ºC)

- Now Read the Exhaust Differential Pressure Sensor while still at WOT.
- Normal: 4HK = 1.0 – 3.4 kPa 6HK = (low hp) 1.0 – 3.3 kPa
  (high hp) 1.0 – 4.0 kPa

- Restricted DPF: 4HK = More th an 3.4 kPa
  6HK = (low hp) more than 3.3 kPa
  (high hp) more than 4.0 kPa

- Less than 1.0 kPa = Inspect Exhaust Pressure Differential Pressure Sensor, pipes and hoses. Inspect for damaged Particulate Filter.

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DPF Cleaner System

- **Information on Diesel Particulate Filter (DPF) Cleaner System Availability**
  Bulletin IB10-X-001 Issue Date: March 2010

  - 2007-2010MY Isuzu N-Series
  - 2007-2010MY GMC and Chevrolet W-Series
  - 2007-2009MY Isuzu F-Series
  - 2007-2009MY GMC and Chevrolet T/C-Series

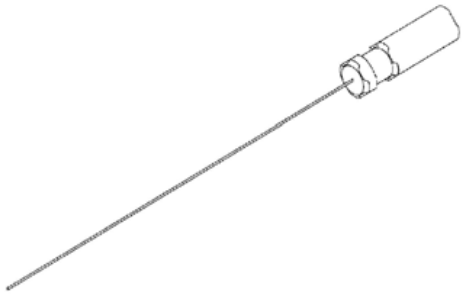
  Equipped with diesel particulate filter (DPF)

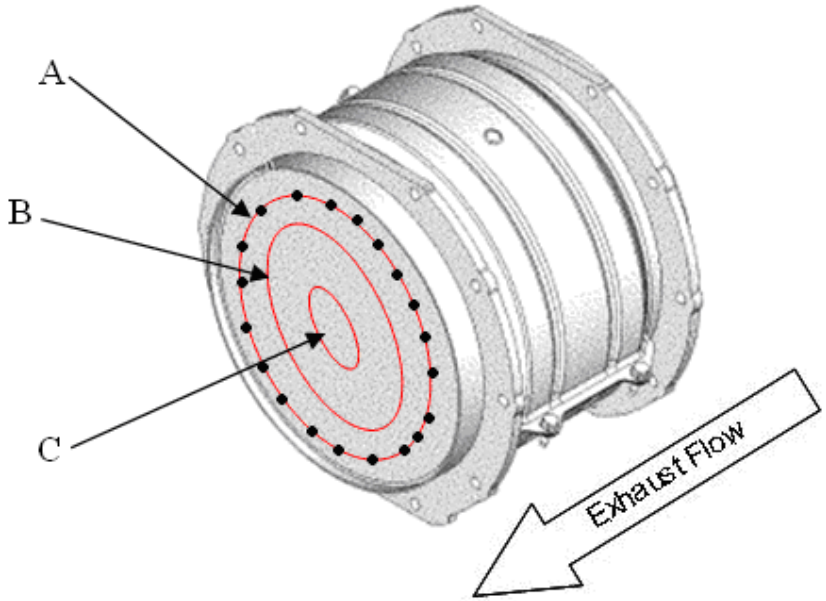
- FSX, Inc is Isuzu Commercial Truck of America's(ICTA) preferred filter cleaning company. ICTA has worked closely with FSX, Inc to ensure the cleaning quality and provide a low cost service with flexible turnaround times.To use FSX, Inc cleaning services, contact FSX, Inc at (360) 691-2999.

- Must determine if the DPF is damaged internally by performing the Pin Gauge test Internally damaged filters have no core value and should be replaced.

Pin Gauge Test

- ***Special Tool EN-50343 Pin Gauge***





- A. 20 cells - approximately 2 inches from the outside edge
- B. Step 4 half way between the edge and the center
- C. Center

2004 – 2007 7.8L 6HK Diesel Engine

2004 - 2007 7.8L 6HK1-TC Diesel Engine Introduction

General Description

For the 2004 model year, the 6HK1-TC 6-cylinder engine was updated to meet 2004 emission standards. The newly developed 6HK1-TC engine has additional features including a water-cooled exhaust gas re-circulation (EGR) system and a Variable Nozzle Turbocharger (VNT). These changes continued through 2007 model year.

Common Rail Type Electronic Control Fuel Injection System

Common Rail Type Electronic Control Fuel Injection System

System Overview

The main components of the common rail system are

:
- The supply pump
- The common rail
- The injectors
- The engine control module (ECM)

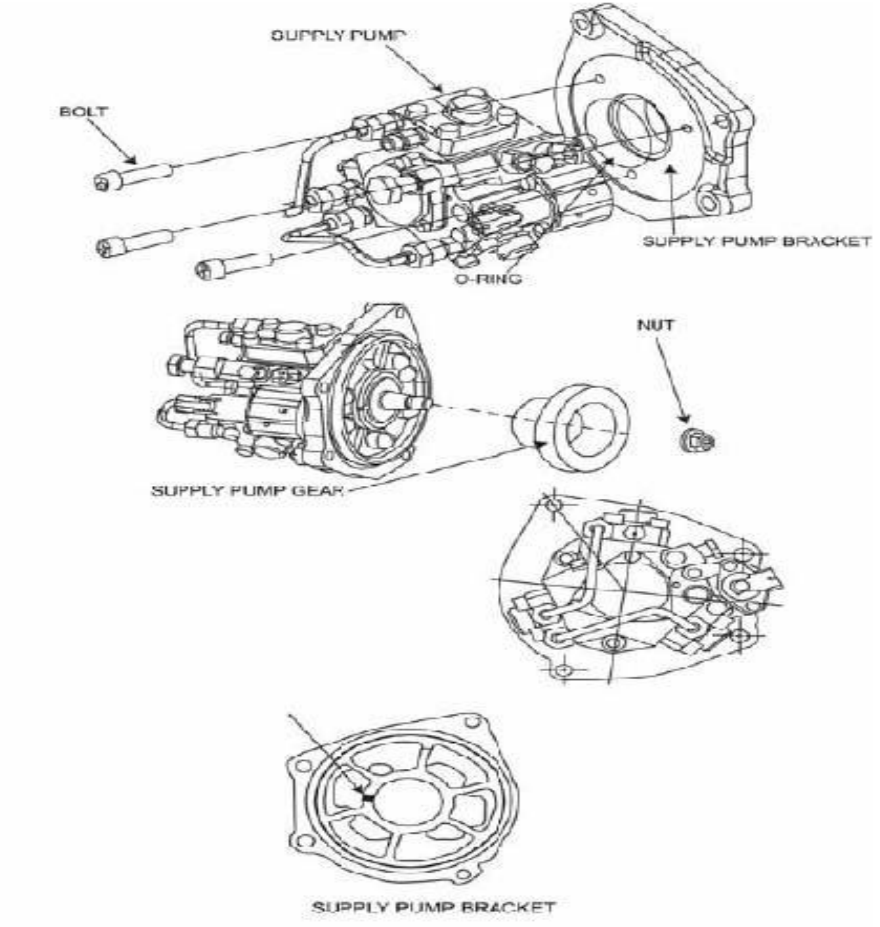
Supply Pump

The supply pump draws fuel from the fuel tank, and pumps the high pressure fuel to the fuel rail. The quantity of the fuel discharged from the supply pump controls the pressure in the fuel rail. The fuel rail pressure regulator (FRP) in the fuel supply pump affects this control in accordance with the command received from the engine control module (ECM).

Along with the use of the common rail type electronic control fuel injection system, the injection pump was replaced by a plunger type supply pump to supply high pressure fuel to the fuel rail. The supply pump is located at the position where the injection pump was, and it is driven 1:1 to the engine. The feed pump (trochoid type), built into the supply pump, feeds fuel from the fuel tank to the plunger chamber. The supply pump attaches with a suction control valve (SCV) to control high pressure fuel supply to the fuel rail. A fuel temperature sensor detects fuel temperature.

Supply Pump

Supply Pump and Bracket



Common Rail

A common rail system stores high pressure fuel between the supply pump and the injectors.

The common rail also serves as an accumulator to dampen the fuel pulsations from the pump. The engine control module (ECM) controls the injection system (injection pressure, injection timing, and injection rate). The common rail system maintains the required fuel pressures during all engine operating conditions.

The Common Rail Components

The Common Rail Components

1-Common Rail

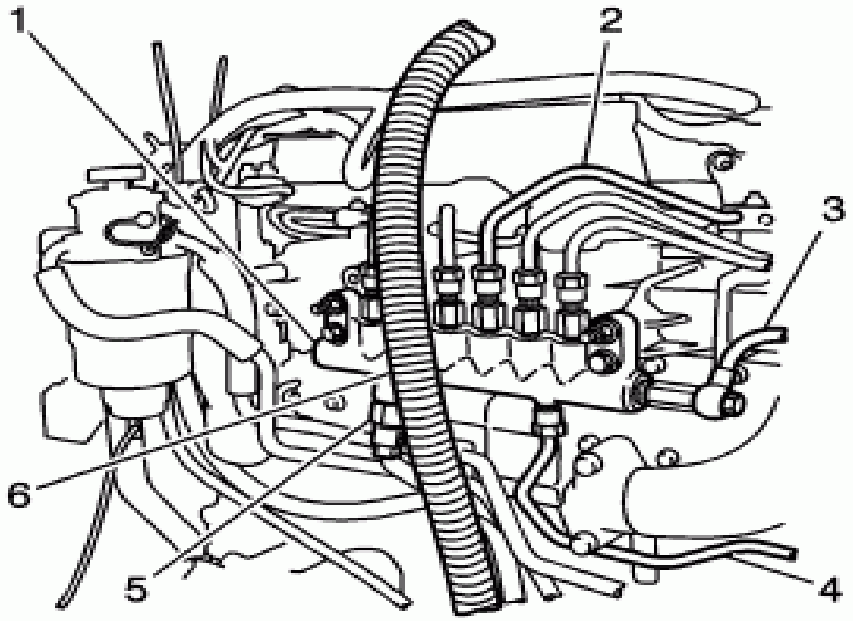
2- High Pressure Fuel Pipes (to injectors)

3-Pressure Limiter

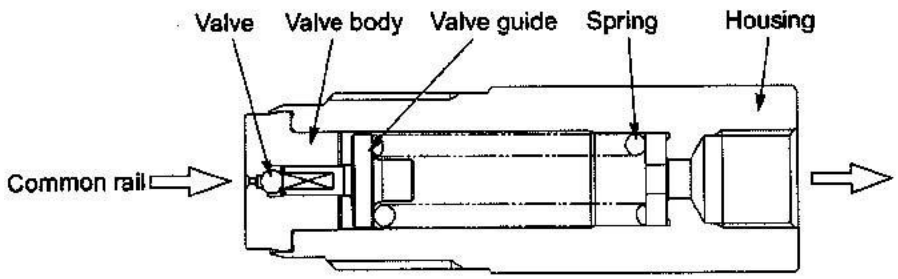
4- High Pressure Fuel Feed Pipes (from supply pump)

5-Pressure Sensor

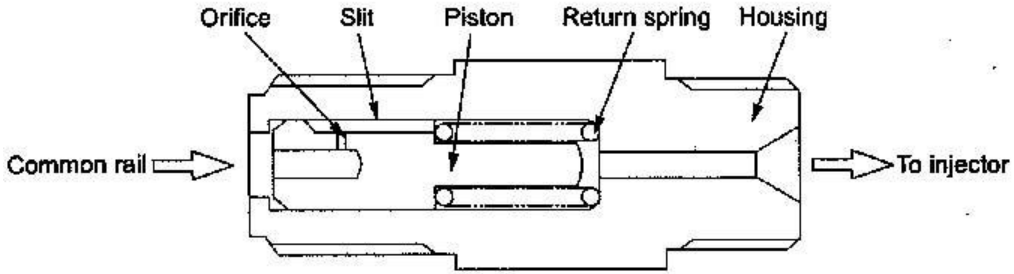
6-Flow Dampers



Pressure Limiter and Flow Damper



The pressure limiter is located on the common rail to open the valve mechanically for pressure relief when the fuel pressure inside the common rail increases extremely.



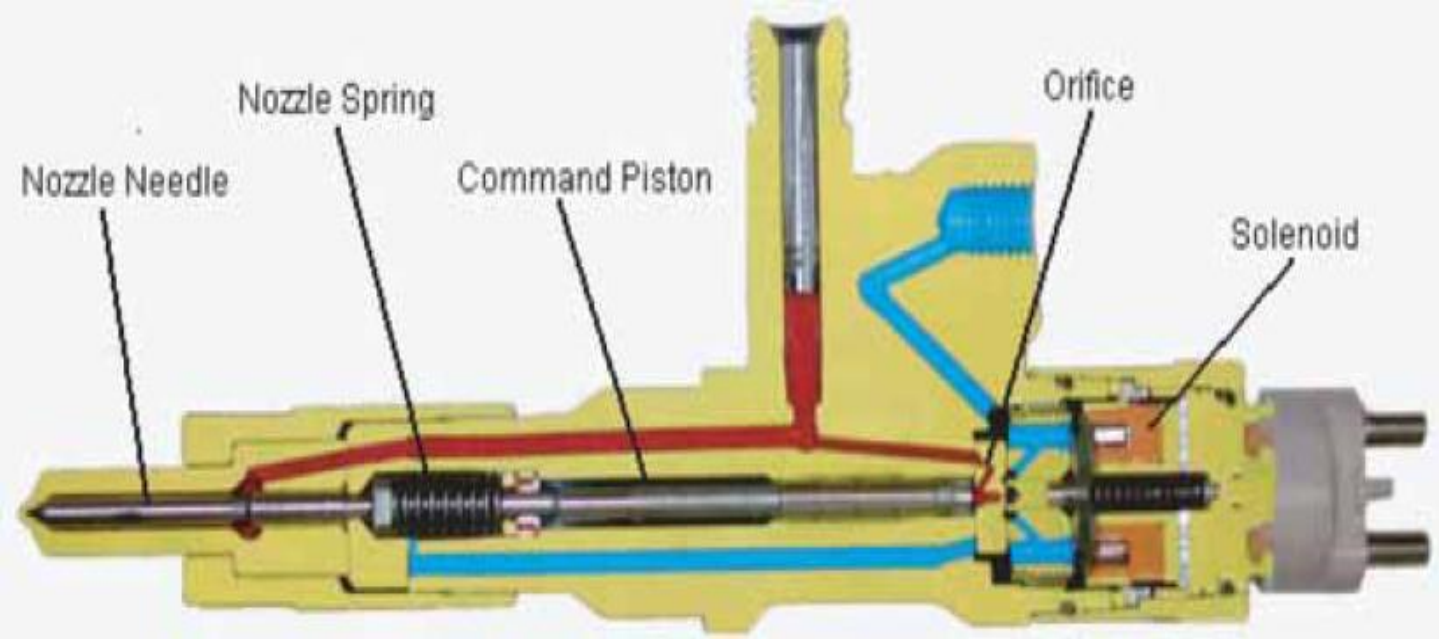
Pressure Limiter Opening Pressure: 230 MPa (33,000psi)

The flow dampers are located at the outlet of the common rail to damp a pulsation of fuel pressure inside the common rail. The flow dampers also cut off the fuel supply if fuel leaks downstream of the flow damper.

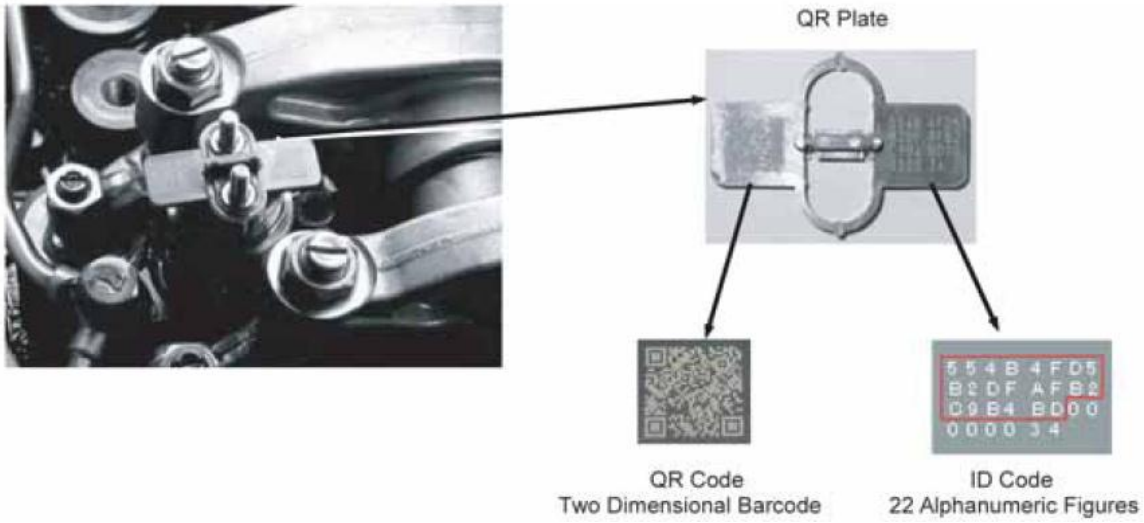
An orifice drilled into the side of the piston located inside of the flow damper supplies fuel to the injector under normal operation. The resistive force of the return spring allows slight piston movement which dampens the pulsation of the fuel as it enters the injector pipe. Should an injector pipe fracture, the return spring and orifice flow cannot hold the piston open and the flow damper will close to prevent fuel leakage.

The piston returns when the fuel pressure inside the common rail becomes about 0.6 MPa (87psi).

Fuel Injector Components



Fuel Injector Programming



Codes displaying various injector characteristics are laser marked in the QR (Quick Response) plate (Figure 21), and ID codes showing these in numeric form (22 alphanumeric figures) are laser marked in the plate. This system uses QR code information to optimize injection quantity control. When installing a new injector in a vehicle, it is necessary to input the ID codes in the ECU.

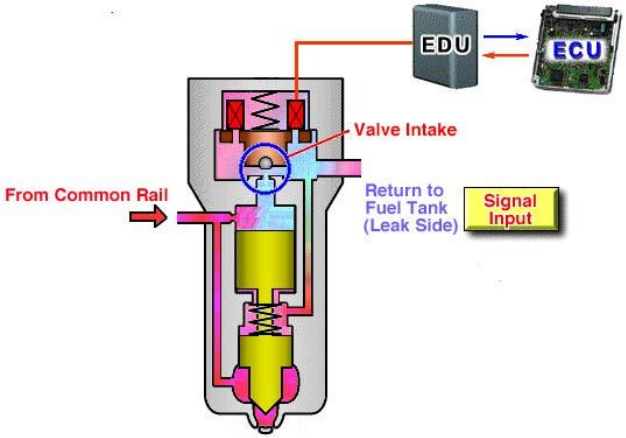
The ECM controls the electronic control type injectors (Figures 2-13 through 2-15). Compared with conventional injection nozzles, a command piston, solenoid valve, etc. have been added.

The codes enhance the injection quantity precision of the injectors. The adoption of QR codes enables injection quantity dispersion control throughout all pressure ranges, contributing to improvement in combustion efficiency, reduction in exhaust gas emissions and so on.

The ECM must be programmed with the injector information using the IDSS (Isuzu Diagnostic Service System**).**

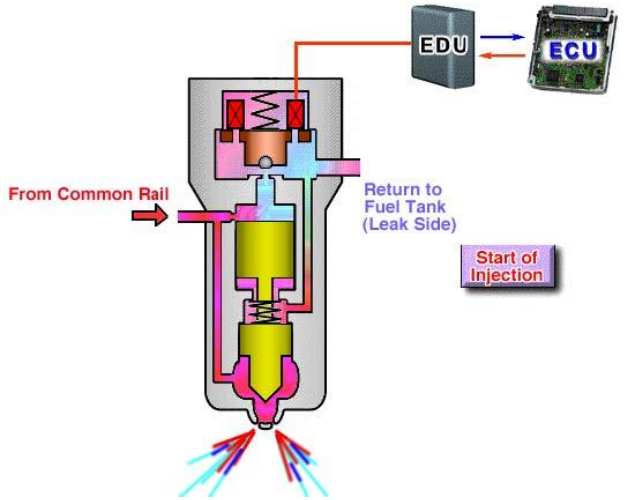
The injector flow rate code for 2004 to 2007 model year 6HK powered vehicles with low horsepower (200 to 230) will always start with 58 and the high horsepower engines (250 to 300) will always start with 57.

Fuel Injector Operation



No Injection State

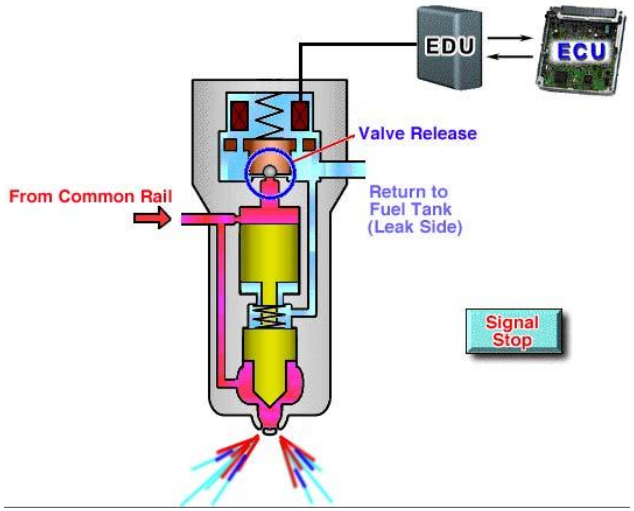
The two-way valve (TWV) closes the outlet orifice by means of a spring force when the ECM supplies no current to the solenoid. At this time, the fuel pressure applied to the nozzle leading end is equal to the fuel pressure applied to the control chamber through the inlet orifice. As for the force competition in this state, the pressure on the command piston upper surface + nozzle spring force defeat the pressure on the nozzle leading end. The nozzle pushes downward to close the injection holes.

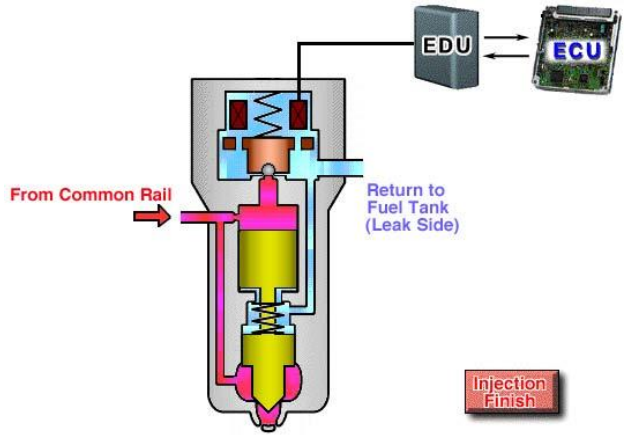


Start of Injection

The TWV pulls up to open the outlet orifice, and the fuel leaks toward the return port, when the ECM supplies current to the solenoid. The nozzle pushes up together with the command piston by the fuel pressure applied to the nozzle leading end, and the nozzle injection holes open to inject the fuel.

Fuel Injector Operation

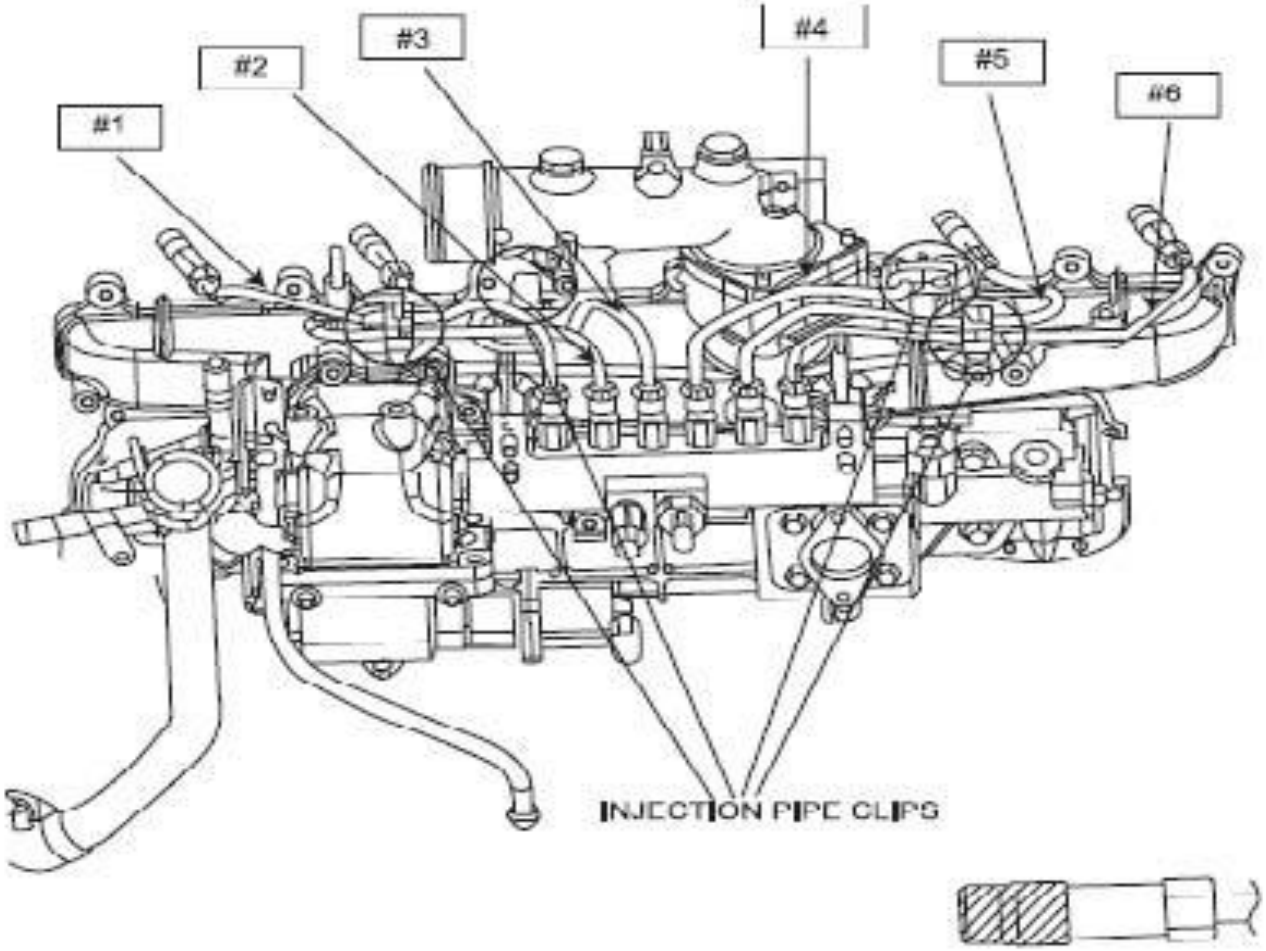




Injection Ends

The TWV lowers to close the outlet orifice, when the ECM shuts off a current supply to the solenoid. As a result, the fuel cannot leak from the control chamber, and the fuel pressure in the control chamber rises abruptly. The command piston pushes down the nozzle in order to close the nozzle injection holes, resulting in the end of fuel injection.

Fuel Injector Pipe Location and Hold Down



ECM

Description

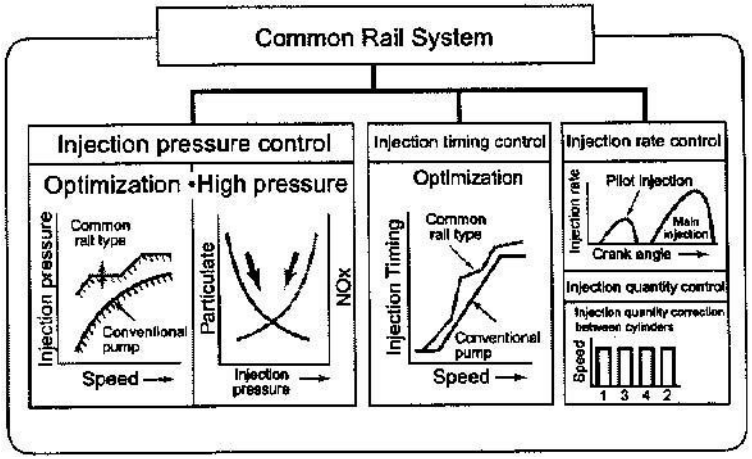
The ECM (Figures 2-19a and 2-19b) is mounted in the engine compartment. The ECM monitors various data sent from diversified sensors and control systems in the powertrain. The ECM diagnoses these systems to detect faults with respect to system operations. The ECM also informs the driver of faulty conditions via the CHECK ENGINE lamp (MIL) and stores diagnostic trouble codes (DTCs).

Function

The ECM supplies 5VDC and 12VDC to various sensors and switches. The ECM is designed to offer excellent driveability and fuel economy while achieving exhaust gas emission control requirements. The ECM monitors engine and vehicle functions via various electronic sensors such as the crankshaft position (CKP) sensor or vehicle speed sensor (VSS).

In addition to controlling injector operation, the engine control module (ECM) also monitors common rail internal pressure through the common rail pressure sensor in order to verify that the actual injection pressure matches the injection pressure commanded by the ECM, as well as the injection timing and the EGR control.

Common Rail System Controls



Injection Pressure Control

High pressure injection from low engine speed range

Optimum control to minimize particulate and NOx emission

Injection Timing Control

More precise optimum control according to the running conditions

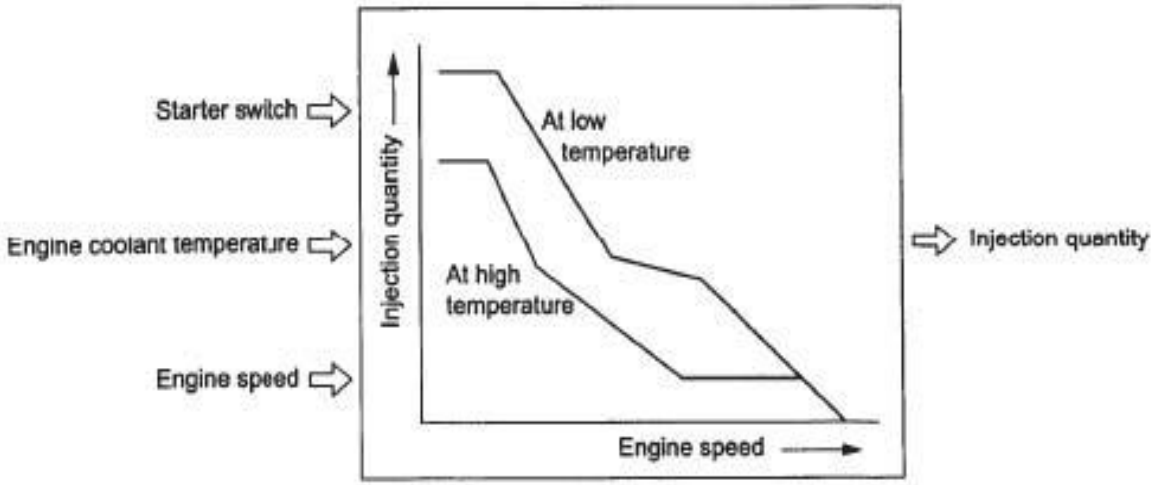
Injection Rate Control

Pilot injection control that performs a small amount of injection before main injection

Fuel under high-pressure in the common rail flows through the high-pressure pipes to the individual injectors. From the injectors, the fuel forces into the combustion chambers. Injection pressure is 25 - 200 MPa (3,625 - 33,500 PSI).

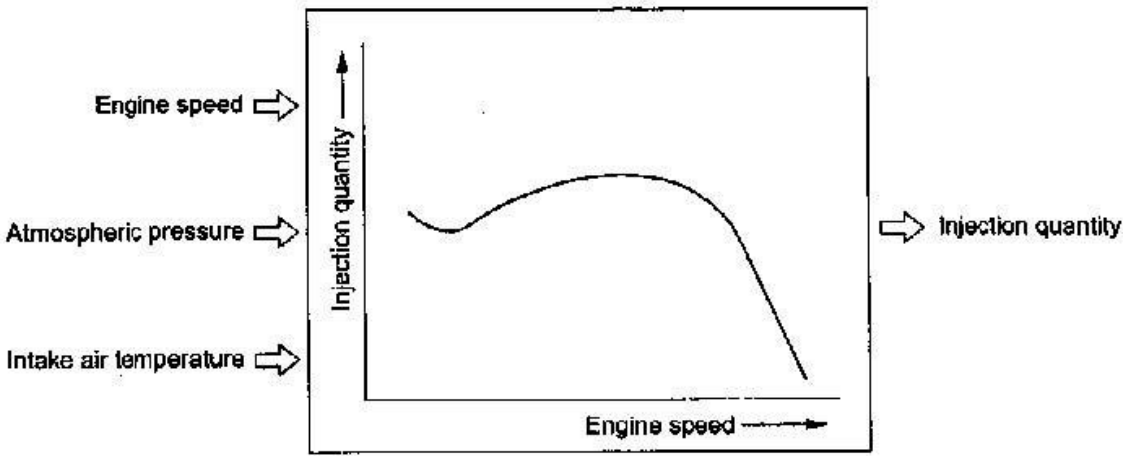
The pressure sensor detects the fuel pressure inside the common rail and sends a signal to the ECM. Based on this signal, the ECM controls the fuel pressure inside the common rail through the SCV.

Fuel Injection Control



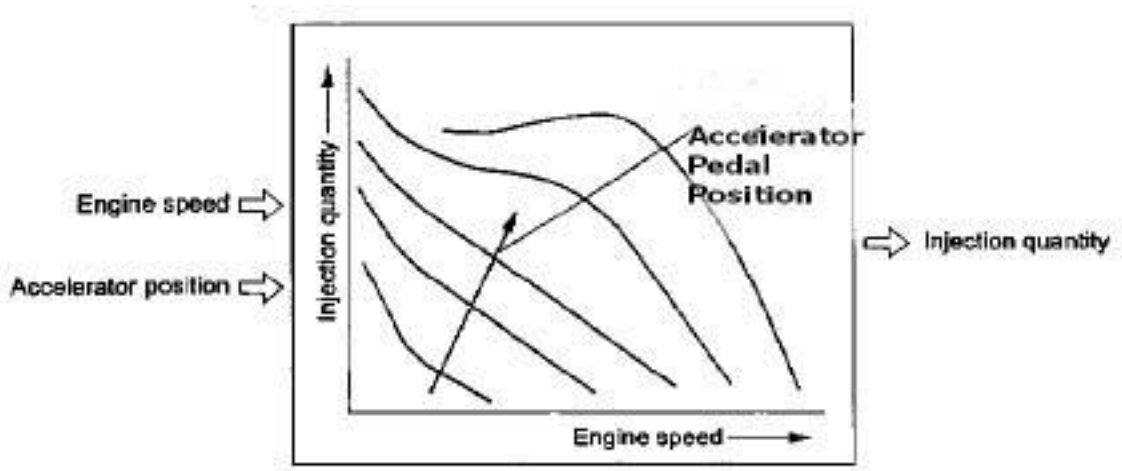
At engine start (after the key switch is turned to the START position to start the engine, and until the return of the key switch to the ON position), optimum fuel injection quantity is controlled based on information from the starter switch, engine speed, and ECT. At low temperature, the fuel injection quantity increases. When the engine starts completely, this boosted quantity mode at starting is cancelled and normal running mode is restored

Fuel Injection Control



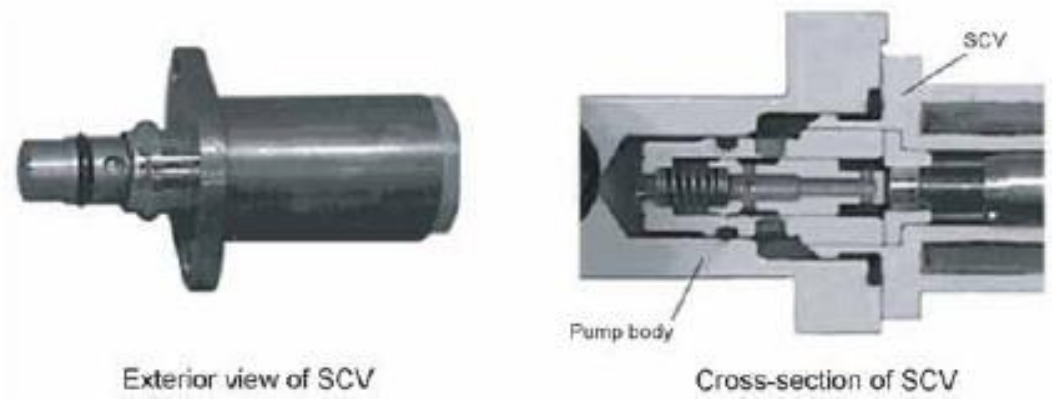
During normal running, the maximum fuel injection quantity is controlled according to the engine speed, ensuring the maximum torque according to the engine characteristics. In any running conditions, the fuel injection quantity is controlled within these characteristics to reduce the smoke and to prevent overload on the engine

Fuel Injection Control



During normal running optimum fuel injection quantity is controlled according to the engine speed and accelerator pedal pressure. Combined with high pressure injection of atomized fuel, this control improves exhaust gas and ensures proper fuel consumption. Compared with conventional mechanical governors, an electronic control system provides a higher degree of freedom of fuel injection quantity control, thereby presenting high accelerator response (acceleration feeling and pressing feeling).

Fuel Rail Pressure Regulator (FRP) aka (SCV)



The suction control valve (SCV), or Fuel Rail Pressure Regulator (FRP) is a linear solenoid type (Figures 2-20 and 2-21). The ECU controls the duty ratio (the length of time that the current is applied to the SCV), in order to control the quantity of fuel that is supplied to the high-pressure plunger. Because only the quantity of fuel that is required for achieving the target rail pressure is drawn in, the drive load of the supply pumps decreases.

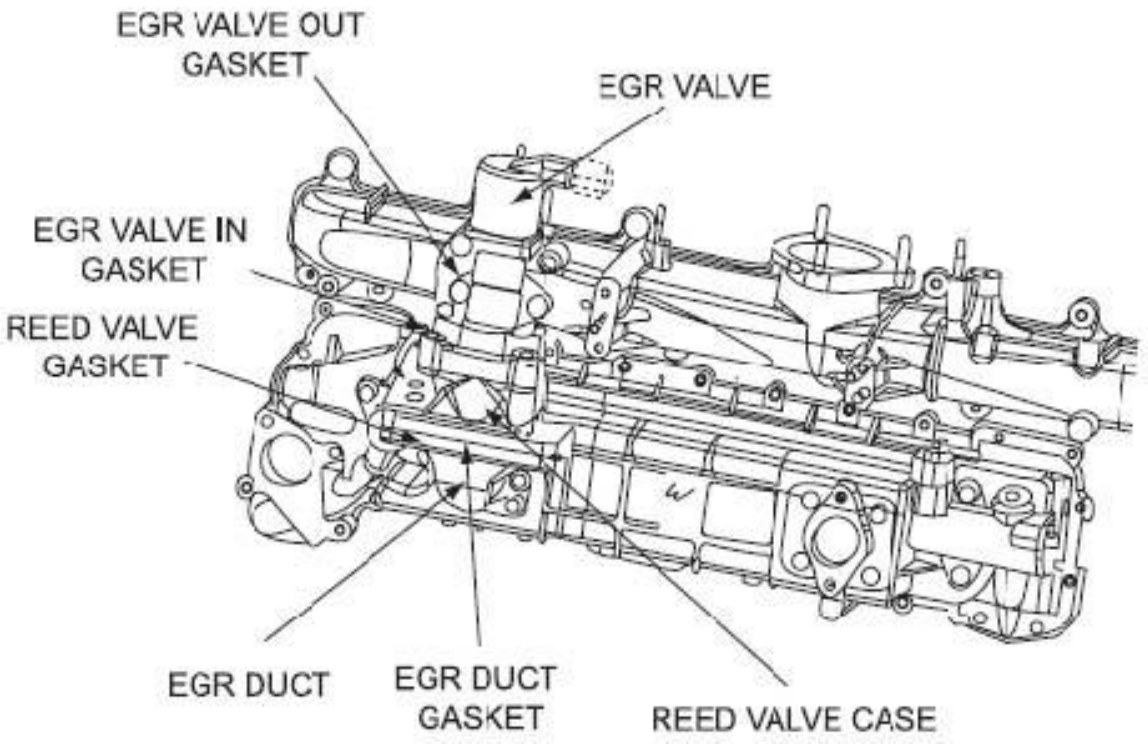
When current flows to the FRP, variable electromotive force results in accordance with the duty ratio, moving the armature to the left side. The armature moves the cylinder to the left side, changing the opening of the fuel passage and thus regulating the fuel quantity.

With the FRP OFF, the return spring contracts, completely opening the fuel passage and supplying fuel to the plungers (Full quantity intake and full quantity discharge).

When the FRP is ON, the force of the return spring moves the cylinder to the right, closing the fuel passage (normally opened).

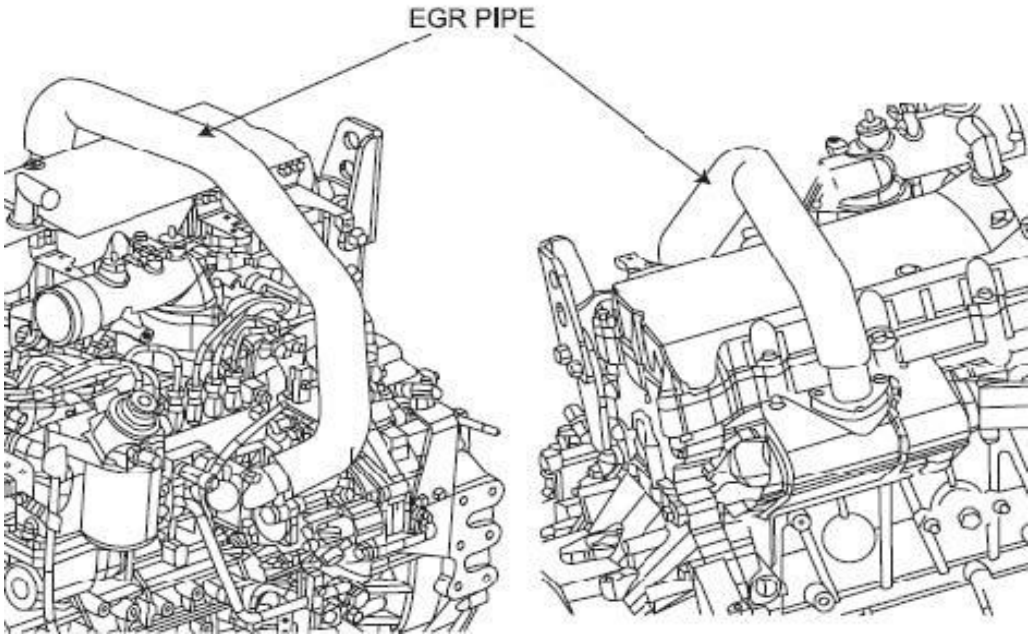
By turning the FRP ON/OFF, fuel is supplied in an amount corresponding to the actuation duty ratio, and the plungers discharge the fuel.

Exhaust Gas Recirculation (EGR) System



The EGR control system uses an electronic control system to ensure both driveability and low emissions. The control current from the ECM operates the DC motor to control the lift amount of the EGR valve. A valve sensor at the rear of the motor feeds the actual valve lift amount back to the ECM for more precise control of the EGR amount.

Exhaust Gas Recirculation (EGR) System

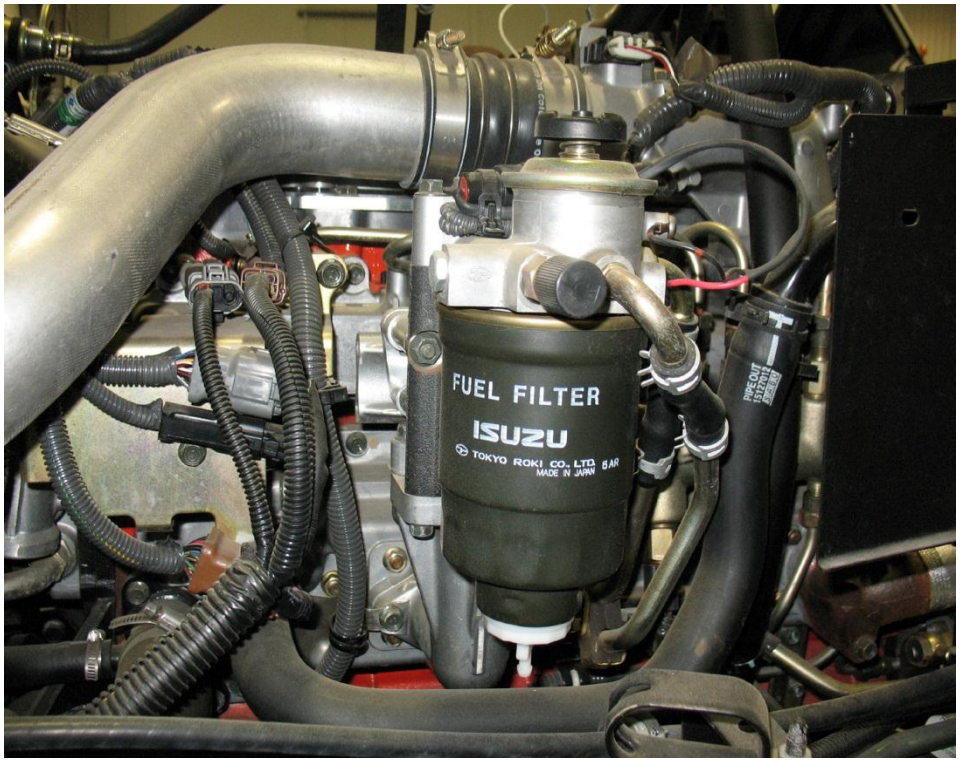


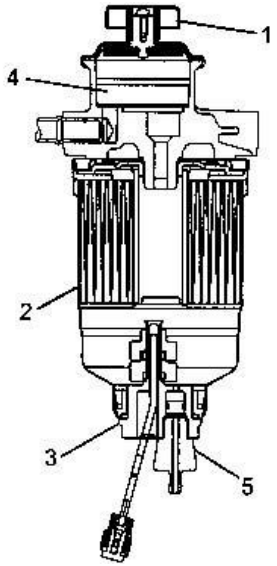
Exhaust gasses are transferred to the EGR cooler by piping from the exhaust manifold

Exhaust Gas Recirculation (EGR) System

- **EGR Operating Conditions** The EGR control starts when the conditions including the engine speed, the ECT, the accelerator pedal angle, the atmospheric pressure, and the system voltage are satisfied, and the valve opening is calculated according to the ECT, the engine speed, and the target fuel injection quantity. Based on this valve opening, the drive duty of DC motor is determined and the DC motor is driven accordingly. However, the EGR control is stopped when the exhaust brake operates, the PTO operates, the AP sensor is faulty, the ECT sensor is faulty, the EGR system is faulty, or the intake throttle system is faulty.
- ***Exhaust Gas Recirculation (EGR) Valve*** As for a control system, same as conventional, the DC motor operates with the duty control current from the ECM to control the lift amount of the EGR valve. An EGR valve position sensor (potentiometer) at the rear of the motor feeds actual valve lift amount back to the ECM for more precise EGR amount control. However, the EGR valve operation stops to ensure the driveability and startability when the ECT is low.
- ***EGR Cooler*** A water cooling type EGR cooler is added to the gas recirculation passage to cool the recirculating gas in order to reduce the combustion temperature, thereby restricting the generation of NOx (nitrogen oxides).

Fuel Filter Assembly





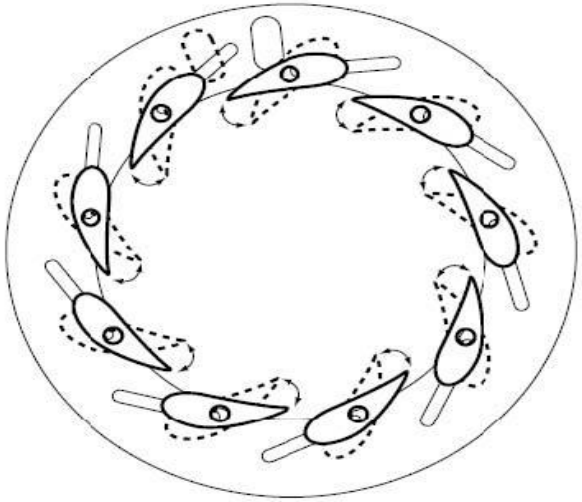
1- Priming Pump

2- Cartridge

3- Water Level Sensor

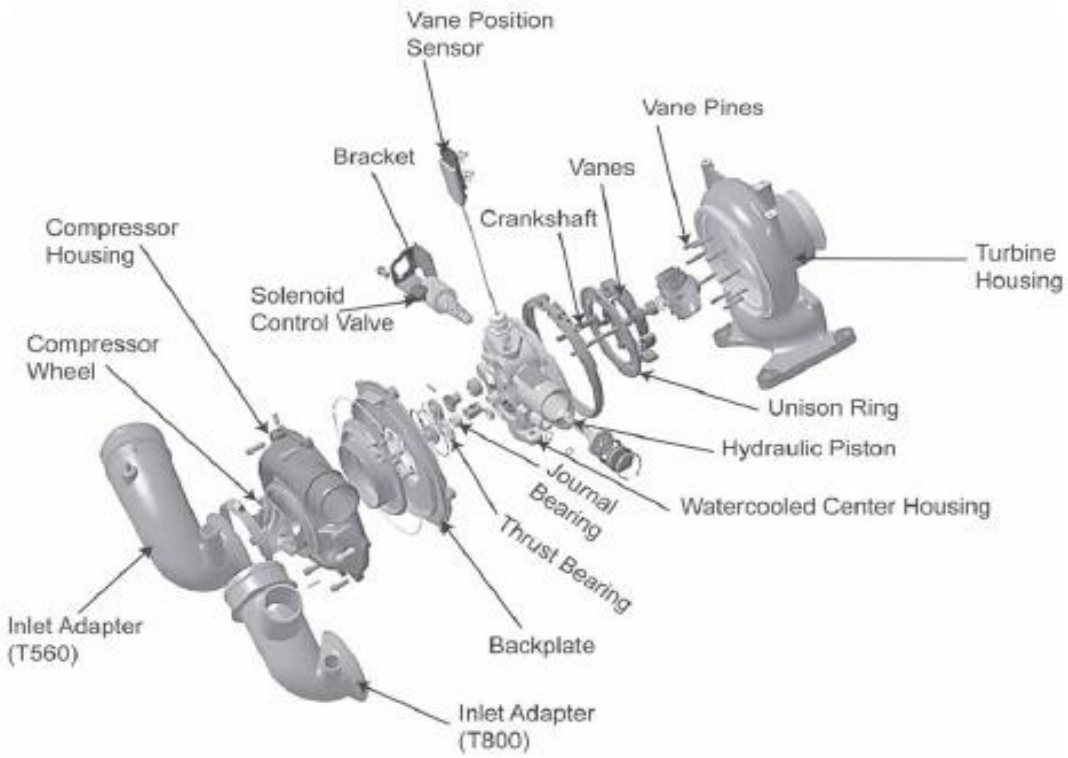
4- Bleed Screw

Variable Nozzle Turbo (VNT)



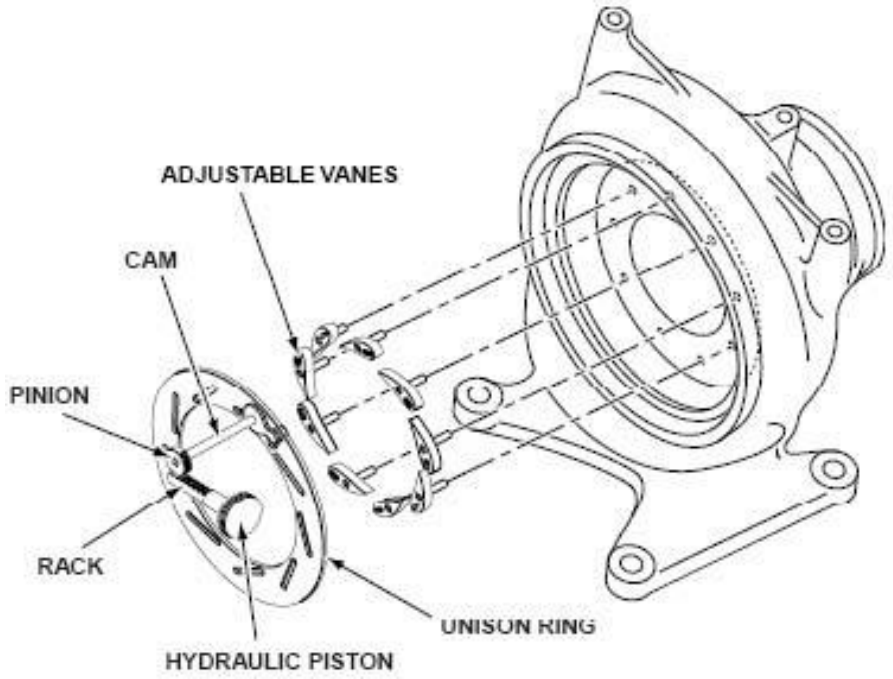
With the variable nozzle turbocharger, nine (9) vanes direct the exhaust gases at the turbine blades (Figure 2-35). These vanes can be opened or closed to vary the velocity of the exhaust gases acting upon the turbine wheel. With the moveable vanes, the speed of the turbine wheel can be controlled along with boost pressure. It is important to note that boost pressure is controlled independent of engine speed and a wastegate is not needed. The turbine wheel is part of a welded assembly with the shaft, called the shaft-wheel assembly. The shaft runs within bearings, which are supported by the center housing. On both ends are oil seals. On the compressor end is a thrust bearing and collar, which carries the axial load imposed by the compressor and turbine wheels. To maintain lubrication of the turbocharger, engine oil enters the top of the housing and exits the bottom. A heat shield protects the center housing and lubrication circuit from the heat radiated by the turbine housing.

Variable Nozzle Turbo (VNT)



The VNT's key distinction is a turbine with an outer ring of self-adjusting vanes to automatically adjust boost pressure and exhaust backpressure independent of engine speed.

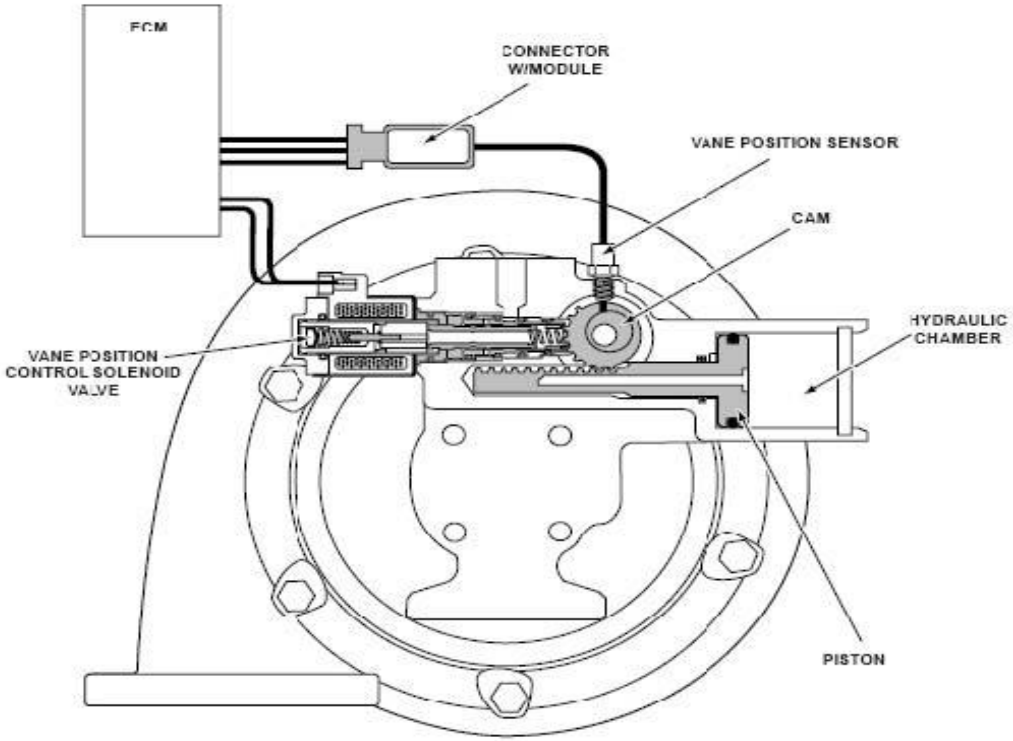
Variable Nozzle Turbo (VNT)



The adjustable vanes mount to a unison ring that allows the vanes to articulate (Figure 2-42). As the position of the unison ring rotates, the vanes change angle. The vanes are opened to minimize flow at the turbine and exhaust backpressure at low engine speeds. To increase turbine speed, the vanes are closed. The velocity of the exhaust gases increase, as does the speed of the turbine.

The unison ring is connected to a cam that is positioned by a rack and pinion gear. The turbocharger's vane position actuator solenoid connects to a hydraulic piston, which moves the rack to rotate the pinion gear and cam

Variable Nozzle Turbo (VNT)



The turbocharger vane position control solenoid valve is used to advance the unison ring's relationship to the turbine and thereby articulate the vanes

This solenoid actuates a spool valve that applies oil under pressure from the engine, to either side of the piston.

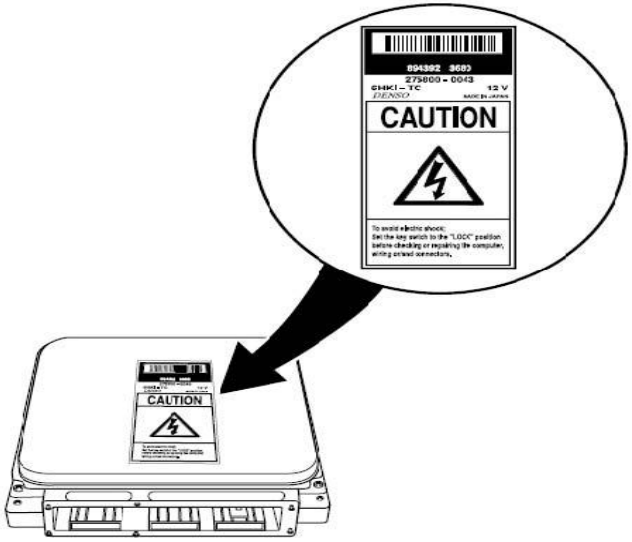
The position of the piston is sent to the ECM by the vane position sensor.

Sensors

Vehicle Speed Sensor (VSS) The signals received from the vehicle speed sensor are used for the engine fuel injection control, the PTO control, the exhaust control, the ABS control, the A/T control, and the speedometer.

EGR Valve Position Sensor A potentiometer (variable resistor) type exhaust gas recirculation (EGR) valve position sensor is located on the EGR valve body. The EGR valve position sensor is applied with reference voltage (5V) at all times from the ECM to detect the EGR valve lift amount in the form of voltage change and sends its signal to the ECM.

1999 to 2003 7.8L 6HK1-TC Engine



All fuel control decisions are made by the Engine Control Module (ECM). Several 5 and 12 volt sensors monitor operating conditions for the ECM so fuel economy, performance and emissions control can be enhanced.

The ECM used on the Duramax 7800 is somewhat unique in that it outputs significant voltage to open the injectors for this high-pressure diesel system

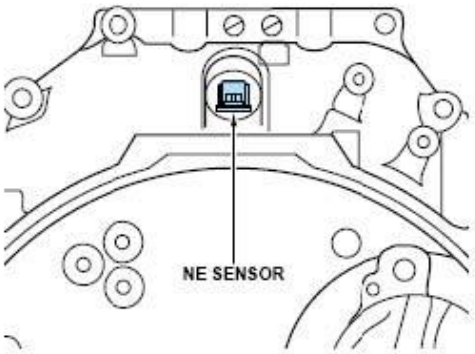
NOTE:

Previous design (99 - 02) three-connector ECM outputs 110 volts

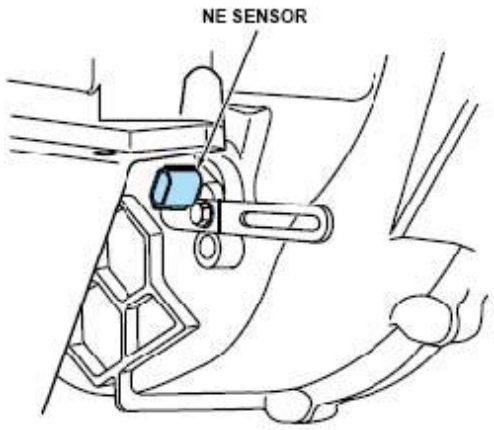
Newer design (03 - 04) five-connector ECM outputs 120 volts

Crankshaft Position Sensor (NE Sensor)

AUTOMATIC



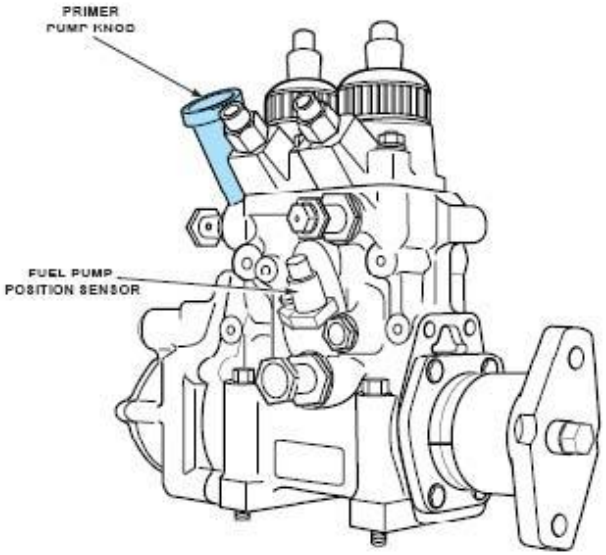
MANUAL



The crankshaft position (CKP) sensor (also referred to as the NE sensor) is located at the top of the bell housing on automatic transmissions, and on the lower left side of the bell housing for manual transmissions

The CKP sensor produces an alternating voltage signal as holes in the flywheel move past it. The ECM uses this sensor as the engine speed signal. The 45 holes in the flywheel are at 7.5-degree intervals. Therefore, every two revolutions of the flywheel create 90 pulses. From these pulses the ECM detects engine RPM and crankshaft angle. If the CKP sensor is disconnected, the vehicle will start using the pump position sensor input. If a fault is detected, a DTC P0335 will set.

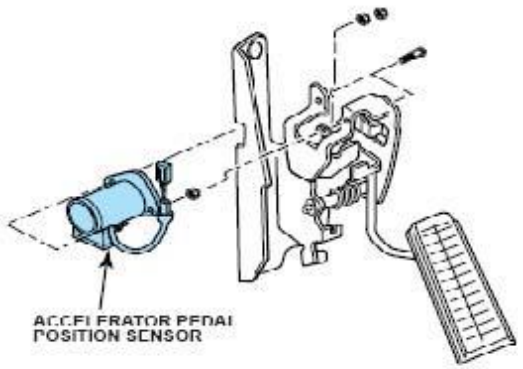
Injection Pump Position Sensor (G sensor / camshaft position sensor)



The injection pump position sensor (also known as the G sensor, auxiliary NE sensor, cam sensor, or crankshaft position "B" sensor) is located at the center of the injection pump body. Similar to the crankshaft position sensor, the fuel pump position sensor detects injection pump camshaft position This sensor also acts as a backup when there is a fault with the crankshaft position sensor. In these cases, the injection pump position sensor signal is used by the ECM to determine engine speed. If the pump position sensor is faulty, the vehicle will start. However, if both the pump position and crankshaft position sensors are disconnected, the engine will not run.

The disc-shaped gear that is provided in the center of the supply pump camshaft has 7 U-shaped notches or cutouts. One is found at each of six 60-degree intervals, plus an additional tooth or notch at the first interval. This sensor will signal the ECM seven times for every two engine revolutions, once every 120 degrees, with an auxiliary pulse at the first 120 degree mark. This auxiliary pulse is recognized by the ECM as the #1 cylinder reference pulse.

Accelerator Pedal Position Sensor

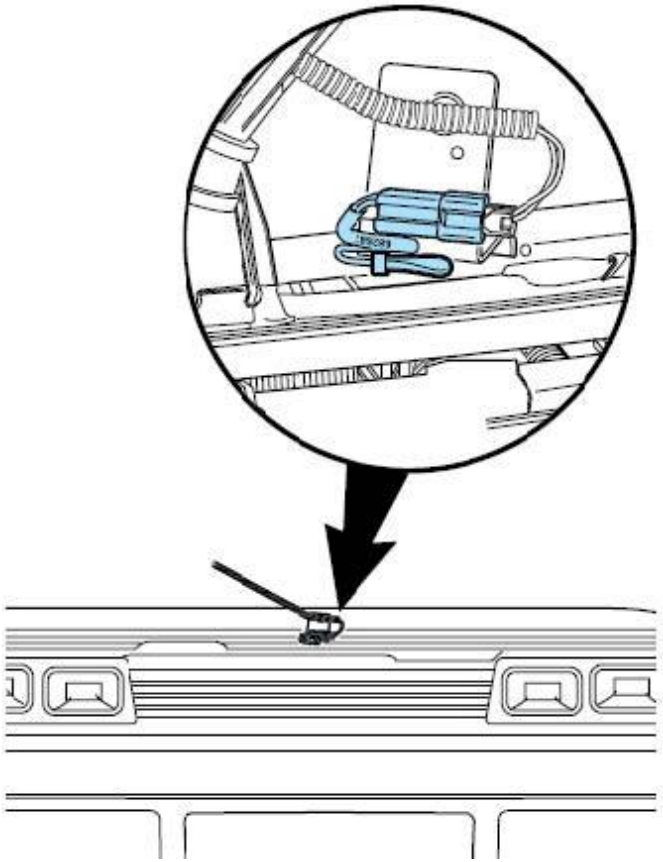


The accelerator pedal position sensor is located under the dash at the adjustable accelerator pedal assembly. This sensor's hall integrated circuitry converts the angle of the accelerator pedal into electrical signals for the ECM. The feedback voltage signal supplied to the ECM is increased as pedal angle is increased.

The ECM supplies a 5-volt reference signal to the accelerator position sensor. Inside the sensor, a magnet is mounted to a shaft that turns in unison with the accelerator pedal. The magnet field orientation changes with rotation of the shaft which alters the signal as monitored by the ECM.

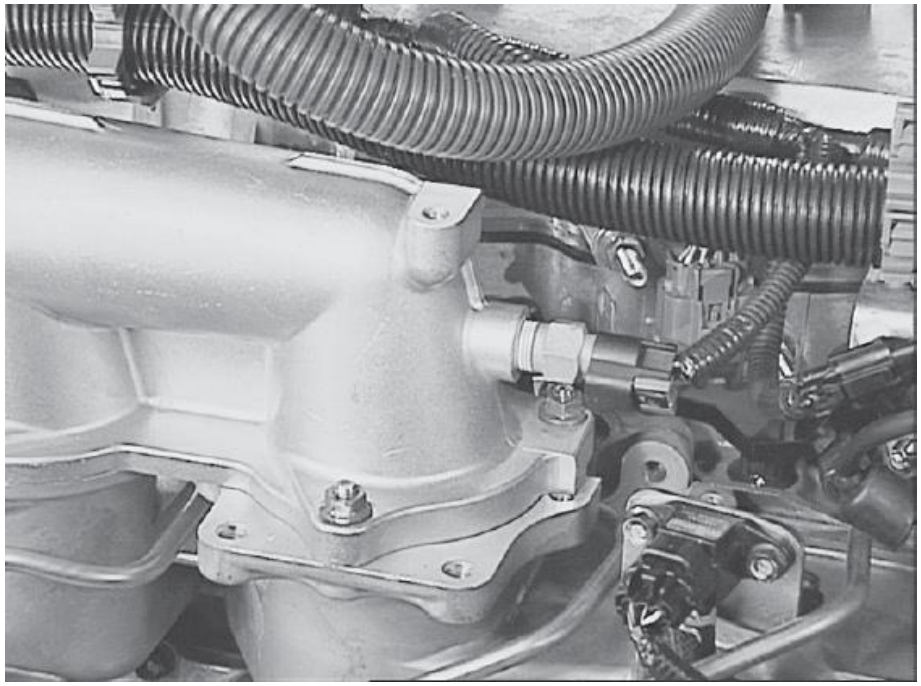
The accelerator pedal position sensor is a two sensor unit on vehicles with the previous Duramax 7800 engine. A three-sensor configuration is used on models with the newer engine. Redundant elements are used to provide safe engine control in the event of a failure at one of the sensor elements. However, if one of the sensor signals is lost or corrupt, the ECM will turn on the MIL and set a DTC

Ambient Air Temperature Sensor



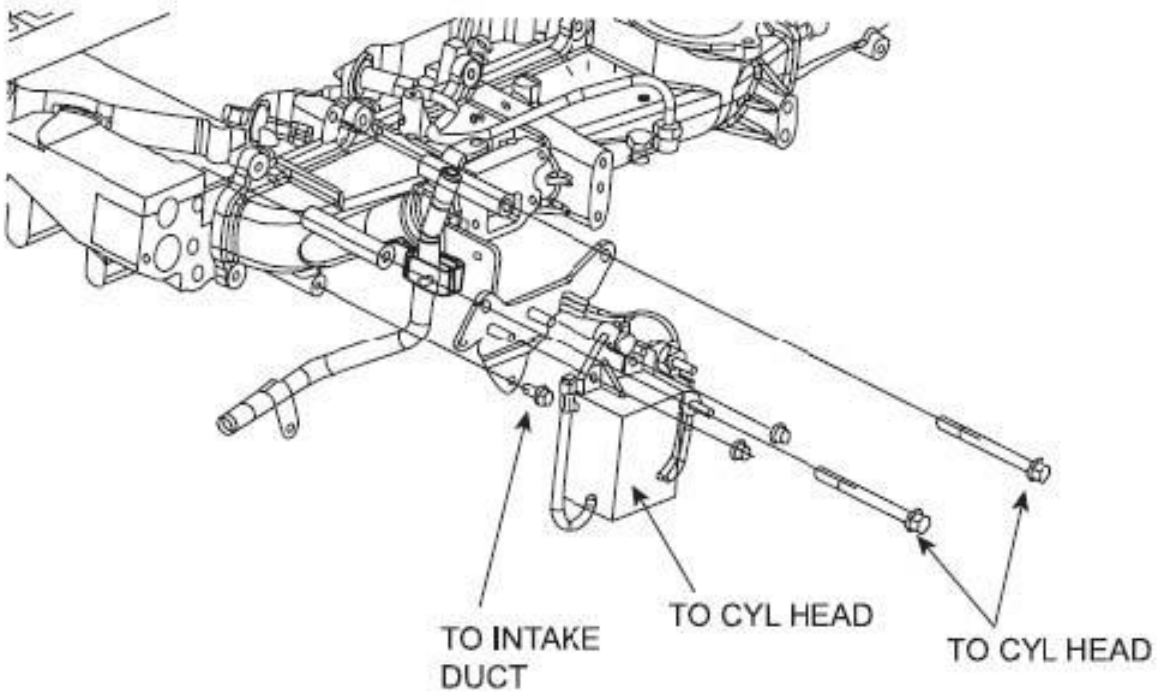
On previous Duramax 7800-equipped vehicles, the ambient air temperature sensor is located behind the cab hood cover. This sensor is a thermistor and operates the same as the coolant and fuel temperature sensors. The voltage signal to the ECM lowers as the ambient temperature rises. If a fault is detected, a DTC sets and a default value of 176° F is used.

Intake Manifold Air Temperature Sensor



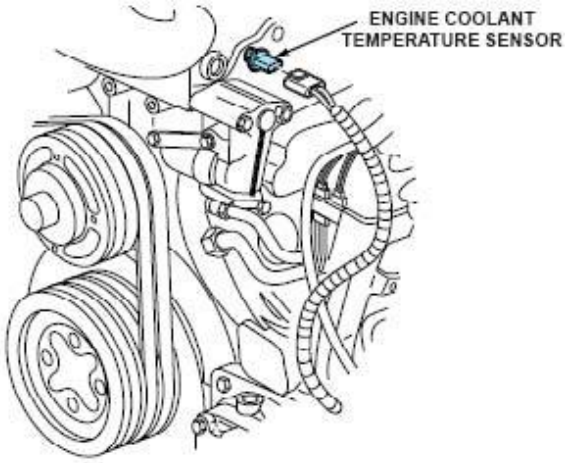
On newer Duramax 7800-equipped vehicles, a manifold air temperature sensor replaces the ambient air temperature sensor. The manifold air temperature sensor is also a thermistor, but is located in the turbocharger inlet adapter at the intake manifold.

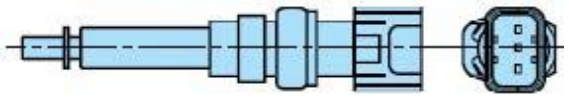
Intake Air Heater



The intake heater was only used on the 2003 "C" series engines in order to minimize white smoke under cold startup and cold running conditions. The need for this heater was eliminated in 2004 model year by recalibrating the ECM.

Engine Coolant Temperature Sensor

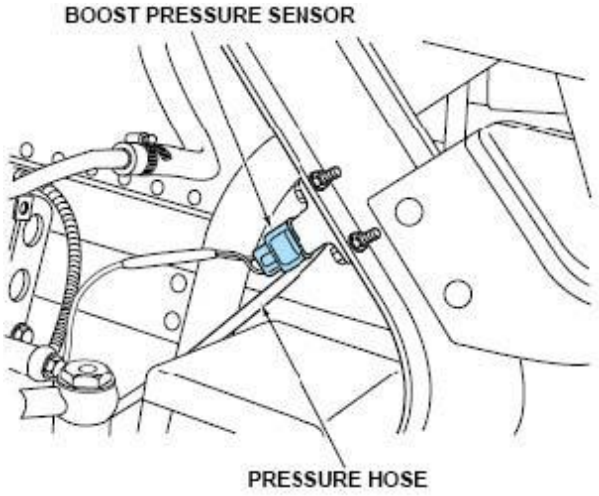


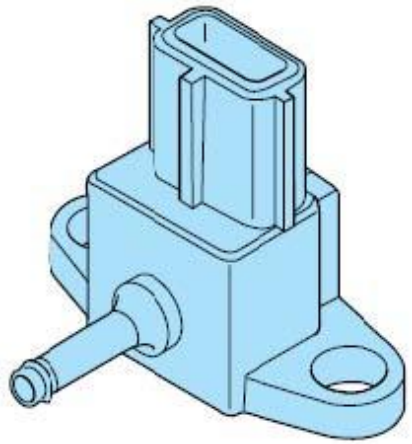


The engine coolant temperature sensor is located at the left front side of the cylinder head.

This sensor detects engine coolant temperature and outputs it to the ECM. The sensor uses a thermistor (temperature controlled resistor) to modify the reference voltage supplied to the sensor by the ECM. The higher the coolant temperature, the lower the voltage signal to the ECM. If a fault is detected in the engine coolant temperature sensor or circuit, a DTC will set and a default value of 176° F (80° C) will be used.

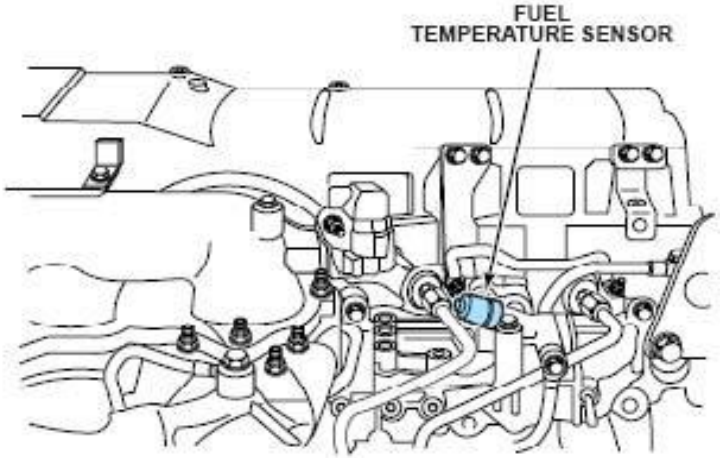
Boost Pressure Sensor





The boost pressure sensor is mounted on the cross-frame rail at the rear of the cab on previous Duramax 7800-equipped vehicles and attached to the intake manifold via a vacuum line. On models with the newer engine, the boost pressure sensor is mounted on the turbocharger inlet adapter with a hose connected to a port on the intake manifold. The boost sensor alters the reference voltage from the ECM based on the turbocharger-generated aspiration pressure present in the intake manifold

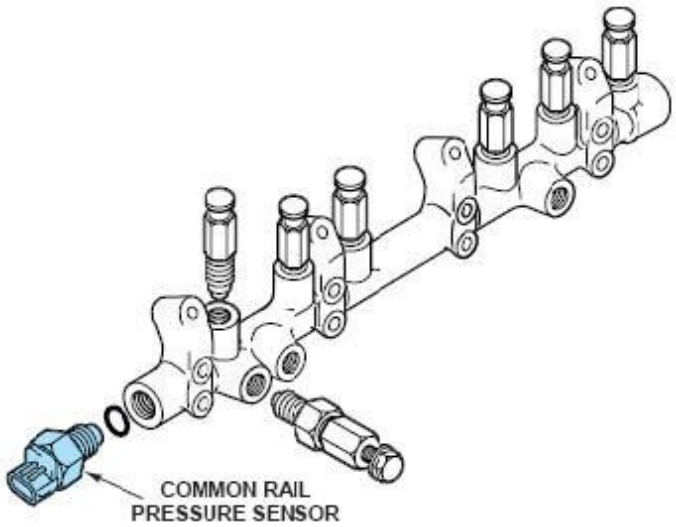
Fuel Temperature Sensor



The fuel temperature sensor is located in the fuel return line, at the rear of the intake manifold.

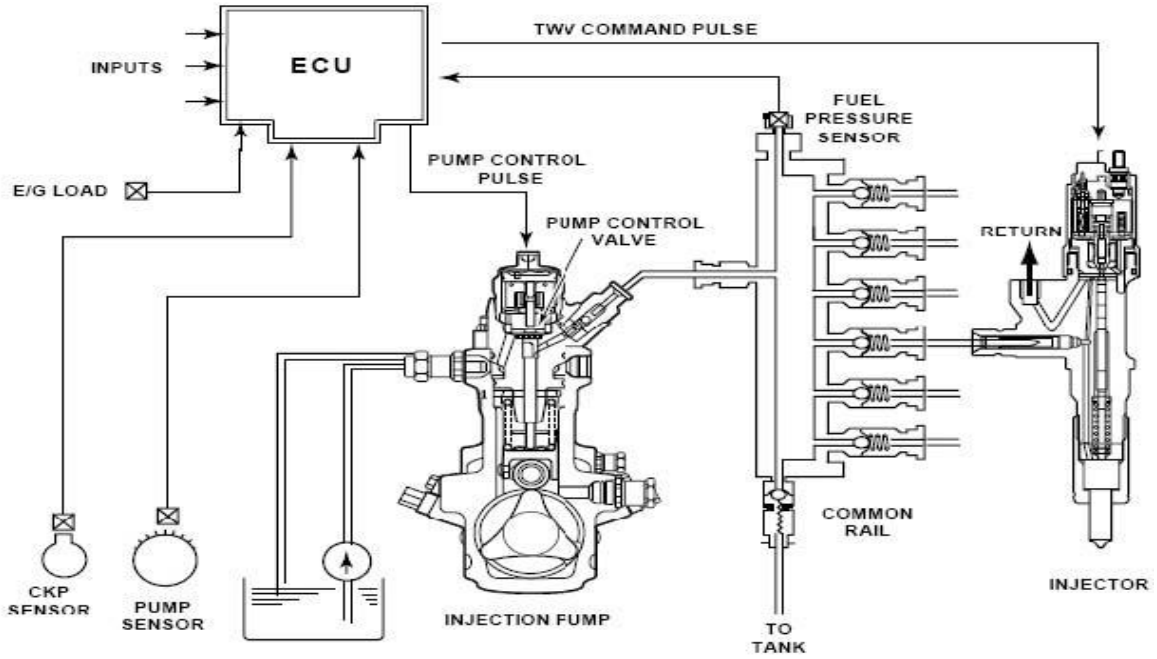
This sensor detects fuel temperature and outputs it to the ECM . The sensor uses a thermistor (temperature controlled resistor) to modify 5-volt reference voltage supplied to the sensor by the ECM. The higher the fuel temperature, the higher the sensor′s resistance and the lower the voltage signal to the ECM. An open or grounded circuit sets a DTC P0182 or P0183, and a default value of 176° F (80° C) is used.

Fuel Rail Pressure Sensor



The fuel rail pressure sensor is located on the left side of the common rail and is monitored by the ECM to ensure the commanded fuel pressure matches what is present in the rail. This sensor varies the ECM 5-volt signal voltage as pressure changes in the common rail. If a fault is detected, a DTC will set.

Fuel System Operation 1999 to 2003

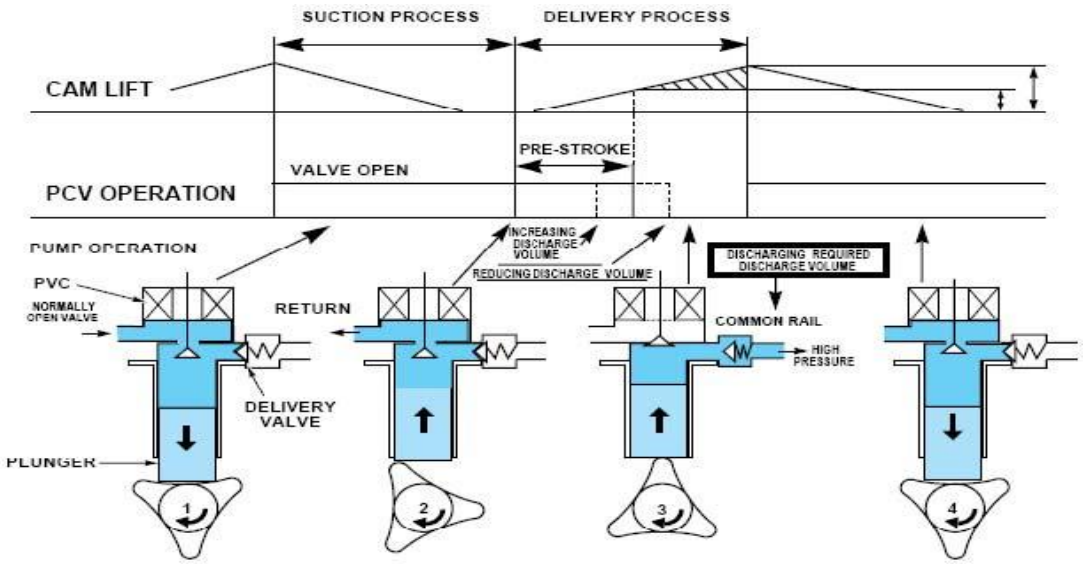


Fuel Volume Control

The two pressure control valves at the injection pump assembly respond to commands from the ECM to regulate the fuel volume discharged by the pump in order to control common rail fuel pressure. Pressure control valve current timing controls the volume of fuel discharged by the pump to the rail.

The pressure control valve relay supplies 12 volts to the valves. Both valves are controlled by the ECM on redundant ground circuits.

Fuel System Operation 1999 to 2003

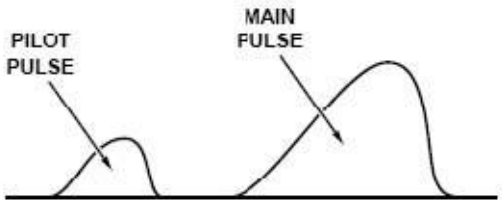


PCV / Supply Pump Operation

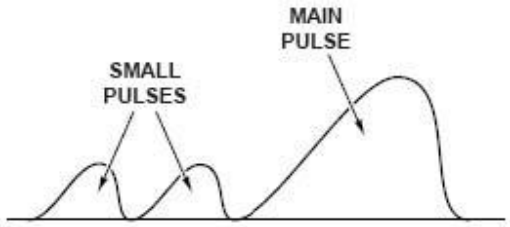
The two pressure control valves work in unison to provide consistent pressure at the injectors :

- 1.The pressure control valve remains open (de-energized) during the downward stroke of the plunger, allowing the low-pressure fuel to be drawn into the plunger chamber via the pressure control valve. Even after the upward stroke of the plunger begins, the valve remains open because current has not been applied to the pressure control valve.
- 2.Next, the ECM applies power to the pressure control valve, which closes the return passage. This causes pressure in the plunger chamber to rise. The amount of fuel that corresponds with the lifting of the plunger after the valve closes becomes the discharge volume. Varying the timing of the pressure control valve closing causes the discharge volume to vary accordingly, thereby regulating common rail fuel pressure.
- 3.From top-dead-center, the plunger down stroke begins, which causes the chamber pressure to decrease. The delivery valve closes, stopping the pumping of the fuel. The ECM interrupts current to the pressure control valve, which opens allowing the low-pressure fuel to be drawn into the plunger chamber.

Fuel System Operation 1999 to 2003



Pilot Injection



Split Injection

The ECM uses several modes of operation (strategies) to handle a wide variety of operating demands:

Pilot Injection – Due to high fuel pressures, NOx and noise may need to be decreased. The ECM accomplishes this with a pilot injection strategy . A small injection of fuel prior to the main injection pulse reduces lag time to help control NOx and noise generation

Main Injection – This is the typical closed-loop operating mode described throughout this section

Split Injection – During the slow engine cranking for start-up, several small injection pulses are used to decrease start-up durations

Fuel System Operation 1999 to 2003

The Duramax 7800 fuel injection system is controlled by ECM calculations based upon the signals received from input sensors. Several control functions allow the ECM to optimize fuel supply:•

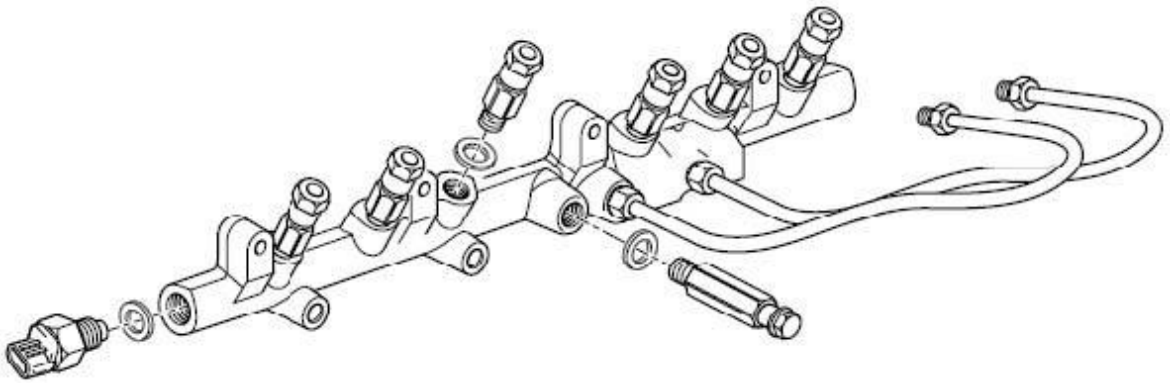
Injection Rate – The fuel is injected through the nozzle in varying, specific time periods, depending on operating conditions•

Injection Volume – Fuel volume is also varied for specific operating conditions, primarily engine speed and throttle position. This logic allows for the elimination of a governor function found on some other fuel-injected diesel engines•

Injection Timing – The specific timing of injector pulses is determined by engine speed and injection volume decisions•

Fuel Pressure – Injection pump discharge volume depends on feedback from the pressure sensor at the common rail. The ECM constantly adjusts injection functions to match available fuel pressure at the common rail

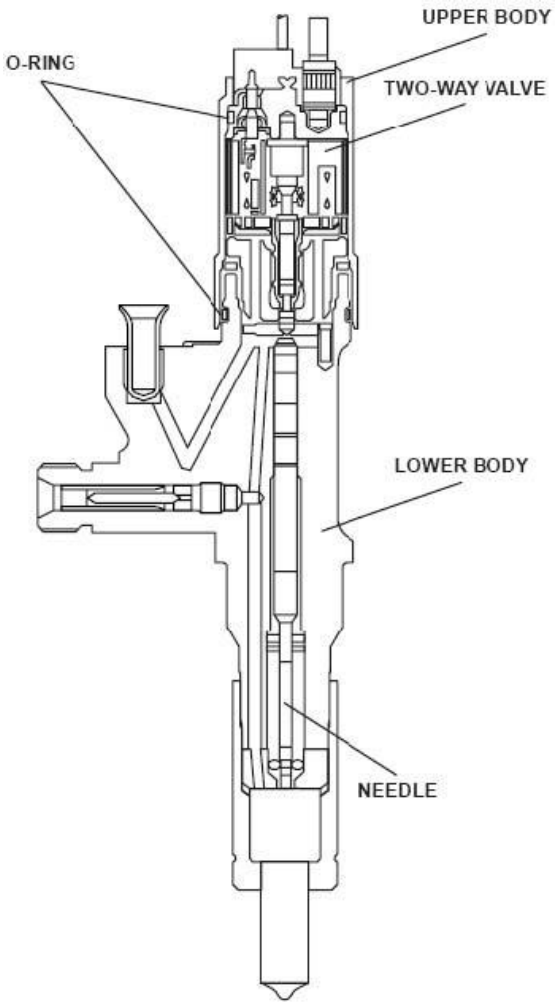
Common Rail



Once the injection pump assembly has created the required high fuel pressure, the common rail distributes the fuel to the injectors. As reviewed previously, the common rail includes:

- Pressure limiter
- Pressure sensor
- Flow dampers (six, one for each injector)

Fuel Injectors



The six electronically-controlled fuel injectors must each precisely control the approximate 2,900 psi fuel for individual combustion events. The electromagnetic two-way valves (TWV) allow the fuel pressure to overcome internal spring force in the injectors.

Diesel Fuel Testing

Specific Gravity Testing

Specific Gravity Requirements	Number 2 Diesel	Number 1 Diesel	Tool
API Gravity	30-39	39-44	J-38641-B

Refer to the Fuel Oil Specific Gravity Requirements table. If the correct fuel is being used in the conditions listed in Fuel Quality, and meets number 1-Diesel or number 2-Diesel fuel oil specific gravity requirements, fuel is OK. If not, the fuel should be replaced.

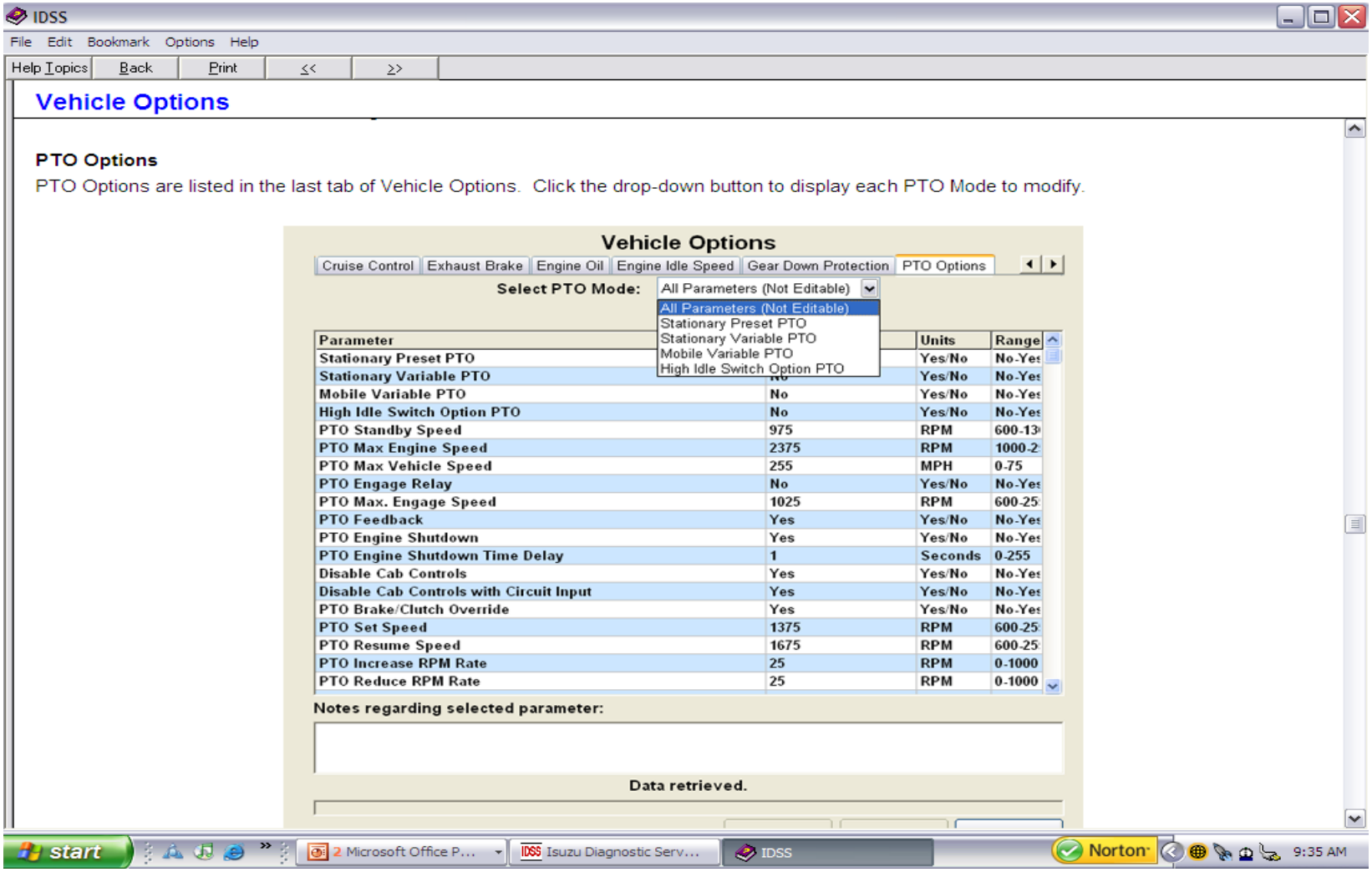
These Service Bulletins can also be helpful when diagnosing fuel related issues:

- IB09-J-003A Symptom Diagnosis – Engine Fuel System
- SB10-J-09 Fuel Injector Failure – Contaminated Diesel Fuel, Secondary Fuel Filter Kit

ECM Programming

PTO Operation and Programming

PTO Operation and Programming



PTO Operation and Programming

3 Modes of PTO Operation

- Stationary Preset
- Stationary Variable
- Mobile Variable

- 6HK engines also have a high idle switch option that is programmed in the PTO section

Stationary Preset PTO

- Used when vehicle is stopped
- Operates when pressing the PTO Main Switch
- Operates engine rpm to the Standby speed that is set in IDSS
- Typical Applications:

  lawn sprayer, dump truck, some lift gates

Stationary Variable PTO

- Used when the vehicle is stopped
- Main PTO Switch is Pressed
- Up and Down Switch is used to “customize” engine rpm to meet the needs of the application.
- Can be set up for remote operation

- Typical Applications:

  pumper vehicle, generator, boom truck

Mobile Variable PTO

- PTO control is performed when the vehicle is running
- Vehicles speed is controlled by PTO speed
- Upfitter - Installed Engage Relay
  used to run pump from PTO drive
- Typical Applications:
  street sweeper, paint striper, hydro blaster

Vehicle Option Programming

All Option Content programming is performed using a scan tool. The following options are available for reprogramming:

- Power Take Off (PTO) Options
- Cruise Control Options
- Exhaust Brake Options
- Vehicle Speed Limit
- Engine Shut Down Protection
- Speedometer Calibration

Power Take Off (PTO) Options

The PTO Option Programming must be done when any of the following procedures are performed:

- When the upfitter installs a PTO
- When the ECM is replaced
- When a change of PTO settings are needed

Refer to the detail programming contents and settings of the Power Take Off (PTO) System

Vehicle Option Programming (cont.)

Cruise Control Options

The Cruise Control Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced
- When a change of minimum cruise control speed is needed
- When a change of maximum cruise control speed is needed

The operational speed range of the cruise control system can be changed by user request within the following allowable range

- Minimum: 25 MPH
- Maximum 75 MPH

Vehicle Option Programming cont.)

Exhaust Brake Options

The Exhaust Brake Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced
- When a change of the exhaust brake assist in cruise control is needed

It is set up during the cruise control so that the exhaust brake may be effective when the actual vehicle speed is higher than the saet speed. It can change by user request. This exhaust brake assist in cruise control is enabled when the following conditions are met:

- Exhaust brake in cruise mode is programmed
- Exhaust brake request switch is ON
- In cruise control
- Accelerator pedal is not pressed
- Actual vehicle speed is more than 4 MPH over the set speed
- The fuel injection quanitity is 0mm3

Vehicle Option Programming (cont.)

Exhaust Brake Options (cont.)

This exhaust brake assist in cruise control is disabled when one of the following conditions is met:

- Exhaust brake in cruise control mode is not programmed
- Exhaust brake request switch is off
- Not being in cruise control
- The accelerator pedal is pressed
- Actual vehicle speed is more than 1.5 MPH below the set speed
- Fuel injection quantity is more than 1 mm3

Vehicle Speed Limit

The Vehicle Speed Limit Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced
- When a change of the maximum vehicle speed is needed

The maximum vehicle speed can be changed within the following range:

- Minimum: 10 MPH
- Maximum 75 MPH

Vehicle Option Programming (cont.)

Engine Shutdown Protection

The Engine Shutdown Protection Option Programming must be done when any of the following procedures are performed:

- When the ECM is replaced
- When a change of the engine shutdown type is needed

The engine shutdown type can select either of the following modes by user request:

- The engine will not be shutdown, however warning continues (preset value)
- The engine will be shutdown 30 seconds after the warning

Speedometer Calibration

The Speedometer Calibration Programming must be done when the ECM is replaced, or the tire diameter has changed, to indicate vehicle speed correctly. The calibration value differs with the GVW, transmission type and final gear ratio. Follow the IDSS on-screen instructions for this programming

Engine Shutdown/Warning Protection System

- The engine control module (ECM/PCM) is equipped with Engine Shutdown/Warning Protection System programmable features which include:
  - Engine Protection Enable

    This feature will enable or disable the Engine Protection System Modes (Engine Shutdown or Warning buzzer).
  - Engine Protection Mode - Engine Shutdown

    When Engine Protection Enable is set to YES AND Engine Protection Mode is set to Engine Shutdown, the engine control module (ECM/PCM) will turn OFF the engine if the engine experiences one of the three following conditions: Low Engine Coolant Level, Low Engine Oil Pressure or High Engine Coolant Temperature. These three variables are factory set in the ECM/PCM and are not adjustable. An alarm will sound along with an illuminated instrument panel indicator 30 seconds before the engine is actually shutdown with the condition present.
  - Engine Protection Mode - Warning Only

    When Engine Protection Enable is set to YES AND Engine Protection Mode is set to Warning Only, the ECM/PCM will sound an alarm if the engine experiences any of the following conditions: Low Engine Coolant Level, Low Engine Oil Pressure or High Engine Coolant Temperature. These three variables are factory set in the ECM/PCM and are not adjustable. The alarm will sound along with an illuminated instrument panel indicator with the condition present.

Engine Shutdown/Warning Protection System (cont'd)

- Programming the Engine Shutdown/Warning Protection System Options to the ECM/PCM
  - The Engine Shutdown/Warning Protection System Options can be programmed using the Isuzu Diagnostic Service System (IDSS) under Controller Programming - Engine Control Module Programming - Vehicle Options - Engine Shutdown/Protection.
  - Default Factory Settings:
    - Engine Protection Enable: Yes
    - Engine Protection Mode: Warning Only
  - Allowable Programmable Ranges:
    - Engine Protection Enable: Yes / No
    - Engine Protection Mode: Warning Only/Engine Shutdown

    - NOTE: If the Technician programs the ECM to activate the "Engine Shutdown" system, a warning label available through AIPDN must be affixed to the drivers inside door panel.

Reference Material

Diagnostic Trouble Code (DTC) List

DTC	DTC Type	DTC Descriptor
P0016	B	Crankshaft Position (CKP) - Camshaft Position (CMP) Correlation
P0027	A	Exhaust Throttle Control Valve Performance
P003A	A	Turbocharger Boost Control Position Not Learned
P0045	A	Turbocharger Boost Control Solenoid Control Circuit
P0079	A	Exhaust Valve Control Circuit Low Voltage
P0080	A	Exhaust Valve Control Circuit High Voltage
P0087	A	Fuel Rail Pressure (FRP) Too Low
P0088	D	Fuel Rail Pressure (FRP) Too High (First Stage)
P0088	A	Fuel Rail Pressure (FRP) Too High (Second Stage)
P0089	A	Fuel Pressure Regulator Performance
P0091	A	Fuel Pressure Regulator Solenoid 1 Control Circuit Low Voltage
P0092	A	Fuel Pressure Regulator Solenoid 1 Control Circuit High Voltage
P0093	A	Fuel System Large Leak Detected
P0097	A	Intake Air Temperature (IAT) Sensor Circuit 2 Low Voltage
P0098	A	Intake Air Temperature (IAT) Sensor Circuit 2 High Voltage
P0101	B	Mass Air Flow (MAF) Sensor Performance
P0102	A	Mass Air Flow (MAF) Sensor Circuit Low Voltage
P0103	A	Mass Air Flow (MAF) Sensor Circuit High Voltage
P0112	A	Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage
P0113	A	Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage
P0116	A	Engine Coolant Temperature (ECT) Sensor Performance
P0117	A	Engine Coolant Temperature (ECT) Sensor Circuit Low Voltage
P0118	A	Engine Coolant Temperature (ECT) Sensor Circuit High Voltage
P0126	B	Engine Coolant Temperature (ECT) Insufficient For Stable Operation
P0128	B	Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature
P0181	A	Fuel Temperature Sensor Performance
P0182	A	Fuel Temperature Sensor Circuit Low Voltage
P0183	A	Fuel Temperature Sensor Circuit High Voltage
P0191	A	Fuel Rail Pressure (FRP) Sensor Performance
P0192	A	Fuel Rail Pressure (FRP) Sensor Circuit Low Voltage
P0193	A	Fuel Rail Pressure (FRP) Sensor Circuit High Voltage
P0201	A	Injector 1 Control Circuit
P0202	A	Injector 2 Control Circuit
P0203	A	Injector 3 Control Circuit
P0204	A	Injector 4 Control Circuit
P0219	D	Engine Overspeed
P0234	A	Turbocharger Engine Overboost
P0237	A	Turbocharger Boost Sensor Circuit Low Voltage
P0238	A	Turbocharger Boost Sensor Circuit High Voltage
P0261	A	Injector 1 Control Circuit Low Voltage

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Diagnostic Trouble Code (DTC) List (cont.)

P0264	A	Injector 2 Control Circuit Low Voltage
P0267	A	Injector 3 Control Circuit Low Voltage
P0270	A	Injector 4 Control Circuit Low Voltage
P0299	A	Turbocharger Engine Underboost
P02E2	A	Intake Air Flow (IAF) Control Circuit Low Voltage
P02E3	A	Intake Air Flow (IAF)Control Circuit High Voltage
P02E7	B	Intake Air Flow (IAF) Position Sensor Performance
P02E8	A	Intake Air Flow (IAF) Position Sensor Circuit Low Voltage
P02E9	A	Intake Air Flow (IAF) Position Sensor Circuit High Voltage
P0300	A	Engine Misfire Detected
P0301	B	Cylinder 1 Misfire Detected
P0302	B	Cylinder 2 Misfire Detected
P0303	B	Cylinder 3 Misfire Detected
P0304	B	Cylinder 4 Misfire Detected
P0335	A	Crankshaft Position (CKP) Sensor Circuit
P0336	A	Crankshaft Position (CKP) Sensor Performance
P0340	A	Camshaft Position (CMP) Sensor Circuit
P0341	B	Camshaft Position (CMP) Sensor Performance
P0381	B	Wait to Start Lamp Control Circuit
P0401	B	Exhaust Gas Recirculation (EGR) Flow Insufficient
P0402	B	Exhaust Gas Recirculation (EGR) Flow Excessive
P0403	A	Exhaust Gas Recirculation (EGR) Solenoid Control Circuit
P0404	B	Exhaust Gas Recirculation (EGR) Open Position Performance
P0405	A	Exhaust Gas Recirculation (EGR) Position Sensor Circuit Low Voltage
P0406	A	Exhaust Gas Recirculation (EGR) Position Sensor Circuit High Voltage
P040B	B	Exhaust Gas Recirculation (EGR) Temperature Sensor 1 Circuit Performance
P040C	A	Exhaust Gas Recirculation (EGR) Temperature Sensor 1 Circuit Low Voltage
P040D	A	Exhaust Gas Recirculation (EGR) Temperature Sensor 1 Circuit High Voltage
P041B	B	Exhaust Gas Recirculation (EGR) Temperature Sensor 2 Circuit Performance
P041C	A	Exhaust Gas Recirculation (EGR) Temperature Sensor 2 Circuit Low Voltage
P041D	A	Exhaust Gas Recirculation (EGR) Temperature Sensor 2 Circuit High Voltage
P042E	B	Exhaust Gas Recirculation (EGR) Closed Position Performance
P0500	B	Vehicle Speed Sensor (VSS) Circuit
P0506	B	Idle Speed Low
P0507	B	Idle Speed High
P0512	B	Start Switch Circuit
P0522	C	Engine Oil Pressure (EOP) Sensor Circuit Low Voltage
P0523	C	Engine Oil Pressure (EOP) Sensor Circuit High Voltage
P0545	A	Exhaust Gas Temperature (EGT) Sensor Circuit 1 Low Voltage
P0546	A	Exhaust Gas Temperature (EGT) Sensor Circuit 1 High Voltage
P0562	C	System Voltage Low

Diagnostics Trouble Code (DTC) List (cont.)

P0563	C	System Voltage High
P0567	C	Cruise Control Resume Switch Circuit
P0568	C	Cruise Control Set Switch Circuit
P0571	C	Cruise Control Brake Switch Circuit
P0602	A	Control Module Not Programmed
P0606	A	Control Module Internal Performance
P062F	A	Control Module Long Term Memory Performance
P0642	A	5 Volt Reference 1 Circuit Low Voltage
P0643	A	5 Volt Reference 1 Circuit High Voltage
P064C	B	Glow Plug Control Module Performance
P0650	B	Malfunction Indicator Lamp (MIL) Control Circuit
P0652	A	5 Volt Reference 2 Circuit Low Voltage
P0653	A	5 Volt Reference 2 Circuit High Voltage
P0671	A	Glow Plug 1 Control Circuit
P0672	A	Glow Plug 2 Control Circuit
P0673	A	Glow Plug 3 Control Circuit
P0674	A	Glow Plug 4 Control Circuit
P0687	D	Engine Controls Ignition Relay Control Circuit High Voltage
P0700	A	Transmission Control Module (TCM) Request MIL Illumination (12,000 lbs GVW)
P0802	B	Transmission Control Module (TCM) MIL Request Circuit (12,000 lbs GVW)
P1085	D	High Pressure Fuel Pump Performance
P1093	B	Fuel Rail Pressure Too Low
P1125	A	Accelerator Pedal Position (APP) System
P1259	C	High Pressure Fuel Pump Performance
P1293	A	Injector Positive Charge Up Control Circuit
P1471	A	Diesel Particulate Filter Regeneration Insufficient
P160B	A	Fuel Injector Calibration Checksum Error
P2002	B	Diesel Particulate Filter Low Efficiency
P2032	A	Exhaust Gas Temperature (EGT) Sensor 2 Circuit Low Voltage
P2033	A	Exhaust Gas Temperature (EGT) Sensor 2 Circuit High Voltage
P2080	A	Exhaust Gas Temperature (EGT) Sensor 1 Performance
P2084	A	Exhaust Gas Temperature (EGT) Sensor 2 Performance
P20E2	B	Exhaust Gas Temperature (EGT) Sensor 1-2 Correlation
P2122	C	Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage
P2123	C	Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage
P2127	C	Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage
P2128	C	Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage
P2138	C	Accelerator Pedal Position (APP) Sensor 1-2 Correlation
P2146	A	Injector Positive Voltage Control Circuit Group 1
P2147	A	Injector Positive Voltage Control Circuit Group 1 Low Voltage
P2148	A	Injector Positive Voltage Control Circuit Group 1 High Voltage

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Diagnostic Trouble Code (DTC) List (cont.)

P2149	A	Injector Positive Voltage Control Circuit Group 2
P2150	A	Injector Positive Voltage Control Circuit Group 2 Low Voltage
P2151	A	Injector Positive Voltage Control Circuit Group 2 High Voltage
P2199	B	Intake Air Temperature Sensor 1-2 Correlation
P2227	B	Barometric Pressure (BARO) Sensor Performance
P2228	A	Barometric Pressure (BARO) Sensor Circuit Low Voltage
P2229	A	Barometric Pressure (BARO) Sensor Circuit High Voltage
P244B	A	Diesel Particulate Filter Differential Pressure Too High
P244C	A	Diesel Particulate Filter Regeneration Duration
P2453	A	Diesel Particulate Filter Differential Pressure Sensor Performance (Learned Position Error)
P2453	B	Diesel Particulate Filter Differential Pressure Sensor Performance (Sensor Signal Range Error)
P2454	A	Diesel Particulate Filter Differential Pressure Sensor Circuit Low Voltage
P2455	A	Diesel Particulate Filter Differential Pressure Sensor Circuit High Voltage
P2457	B	Exhaust Gas Recirculation (EGR) Cooling System Performance
P2463	A	Diesel Particulate Filter - Soot Accumulation
P254D	C	Power Take-Off (PTO) Engine Speed Selector Sensor Circuit High Voltage
P2564	A	Turbocharger Boost Control Position Sensor Low Voltage
P2565	A	Turbocharger Boost Control Position Sensor High Voltage
P256C	C	Engine Idle Speed Selector Sensor Low Voltage
P256D	C	Engine Idle Speed Selector Sensor High Voltage
P268A	A	Fuel Injector Calibration Not Programmed
U0073	A	Control Module Communication Bus Off
U0101	A	Lost Communication with TCM
U0106	B	Lost Communication with Glow Plug Control Module
U010C	A	Lost Communication with Turbocharger Control Module
U0294	D	Lost Communication with Data Recording Module

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Scan Tool Output Control Tests

	Scan Tool Output Control	Descriptions
DPF system	Clear DPF Data	The purpose of this function to clear the DPF status parameters. ***Important: DPF status must be cleared before regeneration with a scan tool.***
DPF system	DPF Normal Regeneration	The purpose of this test is for filter force regeneration. Important: Do not perform this test if the exhaust differential pressure is more than a threshold.
DPF system	DPF Slow Regeneration	The purpose of this test is for filter force regeneration in case of excessively accumulated PM. This very slow regeneration compared with another one. ***Important: Do not perform this test if the exhaust differential pressure is more than a threshold. And, engine oil must be replaced after DPF slow regeneration is completed.***
Fuel system	Cylinder Power Balance	The purpose of this test is for checking whether the fuel injector is operating when commanded ON/ OFF. Faulty injector(s) could be considered if engine does not change speed when commanded OFF.
Fuel system	RPM Control	The purpose of this test is for checking whether the actual engine idle speed is correctly changed to the commanded desired idle speed.
Fuel system	Supply Pump Learn Reset	The purpose of this function to reset the fuel supply pump adjustment value. ***Important: The fuel supply pump relearn procedure must be done when the fuel supply pump or engine is replaced, or an ECM from another vehicle is installed. Refer to Fuel Supply Pump Replacement.***
Lamp control	Cruise Main Lamp	The purpose of this test is for checking whether the cruise main lamp is operating when commanded ON. Faulty circuit(s) or an open circuit could be considered when not operating when commanded ON.
Lamp control	Cruise Set Lamp	The purpose of this test is for checking whether the cruise set lamp is operating when commanded ON. Faulty circuit(s) or an open circuit could be considered when not operating when commanded ON.
Lamp control	Glow Plug Lamp	The purpose of this test is for checking whether the glow indicator lamp is operating when commanded ON. Faulty circuit(s) or an open circuit could be considered when not operating when commanded ON.
Lamp control	Malfunction Indicator Lamp (MIL)	The purpose of this test is for checking whether the MIL is operating when commanded ON. Faulty circuit(s) or an open circuit could be considered when not operating when commanded ON.
Lamp control	Service Vehicle Soon Lamp	The purpose of this test is for checking whether the SVS lamp is operating when commanded ON. Faulty circuit(s) or an open circuit could be considered when not operating when commanded ON.
Solenoid control	EGR Solenoid	The purpose of this test is for checking whether the EGR valve is correctly moved with command. Restricted valve movement by foreign materials, excessive deposits or a faulty valve could be considered if the position difference is large.
Solenoid control	Exhaust Brake	The purpose of this test is for checking whether the exhaust brake control solenoid is operating when commanded ON. Faulty circuit(s) or a faulty solenoid could be considered if not energizing when commanded ON.

Scan Tool Output Control Tests (cont.)

Solenoid control	Intake Airflow (IAF) Valve	The purpose of this test is for checking whether the intake airflow (IAF) valve is correctly moved with command. Restricted valve movement by foreign materials, excessive deposits or a faulty valve could be considered if the position difference is large between the Desired IAF Valve Position and IAF Valve Position.
Solenoid control	PTO Relay	The purpose of this test is for checking whether the PTO engage relay is operating when commanded ON. Faulty circuit(s) or a faulty PTO engage relay could be considered if not energizing when commanded ON.
Solenoid control	Turbocharger Vane	The purpose of this test is for checking whether the turbocharger nozzle control solenoid is correctly moved with command. Restricted actuator movement by foreign materials, excessive deposits, damaged linkage, a faulty solenoid or a faulty position sensor could be considered if the solenoid is not moved correctly.