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LBT-263
Duramax Diesel Diagnostics Update

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GENERAL MOTORS DURAMAX OVERVIEW

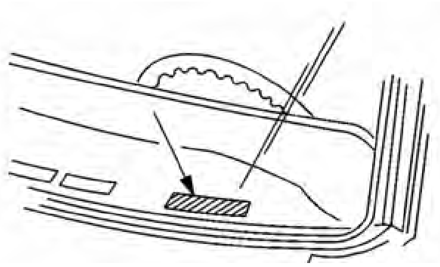
The Duramax is a General Motors diesel engine family for light- and medium duty trucks, designed by Isuzu. The 6.6-liter Duramax is produced by DMAX, a joint venture between GM and Isuzu in Moraine, Ohio. This engine was initially installed in 2001 model year Chevy and GMC trucks and has been an option since then in pickups, vans, and medium-duty trucks. In 2006, production at Moraine was reportedly limited to approximately 200,000 engines per year. On May 9, 2007, DMAX announced the production of the 1,000,000th Duramax V-8 diesel at its Moraine facility.

The chart below helps to compare the 4 generations of Duramax diesels. Starting with the LB7 & ending with the present LML, though the Duramax 6600 has remained similar year to year, there are subtle differences in the design of each engine. Characteristics that are the same with each engine model have been omitted from the chart (i.e: bore, stroke, configuration, & other properties that did not change from model to model).

	6.6L Duramax LB7	6.6L Duramax LLY	6.6L Duramax LBZ	6.6L Duramax LMM	6.6L Duramax LML
Years Produced:	2001 - 2004	2004 - 2006	2006 - 2007	2007.5 - 2010	2011
Compression Ratio:	17.5:1	17.5:1	16.8:1	16.8:1	16.8:1
Aspiration:	Turbocharged, air-to-air intercooler.	Variable geometry turbocharger & air-to-air intercooler.	Variable geometry turbocharger & air-to-air intercooler.	Variable geometry turbocharger & air-to-air intercooler.	Variable geometry turbocharger & air-to-air intercooler.
Injection:	23,000 psi Bosch common rail, CP3 pump	23,000 psi Bosch common rail, CP3 pump	26,000 psi Bosch common rail, CP3 pump	26,000 psi Bosch common rail, CP3 pump	30,000 psi Bosch common rail, Piezo injectors.
Peak Horsepower:	300 hp @ 3,100 RPM	310 hp @ 3,000 RPM	360 hp @ 3,200 RPM	365 hp @ 3,100 RPM	397 hp @ 3,000 RPM
Peak Torque:	520 lb-ft @ 1,800 RPM	605 lb-ft @ 1,600 RPM	650 lb-ft @ 1,600 RPM	660 lb-ft @ 1,800 RPM	765 lb-ft @ 1,600 RPM
Emissions:	N/A	EGR, catalytic converter	EGR, catalytic converter	EGR, catalytic converter, DPF	EGR, SCR, DPF

Position	Definition	Character	Description
1	Country of Origin	1	United States
		2	Canada
2	Manufacturer	G	General Motors
3	Make	B	Chevrolet Incomplete
		C	Chevrolet Truck
		D	GMC Incomplete
		T	GMC Truck
4	GVWR/Brake System	E	6001-7000/Hydraulic
		F	7001-8000/Hydraulic
		G	8001-9000/Hydraulic
		H	9001-10000/Hydraulic
		J	10001-14000/Hydraulic
5	Truck Line/Chassis Type	C	4x2
		K	4x4
6	Series	1	Half Ton Nominal
		2	¾ Ton Nominal
		6	½ Ton Luxury
7	Body Type	3	Four-Door Crew Cab or Utility
		4	Two-Door Cab
		9	Extended Cab
8	Engine Type	1	6.6L V8 DSL (LB7)
		2	6.6L V8 DSL (LLY)
9	Check Digit	--	Check Digit
10	Model Year	4	2004
11	Plant Location	1	Oshawa, Ontario
		E	Pontiac, Michigan
		F	Flint, Michigan
		Z	Fort Wayne, Indiana
		G	Silao
12 THRU 17	Plant Sequence Number	--	Plant Sequence Number

GENERAL MOTORS DURAMAX OVERVIEW



Model Year(s)	8th Digit of VIN	Duramax Model & Notes
2001 - 2004	1	LB7
	2	LLY (introduced midyear 2004)
2005	2	LLY (only engine offered for 2005)
2006	2	LLY (2006 version, different from 2005 version)
	D	LBZ (introduced late 2006)
2007	D	LBZ
	6	LMM
2008 - 2010	6	LMM (only Duramax offered during these years)
2011 - 2013	8	LML (only Duramax offered during these years)

The vehicle identification number (VIN) plate is the legal identifier of the vehicle. The VIN plate is located on the upper LH corner of the instrument panel. The VIN number can be seen through the windshield from the outside of the vehicle.

DURAMAX REVIEW

LB7

RPO LB7 (engine code "1") was first introduced in 1999 and continued until mid 2004. It is a 32-valve design with high-pressure common-rail direct injection and an experimental composite design cylinder head. The most problematic issue with the LB7 is injector failure.

Fuel leaked and entered the crankcase, causing oil dilution. Early on, customers came forward complaining of severe overheating, and in some situations, blown head gaskets. Initially GM denied it was a problem, but after being sued by a consumer group, GM relented and included overheating and blown head gaskets as a warranted item. GM issued a warranty for this after the fact for injectors, which now have 7 year/200,000 mile coverage.

The following trucks use the LB7:

Chevrolet Kodiak/GMC Topkick
Chevrolet Silverado/GMC Sierra HD

LLY

The LLY (internally called the 8GF1) (engine code "2") is a 6,599 cc (402.7 cu in) turbocharged engine which debuted in mid-2004 and continued until the end of 2005. It is a 32-valve design with high-pressure common-rail direct injection and aluminum cylinder heads.

The LLY was GM's first attempt to implement emissions requirements on their diesel trucks. To meet this goal they turned to a newly developed Garrett turbocharger with a variable geometry vane system and they installed an Exhaust Gas Recirculation valve or (EGR Valve).

Learning from problems with injectors in the previous LB7 GM changed the valve covers to allow access to the injectors without having to remove the valve covers, saving significant labor costs if injector replacement became necessary.

The following trucks used the LLY engine:

2006 Hummer H1 Alpha
Chevrolet Silverado/GMC Sierra HD

DURAMAX REVIEW

LBZ

The LBZ (engine code "D") debuted in late 2006 and continued into 2007 sold only in the "classic" body style. It has an improved engine computer tune that produces increased power and torque over the 2005.5 LLY version of the motor. First appearance of the Duramax in the Express/Savanna vans.

Changes include:
* Cylinder block casting and machining changes strengthen the bottom of the cylinder bores to support increased power and torque
* Upgraded main bearing material increases durability
* Revised piston design helps lower compression ratio to 16.8:1 from 17.5:1
* Piston pin bore diameter increased for increased strength
* Connecting rod " I " section is thicker for increased strength
* Cylinder heads revised to accommodate lower compression and reduced cylinder firing pressure
* Maximum injection pressure increased from 23,000 psi (1,585.8 bar) to more than 26,000 psi (1,792.6 bar)
* Fuel delivered via higher-pressure pump, fuel rails, distribution lines and all-new, seven-hole fuel injectors
* Fuel injectors spray directly onto glow plugs, providing faster, better-quality starts and more complete cold-start combustion for reduced emissions
* Improved glow plugs heat up faster through an independent controller
* Revised variable-geometry turbocharger is aerodynamically more efficient to help deliver smooth and immediate response and lower emissions
* Air induction system re-tuned to enhance quietness
* EGR has larger cooler to bring more exhaust into the system
* First application of new, 32-bit E35 controller, which adjusts and compensates for the fuel flow to bolster efficiency and reduce emissions"

LBZ applications:

Chevrolet Silverado HD
Chevrolet Kodiak
GMC Sierra HD
GMC TopKick

LLY applications:

Chevrolet Silverado HD
Chevrolet Kodiak
GMC Sierra HD
Chevrolet Express full-size (reduced power output mated to a 4L85E transmission)
GMC Savana full-size (reduced power output mated to a 4L85E transmission)

Code	Years	Power@rpm	Torque@rpm	Redline (rpm)
LBZ (Chevrolet Silverado 2500HD / 3500 Classic (auto trans), GMC Sierra 2500HD / 3500 Classic (auto trans))	2006–2007	360 bhp (270 kW) @3200	650 lb·ft (881 N·m) @1600	3450
LLY (Chevrolet Kodiak Medium Duty (LRX option), GMC TopKick Medium Duty (LRX option), Hummer H1 Alpha)	2004–2005	300 bhp (220 kW) @3000	520 lb·ft (705 N·m) @1600	3200
LBZ(Chevrolet Kodiak Medium Duty (LPD option), GMC TopKick Medium Duty (LPD))	2006–2007	300 bhp (220 kW) @3000	605 lb·ft (820 N·m) @1600	3200
LLY (Chevrolet Express, GMC Savana)	2006–2007	250 bhp (190 kW) @3200	460 lb·ft (624 N·m) @1600	3450

DURAMAX REVIEW

LMM

The LMM (engine code "6") debuted part way through 2007 and ended production with the start of the 2011 calendar year and is mated to the 6-speed Allison transmission. The LMM was the only Duramax offered for model years 2008-2010.

(Diesel Oxidizing Catalyst) where the fuel is burned to elevate the temperature of the exhaust. This hot exhaust flows into the DPF and burns the trapped soot.

Emission controls:

* Additional combustion control, including an even more efficient variable-geometry turbocharging system, cooled (enhanced) exhaust gas recirculation (EGR) and closed crankcase ventilation to reduce nitrogen oxides (NOx)
* Additional exhaust control, including oxidizing catalyst and new diesel particulate filter (DPF) to reduce soot and particulate matter
* Increased-capacity cooling system
* New engine control software
* Use of low-ash engine oil (CJ-4)

Applications:

2007- Chevrolet Silverado HD[8]
2007- GMC Sierra HD
Chevrolet Kodiak
GMC Topkick
Chevrolet Express/GMC Savanna

Code	Years	Power@rpm	Torque@rpm	Redline (rpm)
LML (Chevrolet Silverado HD, GMC Sierra HD)	2011–2012	397 bhp (296 kW) @3000	765 lb·ft (1,037 N·m) @1600	3450
LMM (Chevrolet Silverado HD, GMC Sierra HD)	2007–2010	365 bhp (272 kW) @3200	660 lb·ft (895 N·m) @1600	3450
LMM (Chevrolet Kodiak Medium Duty (LYE option), GMC TopKick Medium Duty (LYE option))	2007–2010	330 bhp (250 kW) @3000	620 lb·ft (841 N·m) @1600	3250
LMM (Chevrolet Kodiak Medium Duty (LRX option), GMC TopKick Medium Duty (LRX option))	2007–2010	300 bhp (220 kW) @3000	520 lb·ft (705 N·m) @1600	3250
LMM (Chevrolet Express, GMC Savana)	2007–2010	250 bhp (190 kW) @3200	460 lb·ft (624 N·m) @1600	3450

DURAMAX REVIEW

LML

The 6.6L RPO LML (VIN code "8") is the latest version (2011–present) of the Isuzu/GM Duramax V8 diesel engine and actually a further advanced version of the LMM engine with the majority of the changes addressing a required drastic reduction in engine emissions. Some mechanical aspects of the engine, such as piston oil flow design for improved temperature control and oil pump design, were also improved to enhance durability even further.

The LML engine was significantly updated for 2011 to provide improved exhaust emissions that comply with the new federal emission standards for diesel engines, provide better engine rigidity and further noise reduction.

New 29,000 PSI piezo injectors, a complete fuel system-hardening to tolerate up to 20% biodiesel mixtures and urea injection (to reduce Nitrogen oxides) with a 5.3 gallon urea tank are updating the fuel and emissions systems.

This engine has a fuel injector in the exhaust tract, to allow raw fuel injection during the particulate filter recycling routine. The RPO LML engine is rated at 397 horsepower (296 kW) at 3000 rpm and 765 lb·ft (1,037 N·m) of torque at 1600 rpm.

The LML Duramax is equipped with a SCR system that requires the use of DEF (diesel exhaust fluid). DEF is injected into the exhaust stream where a chemical reaction occurs that reduces NOx emissions. The DEF tank is approximately 5 gallons (18.9 liters). On pickup trucks, the DEF tank fill nozzle is located on the passenger side, under the hood and is sealed by a blue cap. On vans, the DEF tank fill nozzle is located in the fuel fill door, and is also sealed by a blue cap. The DEF system will illuminate a warning indicator in the instrument panel when the DEF fluid levels range is estimated to be 1,000 miles. Subsequent warnings will follow.

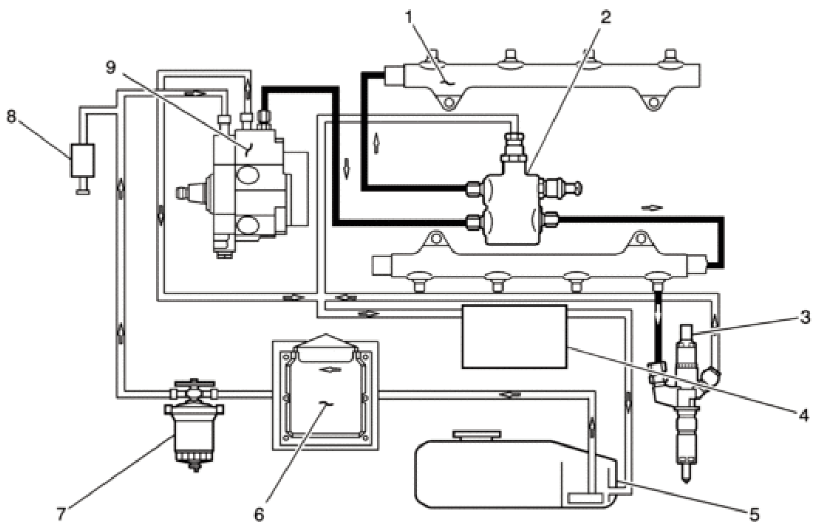
If the DEF fluid level is depleted, an "EXHAUST FLUID EMPTY" notification will be displayed on the instrument panel. Upon restart, the truck will be speed limited to 55 mph. If the tank remains empty, speed will be limited to 4 mph after the second refueling. Performance may also suffer when the truck enters this mode.

If the DEF fluid quality is detected to be low, an "EXHAUST FLUID QUALITY POOR" notification will be displayed on the instrument panel. After 200 miles of driving with poor quality DEF, the truck will be speed limited to 55 mph. If the system continues to detect low quality DEF, speed will be limited to 4 mph upon the next refueling.

If the DEF system detects that it requires service, a "SERVICE EXHAUST FLUID SYSTEM" notification will be displayed on the instrument panel. Failure to have the system serviced within 200 miles will result in speed limited to 55 mph upon the next startup, and 4 mph on the next refuel.

LB7 OVERVIEW

FUEL SYSTEM



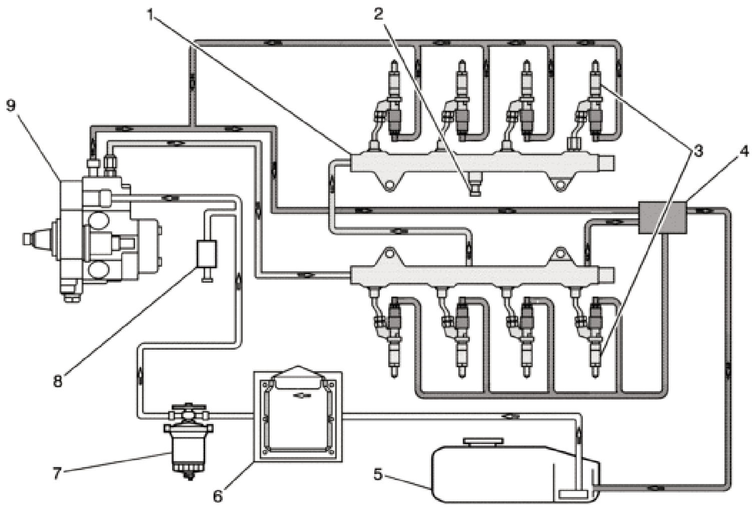
COMPONENT	DESCRIPTION
1	Fuel Rail
2	Fuel Junction Block
3	Fuel Injector
4	Fuel System Cooler
5	Fuel Tank
6	Fuel Injection Control Module
7	Fuel Filter
8	First Start Fuel Bleeder Valve
9	Fuel Injection Pump

The fuel tank (5) stores the fuel supply. A mechanical fuel injection pump (10), located below the engine intake, draws fuel through the fuel injector control module (6) and the fuel filter (7). The fuel is used as a coolant for the fuel injector control module. The fuel pump output is controlled by the ECM, and provides fuel at the pressure needed by the fuel injectors (3). The fuel injectors supply fuel directly to the combustion chambers of the engine. A separate pipe returns unused fuel through a fuel cooler (4) and to the fuel tank.

NOTES

LLY & LBZ OVERVIEW

FUEL SYSTEM



COMPONENT	DESCRIPTION
1	Fuel Rail
2	Fuel Pressure Sensor
3	Fuel Injectors
4	Fuel Return Junction Block
5	Fuel Tank
6	Fuel Injection Control Module
7	Fuel Filter
8	First Start Fuel Bleeder Valve
9	Fuel Injection Pump

The fuel tank (5) stores the fuel supply. A mechanical fuel injection pump (10), located below the engine intake, draws fuel through the fuel injector control module (6) and the fuel filter (7). The fuel is used as a coolant for the fuel injector control module. The fuel pump output is controlled by the ECM, and provides fuel at the pressure needed by the fuel injectors (3). The fuel injectors supply fuel directly to the combustion chambers of the engine. A separate pipe returns unused fuel through a fuel cooler (4) and to the fuel tank.

The fuel injection pump is a mechanical high pressure pump. The fuel injection pump is located below the intake manifold. Fuel is pumped to the fuel rails at a specified pressure. Fuel pressure is regulated by a valve on the inlet of the fuel pump, controlled by the engine control module (ECM). Excess fuel from the fuel injection pump returns to the fuel tank through the fuel return pipe and a fuel cooler.

The fuel feed pipe carries fuel from the fuel tank to the fuel injector control module. The fuel return pipe carries fuel from the fuel rail assemblies back to the fuel tank. The fuel pipes consist of 2 sections:

* The rear fuel pipe assemblies are located from the top of the fuel tank to the chassis fuel pipes. The rear fuel pipes are constructed of steel with sections of rubber hose covered with braiding.
* The chassis fuel pipes are located under the vehicle and connect the rear fuel pipes to the fuel rail pipes. These pipes are constructed of steel with sections of rubber hose covered with braiding.

The left and right fuel rail assemblies attach to the cylinder heads. The fuel rail assemblies distribute pressurized fuel to the fuel injectors through the fuel lines.

The fuel rail assemblies consists of the following components:

The fuel rail pressure sensor in the right fuel rail
The fuel pressure relief valve in the left fuel rail

The fuel rail pressure sensor gives the engine control module (ECM) an indication of fuel pressure. The ECM uses this information to regulate fuel pressure, by commanding the fuel pressure regulator open or closed on the inlet of the fuel injection pump.

LLY & LBZ OVERVIEW

FUEL SYSTEM (CONTINUED)

The fuel pressure relief valve opens only to prevent excessive pressure in the event of a malfunction. Fuel from the fuel pressure relief valve is returned to the fuel tank.

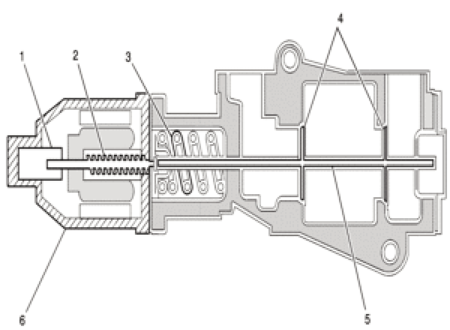
A fuel injector is a solenoid device, controlled by the fuel injection control module (FICM), that meters pressurized fuel to a single engine cylinder. The engine control module (ECM) energizes the low-impedance injector solenoid to open a normally closed valve. Fuel pressure is released from above the fuel injector pintle, and is returned to the fuel tank through the fuel return lines. The difference in fuel pressure above and below the pintle causes the pintle to open. Fuel from the fuel injector tip is sprayed directly into the combustion chamber on the compression stroke of the engine.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The Exhaust Gas Recirculation (EGR) System is used to reduce the amount of nitrogen oxide (NOx) emission levels caused by high combustion temperatures. At temperatures above 1 371°C (2,500°F), oxygen and nitrogen combine to form oxides of nitrogen (NOx). Introducing small amounts of exhaust gas back into the combustion chamber displaces the amount of oxygen entering the engine. With less oxygen in the air/fuel mixture, the combustion pressures are reduced, and as a result, combustion temperatures are decreased, restricting the formation of NOx.

The EGR valve motor is a direct current (DC) stepper motor utilizing a worm gear that extends from the motor to push on the EGR valve stem. The worm gear is not attached to the valve stem, and can only force the valve open. A return spring is used to force the valve closed.

The mass air flow (MAF) sensor signal is used by the engine control module (ECM) to detect the proper amount of EGR flow. One EGR flow test is performed per ignition cycle. The ECM will close the EGR valve for 5 seconds, then open the EGR valve to 100 percent for 5 seconds. The ECM will then calculate the MAF difference and determine if the proper EGR flow has been detected.



COMPONENT	DESCRIPTION
1	EGR Valve Position Sensor
2	EGR Valve Worm Gear
3	EGR Valve Return Spring
4	EGR Valve Head
5	EGR Valve Stem
6	EGR Valve Motor

The exhaust gas recirculation (EGR) valve is controlled by the engine control module (ECM) through the EGR motor high control and EGR motor low control circuits. The ECM supplies voltage that is near ignition voltage to the high and low control circuits at all times. This voltage is used by the ECM as a reference voltage during non EGR operation in order to detect circuit failures. The ECM will pulse width modulate (PWM) the low control circuit to ground and an increase in amperage on the high control circuit can be observed with a DMM when the EGR valve is commanded open. A lower pulse width will increase the open position of the valve. In order to close the EGR valve, the ECM will PWM the high control circuit to ground.

LLY & LBZ OVERVIEW

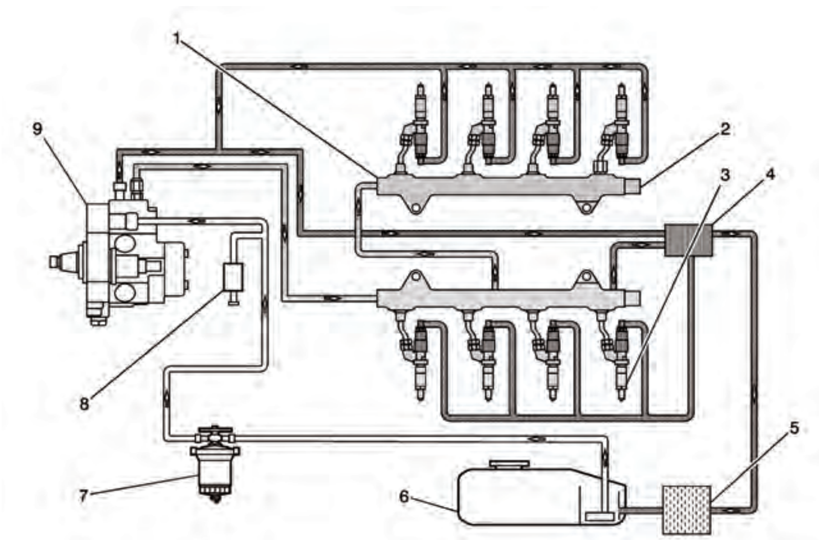
EXHAUST GAS RECIRCULATION (EGR) SYSTEM (CONTINUED)

When the ignition is turned ON, the ECM will drive the EGR motor worm gear out with just enough force to touch the EGR valve stem. The ECM will do this 3 times in quick succession. This action determines the minimum closed position of the valve and only happens once per ignition cycle. If the valve is prevented from closing all of the way after the minimum closed position is learned, the scan tool EGR Position parameter will not reflect this position until the next ignition cycle. The EGR motor worm gear is not connected to the EGR valve stem and can only push the valve open. The valve is returned to the closed position by a return spring.

The ECM uses the EGR position sensor to determine the position of the EGR valve. The ECM sends a reference voltage through the 5-volt reference circuit to the EGR position sensor. The ECM provides a voltage return path for the sensor through the low reference circuit. A variable voltage signal, based on the EGR valve position, is sent from the sensor to the ECM through the EGR position sensor signal circuit.

LMM OVERVIEW

FUEL SYSTEM



COMPONENT	DESCRIPTION
1	Fuel Rail
2	Fuel Pressure Sensor
3	Fuel Injectors
4	Fuel Return Junction Block
5	Fuel Cooler
6	Fuel Tank
7	Fuel Filter/Heater Element Housing
8	First Start Fuel Bleeder Valve
9	Fuel Injection Pump

The fuel tank (6) stores the fuel supply. A mechanical fuel injection pump (9), located below the engine intake, includes the fuel supply pump and the high-pressure pump. Fuel is drawn through the fuel filter/heater element housing (7), which combines a water separator, a hand prime pump, a fuel heater element and a filter element. An integrated hand prime pump is used to prime the fuel system after changing the fuel filter or servicing the fuel system. The mechanical fuel injection pump output is controlled by the ECM, and provides fuel at the pressure needed by the fuel injectors (3). The fuel injectors supply fuel directly to the combustion chambers of the engine. A separate pipe returns unused fuel through a fuel cooler (5) to the fuel tank.

The fuel tanks store the fuel supply. The primary fuel tank is located on the left side of the vehicle. On vehicles that are equipped with dual fuel tanks, the auxiliary fuel tank is located in the rear of the vehicle. The fuel tanks are each held in place by 2 metal straps that attach to the frame. The fuel tanks are molded from high density polyethylene.

LMM OVERVIEW

FUEL SYSTEM (CONTINUED)

The fuel level sensor consists of a float, a wire float arm, and a ceramic resistor card. The position of the float arm indicates the fuel level. The fuel level sensor contains a variable resistor which changes resistance in correspondence with the amount of fuel in the fuel tank. The engine control module (ECM) sends the fuel level information to the instrument panel cluster (IPC). This information is used for the instrument panel (I/P) fuel gauge and the low fuel warning indicator, if applicable. The ECM also monitors the fuel level input for various diagnostics.

The fuel injection pump is a mechanical high pressure pump. The fuel injection pump is located below the intake manifold. Fuel is pumped to the fuel rails at a specified pressure. Fuel pressure is regulated by a valve on the inlet of the fuel pump, controlled by the engine control module (ECM). Excess fuel from the fuel injection pump returns to the fuel tank through the fuel return pipe and a fuel cooler.

The fuel filter is located on the rocker cover. The paper filter element traps particles in the fuel that may damage the fuel injection system.

CHANGE FUEL FILTER will appear on the driver information center when a fuel filter change is required.

The fuel filter life monitor uses two control paths consistent with driving conditions. The primary control is based on the accumulated fuel burned, and the secondary control is based on the fuel rail deviations and high pressure pump duty cycle. If the fuel has been contaminated with water or other contaminates, the monitor will see erratic system corrections and display the message or warning lamp. If the fuel filter is not changed when the message or warning light is displayed, then a fuel restriction could occur and cause other diagnostics to fail. The filter life monitor does not drive the diagnostics, but is a result of the restriction.

You must reset the fuel filter life monitor after each fuel filter change. It will not reset itself. Resetting the filter monitor without changing the filter will cause the fuel filter monitor to be inaccurate until the next fuel filter change and reset.

The fuel heater is an integrated part of the diesel fuel conditioning module (DFCM). Fuel is heated by passing through the fuel heater element, which is operated by a built-in thermostatic switch. The thermostatic switch turns the heater element ON and OFF, depending on the fuel temperature. The fuel heater element has voltage anytime the ignition is turned ON. The warmed fuel then passes through the fuel filters to the fuel injection pump.

The left and right fuel rail assemblies attach to the cylinder heads. The fuel rail assemblies distribute pressurized fuel to the fuel injectors through the fuel lines.

The fuel rail assemblies consists of the following components:

- The fuel rail pressure sensor in the right fuel rail
- The fuel pressure relief valve in the left fuel rail

The fuel rail pressure sensor gives the engine control module (ECM) an indication of fuel pressure. The ECM uses this information to regulate fuel pressure, by commanding the fuel pressure regulator open or closed on the inlet of the fuel injection pump.

The fuel pressure relief valve opens only to prevent excessive pressure in the event of a malfunction. Fuel from the fuel pressure relief valve is returned to the fuel tank.

LMM OVERVIEW

FUEL SYSTEM (CONTINUED)

A fuel injector is a solenoid device, controlled by the engine control module (ECM), that meters pressurized fuel to a single engine cylinder. Fuel pressure is released from above the fuel injector pintle, and is returned to the fuel tank through the fuel return lines. The difference in fuel pressure above and below the pintle causes the pintle to open. Fuel from the fuel injector tip is sprayed directly into the combustion chamber on the compression stroke of the engine.

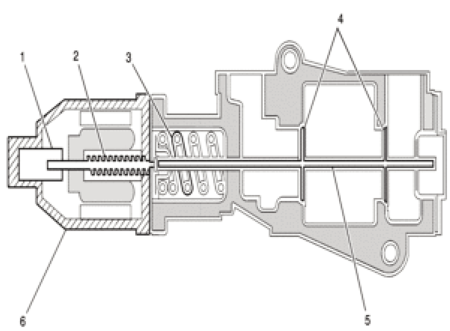
The control functions for the fuel injection system are integrated in the ECM. During the manufacturing process, each injector's flow rate is measured and recorded as injection quantity adjustment (IQA) flow rate data. The flow rate data is then etched as a hexadecimal number on the body of the injector. This data, together with the injector's cylinder position, is stored in the memory of both the glow plug control module (GPCM) and the ECM. When the ignition is turned ON, both the GPCM and the ECM monitor to ensure that the fuel injection flow rate numbers are present. If any of the injector flow rate numbers are missing, the diagnostic for that control module will set the appropriate DTC.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The Exhaust Gas Recirculation (EGR) System is used to reduce the amount of nitrogen oxide (NOx) emission levels caused by high combustion temperatures. At temperatures above 1 371°C (2,500°F), oxygen and nitrogen combine to form oxides of nitrogen (NOx). Introducing small amounts of exhaust gas back into the combustion chamber displaces the amount of oxygen entering the engine. With less oxygen in the air/fuel mixture, the combustion pressures are reduced, and as a result, combustion temperatures are decreased, restricting the formation of NOx.

The EGR valve motor is a direct current (DC) stepper motor utilizing a worm gear that extends from the motor to push on the EGR valve stem. The worm gear is not attached to the valve stem, and can only force the valve open. A return spring is used to force the valve closed.

The mass air flow (MAF) sensor signal is used by the engine control module (ECM) to detect the proper amount of EGR flow. One EGR flow test is performed per ignition cycle. The ECM will close the EGR valve for 5 seconds, then open the EGR valve to 100 percent for 5 seconds. The ECM will then calculate the MAF difference and determine if the proper EGR flow has been detected.



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5	EGR Valve Stem
6	EGR Valve Motor

The exhaust gas recirculation (EGR) valve is controlled by the engine control module (ECM) through the EGR motor high control and EGR motor low control circuits. The ECM supplies voltage that is near ignition voltage to the high and low control circuits at all times. This voltage is used by the ECM as a reference voltage during non EGR operation in order to detect circuit failures. The ECM will pulse width modulate (PWM) the low control circuit to ground and an increase in amperage on the high control circuit can be observed with a DMM when the EGR valve is commanded open. A lower pulse width will increase the open position of the valve. In order to close the EGR valve, the ECM will PWM the high control circuit to ground.

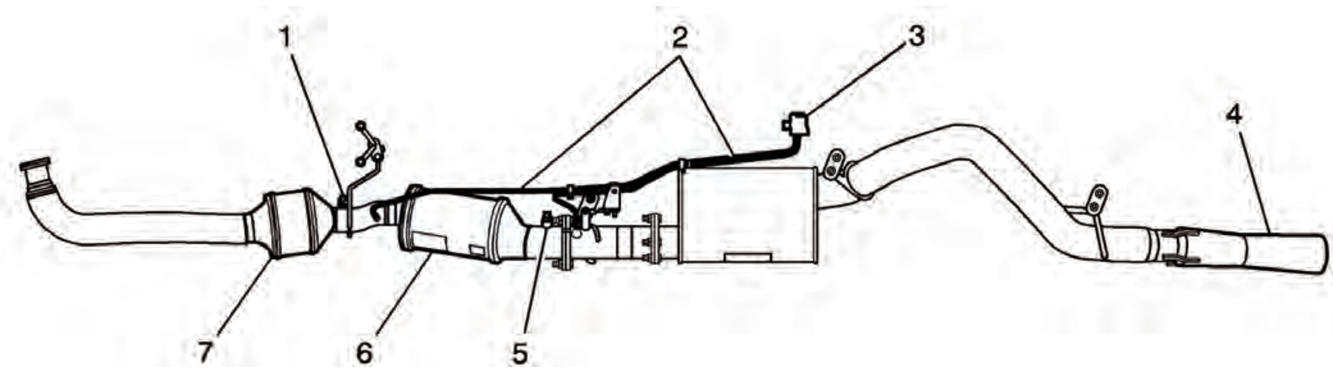
LMM OVERVIEW

EXHAUST GAS RECIRCULATION (EGR) SYSTEM (CONTINUED)

When the ignition is turned ON, the ECM will drive the EGR motor worm gear out with just enough force to touch the EGR valve stem. The ECM will do this 3 times in quick succession. This action determines the minimum closed position of the valve and only happens once per ignition cycle. If the valve is prevented from closing all of the way after the minimum closed position is learned, the scan tool EGR Position parameter will not reflect this position until the next ignition cycle. The EGR motor worm gear is not connected to the EGR valve stem and can only push the valve open. The valve is returned to the closed position by a return spring.

The ECM uses the EGR position sensor to determine the position of the EGR valve. The ECM sends a reference voltage through the 5-volt reference circuit to the EGR position sensor. The ECM provides a voltage return path for the sensor through the low reference circuit. A variable voltage signal, based on the EGR valve position, is sent from the sensor to the ECM through the EGR position sensor signal circuit.

DIESEL PARTICULATE FILTER (DPF) SYSTEM



COMPONENT	DESCRIPTION
1	Exhaust Gas Temperature (EGT) Sensor 1
2	Differential Pressure Sensor (DPS) Pressure Lines
3	Differential Pressure Sensor (DPS)
4	Exhaust Cooler
5	Exhaust Gas Temperature (EGT) Sensor 2
6	Exhaust Particulate Filter (EPF)
7	Diesel Oxidation Catalyst (DOC)

The exhaust particulate filter (EPF) captures diesel exhaust gas particulates, preventing their release into the atmosphere. This is accomplished by forcing particulate-laden exhaust (1) through a filter substrate of porous cells, which removes the particulates from the exhaust gas. The exhaust gas enters the filter, but because every other cell of the filter is capped at the opposite end, the exhaust particulates cannot exit the cell. Instead, the exhaust gas passes through the porous walls of the cell leaving the particulates trapped on the cell wall. The cleaned exhaust gas exits the filter through the adjacent cell. The EPF is capable of reducing more than 90 percent of particulate matter (PM).

Diesel Oxidation Catalyst

The diesel oxidation catalyst (DOC) (7) has two functions. One function is to reduce emissions of non methane hydro-carbons (NMHC) and carbon monoxide (CO), from the exhaust gases. The other function is to help start a regeneration event by converting the fuel-rich exhaust gases to heat. The engine control module (ECM) monitors the functionally of the DOC by determining if the exhaust gas temperature (EGT) sensor 1 (1) reaches

LMM OVERVIEW

DIESEL PARTICULATE FILTER (DPF) SYSTEM (CONTINUED)

a predetermined temperature during a regeneration event. The DOC and the exhaust particulate filter (EPF) (6) are downstream of the turbocharger, and are two separate components under the vehicle.

Differential Pressure Sensor (DPS) and Pressure Lines
The differential pressure sensor (DPS) (3) measures the pressure difference between the inlet and outlet of the exhaust particulate filter (EPF). When pressure difference has increased above a calibrated threshold, a high particulate loading condition is indicated. The ECM will command a regeneration event in order to restore the filter. If the pressure differential continues to increase across the exhaust filter without a regeneration event, the ECM will illuminate an EPF lamp or send a message to the driver information center (DIC) referring the customer to clean the exhaust filter. To clean the exhaust filter the vehicle must be driven under the conditions necessary for a regeneration to take place. If these lamps and messages are ignored, the ECM will eventually illuminate the malfunction indicator lamp (MIL) and revert to Reduced Engine Power which will require the vehicle to be serviced.

The DPS sensor provides a voltage signal to the ECM on a signal circuit relative to the pressure differential changes in the EPF. The ECM converts the signal voltage input to a pressure value.

The DPS pressure lines (2) are connected before and after the EPF. To provide the pressure sensor with accurate back pressure measurements, the DPS pressure lines should have a continuous downward gradient, without any sharp bends or kinks.

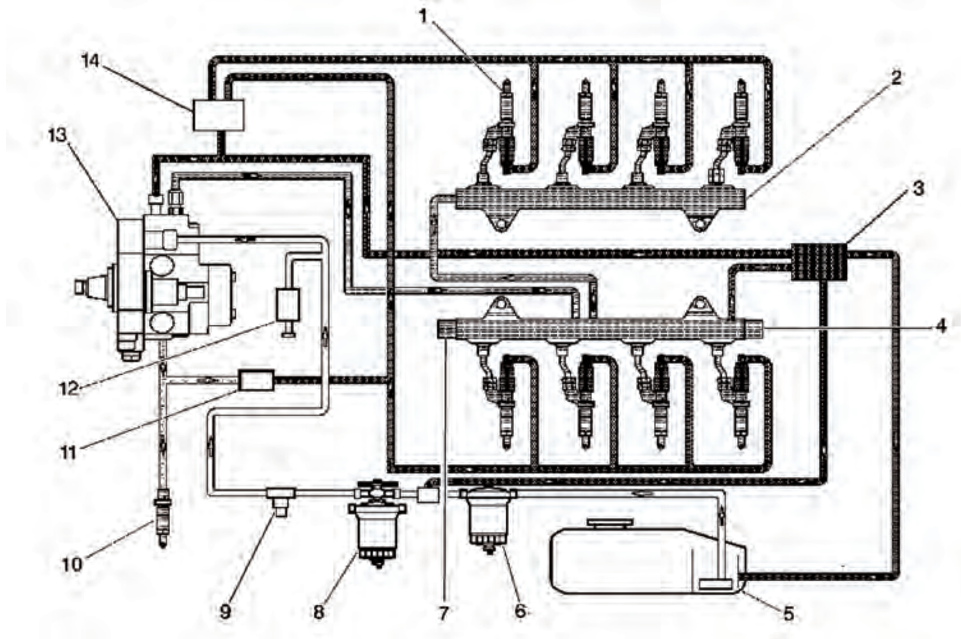
Exhaust Gas Temperature Sensors
The ECM uses two exhaust gas temperature (EGT) sensors to measure the temperature of the exhaust gases at the inlet and outlet of the exhaust particulate filter (EPF). The EGT sensors are variable resistors, when the EGT sensors are cold, the sensor resistance is low, and as the temperature increases, the sensor resistance increases. When sensor resistance is high, the ECM detects a high voltage on the signal circuit. When sensor resistance is low, the ECM detects a lower voltage on the signal circuit. Proper EGTs at the inlet and outlet of the EPF are crucial for proper operation and for initiating the regeneration process. A temperature that is too high in the EPF will cause the EPF substrate to melt or crack. The ECM monitors the temperatures at the EPF inlet and outlet to regulate EPF temperatures.

Intake Air (IA) Valve
The intake air (IA) valve is located upstream of the intake air heater, and is normally in the open position. The ECM commands the valve to close in order to precisely control combustion temperature control during exhaust particulate filter (EPF) regeneration. The IA valve will ensure the temperature of the exhaust gas remains in an efficient range under all operating conditions. The IA valve system uses a position sensor located within the valve assembly to monitor the position of the valve. The IA valve uses a motor to move the valve to a closed position and spring tension returns it to the open position. The motor is operated through Motor Control 1 and 2 circuits.

Exhaust Cooler
The exhaust system has been designed to reduce exhaust gas temperatures during regeneration. The exhaust cooler (4) at the end of the tailpipe draws in cooler air as exhaust gases flow through its openings. The cooler air mixes with the warmer exhaust gas, reducing exhaust gas temperatures at the tailpipe outlet.

LML & LGH OVERVIEW

FUEL SYSTEM



The fuel tank (5) stores the fuel supply. A mechanical fuel injection pump (13), located below the engine intake, includes the fuel supply pump and the high-pressure pump. Fuel is drawn through the diesel fuel conditioning module (8), which combines a water separator, hand operated fuel prime pump, filter element and then through a fuel filter vacuum switch (9) to the fuel injection pump.

The engine control module (ECM) controls the fuel pump pressures by using two fuel pressure regulators, fuel pressure regulator 1 is located on top of the fuel injection pump and fuel pressure regulator 2 (7) is located on a fuel rail (2). The fuel pressure sensor (4) provides a voltage signal to the ECM to indicated fuel rail pressures.

The high pressure fuel is supplied to the fuel injectors (1) through separate high pressure pipes. The fuel injectors supply fuel directly to the combustion chambers of the engine. The fuel that is not injected into the combustion chamber is used to help lubricate and cool the injector and is routed back to the fuel tank. The fuel injector return line pressure regulator (14) maintains fuel pressure on the return side of the fuel injectors. This is required for proper fuel injector operation. In the event the vehicle runs out of fuel a check valve (11) in the indirect fuel injector (10) supply line opens and the fuel supply pump back fills the return side with fuel.

Fuel Transfer Pump
On vehicles equipped with dual fuel tanks, an electric fuel pump is located on the left frame rail. This fuel pump is powered by the fuel pump relay that is controlled by the engine control module (ECM). Fuel is transferred from the auxiliary fuel tank to the primary fuel tank in order to ensure all of the usable fuel volume is available to the fuel injection pump.

Quick-Connect Fittings
Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

LML & LGH OVERVIEW

FUEL SYSTEM (CONTINUED)

Fuel Pipe O-Rings
O-rings seal the connections in the fuel system. Fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.
Fuel Feed and Return Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel injector control module. The fuel return pipe carries fuel from the fuel rail assemblies back to the fuel tank. The fuel pipes consist of 2 sections:

- The rear fuel pipe assemblies are located from the top of the fuel tank to the chassis fuel pipes. The rear fuel pipes are constructed of steel with sections of rubber hose covered with braiding.
- The chassis fuel pipes are located under the vehicle and connect the rear fuel pipes to the fuel rail pipes. These pipes are constructed of steel with sections of rubber hose covered with braiding.

Fuel Conditioning Module
The fuel conditioning module is located on the right side of the engine and consists of a fuel filter, water in fuel sensor and hand operated fuel priming pump. Fuel from the tank or return line system is drawn through the conditioning module by the fuel injection pump. Some return line fuel from the fuel rail is cycled back through the conditioning module to heat the incoming fuel.

Fuel Filter
The paper filter element traps particles in the fuel that may damage the fuel injection system. A CHANGE FUEL FILTER will appear on the driver information center when a fuel filter change is required. The fuel filter life monitor uses two control paths consistent with driving conditions. The primary control is based on the accumulated fuel burned, and the secondary control is based on the fuel rail deviations and high pressure pump duty cycle. If the fuel has been contaminated with water or other contaminates, the monitor will see erratic system corrections and display the message or warning lamp.

If the fuel filter is not changed when the message or warning light is displayed, then a fuel restriction could occur and cause other diagnostics to fail. The filter life monitor does not drive the diagnostics, but is a result of the restriction. You must reset the fuel filter life monitor after each fuel filter change. It will not reset itself. Resetting the filter monitor without changing the filter will cause the fuel filter monitor to be inaccurate until the next fuel filter change and reset.

Water in Fuel Sensor
The Water In Fuel Sensor is located at the bottom of the diesel fuel conditioning module. It is an electrical contact switch that closes when the float arm of the switch rises above the acceptable level of water in the fuel filter. The engine control module (ECM) monitors the voltage on the signal circuit of the water in fuel switch. When the water in fuel switch closes the circuit the ECM detects low voltage on the signal circuit and sends a serial data message to the instrument panel cluster to display the WATER IN FUEL SERVICE REQUIRED message.

Fuel Priming Pump
A hand operated fuel prime pump supplies fuel to the low pressure fuel system. The fuel priming pump is used to prime the fuel system after changing the fuel filter or servicing the fuel system. The hand operated priming pump is part of the diesel fuel conditioning module assembly located on the right side of the engine.

LML & LGH OVERVIEW

FUEL SYSTEM (CONTINUED)

Fuel Filter Pressure Switch
The fuel filter pressure switch is a normally closed switch located next to the fuel conditioning module. If fuel supply line vacuum reaches greater than 14 in Hg the switch will open. The engine control module (ECM) monitors the voltage on the fuel filter pressure switch signal circuit and will send a serial data message to the instrument panel cluster to display the FUEL FILTER RESTRICTED message.

Fuel Temperature Sensor 1
The fuel temperature sensor 1 is a thermistor that is located in the back of the fuel injection pump. The ECM monitors the fuel temperature sensor signal circuit in order to calculate the temperature of the fuel entering the engine fuel rail.

Fuel Temperature Sensor 2
The fuel temperature sensor 2 also referred as the fuel rail temperature sensor, is a thermistor that is located in the return line near the quick-connect fittings. The ECM monitors the fuel rail temperature sensor signal circuit in order to calculate the temperature of the fuel leaving the engine fuel rail.

Fuel Injection Pump
The high pressure fuel pump is a mechanical high pressure pump. The high pressure fuel pump is located below the intake manifold. Fuel is pumped to the fuel rails at a specified pressure. Fuel pressure is regulated by a valve on the inlet of the fuel pump and one on the fuel rail, both are controlled by the engine control module (ECM). Excess fuel from the high pressure fuel pump returns to the fuel tank through the fuel return pipe.
Indirect Fuel Injector

The indirect fuel injector is located on the right side cylinder head. The indirect fuel injector is used to inject fuel into the exhaust system to generate the required heat needed by the exhaust aftertreatment to function properly and helps to extend engine oil life.

Fuel Rail and Pipes
The left and right fuel rail assemblies attach to the cylinder heads. The fuel rail assemblies distribute pressurized fuel to the fuel injectors through the fuel lines.

Fuel Rail Pressure Sensor
The fuel rail pressure sensor in located in the back of the left sdie fuel rail assembly. The fuel rail pressure sensor provides the engine control module (ECM) an indication of the actual fuel rail pressure. The ECM uses this information to regulate the fuel pressure, by commanding the fuel pressure regulators to obtain the desired fuel pressure.

Fuel Pressure Regulators
The engine control module (ECM) controls the fuel rail pressure using two pulse width modulated fuel rail pressure regulators. Fuel pressure regulator 1 is located on the fuel injection pump and meters the amount of fuel that enters the high pressure side of the pump. From the high pressure pump, the fuel moves to the two fuel rails through a high pressure metal line.

The fuel rails distributes high pressure fuel to all 8 fuel injectors. The ECM varies the pulse width modulated voltage to the fuel pressure regulator 2 to relieve excessive fuel pressure which returns to the fuel supply line. This warms the fuel entering the fuel conditioning module. When the ignition is OFF, fuel pressure regulator 2 opens to bleed off the pressure in the fuel rail.

LML & LGH OVERVIEW

FUEL SYSTEM (CONTINUED)

The ECM controls fuel pressure in three different operating modes. The ECM commands fuel pressure regulator 2 to control fuel pressure at idle and commands fuel pressure regulator 1 to control fuel pressure when engine speeds are above 1700 RPM. Under certain conditions both regulators are used to control fuel pressure.

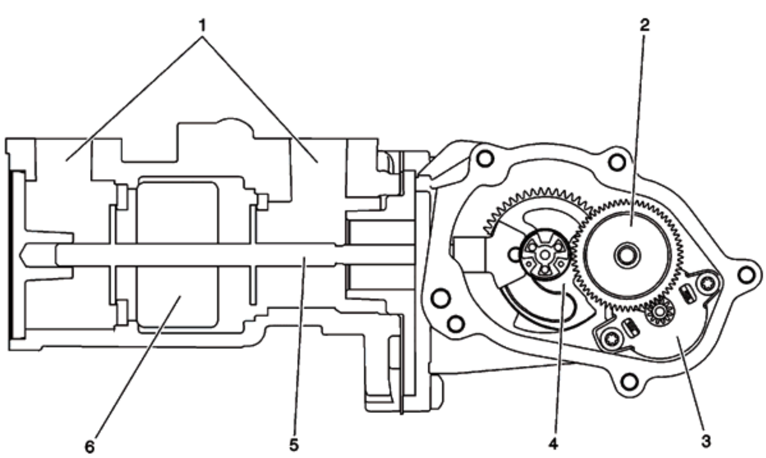
Fuel Injectors
The fuel injectors are located above each cylinder and deliver fuel directly into the cylinder. Each injector has a high pressure fuel pipe from the fuel rail and a return line.

The engine control module (ECM) supplies a high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit and supplying each fuel injector with up to 250 V and 20 amps on the voltage supply circuit to activate the piezo type fuel injectors.

This is controlled by boost capacitors in the ECM. During the 250 V boost phase, the capacitor is used to charge the injector piezo stack, allowing for injector opening. The injector is then held open with this high voltage. At the end of the injection event the ECM closes the injector by discharging the injector piezo stack.
Return Line Pressure Regulator

The fuel injector return line pressure regulator maintains 4-11 bar (58-158 psi) of fuel pressure on the return side of the fuel injectors. This is required for proper fuel injector operation. In the event the vehicle runs out of fuel a check valve in the return line opens and the fuel supply pump back fills the return side with fuel.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM



COMPONENT	DESCRIPTION
1	Outlets to Intake Manifold
2	Intermediate Gear
3	DC Motor
4	Output Gear w/Cam Slot
5	Stem and Poppet
6	Inlet Port

The Exhaust Gas Recirculation (EGR) System is used to reduce the amount of nitrogen oxide (NOx) emission levels caused by high combustion temperatures. At temperatures above 1,371°C (2,500°F), oxygen and nitrogen combine to form NOx. Introducing small amounts of exhaust gas back into the combustion chamber displaces the amount of oxygen entering the engine. With less oxygen in the air/fuel mixture, the combustion pressures are reduced, and as a result, combustion temperatures are decreased, restricting the formation of NOx.

The EGR system on the LGH engine of a single or dual EGR coolers, an EGR valve and a Mass Air Flow (MAF) sensor.The EGR system on the LML engine applications utilizes dual EGR coolers, an EGR valve, MAF sensor and an EGR cooler bypass valve, controlled by the ECM, to prevent coking of the EGR coolers during light load and idling.

LML & LGH OVERVIEW

EXHAUST GAS RECIRCULATION (EGR) SYSTEM (CONTINUED)

The EGR and EGR cooler bypass valve motors are Direct Current (DC) motors utilizing a multi-stage gear drive connected to the valve stem. The motors are controlled by the ECM and actively force the valves open and closed. Each valve contains an integral valve position sensor which reflects the true position of the valve. The MAF sensor signal is used by the Engine Control Module (ECM) to detect the proper amount of EGR flow. The ECM continually does a consistency check on the indicated EGR flow by comparing the desired MAF to the actual MAF. If the actual MAF is less than or greater than a calibrated threshold level, the amount of EGR flow is determined to be out of range and a DTC will set.

The EGR valve is controlled by the ECM through the EGR motor high control and EGR motor low control circuits. The ECM supplies voltage that is near ignition voltage to the high and low control circuits at all times. This voltage is used by the ECM as a reference voltage during non EGR operation in order to detect circuit failures. The ECM Pulse Width Modulates (PWM) the low control circuit to ground when the EGR valve is commanded open. A lower pulse width increases the open position of the valve. In order to close the EGR valve, the ECM will PWM the high control circuit to ground.

When the ignition is turned OFF, the EGR valve executes a series of clean and learn operations. The valve goes through a number of full sweeps, (cleaning operation), followed by a number of learn events that pushes the poppet just off the seat and then pulls it into the seat to determine the correct sensor position voltage. Certain environmental conditions, such as low temperature, may inhibit the clean and learn operations, so they may not occur during every ignition cycle.

The EGR valve has an integral position sensor that feeds back to the ECM. The sensor is located on the output gear of the actuator and is a non-contacting type sensor. The ECM uses the position sensor to determine the position of the valve. The ECM sends a reference voltage through the 5-volt reference circuit to the EGR position sensor. The ECM provides a voltage return path for the sensor through the low reference circuit. A variable voltage signal, based on the EGR valve position, is sent from the sensor to the ECM through the EGR position sensor signal circuit.

The ECM commands the required valve position based on engine requirements. The outlet of the EGR valve flows directly into the intake manifold.

EGR Cooler Bypass Valve
The EGR Cooler Bypass Valve (if equipped) is fed off of the passenger side rear exhaust bank. The ECM commands the Bypass Valve to one of two positions - HOT EGR or COLD EGR, depending on engine operating conditions. Under normal to high engine load and temperature conditions the intake system requests COLD EGR and the bypass valve is commanded to the COLD EGR position. The exhaust flow is directed into the two EGR coolers in series and then to the EGR Valve. Under light load/idle conditions, the intake system requests HOT EGR and the bypass valve is commanded to the HOT EGR position. The exhaust flow is directed through the bypass pipe directly into the EGR valve to prevent fouling of the EGR coolers.

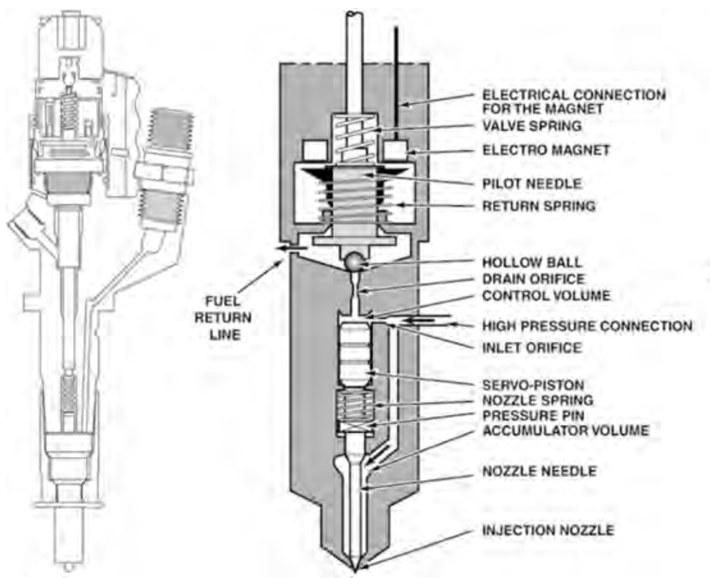
When the ignition is turned OFF, the EGR Cooler Bypass Valve executes its own clean and learn operation. The bypass valve switches from seat to seat several times, effectively cleaning the stem while learning the seat position. Certain environmental conditions, such as low temperature, may inhibit the clean and learn operation, so it may not occur during every ignition cycle.

LML & LGH OVERVIEW

EXHAUST GAS RECIRCULATION (EGR) SYSTEM (CONTINUED)

The EGR Cooler Bypass Valve has an integral position sensor that feeds back to the ECM. The sensor is located on the output gear of the actuator and is a non-contacting type sensor. The ECM uses the position sensor to determine the position of the valve. The ECM sends a reference voltage through the 5-volt reference circuit to the position sensor. The ECM provides a voltage return path for the sensor through the low reference circuit. A variable voltage signal, based on the valve position, is sent from the sensor to the ECM through the position sensor signal circuit.

COMMON RAIL FUEL INJECTOR OPERATION



In common rail systems, a high-pressure pump stores a reservoir of fuel at high pressure — up to and above 2,000 bars (29,000 psi). The term "common rail" refers to the fact that all of the fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. This accumulator supplies multiple fuel injectors with high-pressure fuel. This simplifies the purpose of the high-pressure pump in that it only has to maintain a commanded pressure at a target (either mechanically or electronically controlled).

The fuel injectors are typically ECU-controlled. When the fuel injectors are electrically activated, a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed into the cylinders at the desired pressure. Since the fuel pressure energy is stored remotely and the injectors are electrically actuated, the injection pressure at the start and end of injection is very near the pressure in the accumulator (rail), thus producing a square injection rate. If the accumulator, pump and plumbing are sized properly, the injection pressure and rate will be the same for each of the multiple injection events.

High-pressure connectors, mounted into the side of the cylinder head, connect each fuel injector to each high-pressure fuel line. The injector part number is laser-burned onto the injector. Failure to replace with the proper injector will cause severe engine damage.

COMMON RAIL FUEL INJECTOR OPERATION

High-pressure fuel is supplied from the injection pump, through a high-pressure fuel line, into a fuel rail, through high-pressure lines, through steel connectors and into the solenoid actuated fuel injector. The ECM actuates the solenoid causing the needle valve to rise and fuel flows through the spray holes in the nozzle tip into the combustion chamber.

Each fuel injector is connected to the fuel rail by a high-pressure fuel line and a steel connector. This steel connector is positioned into the cylinder head and sealed with an O-ring. The connector is retained in the cylinder head by a nut (fitting) that is threaded into the cylinder head.

The torquing force of this threaded nut (fitting) provides a sealing pressure between the fuel line connector and the fuel injector. Retaining nut torque is very critical. If the nut (fitting) is under torqued, the mating surfaces will not seal and a high-pressure fuel leak will result. If the fitting is over torqued, the connector and injector will deform and also cause a high-pressure fuel leak. This leak will be inside the cylinder head and will not be visible. The result will be a possible fuel injector miss-fire and low power, or a no-start condition.

The fuel injectors use hole type nozzles. High-pressure flows into the side of the injector, the ECM activates the solenoid causing the injector needle to lift and fuel to be injected. The clearances in the nozzle bore are extremely small and any dirt or contaminant's will cause the injector to stick. Because of this, it is very important to do a thorough cleaning of any lines before opening up any fuel system component. Always cover or cap any open fuel connections before a fuel system repair is performed.

SERVICE INFORMATION

OE SUBSCRIPTION OPTIONS AND RATES

GM Service Information can help you diagnose and repair the latest GM vehicles, even identifying vehicle specific issues which may not yet be published in bulletin form, including:

- Vehicle diagnostic and service repair manuals for GM vehicles from 1998 to present
- Campaigns, Service Bulletins and Preliminary Information for GM vehicles from 1980 to present
- GM Owner's Manuals and Glove Box Supplements from 2003 to present

Subscription Rates
- $20 for three days
- $150 per month
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TIS 2 Web, the next-generation Technical Information System, is web-based so you can always access the most current General Motors vehicle control module calibrations, Tech 2 software updates and Global Diagnostic System. Four options are available to meet your shop's needs.

Choose from:
- Option 1 = Complete GM Service Support Package
  - $3100 per year; includes:
    - GM Si
    - Tis2Web–all access
    - GDS 2
    - Tech2Win
- Option 2 = Tech 2 and Service Programming Package

SERVICE INFORMATION

OE SUBSCRIPTION OPTIONS AND RATES (CONTINUED)

- $1395 per year; includes:
  - Tech 2 diagnostic software updates
  - Tech 2 View
  - Tech 2 Snap Shot
  - Tech2Win
  - Service Programming Software

Option 3 = Service Program Only–Vehicle calibration software
- $55 2 days
- $275 3 months
- $995 per year

Option 4 = Tech 2 Diagnostics–Tech 2 Diagnostic software updates
- $750 per year

Option 5 = GM Global Diagnostic System 2–Diagnostic software for GM Global A vehicles
- $55 3 days
- $225 monthly
- $550 per year

Option 6 = Tech2Win–Software to emulate the Tech 2 on PC (requires a GM MDI)
- $55 3 days

Option 7 = GM Vehicle Communication Interface Package
- $750 per year; includes:
  - GDS2
  - Tech2Win

NOTES

SERVICE INFORMATION

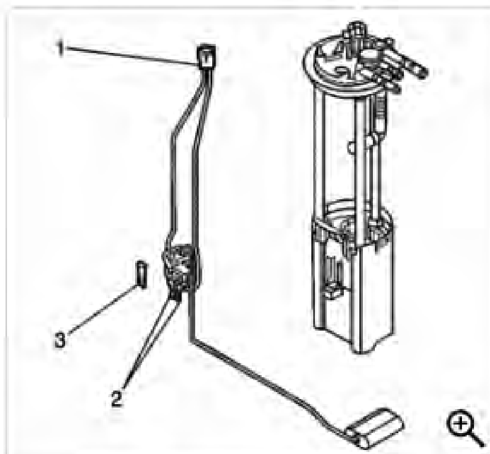
SAMPLE REPAIR PROCEDURE

Engine

6.6L (LB7)

Fuel Level Sensor Replacement

Removal Procedure



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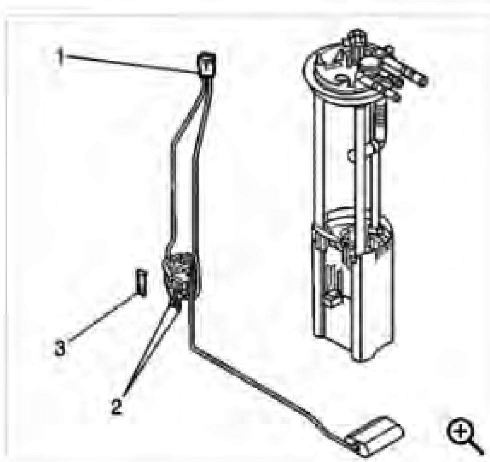
1. Remove the sending unit. Refer to Fuel Sender Assembly Replacement .
2. Disconnect the fuel level sensor electrical connector (1).
3. Remove the sensor retaining clip (3).
4. Squeeze the locking tangs (2) and remove the fuel level sensor.

Installation Procedure



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1. Install the fuel level sensor.
2. Install the sensor retaining clip (3).
3. Connect the sensor electrical connector (1).
4. Install the sending unit. Refer to Fuel Sender Assembly Replacement .

SERVICE INFORMATION

SAMPLE PINPOINT TEST

Engine

6.6L (LB7)

Diagnostic System Check - Engine Controls

Test Description

The number below refers to the step number on the diagnostic table.

11. This step is for areas that have inspection and maintenance testing procedures for emissions testing. Use this step if the testing facility found one or more inspection/maintenance (I/M) system statuses that did not set.

Step	Action	Yes	No
1	Perform the following preliminary inspections: • Ensure that the battery is fully charged. Refer to Battery Inspection/Test in Engine Electrical. • Ensure that the battery cables are clean and tight. • Inspect the easily accessible systems or the visible system components for obvious damage or conditions that could cause the symptom. Refer to Strategy Based Diagnosis in General Information. • Ensure that the engine and control module grounds are clean, tight, and in the correct location. • Inspect for aftermarket devices that could affect the operation of the system. Refer to Checking Aftermarket Accessories in Wiring Systems. • Ensure the resistance between the engine control module (ECM) housing and the battery negative cable is less than 0.5 ohms. Did you find and correct the condition?	System OK	Go to Step 2
2	1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the ECM. Does the scan tool communicate with the ECM?	Go to Step 3	Go to Data Link References in Data Link Communications
3	**Important:** The engine may start during the following step. Turn OFF the engine as soon as you have observed the Crank power mode. 1. Access the Class 2 Power Mode in the Diagnostic Circuit Check on the scan tool. 2. Rotate the ignition switch through all positions while observing the ignition switch power mode parameter. Refer to Body Control System Description and Operation in Body Control System for a list of the power mode states that correspond to each ignition switch position. Does the ignition switch parameter reading match the ignition switch position for all switch positions?	Go to Step 4	Go to Power Mode Mismatch in Body Control System
4	Attempt to start the engine. Does the engine crank?	Go to Step 5	Go to Symptoms - Engine Electrical in Engine Electrical
5	Did the engine start and idle?	Go to Step 6	Go to Engine Cranks but Does Not Run

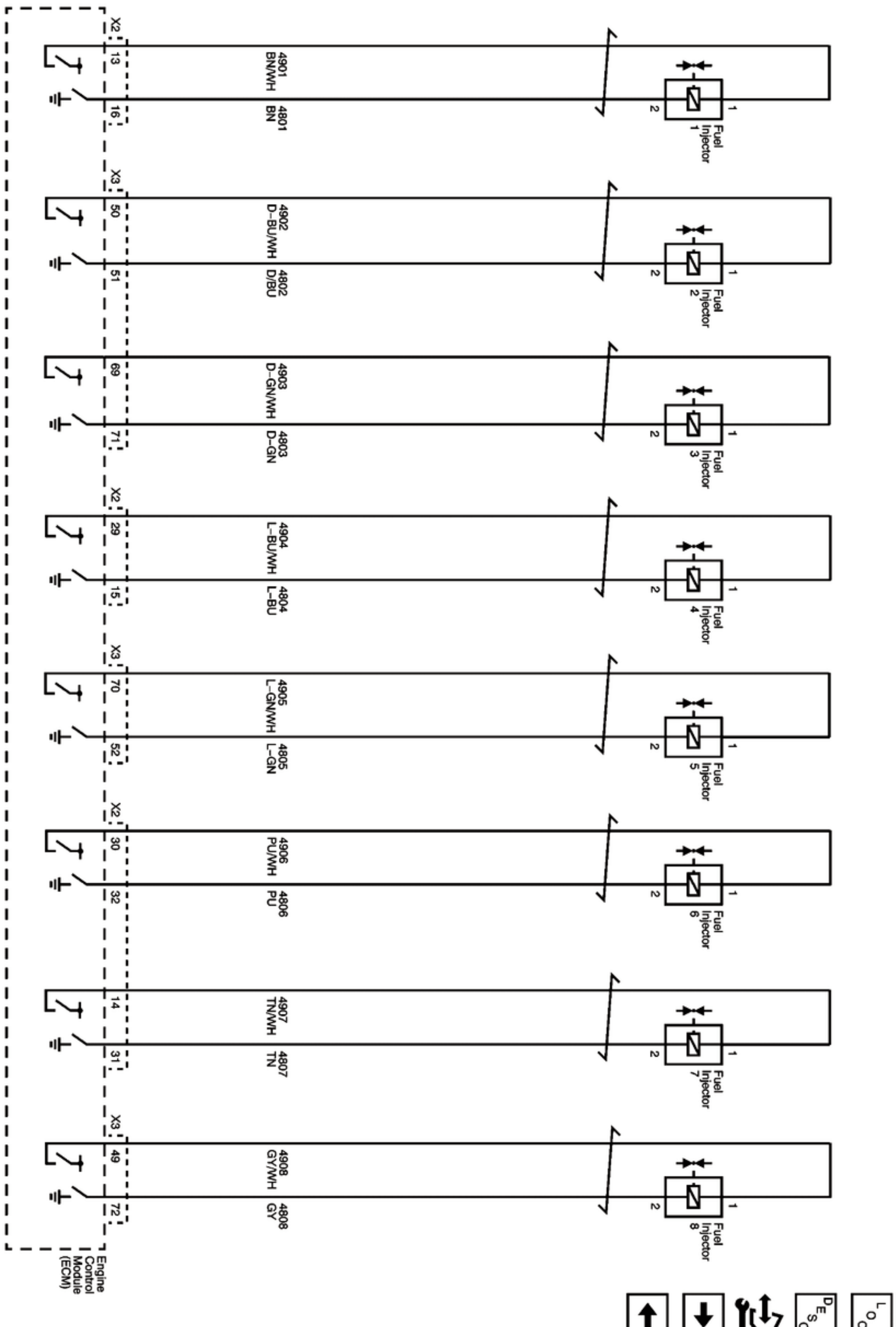
SERVICE INFORMATION

SAMPLE PINPOINT TEST (CONTINUED)

6	**Important:** Do NOT clear the DTCs unless instructed by a diagnostic procedure. 1. Select the DTC display function for the engine control module and record the DTCs. 2. If multiple powertrain DTCs are stored, diagnose the DTCs in the following order: A. Test for component level DTCs. For example, sensor DTCs, solenoid DTCs, and relay DTCs Begin with the lowest number DTC unless the diagnostic table directs you otherwise. B. Test for system level DTCs. For example, misfire DTCs, EVAP system DTCs and fuel trim DTCs. 3. If there are any powertrain DTCs, Select Capture Info in order to store the Powertrain DTC information with a scan tool. Does the scan tool display any DTCs?	Go to Step 7	Go to Step 10
7	Does the scan tool display DTCs which begin with a "U"?	Go to Data Link References in Data Link Communications	Go to Step 8
8	Does the scan tool display DTCs P0601, P0602, P0604, or P0606?	Go to DTC P0601-P0607, P1600, P1621, P1627, P1680, P1681, P1683, or P2610	Go to Step 9
9	Does the scan tool display DTCs P0560, P0562, P0563, P0625, P0626, or P1668?	Go to Diagnostic Trouble Code (DTC) List in Engine Electrical	Go to Diagnostic Trouble Code (DTC) List
10	Are there any transmission control module (TCM) DTCs or any automatic transmission symptoms?	Go to Diagnostic System Check - Automatic Transmission in Automatic Transmission - Allison	Go to Step 11
11	Is the customer's concern with inspection and maintenance (I/M) testing?	Go to Inspection/Maintenance (I/M) System Check	Go to Step 12
12	Are there any engine controls or driveability symptoms observed?	Go to Symptoms - Engine Controls	System OK

SERVICE INFORMATION

SAMPLE INJECTOR WIRING DIAGRAM



SERVICE INFORMATION

SAMPLE TECHNICAL SERVICE BULLETIN (TSB)

Subject:	Service Exhaust Fluid Message Will Not Clear
Models:	2010-2011 Chevrolet Express, Silverado
	2010-2011 GMC Savana, Sierra
	Equipped with the 6.6 Duramax Diesel Engine RPO codes LML or LGH.

This PI was superseded to add info about ambient air temp above -7 and running the vehicle in the shop to achieve temp increase. Please discard PIP4829A.

The following diagnosis might be helpful if the vehicle exhibits the symptom(s) described in this PI.

Condition/Concern:

A dealer may find that the DIC message "Service Exhaust Fluid System - See Owner's Manual Now" stays on after a DEF system repair has been completed. The vehicle may progress to setting a "Speed Limited To 55 MPH" or "Speed Limited To 4 MPH" message if driven long enough.

A service exhaust fluid message sets when the Engine Control Module (ECM) detects a drop in the SCR NOx reduction efficiency. This could occur with poor DEF quality or a DEF system DTC.

1. All DTCS must be addressed and repaired before the attempting to turn off the "Service Exhaust Fluid System - See Owner's Manual Now" message.
2. All DEF System DTCs must run and pass before the "Service Exhaust Fluid System - See Owner's Manual Now" message will clear.

A SERVICE Exhaust Fluid Message should not be confused with an Exhaust FLUID LOW Message. These messages have two different repair strategies.

Please see the newest version of PIP4864 for Exhaust Fluid Low Messages.

Recommendation/Instructions:

If a DEF system DTC was set in history (possibly cleared during the repair) the Service Exhaust Fluid Message will stay latched until the vehicle is driven and all DEF system DTCs have run and passed. As an example, the reductant heaters must cycle for certain DTCs to run and pass the system testing. Since ambient temperatures may not be below freezing, the heaters will not cycle, and the system test will not complete to clear the DIC Message. To get the DTCs to run and pass complete the procedure below.

If a Technician has cleared all DTCs and still has a latched "SERVICE Exhaust Fluid Message" complete steps below.

DEF tamper and quality conditions will always have DTC's set. Clearing the DTC's with a Tech2 will not clear the ECM default action. For each DTC set, perform the SI repair procedure including the "Repair Verification". Once the repair has been completed including the "Repair Verification" the warning message should go out. If it does not, or the DTC's were cleared without documenting them, continue with the next steps in the PI.

1. To complete the Service Exhaust Fluid reset procedure the ambient air temperature sensor and the DEF tank temperature must be above -7C (19F). If the vehicle has been parked in a heated shop for more than five hours (Tech 2 showing DEF tank and ambient temp above -7C) continue with the reset procedure below.
2. If the vehicle was just brought in from the cold, the ECM will not update the Service Exhaust Message until the ambient temperature sensor warms to greater then -7C with the vehicle speed above 20 MPH(32 KMH). To achieve the temperature and speed portion of the reset, the vehicle will have to be run in the shop. Properly raise and support the vehicle so it can be run at above 20 MPH (32 KMH). Run the vehicle at above 20 MPH in a warm shop until the ambient air temperature sensor reads above -7C then continue with the reset procedure below. ABS wheel speed DTC's may set and must be cleared.

Note: The Ambient Temperature will not update at speeds less than 20 mph. If the vehicle is speed limited to 4 mph the vehicle will have to be parked in a warm garage (above -7C) for more than five hours.

1. Follow the current SI procedure for completing a Reductant System Quality Test. The reductant quality test will be found in ECM special function/output controls. During the quality test the intake air temp must be above -7C or the test will fail. The quality test can take up to one hour.
2. After the quality test has been completed, use the Tech 2 to command all three reductant heaters on for 30 seconds each. Reductant heaters will be found in Glow Plug Control Module special functions.
3. Follow the current SI procedure and complete the Reductant System Leak Test allowing pressure to build to 425kPa, this may take more than 2 minutes. The leak test will be found in ECM reductant special functions.

SERVICE INFORMATION

SAMPLE TECHNICAL SERVICE BULLETIN (TSB)

4. Evaluate the DIC Service Exhaust Fluid Message.
5. If Service Exhaust Fluid message still has not cleared, check all DEF fluid DTC pass or not run criteria (Tech 2 additional DTC information-not ran since code cleared) information. All DEF DTCs must run and pass to clear the Service Fluid Message. The DTC description and when they should clear is listed below.
6. If a specific DEF fluid DTC has not passed the vehicle may not have reached criteria necessary to pass the DTC or the condition that set the specific DTC has not been corrected and needs to be diagnosed using the current SI diagnostic for that DTC.

Note: Always complete the Repair Verification portion of the SI Document being used. Operating the special function and/or completing test drive criteria referred to in Repair Verification may complete the test needed to pass a specific DTC.

Codes that will run and clear when the Reductant Quality Test is completed.

Lost Communications With Reductant Control Module U010E

NOx 1 loss of comm U029D

NOx 2 loss of comm U029E

NOx Sensor Circuit Bank 1 Sensor 2 P229E

NOx Heater Control Circuit Bank 1 Sensor P22A3

NOx Sensor Circuit Bank 1 Sensor 1 P2200

NOx Heater Control Circuit Bank 1 Sensor 1 P2205

Reductant Level Sensor 1 Circuit High P203D

Reductant Level Sensor 2 Circuit High P21AB

Reductant Level Sensor 3 Circuit High P21B0

Reductant Pump Pressure Sensor Circuit Low P204C

Reductant Injector Control Circuit P2047

Reductant Tank Temperature Sensor Circuit Low P205C

Reductant Pump Control Circuit P208A

Reductant System Performance Bank 1 P204F

Reductant Injector Performance P202E

Codes that will run and clear within 30 sec of the engine running at idle.

Exhaust Gas Temperature (EGT) Sensor 3 Circuit High Voltage P242D

Exhaust Gas Temperature (EGT) Sensor 2 Circuit High Voltage P2033

Reductant Purge Valve Control Circuit P20A0

Codes that will run and clear when the reductant heaters are cycled on for 30 seconds.

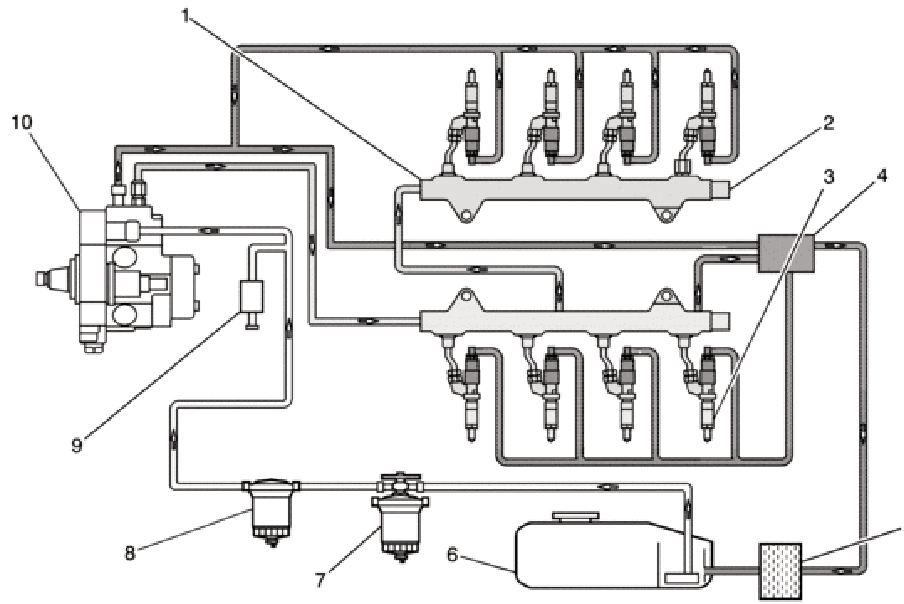
Reductant Heater 1 Control Circuit P20B9

Reductant Heater 2 Control Circuit P20BD

Reductant Heater 3 Control Circuit P20C1

Please follow this diagnostic or repair process thoroughly and complete each step. If the condition exhibited is resolved without completing every step, the remaining steps do not need to be performed.

EXPRESS VANS



The Duramax Diesel engine was introduced into the Express/Savanna vans beginning with the LLY RPO version. It is important to note the fact the Express/Savanna vans were the only vehicles that utilized a lift pump. This pump is called a Diesel Fuel Conditioning Module (#8 in the illustration above).

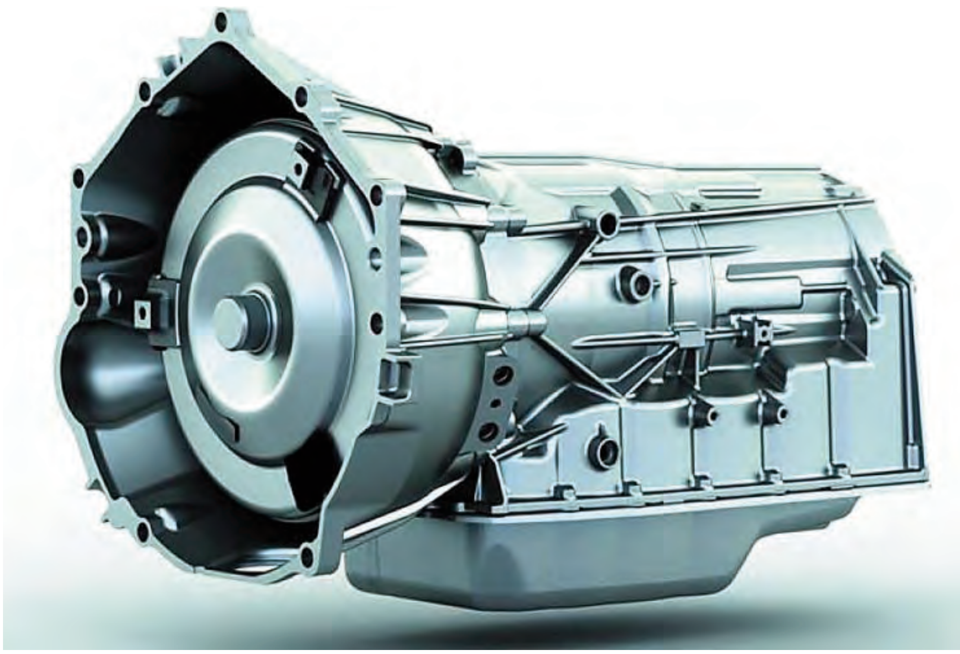
Fuel is drawn through the diesel fuel conditioning module (DFCM), which combines a water separator, an electric fuel prime pump, a fuel heater element, and a filter element. Fuel passes through a second screw on the fuel filter, then to the fuel injection pump.

ENGINE ENHANCEMENTS

Changes include:

* Cylinder block casting and machining changes strengthen the bottom of the cylinder bores to support increased power and torque
* Upgraded main bearing material increases durability
* Revised piston design helps lower compression ratio to 16.8:1 from 17.5:1
* Piston pin bore diameter increased for increased strength
* Connecting rod " I " section is thicker for increased strength
* Cylinder heads revised to accommodate lower compression and reduced cylinder firing pressure
* Maximum injection pressure increased from 23,000 psi (1,585.8 bar) to more than 26,000 psi (1,792.6 bar)
* Fuel delivered via higher-pressure pump, fuel rails, distribution lines and all-new, seven-hole fuel injectors
* Fuel injectors spray directly onto glow plugs, providing faster, better-quality starts and more complete cold-start combustion for reduced emissions
* Improved glow plugs heat up faster through an independent controller
* Revised variable-geometry turbocharger is aerodynamically more efficient to help deliver smooth and immediate response and lower emissions
* Air induction system re-tuned to enhance quietness
* EGR has larger cooler to bring more exhaust into the system
* First application of new, 32-bit E35 controller, which adjusts and compensates for the fuel flow to bolster efficiency and reduce emissions.

EXPRESS/SAVANNA TRANSMISSION UPDATE



Unlike the Sierra/Sliverao and the Topkick/Kodiak trucks, the Express/Savanna vans do not use an Allison transmission. The Express/Savanna vans utilize the 4L80E/4L85E transmission.

The 4L80-E is a fully automatic rear wheel drive electronically controlled transmission. The 4L80-E provides 4 forward ranges, including OVERDRIVE and REVERSE. A gear type of oil pump controls shift points. The powertrain control module (PCM), transmission control module (TCM) and the pressure control (PC) solenoid, force motor, regulate these shift points. The PCM/TCM also controls shift schedules and torque converter clutch (TCC) apply rates. Transmission temperature also influences shift schedules and TCC apply rates.

The mechanical components of this unit are as follows:

- A torque converter with a torque converter clutch (TCC)
- A gear type oil pump
- Five multiple disk clutches
- Two band assemblies
- Three planetary gear sets
- One sprag clutch
- Two roller clutches
- A control valve body assembly

The electrical components of this unit are as follows:

- Two shift solenoid valves, 1-2 and 2-3
- A torque converter clutch (TCC) solenoid valve
- A transmission pressure control (PC) solenoid valve
- An automatic transmission fluid temperature (TFT) sensor
- An automatic transmission fluid pressure (TFP) manual valve position switch assembly
- An output speed sensor (OSS)
- An input speed sensor (ISS)

EXPRESS/SAVANNA INJECTORS

The fuel injectors used for '041/2 to '05 LLY Duramax engines had a six-hole spray pattern from the tip while the '06 version of the LLY employed a seven-hole design that also featured a double-guided and modified case that was 25 percent harder. The step bore improved installation with less chance of damaging the pintle.

The later LLY, as well as newer versions of the Duramax, used a new injector identified as an IQA, or injector quantity adjustment. It is also referred to as injector flow rate programming (IFRP), and involves values assigned to each injector after flow testing at the production plant. During the manufacturing process, each injector is tested and its flow rate is measured at several duty cycles. These measurements are recorded as the injector flow rate value. This data is then recorded on the bar code label. It is laser etched as a hex number on the body of the injector before it is shipped to the Duramax engine plant in Moraine, Ohio.

The IQA values for each cylinder are written in the GPCM memory at the engine assembly plant. During final vehicle assembly (at another location), the values and cylinder position information from the GPCM are copied and written to the ECM memory.

The vehicle leaves the assembly plant with two identical copies of the stored IQA values, one in the GPCM and the other in the ECM.

The IQA values are used by the ECM to fine-tune the fuel delivery to each cylinder under all engine operating conditions.

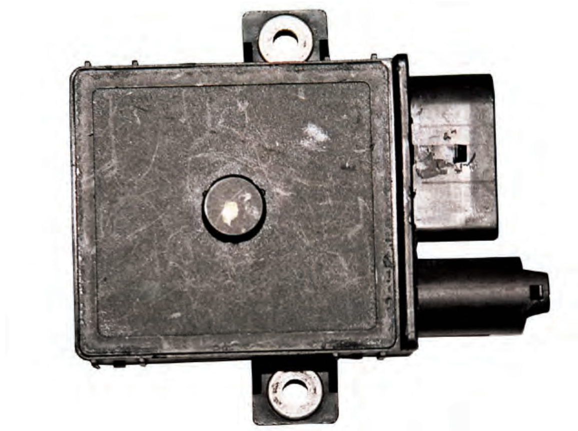
Fuel Injector Flow Rate Programming
The control functions for the fuel injection system are integrated in the engine control module (ECM). Each injector's flow rate information and cylinder position are stored in the memory of both the glow plug control module (GPCM) and the ECM. The fuel injector flow rate programming must be done when any of the following procedures are performed:

- The ECM is replaced
- The GPCM is replaced
- Any fuel injectors are replaced

If the ECM does not communicate, the flow rate information can be retrieved from the GPCM. If both control modules fail to communicate, the fuel injector flow rate information, or injection quantity adjustment (IQA) flow rate numbers, will need to be retrieved from each individual injector.

Circuit/System Verification
Review the Display ECM & GPCM Inj. Flow Rates parameter with a scan tool. All cylinders should be programmed with a flow rate number. Both the GPCM and the ECM should be programmed with the same flow rate numbers for the corresponding cylinders.

GLOW PLUG CONTROL MODULE



The '01 to '03 and '06-and-later versions of the engine have the intake air heater (IAH) and glow plug relays located in one assembly. Both relays have a power feed from a 175-amp fuse that is hot at all times. The ECM controls each relay independently and uses self-diagnostics related to the control of each function that includes diagnostic trouble codes. Fusible links provide circuit protection.

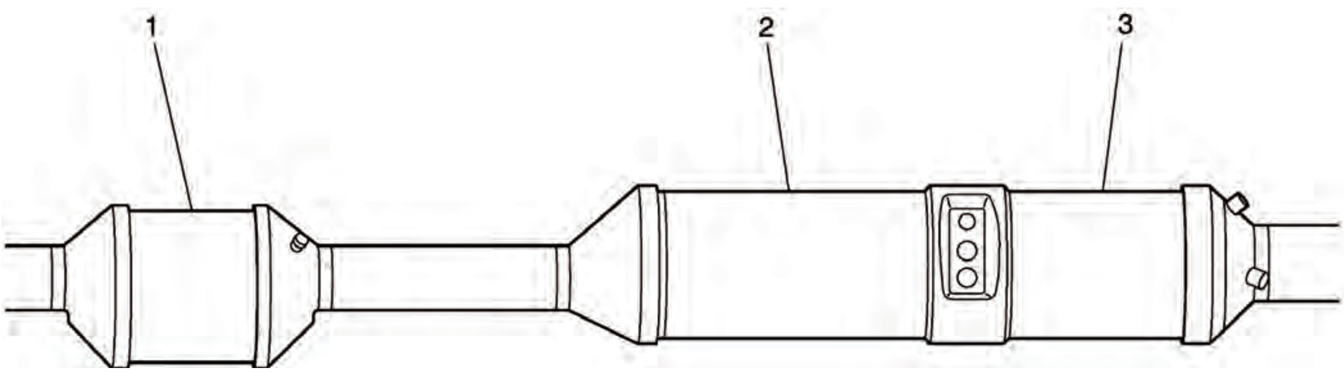
Both the IAH and glow plugs use different control circuitry on vehicles sold in California. These applications use a glow plug controller.

Cold weather start-ups are achieved at temperatures as low as minus 20 degrees F by the use of glow plugs in the combustion chambers. The initial glow plug heating time varies based on the system voltage and temperature. A lower temperature requires longer heating times. The ECM provides glow plug operation after starting a cold engine, which helps reduce white exhaust smoke and improves idle quality after starting up.

The '01 to '03 engine used the intake air heater (IAH) to warm the air entering the engine for proper combustion. The ECM operates the IAH to also reduce white smoke during warm-up and after long deceleration. The '04 and '05 models did not use an IAH. The IAH system returned for '06 but with modifications. The '06 LLY applications use a grid-style IAH controlled by the glow plug control module.

NOTES

EXHAUST AFTERTREATMENT SYSTEM



The diesel exhaust aftertreatment system is designed to reduce the levels of hydrocarbons (HC), carbon dioxide (CO), oxides of nitrogen (NOx), and particulate matter remaining in the vehicle's exhaust gases. The Aftertreatment System consists of three catalyst elements, all working together to drastically reduce tailpipe emissions. Reducing these pollutants to acceptable levels is achieved through a 3 stage process:

1. A diesel oxidation catalyst (DOC) stage
2. A selective catalyst reduction (SCR) stage
3. A diesel particulate filter (DPF) stage

In stage 1, the DOC removes exhaust HC and CO through an oxidation process. After the stage 1 treatment, diesel exhaust fluid (DEF), also known as reductant or urea, is injected into the exhaust gases prior to entering the SCR stage. Within the SCR, NOx is converted to nitrogen, CO_2 , and water vapor through a catalytic reduction fueled by the injected DEF. In the final or stage 3 process, particulate matter consisting of extremely small particles of carbon remaining after combustion are removed from the exhaust gas by the large surface area of the DPF.

DIESEL OXIDATION CATALYST (DOC)
The Diesel Oxidation Catalyst (DOC) is a ceramic flow through substrate coated with a catalyst washcoat that is integral to the DOC assembly. The close coupled DOC treats engine exhaust gases by converting harmful carbon monoxide, unburned hydrocarbons and other compounds into water, carbon dioxide and heat.

DIESEL PARTICULATE FILTER (DPF)
The diesel particulate filter (DPF) is a wall-pass ceramic filter substrate coated with a catalyst washcoat. It is located just downstream of the NAC. Exhaust gases flow from the NAC into the catalyzed diesel particulate filter (DPF) which traps and accumulates particulate matter, and further treats the exhaust gases to reduce any remaining unburned hydrocarbons and other harmful compounds. The trapped particulate matter will be periodically removed from the DPF via a regeneration process controlled by the engine's electronic control module (ECM).

SYSTEM OPERATION
The oxidation catalyst raises the exhaust gas temperatures to regenerate the DPF, which is passive regeneration. If the passive regeneration cannot keep up with the buildup of soot in the DPF, the ECM will actively regenerate the DPF to burn off the soot. Residue remains inside the DPF in the form of non burnable ash. Ash comes from the oils and other materials that are trapped in the oils and are present in the soot.

EXHAUST AFTERTREATMENT SYSTEM

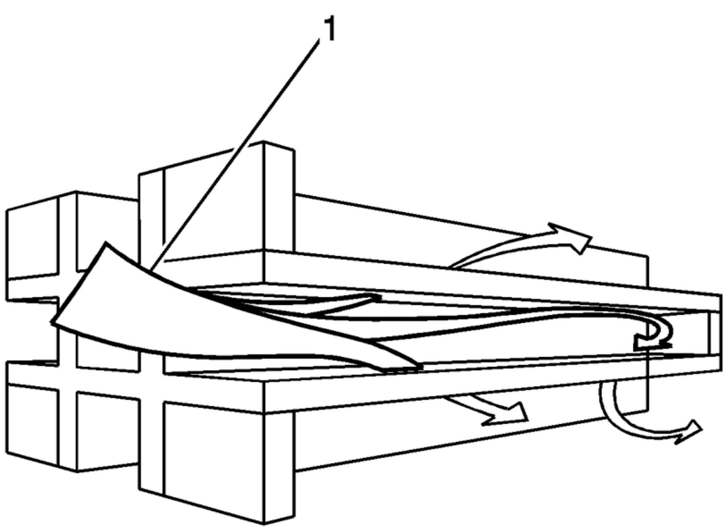
The catalyst contains a large number of parallel channels, which run in the axial direction and are separated by thin porous walls. The channels are alternatively open at one end, but plugged at the other. The exhaust gases flow through the walls and escape through the pores in the wall material. Particulates, however, are too large to escape and are trapped in the monolith walls.

The ECM starts the regeneration of the DPF if the soot load exceeds a performance MAP value. The ECM determines the load condition of the DPF based upon the exhaust gas pressure upstream and downstream of the DPC/DPF. A pressure differential sensor provides the pressure input to the ECM.

During the regeneration process, the ECM raises the temperature in the DOC/DPF to burn off the soot accumulated. Under normal operation, the engine does not produce enough heat to oxidize the soot inside the DOC/DPF. This process requires temperatures above 550 ºC (1,022 ºF). After regeneration, the ECM reads the actual pressure difference at the DOC/DPF and compares it with a reference value. From this comparison, the ECM determines the ash quantity inside the DOC/DPF.

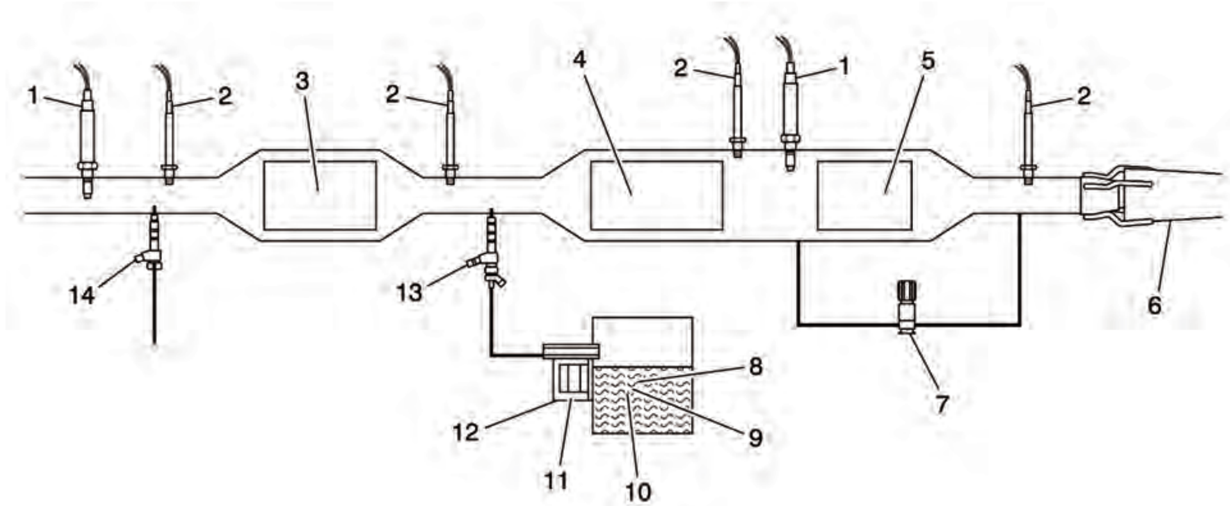
All Diesel Particulate Filters (DPFs) require regular service. Service is required to remove the ash that has accumulated inside the DPF. A poorly maintained DPF can result in exhaust back pressure that will lead to increased regeneration times, loss of horsepower, reduced fuel economy, filter damage, and ultimately engine damage. It is important that all on road fleet owners create a DPF Maintenance Program. Regularly scheduled filter cleaning will save you time and money by reducing the need for DPF repairs and/or truck downtime for additional maintenance.

DPF OPERATIONS



The DPF captures diesel exhaust gas particulates, also known as soot, preventing their release into the atmosphere. This is accomplished by forcing particulate-laden exhaust through a filter substrate consisting of thousands of porous cells. Half of the cells are open at the filter inlet but are capped at the filter outlet. The other half of the cells are capped at the filter inlet and open at the filter outlet. This forces the particulate-laden exhaust gases (1) through the porous walls of the inlet cells into the adjacent outlet cells trapping the particulate matter. The DPF is capable of removing more than 90% of particulate matter, or soot carried in the exhaust gases.

DPF OPERATIONS



COMPONENT	DESCRIPTION
1	NOx Sensor (2)
2	Exhaust Gas Temperature Sensor (4)
3	Diesel Oxidation Catalyst (DOC)
4	Selective Catalyst Reduction (SCR)
5	Diesel Particulate Filter (DPF)
6	Exhaust Cooler
7	DPF Differential Pressure Sensor
8	Reductant Heater (3)
9	Reductant Pressure Sensor
10	Reductant Level/Temperature Sensor
11	Reductant Purge Valve
12	Reductant Pump
13	Reductant Injector
14	Hydrocarbon Injector (HCI)

Normal DPF Regeneration
Over time, the soot trapped on the cell walls acts to restrict exhaust flow through the DPF reducing its effectiveness as well as reducing engine efficiency. This restriction in exhaust flow produces a pressure drop across the DPF that increases as the once porous cell walls become saturated with trapped soot. A DPS monitors the pressure drop across the DPF and provides the ECM with a voltage signal proportional to soot buildup. Once soot buildup reaches a specified limit, as signaled by the increased pressure drop across the DPF, the ECM commands a regeneration event to burn-off the collected soot during normal vehicle operation. Regeneration events occurring during vehicle operation are known as normal regenerations as they occur automatically and without driver knowledge. In general, the vehicle will need to be operating continuously at speeds above 48 km/h (30 mph) for approximately 20-30 minutes for a full and effective regeneration to complete.

The frequency of normal DPF regeneration is a function of the engine run time, miles driven, and fuel consumed since the last regeneration event. To initiate a regeneration event, the ECM commands the HCI to inject additional fuel upstream of the DOC in order to create the additional exhaust heat necessary to promote regeneration and burn-off the collected soot.

During regeneration exhaust temperatures may exceed 550°C (1,022°F) due to the rapid catalytic combustion of soot within the DPF. Conversely, under low engine speed or light loads, exhaust temperatures may be too low to

DPF OPERATIONS

promote proper regeneration. To protect the DPF catalyst from thermal damage due to excessive soot combustion or from sulfate poisoning at low temperatures, the ECM monitors EGT sensors upstream and downstream of the DPF during regeneration.

Should the EGT sensors indicate that regeneration temperatures have exceeded a calibrated threshold, regeneration will be temporally suspended until the sensors return to a normal temperature. If regeneration temperatures fall below a calibrated threshold, regeneration is terminated and a corresponding DTC is set in the ECM.

Under most conditions, the soot collected within the DPF burns off during normal regeneration cycles. Periodic regeneration prevents the buildup of soot from reaching a level where its burn-off could produce damaging high temperatures within the DPF. Vehicles operated at prolonged low speed or low loads where normal regeneration does not occur will eventually reach a high soot load condition. When the increased pressure drop across the DPF is detected by the DPS, the ECM illuminates the DPF lamp in the instrument cluster and sends a Clean Exhaust Filter message to the driver information center (DIC). The owner manual diesel supplement describes how the vehicle should be driven in order to enable normal regeneration.

Service Regeneration

Warning: Tailpipe outlet exhaust temperature will be greater than 300°C (572°F) during this procedure. To help prevent personal injury or property damage from fire or burns, perform the following:

1. **Do not connect any shop exhaust removal hoses to the vehicle tailpipe.**
2. **Park the vehicle outdoors and keep people, other vehicles, and combustible material away during this procedure.**
3. **Do not leave the vehicle unattended.**

Should the vehicle operator fail to drive the vehicle within the conditions necessary to initiate a normal regeneration cycle, the ECM illuminates the Service Engine Soon lamp and displays a REDUCED ENGINE POWER message on the DIC once the soot buildup exceeds a calibrated value. The vehicle will remain in the reduced power model until service regeneration is performed.

Service regeneration is required because the amount of soot collected in the DPF, known as soot load, is too high to be burned off without possible thermal damage to the DPF's ceramic substrate.

Service regeneration is one of several output control functions available on the scan tool. When service regeneration is commanded, the ECM takes control of engine operation until the service regeneration is completed in about 35 minutes or until the service regeneration is either cancelled by the technician or is aborted by the ECM when it detects unexpected conditions.

The service regeneration can be terminated by applying the brake pedal, commanding service regeneration OFF using the scan tool, or disconnecting the scan tool from the vehicle.

Service Regeneration Precautions
Exhaust temperatures at the tailpipe may exceed 300°C (572°F) during service regeneration. Observe the following precautions:

- Service regeneration must be performed outdoors. Most exhaust removal hoses cannot withstand the high exhaust temperatures generated during regeneration.
- Park the vehicle outdoors and keep people, other vehicles, and combustible material away during service regeneration.
- Park the vehicle in an area that provides a clearance area of at least 10 feet on all sides of the vehicle and open the hood.

DPF OPERATIONS

- Ensure the tailpipe exhaust cooler is not obstructed by mud or debris.
- Do not leave the vehicle unattended during service regeneration.

The ECM uses two EGT sensors to measure the temperature of the exhaust gases at the inlet (EGT 3) and outlet (EGT 4) of the particulate filter. Optimum particulate filter temperature is crucial for emission reduction and for ensuring complete regeneration. Excessive particulate filter temperatures could damage the ceramic substrate. The ECM monitors the inlet and outlet exhaust gas temperature sensors in order to maintain the particulate filter at its optimum temperature.

Intake Air (IA) Valve
The intake air (IA) valve is located upstream of the intake air heater, and is normally in the open position. The ECM commands the valve to close in order to precisely control combustion temperature control during DPF regeneration. The IA valve will ensure the temperature of the exhaust gas remains in an efficient range under all operating conditions. The IA valve system uses a position sensor located within the valve assembly to monitor the position of the valve. The IA valve uses a motor to move the valve to a closed position and spring tension returns it to the open position. The motor is operated through Motor Control 1 and Motor Control 2 circuits.

Exhaust Cooler
The exhaust system has been designed to lower tailpipe exhaust gas temperatures during regeneration. The exhaust cooler at the end of the tailpipe draws in cooler air as exhaust gases exit the tailpipe. Fresh air mixes with the hot exhaust gases reducing exhaust gas temperatures at the tailpipe outlet.
Ash Loading

Ash is a non-combustible byproduct from normal oil consumption. Low Ash content engine oil (CJ-4 API) is required for vehicles with the DPF system. Ash accumulation will eventually cause a restriction in the DPF. Being non-combustible, ash is not burned off during regeneration. An ash loaded DPF will need to be removed from the vehicle and replaced.

Differential Pressure Sensor (DPS)
Pressure connections at the DPF inlet and outlet allow the differential pressure sensor (DPS) to measure the pressure drop across the filter. This pressure drop increases as trapped soot collects in the cells of the DPF during vehicle operation. The rate at which soot collects varies with the power demands placed on the engine. If left unchecked, the increasing backpressure will eventually result in a driveability problem.

You may have noticed if you have one the 07+ diesel pickups that it never puts out any black smoke at all. The DPF will capture 90% or better of all harmful diesel emissions. Once the DPF has become "full" of soot, it will need to have a regeneration cycle in order to burn all the soot out. You may have noticed a light on your dash from time to time that alerts you that the DPF is in "regen" or "cleaning filter."

Basically what is happening during this process is that the engine's computer has decided from the information that it receives from the sensors installed in the exhaust that the DPF has filled up past its acceptable limit. The computer then opens the EGR (exhaust recirculation valve) introducing hot exhaust into the intake to help get exhaust gas temps higher and also injects a small shot of fuel into the cylinders when the exhaust valves are open.

The raised exhaust temps and the small amount of fuel then burn out the particulate (soot) that the DPF has collected since its last regen. Once the computer gets readings from the sensors in the exhaust that the filter is passing exhaust gas an acceptable limit again, it ends the regen cycle. The frequency of this cleaning cycle is different from vehicle to vehicle depending on use, mileage, and engine condition.

DPF OPERATIONS

Common problems with the DPF system:

1. Poor Fuel economy - This is the number one complaint we get from customers who have trucks equipped with a DPF. Most customers who traded in their pre-07 diesel pickups have been completely unhappy with the lack of fuel mileage that used to enjoy. The average fuel economy we hear people report on the DPF equipped trucks is usually 12-14 mpg. Many of these folks traded in trucks that did 18-22 mpg and are completely disgusted.

2. Excessive regens - Many of our customers who use their trucks for work complain about very frequent regens that kill their fuel mileage and performance. Many customers who work outdoors in the winter were used to leaving their old diesels run all day while they were on the job site. The DPF equipped trucks don't handle this very well. The cooler idling temperature of the exhaust gas will soot up the DPF on an accelerated rate. It is not uncommon for these customers to be on their second or third filter change because the truck went into constant limp mode. The usually dealership response is: "You can't let these new trucks idle."

3. High replacement cost - A replacement DPF (which isn't available aftermarket yet) runs roughly $2000-$2600 for the just the filter alone.

What can be done to extend DPF life and limit regens?

Since we are not allowed by law to remove the DPF system, we are stuck with it if you want to comply with Federal emissions and keep your truck legal. Here are a few tips to help mileage and DPF life:
1. Use the right fuel - It is absolutely crucial and necessary to use ultra low sulphur fuel in any vehicle equipped with a particulate filter. High amounts of sulfur in the fuel will plug the DPF immediately.

2. Use the proper engine oil - Make sure you are using engine oil that is rated properly for your truck. Some engine oil gets burnt up in combustion no matter what. If you are running oil that is not formulated for a DPF equipped vehicle, it will soot up the filter sooner.

3. Keep idling to a minimum - Simply put, idling contributes to DPF problems.

4. Run it hard once in a while - Don't be afraid once in a while when going up a hill to press the accelerator pedal to the floor for a few seconds. Running the truck hard and getting things nice and warm will help clear out soot deposits.

I want to remove the DPF. What can I do and what will be the benefits?
First thing, it is absolutely against the law to remove or disable any emissions device for any vehicle that is going to be operated on the public highways. If you decide you want to remove emissions equipment for any reason, it is solely up to you and your mechanic to decide what is safe and legal for your application.

Passive Regeneration
Passive regeneration is an automated regeneration which often occurs on drives where there is prolonged high exhaust temperatures like for example on motorway-type runs, but it can't be said that all cars get the required long journey motorway-type trips necessary to complete a passive regeneration of the DPF system and so manufacturers have had to adapt the technology and design-in an "active" regeneration process controlled by the Engine Management Computer also known as the Engine Control Module (ECM).

Active Regeneration
When the diesel particulate (soot) loading in the diesel particulate filter (DPF) reaches a pre-set limit, the ECM will make minor adjustments to the fuel injection timing system which will in turn increase the exhaust temperatures and help initiate the DPF regeneration process. This is a smart way of getting a motorway-type

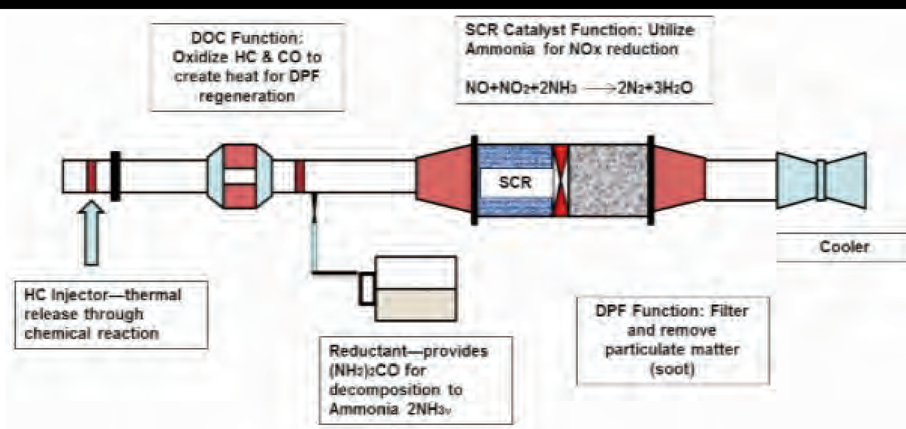
DPF OPERATIONS

temperature to build up inside the DPF system and begin a full regeneration to bring the unit back to good health, however, if the journey is a bit stop/start where you're in a built up city with traffic then the chances are the regeneration will not complete and eventually the DPF light will illuminate on the dash to tell you that the DPF system is partially blocked.

If you do not do this and choose to ignore the light, it may go out but come back on and as you continue in a relatively slow, stop/start pattern of driving the soot loading will continue to build up and clog up the DPF system until it reaches closer to 75% blocked at which point you can expect other more serious warning lights to appear on the dashboard. By now, driving at speed alone will no longer be sufficient and the car will need to go to a specialized garage or a dealership for regeneration. The other lights may be the engine management light constantly on & possibly even the glow plug light blinking constantly. It is not advised to continue driving the vehicle under these conditions to avoid further costly damages to the DPF system and other mechanical components.

Manual Regeneration
Manual regeneration is essentially the same as active regeneration however it is typically initiated using a diagnostic tool by a technician for service or diagnostic purposes. Some manufactures of medium and heavy duty trucks will allow a driver to manually disable regeneration if conditions are not favorable. These vehicles are equipped with a disable switch and some will also have a force regen switch to manually initiate regeneration when certain conditions are met.

SELECTIVE CATALYST REDUCTION (SCR) SYSTEM



While diesel engines are more fuel efficient and produce less HC and CO than gasoline engines, as a rule they generate much higher levels of NOx. In order to meet today's tighter NOx limits, an SCR catalyst, along with DEF, is used to convert NOx into nitrogen gas (N2), carbon dioxide (CO2), and water vapor (H2O).

The ECM uses two smart NOx sensors to control exhaust NOx levels. The first NOx sensor is located in the turbocharger outlet and monitors the engine out NOx. The second NOx sensor is located in the exhaust pipe downstream of the SCR and monitors NOx levels exiting the aftertreatment system. The smart NOx sensors communicate with the ECM over the serial data line.

Similar to the way the ECM uses oxygen sensor signals to maintain an optimum air/fuel ratio under various loads in gasoline applications, the ECM uses exhaust oxygen and NOx data from the NOx sensors to maintain the desired air/fuel ratio and to calculate the amount of DEF required to reduce exhaust NOx levels.

SELECTIVE CATALYST REDUCTION (SCR) SYSTEM

The NOx sensors incorporate an electric heater to quickly bring the sensors to operating temperature. As moisture remaining in the exhaust pipe could interfere with sensor operation, the ECM delays turning on the heaters until the exhaust temperature exceeds a calibrated value. This allows any moisture remaining in the exhaust pipe to boil off before it can effect NOx sensor operation.

Depending on engine temperature at start up, the delay can be less than a minute or as long as two minutes. Typically, NOx sensor 1 will reach operating temperature faster than NOx sensor 2 as it's closer to the engine's hot exhaust. At idle or low engine speeds, NOx sensor 2 may require up to 5 minutes to reach operating temperature. The sensors must be hot before accurate exhaust NOx readings are available to the ECM.

DEF is a mixture of 66% deionized water and 34% urea. Within the SCR, exhaust heat converts the urea into ammonia (NH_3) that reacts with NOx to form nitrogen, CO_2, and water vapor. Optimum NOx reduction occurs at SCR temperatures above 250°C (480°F). At temperatures below 250°C, the incomplete conversion of urea forms sulfates that can poison the catalyst. To prevent this poisoning, the ECM suspends DEF injection when exhaust temperature falls below a calibrated limit.

The 6.6L (LML) engine uses exhaust gas temperature management to maintain the SCR catalyst within the optimum NOx conversion temperature range of 200-400°C (390-750°F). The ECM monitors EGT sensors located upstream (EGT 2) and downstream (EGT 3) of the SCR in order to determine if the SCR catalyst is within the temperature range where maximum NOx conversion occurs. The 6.6L (LGH) engine does not use exhaust gas temperature management; the ECM calculates SCR temperature based on the engine speed and load. For LGH applications, SCR temperatures are typically at the lower end of the temperature range under normal driving conditions; however, SCR temperatures will increase when hauling a trailer.

The on-board reservoir holds approximately 19 liters (5 gallons) of DEF. An ECM controlled pump within the reservoir supplies pressurized DEF to the reductant injector located upstream of the SCR. A smart DEF level sensor within the reductant reservoir sends the ECM a serial data message indicating DEF level. The DEF pressure sensor provides the ECM with a voltage signal proportional to the reductant pressure generated by the DEF pump. The ECM varies the duty-cycle of the pump voltage to maintain reductant pressure within a calibrated range.

The state of the reductant purge valve determines whether DEF from the reductant pump is directed to the reductant injector or returned to the reservoir. In the normally de-energized state, the reductant purge valve directs reductant from the pump to the reductant injector. When the ignition is turned OFF, the ECM energizes both the reductant purge valve and reductant pump for about 30 to 45 seconds in order to purge the supply line of DEF. The ECM also commands the reductant injector to 100% to prevent vacuum from forming during the purge process. Purging prevents the reductant from freezing in the pump or supply line to the reductant injector.

The ECM energizes the reductant injector to dispense a precise amount of reductant upstream of the SCR in response to changes in exhaust NOx levels. Feedback from NOx sensors 1 and 2 allow the ECM to accurately control the amount of reductant supplied to the SCR. If more reductant is supplied to the SCR than is needed for a given NOx level, the excess reductant results in what is called ammonia slip where significant levels of ammonia exit the SCR. Since the NOx sensors are unable to differentiate between NOx and ammonia, ammonia slip will cause NOx sensor 2 to detect higher NOx levels than actually exist.

As reductant will freeze at temperatures below 0°C (32°F), there are 3 reductant heaters. Reductant heater 1 is in the reductant reservoir, reductant heater 2 is in the supply line to the reductant injector, and reductant heater 3 is at the reductant pump. The ECM monitors the reductant temperature sensor located within the reservoir in order to determine if reductant temperature is below its freeze point. If the ECM determines that the reductant may be frozen, it signals the Glow Plug Control Module (GPCM) to energize the reductant heaters.

SELECTIVE CATALYST REDUCTION (SCR) SYSTEM

Reductant pump operation is disabled for a calibrated amount of time to allow the heaters time to thaw the frozen reductant. Once the thaw period expires, the ECM energizes the reductant pump to circulate warm reductant through the de-energized reductant purge valve and back to the reservoir to speed thawing. The ECM looks for an increase in the reductant temperature to verify that the reductant reservoir heater is working.

DEF FLUID

An adequate on-board supply of Diesel Exhaust Fluid (DEF) is critical for the reduction of exhaust Oxides of Nitrogen (NOx) levels within the Selective Catalyst Reduction (SCR) stage. This vehicle provides the driver with an elaborate series of prompts and warnings that are initiated when the DEF level falls below a calibrated value.

The Engine Control Module (ECM) monitors the DEF level and consumption rate in order to calculate an estimated range in miles remaining until the DEF reservoir is empty. DEF levels are detected by the 3-position solid-state DEF level sensor. Typically, DEF warnings begin once the estimated mileage falls below 1,609 km (1,000 mi). Once initiated, DEF warnings grow increasingly more serious as the remaining mileage decreases without a DEF refill. The vehicle’s current DEF warning level is displayed on the scan tool as Reductant Level Warning Indicator Command Level 1 through Level 9.

Warning Level 1
Warning Level 1 is triggered when the DEF level falls below the top-most position of the DEF Level Sensor and the estimated range remaining is greater than 1609 km (1000 mi). No prompts or warnings are presented to the driver.

Warning Level 2
Warning Level 2 is triggered when the estimated range remaining falls below 1,609 km (1,000 mi) based on current DEF consumption rates. The Driver Information Center (DIC) displays the message Exhaust Fluid Range X MI, where X is the estimated range remaining in miles. This message remains on the DIC until acknowledged by the driver.

Warning Level 3
Warning Level 2 automatically advances to Warning Level 3 when the ECM detects an ignition ON to ignition OFF event. A level 3 warning remains active as long as the estimated range remaining is greater than 644 km (400 mi) based on current DEF consumption rates. No prompts or warnings are presented to the driver.

Warning Level 4
Warning Level 4 is triggered when the estimated range remaining falls below 644 km (400 mi) based on current DEF consumption rates. The message Exhaust Fluid Range X MI, where X is the estimated range remaining in miles is displayed on the DIC. This message is also displayed at the beginning of each ignition cycle. This message remains on the DIC until acknowledged by the driver.

Warning Level 5
Warning Level 5 is triggered when the estimated range remaining is less than approximately 121 km (75 mi) based on current DEF consumption rates. The message Exhaust Fluid Low - Speed Limited Soon, is displayed on the DIC. This message is also displayed at the beginning of each ignition cycle. This message remains on the DIC until acknowledged by the driver.

DEF FLUID

Warning Level 6
Warning Level 6 is triggered when the estimated range remaining is less than approximately 0 km (0 mi) based on current DEF consumption rates. The driver will hear 4 chimes on entering Warning Level 6. The DIC displays the following messages:

- Exhaust Fluid Empty Refill Now
- 89 km/h (55 mph) Max Speed Upon Restart

The messages are also displayed at the beginning of each ignition cycle. The Exhaust Fluid Empty Refill Now message remains on the DIC until acknowledged by the driver. The 89 km/h (55 mph) Max Speed Upon Restart message is not acknowledgeable.

At the next ignition ON event, the system will advance from Warning Level 6 to Warning Level 7. If fuel is added to the vehicle without an ignition cycle the system will advance to Warning Level 8.

In the event of a refill, the scan tool may show that fluid has been added, but the vehicle may not release from the warning level unless it is driven for greater than 6 mph (10 km/h) for approximately 5 minutes.

Warning Level 7
Warning Level 7 is active at the next ignition ON event. The driver will hear 4 chimes on entering Warning Level 7. The 4 chimes are repeated 3 more times during this ignition cycle. The DIC displays the following messages:

- Exhaust Fluid Empty Refill Now
- Speed Limited to 89 km/h (55 mph)

The messages are alternately displayed every 5 seconds on the DIC. Both messages remain on the DIC until acknowledged by the driver; however, the Speed Limited to 89 km/h (55 mph), remains locked on the DIC.

The DEF Indicator in the instrument panel flashes continuously. Warning Level 7 remains active until a refueling event is detected. Vehicle speed is now limited to 89 km/h (55 mph) maximum.

In the event of a refill, the scan tool may show that fluid has been added, but the vehicle may not release from the warning level unless it is driven for greater than 6 mph (10 km/h) for approximately 5 minutes.

Warning Level 8
Warning Level 8 is triggered when the ECM detects that additional fuel was added without a refill of the DEF reservoir. The driver will hear 4 chimes on entering Warning Level 8. The 4 chimes will repeat 3 more times during this ignition cycle. The DIC displays the following messages:

- Exhaust Fluid Empty Refill Now
- Speed Limited to 89 km/h (55 mph)
- 6 km/h (4 mph) Max Speed at Next Fuel Fill

The messages are alternately displayed every 5 seconds on the DIC. The three messages remain on the DIC until acknowledged by the driver. Once acknowledged, the Speed Limited to 89 km/h (55 mph), and 6 km/h (4 mph) Max Speed at Next Fuel Fill, remain locked on the DIC.

The DEF Indicator in the instrument panel flashes continuously. The vehicle remains in Warning Level 8 until the DEF reservoir is refilled or a second refueling event is detected.

Vehicle speed is limited to 89 km/h (55 mph) maximum.

In the event of a refill, the scan tool may show that fluid has been added, but the vehicle may not release from the warning level unless it is driven for greater than 6 mph (10 km/h) for approximately 5 minutes.

DEF FLUID

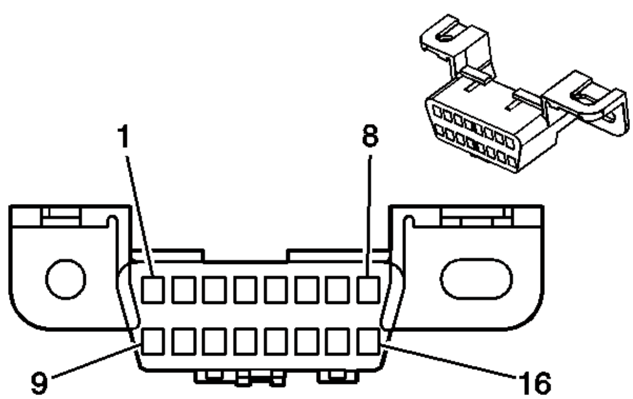
Warning Level 9
Warning Level 9 is triggered on the next ignition cycle following a second refueling event without a refill of the DEF reservoir. The driver will hear 4 chimes on entering Warning Level 9. The 4 chimes will repeat every 3 minutes until the DEF reservoir is refilled. The DIC displays the following messages:
- Exhaust Fluid Empty Refill Now
- Speed Limited to 6 km/h (4 mph) Max

The messages are alternately displayed every 5 seconds on the DIC. Both messages remain on the DIC until acknowledged by the driver; however, the Speed Limited to 6 km/h (4 mph) Max, message remains locked on the DIC.

The DEF Indicator in the instrument panel flashes continuously. The vehicle remains in Warning Level 9 until the DEF reservoir is refilled.Vehicle speed is limited to 6 km/h (4 mph) maximum.

In the event of a refill, the scan tool may show that fluid has been added, but the vehicle may not release from the warning level unless it is driven for greater than 6 mph (10 km/h) for approximately 5 minutes.

DATA LINK CONNECTOR

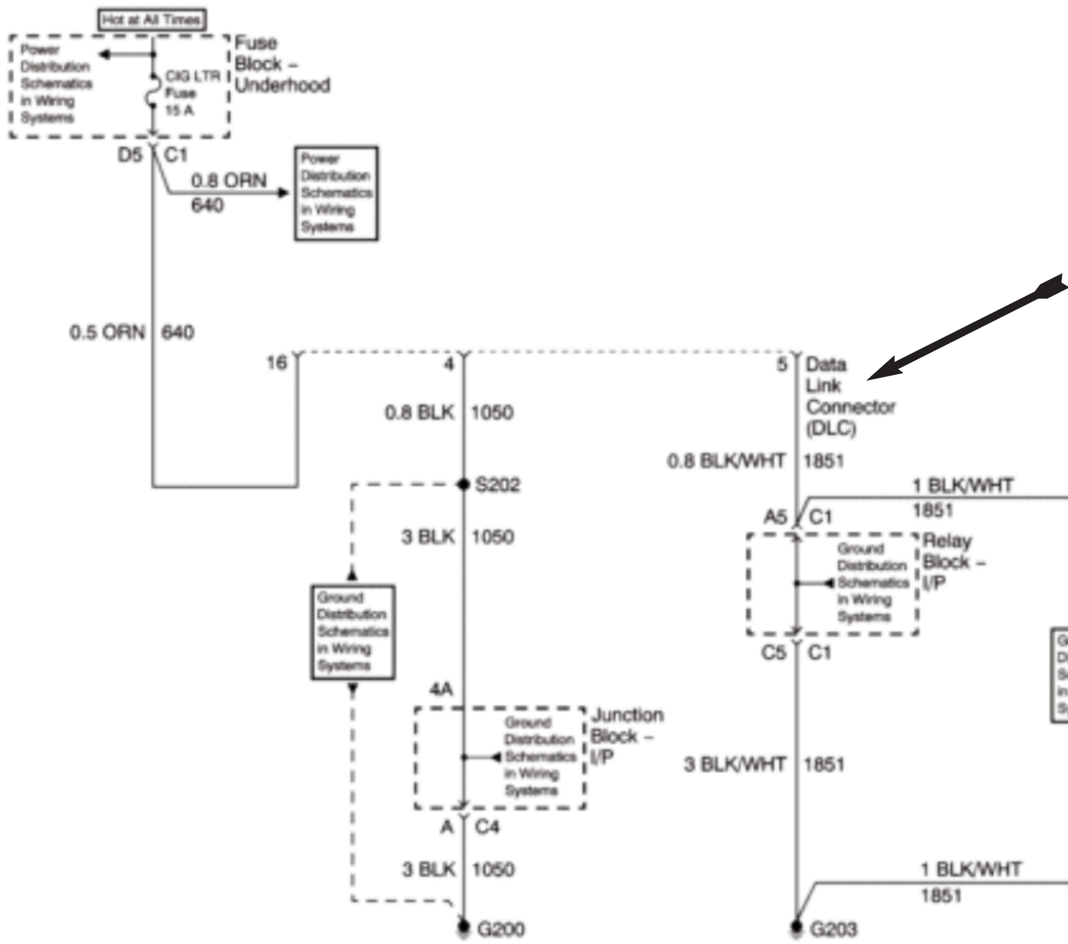


The data link connector (DLC) is a standardized 16-cavity connector. The DLC low speed serial data circuit is connected directly to the instrument panel (I/P) splice then to all other splices or modules. Connector design and location is dictated by an industry wide standard, and is required to provide the following:
- Pin 1 GMLAN low speed communications terminal
- Pin 4 scan tool power ground terminal
- Pin 5 common signal ground terminal
- Pin 6 high speed GMLAN serial data bus (+) terminal
- Pin 14 high speed GMLAN serial data bus (-) terminal
- Pin 16 scan tool power, battery positive voltage terminal

Serial Data Reference
The scan tool communicates over the various busses on the vehicle. When a scan tool is installed on a vehicle, the scan tool will try to communicate with every module that could be optioned into the vehicle. If an option is not installed on the vehicle, the scan tool will display No COMM for that options specific control module.

In order to avert misdiagnoses of No Communication with a specific module, refer to Data Link References for a list of modules, the busses they communicate with, and the RPO codes for a specific module.

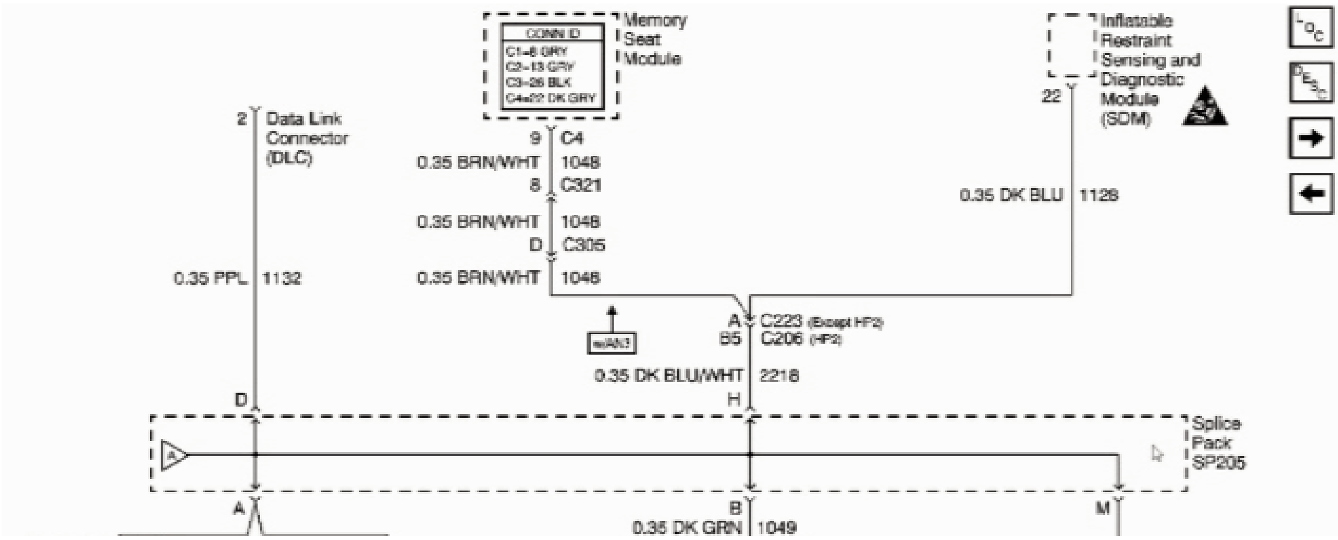
DATA LINK CONNECTOR



The communication among control modules is performed through the high speed GMLAN serial data circuits and the low speed GMLAN serial data circuit. The modules that need real time communication are attached to the High Speed GMLAN network. The body control module (BCM) is the gateway between the high and low speed networks. Refer to Body Control System Description and Operation for more information about the gateway.

Signal supervision is the process of determining whether an expected signal is being received or not. Some messages are sent on a periodic basis and are interpreted as a heartbeat of a device. If such a signal is lost, the signal supervision part of the software will set a no communication DTC (U. code) against the missing device. This code is mapped on the Tech 2 screen as a code against the physical device. A lost communication DTC typically is set in modules other than the module with a communication failure.

DATA LINK CONNECTOR



The modules on the GMLAN low speed serial data buss are connected to the buss using several splice or "star" connectors separating groups of modules. The following lists state the splices and modules connected to the low speed serial data circuits:

I/P Splice

- Data link connector (DLC), connected only to the instrument panel (I/P) splice
- Amplifier (Amp)
- Rear seat audio (RSA)
- Vehicle communication interface module (VCIM)
- Digital radio receiver (DRR)
- Inside rearview mirror module (ISRVM), connected through the mid I/P fuse block
- Instrument panel cluster (IPC)
- Body control module (BCM)
- Theft deterrent module (TDM)
- Heater ventilation and air conditioning (HVAC)
- Radio
- Driver door switch (DDS), connected through the left I/P fuse block
- Passenger door switch (PDS), connected through the right I/P fuse block

Body Splice

- Articulating running board module (ARBM)
- Ultrasonic park assist (UPA)
- Memory seat module (MSM)
- Liftgate module (LGM)
- Passenger presence system (PPS)
- Inflatable restraint vehicle rollover sensor (ROS)
- Inflatable restraint sensing and diagnostic module (SDM)

CAN NETWORK

A modern automobile may have as many as 70 electronic control units (ECU) for various subsystems.[3] Typically the biggest processor is the engine control unit (also engine control module/ECM or Powertrain Control Module/PCM in automobiles); others are used for transmission, airbags, antilock braking/ABS, cruise control, electric power steering/EPS, audio systems, windows, doors, mirror adjustment, battery and recharging systems for hybrid/electric cars, etc. Some of these form independent subsystems, but communications among others are essential. A subsystem may need to control actuators or receive feedback from sensors. The CAN standard was devised to fill this need.

The CAN bus may be used in vehicles to connect the engine control unit and transmission, or (on a different bus) to connect the door locks, climate control, seat control, etc. Today the CAN bus is also used as a fieldbus in general automation environments, primarily due to the low cost of some CAN controllers and processors.

CAN features an automatic arbitration-free transmission. A CAN message that is transmitted with highest priority will succeed, and the node transmitting the lower priority message will sense this and back off and wait.

This is achieved by CAN transmitting data through a binary model of "dominant" bits and "recessive" bits where dominant is a logical 0 and recessive is a logical 1. This means open collector, or wired or physical implementation of the bus (but since dominant is 0 this is sometimes referred to as wired and). If one node transmits a dominant bit and another node transmits a recessive bit then the dominant bit "wins" (a logical AND between the two).

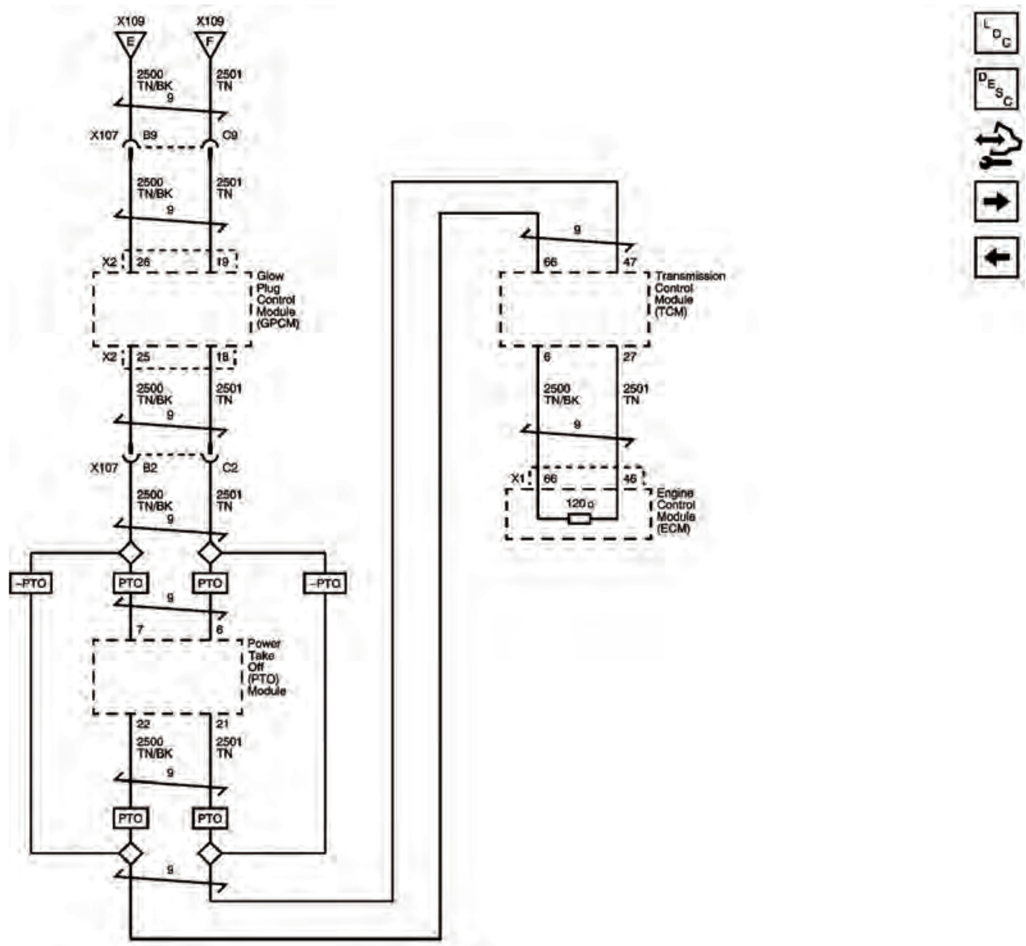
So, if a recessive bit is being transmitted while a dominant bit is sent, the dominant bit is displayed, evidence of a collision. (All other collisions are invisible.) A dominant bit is asserted by creating a voltage across the wires while a recessive bit is simply not asserted on the bus. If any node sets a voltage difference, all nodes will see it. Thus there is no delay to the higher priority messages, and the node transmitting the lower priority message automatically attempts to re-transmit six bit clocks after the end of the dominant message.

When used with a differential bus, a carrier sense multiple access/bitwise arbitration (CSMA/BA) scheme is often implemented: if two or more devices start transmitting at the same time, there is a priority based arbitration scheme to decide which one will be granted permission to continue transmitting. The CAN solution to this is prioritized arbitration (and for the dominant message delay free), making CAN very suitable for real time prioritised communications systems.

During arbitration, each transmitting node monitors the bus state and compares the received bit with the transmitted bit. If a dominant bit is received when a recessive bit is transmitted then the node stops transmitting (i.e., it lost arbitration). Arbitration is performed during the transmission of the identifier field. Each node starting to transmit at the same time sends an ID with dominant as binary 0, starting from the high bit. As soon as their ID is a larger number (lower priority) they will be sending 1 (recessive) and see 0 (dominant), so they back off. At the end of ID transmission, all nodes but one have backed off, and the highest priority message gets through unimpeded.

For example, consider an 11-bit ID CAN network, with two nodes with IDs of 15 (binary representation, 00000001111) and 16 (binary representation, 00000010000). If these two nodes transmit at the same time, each will transmit the first six zeros of their ID with no arbitration decision being made. When the 7th bit is transmitted, the node with the ID of 16 transmits a 1 (recessive) for its ID, and the node with the ID of 15 transmits a 0 (dominant) for its ID. When this happens, the node with the ID of 16 will realize that it lost its arbitration, and allow the node with ID of 15 to continue its transmission. This ensures that the node with the lower bit value will always win the arbitration. The ID with the smaller number will win the right to use.

CAN NETWORK

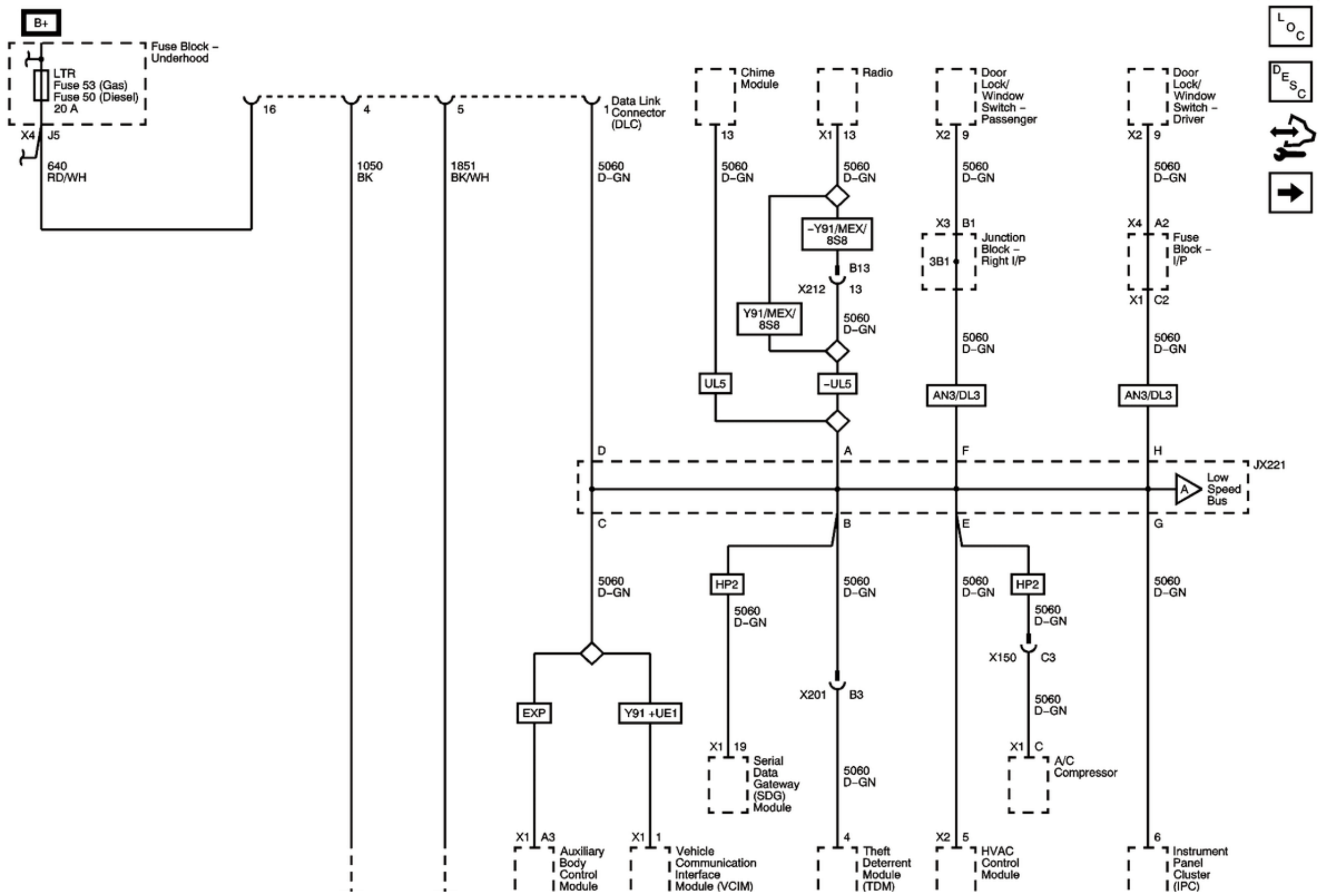


GMLAN High Speed Circuit Description
The data link connector (DLC) allows a scan tool to communicate with the high speed GMLAN serial data circuit. The serial data is transmitted on 2 twisted wires that allow speed up to 500 Kb/s. The twisted pair is terminated with two 120-ohm resistors, one is internal to the engine control module (ECM) and the other is after the electronic brake control module (EBCM), or if equipped, the suspension control module. The high speed GMLAN is a differential bus. The high speed GMLAN serial data bus (+) and high speed GMLAN serial data (-) are driven to opposite extremes from a rest or idle level.

The idle level, which is approximately 2.5 volts, is considered recessive transmitted data and is interpreted as a logic 1. Driving the lines to their extremes, adds 1 volt to the high speed GMLAN serial data bus (+) and subtracts 1 volt from the high speed GMLAN serial data bus (-) wire. If a communication signal is lost, the application will set a no communication code against the respective control module. This code is mapped on the Tech 2 screen as a code against the physical device. Note: a loss of serial data DTC does not represent a failure of the module that the code is set in.

The high speed GMLAN serial data allows communication between the body control module (BCM), ECM, transmission control module (TCM), vehicle communication interface module (VCIM), 4WD control module, EBCM, and the suspension control module depending on RPO.

CAN NETWORK



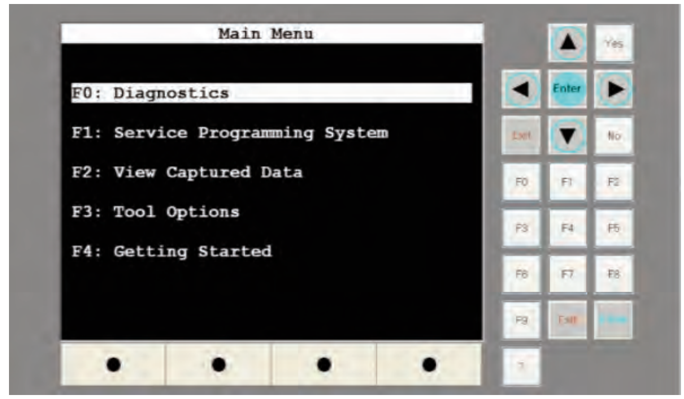
GMLAN Low Speed Circuit Description

The data link connector (DLC) allows a scan tool to communicate with the low speed GMLAN serial data circuit. The serial data is transmitted over a single wire to the appropriate control modules. Under normal vehicle operating conditions, the speed of the buss is 33.33 Kb/s. This protocol produces a simple pulse train sent out over the GMLAN low speed serial data bus. When a module pulls the buss high, 5 volts, this creates a logic state of 0 on the buss. When the buss is pulled low, 0 volts, it is translated as a logic state of 1.

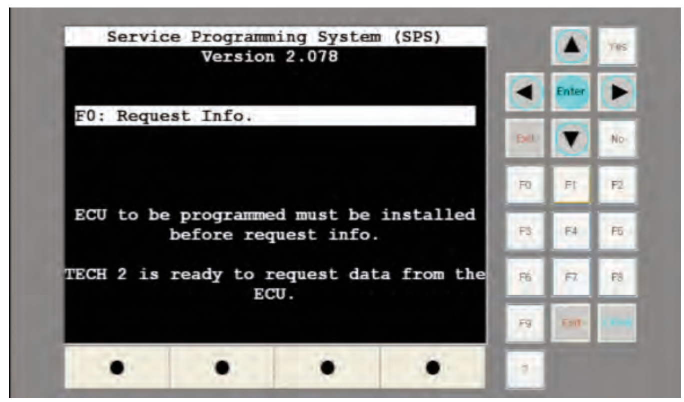
To wake the control modules connected to the GMLAN low speed serial data buss, a wake up signal is sent out over the buss. Modules connected to the GMLAN low speed buss can be part of a virtual network as described in GMLAN High Speed Circuit Description above. The modules on the GMLAN low speed serial data buss are connected to the buss using several splice or "star" connectors separating groups of modules.

PROGRAMMING TECH 2

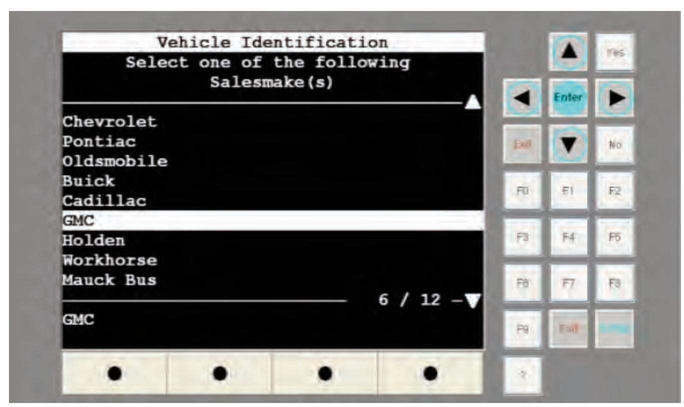
The first step in programming is to connect the Tech 2 to the vehicle and select the Service Programming System option from the main menu.



Next you want to select the Request Info menu option. This function will pull the VIN from the ECM as well as the ECMs current calibration number.



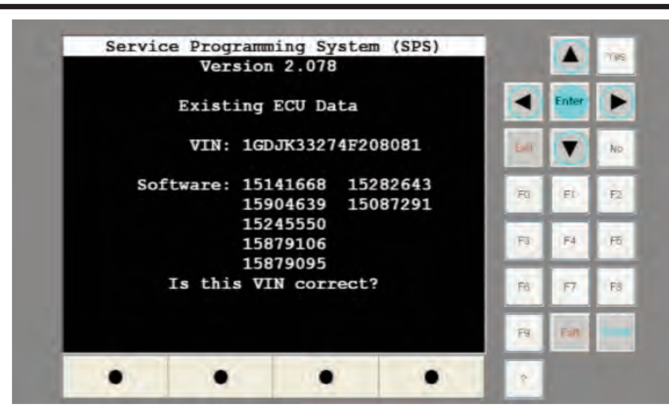
After making sure you have the latest Tech 2 software and you have your scan tool fully charged, you will have the option to begin to select the vehicle you are working on from a series of Vehicle Selection menus.



For our demonstration we have chosen a 2004 GMC Sierra (new body style) with a 6.6L LLY VIN 2 Diesel engine.

Once we have selected our model data a screen will appear listing the VIN of the vehicle we are working on and all of the software version of the ECU.

It is important to note the tool will ask you if the VIN displayed on the screen matches the VIN of the vehicle you are working on. If they do not match, you need to determine if the ECU in the vehicle is actually the one needed to run the vehicle.



PROGRAMMING TECH 2

If the VIN from the ECU is a match to the VIN of the vehicle, you will be able to access the GM tech info website and view the available calibrations. If there is a calibration that is newer than any of the calibrations listed on the Tech 2, you need to download the update from the GM tech info website and install it onto the ECM.

ALLISON 1000 DURAMAX

The transmission control module (TCM) produces excellent shift quality by applying closed loop control that constantly adjusts shift characteristics for changes in operating conditions. These adjustments are based on vehicle conditions, such as grade, load, and engine power.

The learning process of comparing and adjusting shift parameters is referred to as adaptive control. Adaptive control establishes initial conditions for shifts and makes during shift adjustments. The TCM constantly monitors operating conditions, such as battery voltage and transmission sump temperature, and adjusts shift parameters accordingly. After a shift is completed, the TCM compares the shift to a target shift profile in the TCM calibration and makes adjustments before the next shift of the same kind is made.

The Allison 1000 Series transmission consists of 5 clutches. A combination of 2 clutches is required to be engaged, in order to attain a torque path from the input to the output of the transmission. The following table indicates the clutch combinations for each gear range.

The Allison 1000 Series transmission utilizes clutch-to-clutch shift control to achieve range changes. In every case, except shifts to or from NEUTRAL, 1 clutch is exhausted and another applied in order to make a range shift. The hand-off between exhausting and applying clutches is precisely controlled by the use of 2 pressure control solenoids (PCS). These solenoids are labeled PCS1 and PCS2 in the transmission. For example, to make a 1-2 shift, PCS1 is used to trim pressure off the low and reverse clutch, and PCS2 is used to trim pressure on the 2-6 clutch. The TCM modulates the current to both PCS1 and PCS2, which translates to a proportional level of pressure to the clutch. In order to make a shift, the TCM uses software and calibration settings of several program parameters in order to determine the level of current sent to the respective PCS. These parameters are referred to as adaptive values.

With a new transmission and TCM calibration, the adaptive values are set to base calibration level. The transmission uses the base calibration to perform the first of each type of shift. However, once the transmission has performed a shift, the TCM evaluates the actual shift and compares it to an ideal shift in the TCM memory. Based on that comparison, the TCM changes the settings of the adaptive values to a level that it believes will result in a shift closer to the ideal shift the next time it makes that type of shift. This is referred to as adaptive

ALLISON 1000 DURAMAX

shifting. When the transmission/TCM calibration is new, the TCM is in fast adaptive mode. The TCM is allowed to make large changes in the adaptive values after each shift. Once the TCM determines that a given shift is close to the ideal level, it switches to slow adaptive mode. In slow adaptive, the TCM still is evaluating shifts and changing adaptive values, but is only allowed to do so in smaller increments.

When a shift switches from fast to slow adaptive mode, it is described as converged. It is important to understand that there are many different distinct shifts recognized by the TCM, and each of these shifts has its own adaptive values. There are upshifts and downshifts to and from each range, as well as unique adaptive values for several different throttle regions for each upshift and downshift. It may take a significant amount of time before some shifts converge from fast to slow adaptive, and thus it is not unusual to experience somewhat harsh or unpleasant shift quality until these shifts are adapted. In order to learn the transmission variation and provide near converged shift quality without performing a shift, FastLearn should be performed.

TCC engagement is accomplished by a separate PCS. There are adaptive values for this as well, and thus it will also require some driving for TCC engagement to converge.

If you are experiencing harsh shifts, it is important to verify whether the particular shift is converged. Use the scan tool in order to determine if the shift is converged.

- If the shift is not converged, the TCM is learning how to adapt that shift, and needs to be driven more, with the intention of performing more of the particular type of shift.
- If a particular shift is converged, but still objectionable, it is good troubleshooting practice to reset the adaptive values for that shift back to base calibration level. This will automatically reset the TCM to fast adaptive mode. The vehicle should then be driven in order to allow the TCM to relearn the shift. Many times this will correct the condition. It is possible to reset individual shifts without affecting the other shifts.

Note: WHEN REPLACING A FAILED TRANSMISSION WITH A REPLACEMENT UNIT, IT IS IMPORTANT TO RESET THE TCM IN ORDER TO BASE CALIBRATION AND FAST ADAPTIVE FOR ALL SHIFTS. This can be done in 1 step with FastLearn. If this is not done, the TCM adaptive values will be at the settings that it learned for the old transmission, and will be in slow adaptive mode. Under these conditions, it would take an unacceptably long time for the adaptive values to converge to levels suitable for the new transmission.

			1-2 Shift Output Shaft RPM				2-3 Shift Output Shaft RPM			
Engine		% of TPS	12	25	50	100	12	25	50	100
		Mode								
LML	6.6L	Normal	425	450	722	N/A*	867	867	1199	N/A*
LGH	6.6L	Normal	433	435	690	N/A*	867	867	1175	N/A*
LML	6.6L	Tow/Haul	549	549	722	N/A*	1127	1127	1358	N/A*
LGH	6.6L	Tow/Haul	549	549	722	N/A*	1127	1127	1358	N/A*
*Varies based on vehicle acceleration										

			3-4 Shift Output Shaft RPM			4-5 Shift Output Shaft RPM			5-6 Shift Output Shaft RPM			Closed Throttle Downshift Output Shaft RPM				
												5-Jun	4-May	3-Apr	2-Mar	1-Feb
		% of TPS	12	25	50	12	25	50	12	25	50	0	0	0	0	N/A*
Engine		Mode														
LML	6.6L	Normal	1053	1156	1199	1450	1503	2139	2100	2150	2600	1725	1416	954	712	N/A*
LGH	6.6L	Normal	1127	1272	1676	1660	1702	2100	2100	2100	2575	1631	1407	1000	712	N/A*
LML	6.6L	Tow/Haul	1561	1561	1821	2196	2196	2399	2630	2630	2861	2312	2052	1503	1098	N/A*
LGH	6.6L	Tow/Haul	1561	1561	1821	2196	2196	2399	2630	2630	2861	2312	2052	1503	1098	N/A*
*Varies based on vehicle deceleration																

DURAMAX CLOSING

There is no question we have covered a lot of information concerning the description, operation and diagnostics of the Duramax Diesel engine. But no matter how much information we have covered, there is always more information available.

The best source of information with these vehicles in mind is the OEM service and diagnostic information. If you do not have the access to this information, you need to get it as soon as possible. Nothing will help you more than knowing how to access, navigate and understand how the factory service information works.

Also, you must have the appropriate scan tool. There are many good scan tools out on the market and this includes the GM Tech 2. Whatever scan tool you buy, make sure it can communicate with the vehicle correctly and also make sure it has the ability to bi-directionally control certain actuators.

NOTES

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