6.6L DURAMAX DIESEL

REFERENCE AND DIAGNOSTICS MANUAL

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A QUICK OVERVIEW

In 1982 General Motors (GM) introduced a diesel-powered V8 engine for the C/K generation of pickup trucks. There were two sizes of V8 engines in this family, a 6.2L and a 6.5L. Both engines were available as options on all 1982 through 2000 full-size SUVs, pickups, and vans.

These engines were also standard equipment on the AM General military High Mobility Multipurpose Wheeled Vehicle (HMMWV), commonly known as the military Humvee. Versions of the engine were also available on the civilian Hummer H1, and the GM built Commercial Utility Cargo Vehicle for military use.

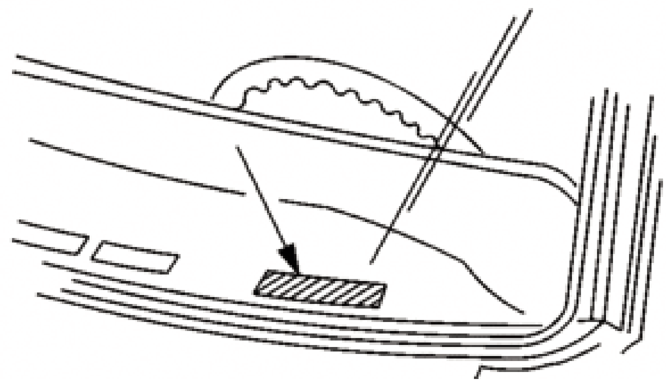
In 2001, GM introduced the Duramax engine line. The V8 version is a 6.6L engine produced by DMAX, a joint venture between GM and Isuzu in Moraine, Ohio. The cylinder block and cylinder heads for the Duramax V8 engines are cast at the Defiance GM Powertrain foundry in Defiance County, Ohio.

Initially, the engine was installed in the Chevrolet and GMC full-size pickup truck line and is also popular as an option in the van and medium-duty truck line. According to GM, production of the Duramax V8 was limited to approximately 200,000 engines per year.

In May of 2007, DMAX announced the production of the 1,000,000th Duramax V8 engine. This number was surpassed on March 24, 2017, by producing the 2,000,000th Duramax V8 engine.

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 Numbe

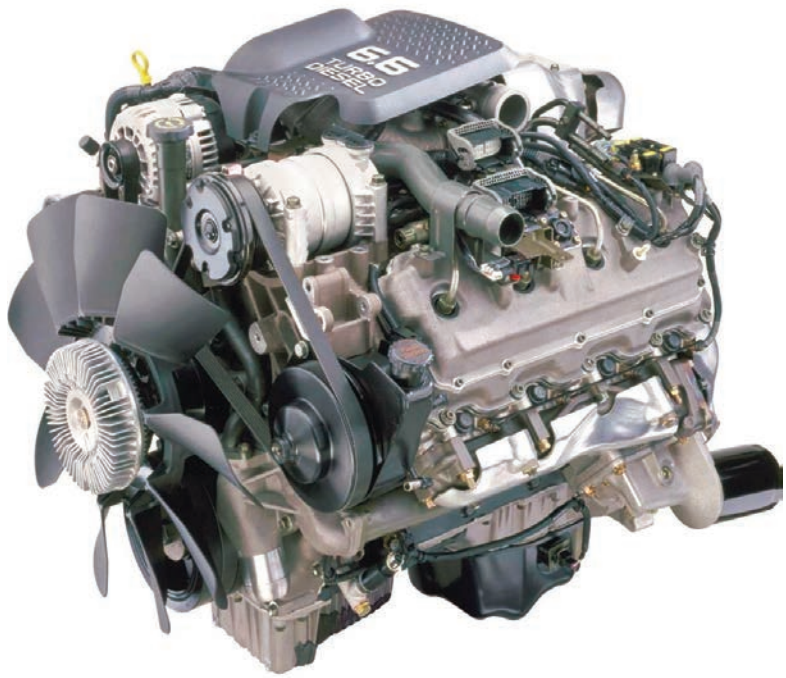
A QUICK OVERVIEW



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 can be seen through the windshield from the outside of the vehicle.

Model Year(s)	8th Digit of VIN	Duramax Model (GM RPO Code)	Special Notes
2001 - 2004	**1**	LB7	
	2	LLY	Introduced mid-year in 2004
2005	**2**	LLY	Only variation offered for 2005
2006	**2**	LLY	2005 variation is different from the 206 version
	D	LBZ	Introduced in late 2006
2007	**D**	LBZ	
	6	LMM	
2008 - 2010	**6**	LMM	Only variation offered for model years 2008-2010
2011 - 2016	**8**	LML	
	L	LGH	
2017 2022	**Y**	L5P	

LB7 VARIANT



Duramax LB7 - Courtesy GM Corporation

6.6L LB7 Engine Vitals	
Displacement:	6.6L / 403 cu. in.
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, GMC Sierra HD
Introduced:	2001 model year
Discontinued:	2004 model year
Predecessor:	–
Successor:	LLY Duramax V8
Assembly:	Moraine, Ohio, USA

GM 6.6L LB7 V-8 Duramax Turbo Diesel Engine Vehicle Applications					
Year	**Make**	**Model**	**Transmission**	**Power (hp / kW) @ RPM**	**Torque (lb-ft / Nm) @ RPM**
2001-2003	Chevrolet	Silverado HD	5-Speed Manual or 5-Speed Allison Automatic	235 / 175 @ 2700	500 / 678 @ 1600
2001-2003	GMC	Sierra HD	5-Speed Manual or 5-Speed Allison Automatic	235 / 175 @ 2700	500 / 678 @ 1600
2004	Chevrolet	Silverado HD	5-Speed Manual or 5-Speed Allison Automatic	300 / 225 @ 3100	520 / 705 @ 1800
2004	GMC	Sierra HD	5-Speed Manual or 5-Speed Allison Automatic	300 / 225 @ 3100	520 / 705 @ 1800

LB7 VARIANT

GM 6.6L LB7 V-8 Duramax Turbo Diesel Engine Specs	
Type	6.6L V-8 Turbo-Diesel
GM RPO Code	LB7
Displacement	403 ci
Compression Ratio	17.5:1
Valve Configuration	Overhead
Valves Per Cylinder	4
Assembly Site	Moraine, Ohio, USA
Valve Lifters	Mechanical roller
Firing Order	1 – 2 – 7 – 8 – 4 – 5 – 6 – 3
Bore x Stroke	4.055 in. or 103 mm x 3.897 in. or 99 mm
Fuel System	Direct injection with high-pressure common rail w/ Bosch CP3 pump
Fuel Type	Diesel
Fuel Tank Size:	26 Gallons
Maximum Powered Speed	3250 rpm
Emissions Controls	None
Block	Cast iron
Cylinder Head	Cast aluminum
Intake Manifold	Cast aluminum
Exhaust Manifold	Cast nodular iron with steel pipe extension
Main Bearing Caps	Cast nodular iron
Crankshaft	Forged steel
Camshaft	Steel
Connecting Rods	Forged Steel
Engine Oil Capacity	10 qt./9.5L w/ Filter
Engine Mass:	Approximately 835 pounds

LB7 VARIANT

The LB7 Duramax engine was manufactured from 2001-2004 at the GM Duramax plant in Moraine, Ohio, USA. The LB7 was a 6.6L V8 diesel engine used in the Chevrolet Silverado HD and the GMC Sierra HD models.

The cylinder block was cast iron and used aluminum cylinder heads. Supplying fuel was a high-pressure common rail injection system. The engine produced 3,100 rpm and 520 ft-lb at 1,800 rpm, the highest in its respective segment. A commercial-grade Allison 5-speed transmission was a popular option at the time.

The LB7 was relatively simplistic. GM built the engine before any rigorous diesel emission standards or regulations, such as Diesel Exhaust Fluid (DEF), Selective Catalyst Reduction (SCR), or a Diesel particulate Filter (DPF).

Although the LB7 was considered reliable to the standards, the unique (for it's time) fuel injection system was problematic early on. One infamous characteristic regarding issues with the injection system was fuel injector failure.

The failure rate of the injectors was indeed high enough to warrant a recall by GM. GM replaced the faulty injectors and extended the warranty to 200,000 for new components. Data collected over time pointed to poorly filtered or contaminated diesel fuel as the leading cause for injector failure and the failure of other major fuel injection components, such as the high-pressure fuel pump.

The aftermarket companies have created a robust sector dedicated to fixing the problems that faced the early versions of the LB7. Aside from the fuel issues, the LB7 is regarded as a very reliable and capable engine.

LB7 Quick Identification tips:
LB7 Engines used from 2001-2004
LB7 Injectors and injector harnesses under the valve covers.
LB7 The Fuel Injection Control Module (FICM) is located on the front of the passenger side valve cover.

Major Issues;
Lack of a factory lift pump
Fuel filter housing O-ring leaks
Water pump leaks
Overheating
Head gasket failure

LLY VARIANT

6.6L LLY Engine Vitals	
Displacement:	6.6L / 403 cu. in.
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, GMC Sierra HD
Introduced:	mid-2004 model year
Discontinued:	2006 model year
Predecessor:	LB7 Duramax V8
Successor:	LBZ Duramax V8
Assembly:	Moraine, Ohio, USA

GM 6.6L LLY V-8 Duramax Turbo Diesel Engine Vehicle Applications

Year	Make	Model	Transmission	Power (hp / kW) @ RPM	Torque (lb-ft / Nm) @ RPM
2004.5-2005	Chevrolet	Silverado HD	5-Speed Manual or 5-Speed Allison Automatic	310 / 520 @ 3000	520 / 705 @ 1600
2004.5-2005	GMC	Sierra HD	5-Speed Manual or 5-Speed Allison Automatic	310 / 520 @ 3000	520 / 705 @ 1600
2006	Chevrolet	Silverado HD	5-Speed Manual or 5-Speed Allison Automatic	310 / 605 @ 3000	605 / 820 @ 1800
2006	GMC	Sierra HD	5-Speed Manual or 5-Speed Allison Automatic	310 / 605 @ 3000	605 / 820 @ 1800

LLY VARIANT

GM 6.6L LLY V-8 Duramax Turbo Diesel Engine Specs	
Type	6.6L V-8 Turbo-Diesel
GM RPO Code	LLY
Displacement	403 ci
Valve Configuration	Overhead
Valves Per Cylinder	4
Assembly Site	Moraine, Ohio, USA
Valve Lifters	Mechanical roller
Firing Order	1 – 2 – 7 – 8 – 4 – 5 – 6 – 3
Bore x Stroke	4.055 in. or 103 mm x 3.897 in. or 99 mm
Fuel System	Direct injection with high-pressure common rail w/ Bosch CP3 pump
Fuel Type	Diesel
Fuel Tank Size:	26 Gallons
Maximum Powered Speed	3250 rpm
Emissions Controls	None
Block	Cast iron w/ deep skirt
Cylinder Head	Cast aluminum
Intake Manifold	Cast aluminum
Exhaust Manifold	Cast nodular iron with steel pipe extension
Main Bearing Caps	Cast nodular iron
Crankshaft	Forged steel
Camshaft	Steel
Connecting Rods	Forged Steel
Engine Oil Capacity	10 qt./9.5L w/ Filter
Engine Mass:	Approximately 835 pounds

LLY VARIANT

The LLY Duramax V8 engine was introduced during the middle of the 2004 model year, replacing the LB7 Duramax V8 engine.

The engine was used in the Chevrolet Silverado HD and the GMC Sierra HD midway through the 2004 model year until 2006 when GM replaced it with the LBZ version of the Duramax engine. At the beginning of the LLY's run, it produced 310 hp and 520 ft.-lbs.t of torque, and in the final year of production, the torque was increased to 605 ft.-lbs.

The LLY was also available as an option on 2006-2007 Chevrolet Express and GMC Savana vans. Power had to be restricted on these models to keep the vans' four-speed automatic transmissions from failure.

The LLY received a redesigned Variable Valve Timing (VVT) valvetrain, which enabled the engine to deliver torque at an astoundingly low 1,600 rpm. GM added a Variable Geometry Turbocharger (VGT) to improve throttle response and low-end power. Finally, GM also added an Exhaust Gas Recirculation (EGR) system and other emission control technology to lower tailpipe emissions.

The most significant difference between the LLY and its predecessor, the LB7, is that the LLY is fitted with a new system to control emissions. While this system did have its drawbacks, it proved to have better driveability and fewer pollutants.

GM did a pretty good job fixing the injection system problems with the LB7, but new problems arose altogether. Engine overheating was a big problem with the LLY, and the problem was most prevalent with vehicles used to tow heavy loads.

Causes of overheating ranged from improper cooling system maintenance, contaminated fuel, and restricted airflow to the cooling components.

LLY Quick Identification tips:
LLY Exposed injectors and injector harnesses.
LLY Variable Vane Turbocharger.
LLY Fuel Injection Control Module (FICM) is located on the passenger side valve cover.
LLYs EGR cooler is cylindrical in shape.

LBZ VARIANT

Duramax LBZ - Courtesy GM Corporation

6.6L LBZ Engine Vitals	
Displacement:	**6.6L / 403 cu. in.**
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, GMC Sierra HD
Introduced:	Mid-2006 model year
Discontinued:	2007 model year
Predecessor:	LLY Duramax V8
Successor:	LMM Duramax V8
Assembly:	Moraine, Ohio, USA

LBZ VARIANT

GM 6.6L LBZ V-8 Duramax Turbo Diesel Engine Specs	
Type	6.6L V-8 Turbo-Diesel
GM RPO Code	LBZ
Displacement	403 ci
Valve Configuration	Overhead
Valves Per Cylinder	4
Assembly Site	Moraine, Ohio, USA
Valve Lifters	Mechanical roller
Firing Order	1 – 2 – 7 – 8 – 4 – 5 – 6 – 3
Bore x Stroke	4.055 in. / 103 mm x 3.897 in. / 99 mm
Fuel System	Direct injection with high-pressure common rail w/ Bosch CP3 pump
Fuel Type	Diesel
Fuel Tank Size:	26 Gallons
Maximum Powered Speed	3250 rpm
Emissions Controls	Exhaust Gas Recirculation (EGR), Diesel Oxidation Catalyst (DOC)
Block	Cast iron w/ deep skirt
Cylinder Head	Cast aluminum
Intake Manifold	Cast aluminum
Exhaust Manifold	Cast nodular iron with steel pipe extension
Main Bearing Caps	Cast nodular iron
Crankshaft	Forged steel
Camshaft	Steel
Connecting Rods	Forged Steel
Engine Oil Capacity	10 qt./9.5L w/ Filter
Engine Mass:	Approximately 835 pounds

LBZ VARIANT

GM 6.6L LBZ V-8 Duramax Turbo Diesel Engine Vehicle Applications					
Year	**Make**	**Model**	**Transmission**	**Power (hp / kW) @ RPM**	**Torque (lb-ft / Nm) @ RPM**
2006-2007	Chevrolet	Silverado HD	Allison 1000 6-Speed Automatic or ZF S6-650 6-Speed Manual	360 / 270 @3200	650 / 881 @1600
2006-2007	GMC	Sierra HD	Allison 1000 6-Speed Automatic or ZF S6-650 6-Speed Manual	360 / 270 @3200	650 / 881 @1600

GM introduced the LBZ Duramax V8 engine midway through the 2006 model year when it replaced the LLY engine. The LBZ was used in the Chevrolet Silverado HD and the GMC Sierra HD pickup trucks through the model year 2007.

The LBZ was a nearly total re-engineered version of an already proven design of the Duramax V8 engine family. The redesign consisted of stronger connecting rods and new style pistons. GM also added a new high-pressure fuel injection pump along with improved emission control systems.

The engine produced a beefy 360 hp and 650 ft-lb of torque. The LBZ engine, coupled with the new Allison 1000 six-speed transmission , made the LBZ one of the most desirable Duramax V8 engines. Introduced midway through the 2006 model year, it replaced the LLY Duramax variant. The LBZ variant powered the Chevrolet Silverado HD as well as the GMC Sierra HD through 2007.

Due to the various improvements made to the LBZ variant, it quickly became one of the most desirable Duramax variants over all of its predecessors. These improvements included more simplified emission control systems.

Other improvements included:
- A more rigid engine block.
- Stronger connecting rods.
- It improved fuel injectors with a higher system maximum pressure, from 23,000 to 26,000 psi, and a larger intake manifold for the turbocharger.

The LBZ variant was not entirely free of emission controls; the Diesel Oxidation Catalyst (DOC) and the Exhaust Gas Recirculation (EGR) did inhibit performance and fuel economy as much as the later emission system and components.

The LBZ did, however, have its faults. The pistons were a central weak point of this variant of the Duramax engine. The cast aluminum components are prone to cracking, mainly when the engine's output is boosted. Wrist pin bushings were also a leading cause of failure to the LBZ variant.

There are two VIN codes for the LBZ. The first is VIN 2, produced in late 2005 and early 2006. The VIN 2 engine is mechanically and physically the same as the VIN D engine. Still, it utilizes LLY engine tuning due to the LBZ tuning taking longer to be EPA certified and placed into production.

The second is VIN D. This was introduced in 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 LLY version of the engine—the first appearance of the Duramax in the Express/Savanna vans.

The LBZ is one of the more sought-after Duramax engines due to its strength, reliability, and pre-emissions (DPF appeared on the next generation LMM in 2007).

LBZ VARIANT

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 lowers 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 a 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 complete cold-start combustion for reduced emissions.
· Improved glow plugs to 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 a 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 Quick Identification tips:
LBZ Exposed injectors and injector harnesses.
LBZ Variable Vane Turbocharger.
LBZ There is NO Fuel Injection Control Module (FICM).
LBZ EGR cooler is cylindrical.

NOTES

LMM VARIANT

Duramax LMM - Courtesy GM Corporation

6.6L LMM Engine Vitals	
Displacement:	6.6L / 403 cu. in.
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, GMC Sierra HD
Introduced:	2007 model year
Discontinued:	2010 model year
Predecessor:	LBZ Duramax V8
Successor:	LGH Duramax V8
Assembly:	Moraine, Ohio, USA

LMM VARIANT

GM 6.6L LMM V-8 Duramax Turbo Diesel Engine Specs	
Type	6.6L V-8 Turbo-Diesel
GM RPO Code	LMM
Displacement	403 ci
Valve Configuration	Overhead
Valves Per Cylinder	4
Assembly Site	Moraine, Ohio, USA
Valve Lifters	Mechanical roller
Firing Order	1 – 2 – 7 – 8 – 4 – 5 – 6 – 3
Bore x Stroke	4.055 in. / 103 mm x 3.897 in. / 99 mm
Fuel System	Direct injection with high-pressure common rail w/ Bosch CP3 pump
Fuel Type	Diesel
Fuel Tank Size:	26 Gallons
Maximum Powered Speed	3250 rpm
Emissions Controls	Exhaust Gas Recirculation (EGR), Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF)
Block	Cast iron w/ deep skirt
Cylinder Head	Cast aluminum
Intake Manifold	Cast aluminum
Exhaust Manifold	Cast nodular iron with steel pipe extension
Main Bearing Caps	Cast nodular iron
Crankshaft	Forged steel
Camshaft	Steel
Connecting Rods	Forged Steel
Engine Oil Capacity	10 qt./9.5L w/ Filter
Engine Mass:	Approximately 835 pounds

GM 6.6L LMM V-8 Duramax Turbo Diesel Engine Vehicle Applications					
Year	Make	Model	Transmission	Power (hp / kW) @ RPM	Torque (lb-ft / Nm) @ RPM
2007.5-2010	Chevrolet	Silverado HD	Allison 1000 6-Speed Automatic or ZF S6-650 6-Speed Manual	365 / 272 @3200	660 / 895 @1600
2007.5-2010	GMC	Sierra HD	Allison 1000 6-Speed Automatic or ZF S6-650 6-Speed Manual	365 / 272 @3200	660 / 895 @1600

GM released the LMM Duramax variant in response to tighter emission standards, and devised new technology to improve the engine. Engineers added an intake airflow valve that regulates gas temperatures. Engineers also designed a new cylinder head feature with more efficient and effective coolant passages.

Heat dissipation is critical to the proper operation of the DPF, EGR, and the ability to reduce nitrogen oxide (NOx) emissions. To help achieve this, GM added a much larger EGR cooler to the engine.

Despite the more stringent emission controls, the LMM still increased power by five horsepower and ten ft.-lbs.s of torque compared to its predecessor. Another refined bit of hardware featured on the LMM is a revised fuel injector design.

While the LBZ was equipped with a 7-hole, 158-degree injector nozzle, the LMM returned to a 6-hole nozzle design with a 159-degree range.

LMM VARIANT

One unfortunate similarity between the LMM and the LBZ is the infamous pistons, which are prone to cracking under heavy load.

Emission controls:
· Additional combustion control, including an even more efficient variable-geometry turbocharging system (VGT), cooled (enhanced) exhaust gas recirculation (EGR), and closed crankcase ventilation to reduce nitrogen oxides (NOx).
· Additional exhaust control, including oxidizing catalyst (OC) 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).

LMM Quick Identification tips:
LMM Exposed injectors and injector harnesses.
LMM Variable Vane Turbocharger.
LMM There is NO Fuel Injection Control Module (FICM).
LMM EGR cooler is rectangular.

LGH VARIANT

Duramax LGH - Courtesy GM Corporation

6.6L LGH Engine Vitals	
Displacement:	**6.6L / 403 cu. in.**
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, Chevrolet Express, GMC Sierra HD, GMC Savana
Introduced:	2011 model year
Discontinued:	2016 model year
Assembly:	Moraine, Ohio, USA

LGH VARIANT

GM 6.6L LGH Turbo Diesel V8 Duramax Engine Specs	
Type:	6.6L V8 Turbo Diesel Engine Duramax
Displacement:	6.6L (403 ci)
Engine Orientation:	Longitudinal
Compression ratio:	16.0:1
Valve configuration:	OHV
Valves per cylinder:	4 valves per cylinder
Assembly site:	DMAX Moraine, Ohio, USA
Valve lifters:	Mechanical roller
Firing order:	1 – 2 – 7 – 8 – 4 – 5 – 6 – 3
Bore x stroke:	103 mm x 99 mm
Maximum Engine Speed:	3000 RPM
Fuel system:	Direct injection diesel with high pressure common rail
Fuel Type:	Ultra-low sulfur diesel & B20 Biodiesel
Materials	
Block:	Cast iron
Cylinder head:	Cast aluminum
Intake manifold:	Cast aluminum
Exhaust manifold:	Cast nodular iron with steel pipe extension
Main bearing caps:	Cast nodular iron
Crankshaft:	Forged steel
Camshaft:	Steel
Connecting rods:	Forged steel, stress fractured
Additional features"	
Charge air cooling"	
Recommended oil-change interval:	Per the computerized Oil Life System (requires CJ-4 Engine Oil to Maximize Life)"
Recommended coolant change interval:	5 Years or 150,000 Miles
Emissions controls"	
Cooled Exhaust Gas Recirculation (EGR)"	
Selective Catalytic Reduction (SCR)"	
Diesel Particulate Filter (DPF)"	
Intake throttle"	
Capacities"	
Engine Oil (qt/L):	10/9.5

GM 6.6L LGH Turbo Diesel V8 Duramax Engine Vehicle Applications			
Vehicle	**Transmission**	**Power (hp / kW) @ RPM**	**Torque (lb-ft / Nm) @ RPM**
Chevrolet Express (Cargo, Pass, Cutaway)	6-Speed Auto (MYD-6L90)	260 / 194 @ 3100	525 / 712 @ 1600

LGH VARIANT

Designed purposely for use in the Chevrolet Express and GMC Savana, the Duramax LGH, like its corporate cousins, is a turbocharged 6.6L V-8. Rated at 335 hp and 685 ft.-lbs. for chassis cab applications and 260 hp and 525 ft.-lbs. for cargo and passenger vans, the LGH is slightly downrated compared to the contemporary LML, suiting the vans' reputation for longevity and preserving the Hydra-Matic six-speed automatic transmission.

The 6.6L Duramax V-8 was discontinued for the vans' 2017 model year, and GM promises it will replace the big diesel with a version of the 2.8L Duramax I-4 soon.

The 6.6L Turbo-Diesel V8 Duramax LGH is an engine produced by General Motors for full-size heavy-duty (HD) vans. Displacing 6.6 liters in a V8 configuration, the LGH is part of the Duramax engine family of turbo-diesel engines initially created with Isuzu.

It is mechanically similar to the 6.6L LML Duramax engine. However, it has a lower power rating and was utilized by 2010 – 2011 Chevrolet Silverado HD and GMC Sierra HD pickup trucks and Chevrolet Express and GMC Savana vans.

With nearly 1.3 million Duramax diesel engines in operation, no other automaker has as much diesel engine development experience in meeting the demands of the heavy-duty truck customer as General Motors.

The Duramax 6.6L turbo-diesel engine is robust, powerful, and efficient. Features such as common rail fuel injection and aluminum heads with a six-bolt-per-cylinder design have helped cement the Duramax's foundation years ago and continue to make the Duramax diesel a relevant product.

Engine highlights:
Cylinder Block and Rotating Assembly: the Duramax block features casting enhanced to support smoother and quieter engine operation.

It uses a robust cast-iron foundation known for its durability, with induction-hardened cylinder walls and five nodular iron main bearings. A die-cast aluminum lower crankcase strengthens the engine block and serves as the lower engine cover while also reducing the engine's overall weight.

Working within the cylinder block is a robust rotating assembly that features a forged steel crankshaft, forged steel connecting rods, and forged aluminum pistons. The crankshaft is surface-hardened by nitriding, a process widely acknowledged as the most effective means of limiting wear and ensuring durability.

Pistons: the pistons are redesigned without pin bushings to reduce reciprocating weight, which helps the engine rev quicker and responds more immediately to throttle changes. The connecting rods used with the pistons feature a smaller-diameter pin bore on the small end to support the strengthened pistons.

Piston-cooling oil jets are located at the bottom of the cylinder bores and spray engine oil on the bottom of the pistons. The extra lubrication cools the pistons, reducing friction and operational noise while bolstering the engine's durability.

Cylinder Heads: the Duramax diesel features an aluminum cylinder head design, with six head bolts per cylinder and four valves per cylinder. The aluminum material helps reduce the engine's overall weight, while the six-bolt design provides exceptional head-clamping strength – a must in a high-compression, turbocharged application.

2000-Bar Fuel System with Piezo Injectors: Duramax uses a common-rail direct injection fuel system. Piezo injectors allow more precise fuel metering, especially for minimal quantities of injected fuel, which leads to a smoother idle and lower combustion noise.

Variable Geometry Turbocharging System: a variable-vane turbocharger is employed on the Duramax 6.6L. The variable-geometry turbocharger delivers more power with lower exhaust emissions and no decrease in overall fuel efficiency.

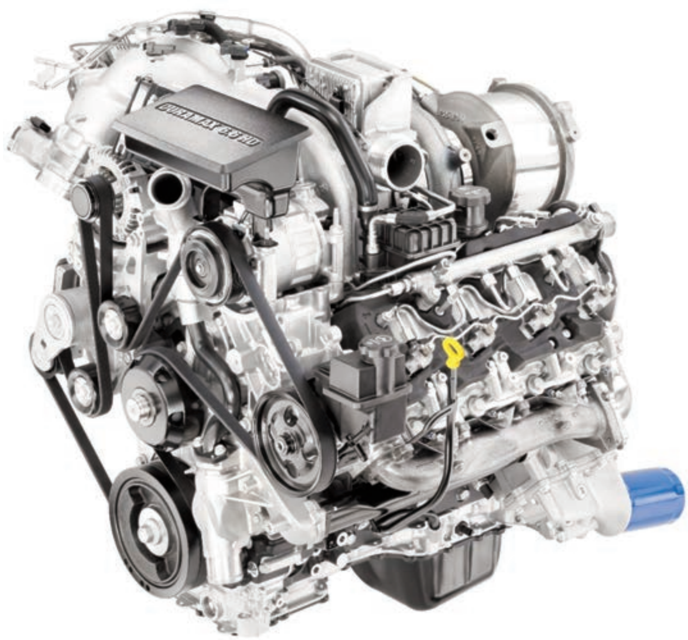
The system uses self-adjusting turbine vanes and sophisticated electronic controls to adjust boost pressure and exhaust backpressure automatically.
Emissions and Particulate Control Technology: The Duramax diesel features the latest emission control technology, making it the cleanest Duramax engine ever produced, with NOx emissions reduced by at least 63 percent in the LML version.

LGH VARIANT

B20 Biodiesel Capability: the LML version of the Duramax 6.6L turbo-diesel can run on B20 biodiesel, a fuel composed of 20 percent biodiesel and 80 percent conventional diesel.

B20 helps lower carbon dioxide emissions and lessens dependence on petroleum. It is a domestically produced, renewable fuel made primarily of plant matter — mainly soybean oil.

L5P VARIANT



Duramax L5P - Courtesy GM Corporation

6.6L L5P Engine Vitals	
Displacement:	**6.6L / 403 cu. in.**
Aspiration:	Natural
Vehicles:	Chevrolet Silverado HD, GMC Sierra HD
Introduced:	2017 model year
Discontinued:	–
Predecessor:	LML Duramax V8
Successor:	–
Assembly:	Moraine, Ohio, USA

GM 6.6L L5P V-8 Duramax Turbo Diesel Engine Vehicle Applications

Vehicle	Transmission	Power (hp / kW) @ RPM	Torque (lb-ft / Nm) @ RPM
2017-2022 Chevrolet Silverado HD (and newer)	Allison Transmission MW7-LCT 1000	445 / 322 @ 2800	910 / 1234 @ 1600
2017-2022 GMC Sierra HD (and newer)	Allison Transmission MW7-LCT 1000	445 / 322 @ 2800	910 / 1234 @ 1600

L5P VARIANT

Sharing only its bore and stroke dimensions with the Duramax engines of the past, the L5P is the first total redesign of the engine family, with changes aimed at improving fuel economy, durability, and emissions while increasing power to a tops-in-segment 445 hp and torque to a competitive 910 ft.-lbs.

The 6.6L Duramax L5P engine is manufactured at the GM Duramax plant in Moraine, Ohio, USA.

GM 6.6 Liter L5P V-8 Duramax Turbo Diesel Engine
The GM L5P Duramax is a turbo-diesel engine produced by General Motors in full-size heavy-duty (HD) pickup trucks.

Displacing 6.6 liters in a V-8 configuration, the L5P is part of a new generation of Duramax engines. It succeeds the 6.6L Duramax V-8 LML engine.

When the GM L5P engine debuted in the 2017 Chevrolet Silverado HD and 2017 GMC Sierra HD, it produced an SAE-certified 910 pound-feet of torque (1,234 Nm) and 445 horsepower (332 kW). Output remained the same for the next-generation 2020 Chevrolet Silverado HD and 2020 GMC Sierra HD models.

Notably, the Duramax 6.6L represents a next-generation redesign that features an all-new, more robust cylinder block and rotating assembly, as well as a new, GM-developed control system.

The engine’s production of low-rpm torque — a Duramax Diesel signature — hasn’t changed: the L5P offers 90 percent of peak torque at a low 1,550 rpm and sustains it through 2,850 rpm, an attribute that contributes to the strong, confident pulling power at low speeds of the vehicles in which it powers.

The new L5P also features a new camshaft profile and improved cylinder head design; a new electronically controlled, variable-vane turbocharger allows the engine to produce more power with lower exhaust emissions.

The engine’s advanced variable-vane mechanism allows greater exhaust temperature capability, enabling the engine to achieve higher power at lower cylinder pressure.

Additionally, a new, patent-pending vehicle air intake system with a functional hood scoop drives cool, dry air into the engine for sustained performance and cooler engine temperatures during difficult conditions, such as trailering (towing) on steep grades.

Cooler air helps the engine run better under load, significantly when engine and transmission temperatures rise quickly. This enables the Duramax to maintain more power and vehicle speed when trailering in the most demanding conditions.

The upgrades provide increases in real-world towing experience for the heart of the Heavy Duty pickup truck market — with 89 percent of all HD customers purchasing trucks rated less than 25,000 pounds of towing capacity. For these customers, the new Duramax diesel in the 2017 Chevrolet Silverado HD and 2017 GMC Sierra HD offers:

· Unladen, 0-60 mph acceleration in as quick as 7.1 seconds in the GM 2500HD Crew Cab 4WD models, seven-tenths of a second quicker than the last-generation model.

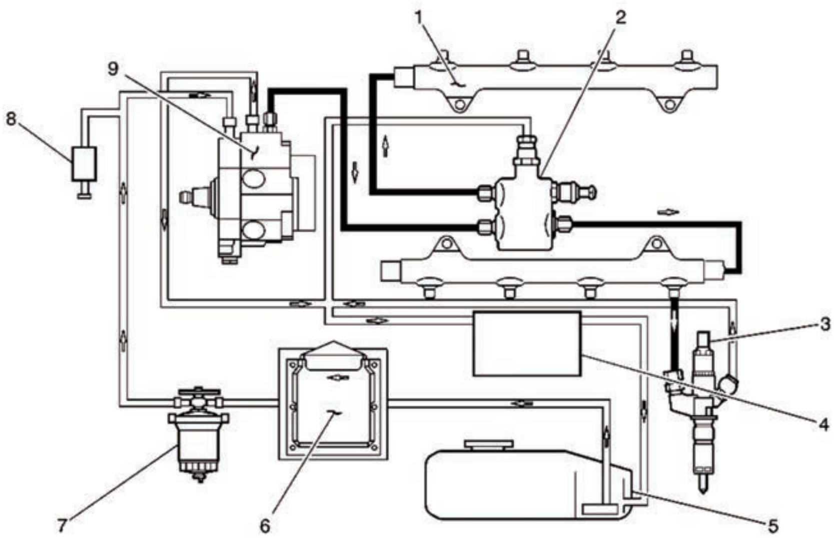
· Towing 10,000 pounds, acceleration from 50 to 70 mph in 10.6 seconds in the 2500HD regular cab 4WD models, 1.5 seconds quicker than the last-generation model.

· When towing 23,000 pounds in 110-degree Fahrenheit ambient temperature, the Silverado and Sierra 3500HD Crew Cab 2WD with DRW climbs the Davis Dam grade 40 seconds quicker than the last-generation model.

“The new Duramax delivers impressive output, but what customers will appreciate the most is an improved driving experience,” said Eric Stanczak, Silverado chief engineer. “It delivers quicker acceleration in virtually all measures, more confidence when trailering up a steep grade, better engine braking on a descent, and more refined noise levels cruising on the highway.”

NOTES

EARLY DURAMAX FUEL SYSTEMS



COMPONENT ID	COMPONENT
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

Duramax LB7 Fuel System Diagram - Courtesy GM Corporation

The Fuel Tank
The fuel tank stores the diesel fuel supply. A mechanical fuel injection pump, located below the engine intake, draws fuel through the Fuel Injector Control Module (FICM) and the fuel filter and is used as a coolant by the FICM.

The engine control module (ECM) controls the fuel pump output and provides fuel at the pressure needed by the fuel injectors. The fuel injectors supply fuel directly to the combustion chambers of the engine. A separate pipe returns unused fuel through the fuel cooler and back to the fuel tank.

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 blown head gaskets in some situations. 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.

Duramax LB7 Primary Fuel Tank

GM issued a warranty for this after the fact for injectors, which now have seven-year/200,000-mile coverage.

The primary fuel tank is located on the left side of the vehicle. On vehicles equipped with dual fuel tanks, the auxiliary fuel tank is located in the vehicle's rear. The fuel tanks are each held in place by two metal straps attached to the frame. The fuel tanks are molded from high-density polyethylene.

A couple of issues can arise when aftermarket fuel tanks are plumbed into the factory fuel filler.

EARLY DURAMAX FUEL SYSTEMS

If the aftermarket tank is situated above the factory fuel tank and allowed to gravity feed, it can sometimes cause the fuel filler cap to leak through its vent. Also,

if the truck is driven continuously for long enough without the fuel level in the factory tank dropping, the ECM can set a trouble code for the fuel level sensor, usually a P0461.

The ECM expects the fuel level sensor to drop over a certain distance. If a fuel level sensor DTC sets, the fuel gauge will default to always showing low fuel.

The dual tank system would work fine in a perfect world, but they have proven to be very fussy. An ECM programming update from GM addresses most of the issues; however, the most significant service issue that we still deal with results from operators neglecting to shut down the engine while fueling.

While it may be illegal and unsafe, many people in cold climates fuel their trucks with the engine running. When the active ECM sees one fuel sender rising with the addition of fuel, it can get confusing, set a DTC, and shut down the fuel transfer system and fuel gauge.

As a result, the truck will run off the fuel in the primary fuel tank only, and the driver will be left with no indication of how much fuel is left in the tank.

Fuel Level Sender Assembly
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.

Duramax LB7 Fuel Level Sender Assembly

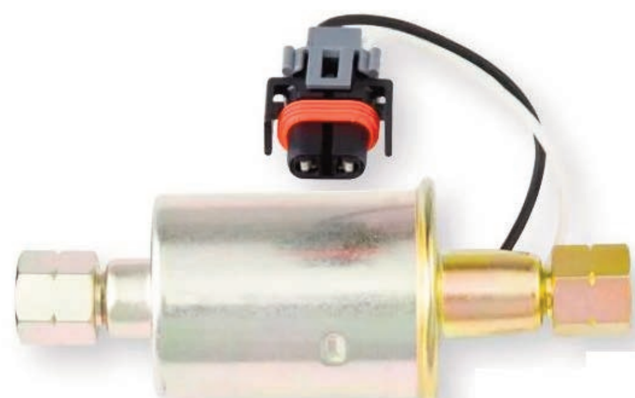
The fuel level sensor contains a variable resistor that changes resistance to the amount of fuel in the fuel tank.

The ECM sends the fuel level information to the instrument panel (IP) cluster via the Class II circuit. If applicable, this information is used for the IP fuel gauge and the low fuel warning indicator. The ECM also monitors the fuel level input for various diagnostics.

The fuel strainer attaches to the lower end of the fuel sender. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick fuel.

The fuel strainer is self-cleaning and typically requires no maintenance. Fuel stoppage at this point indicates that the fuel tank contains an abnormal amount of sediment.

Lift 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 ECM.



Duramax LB7 Electric Fuel Pump

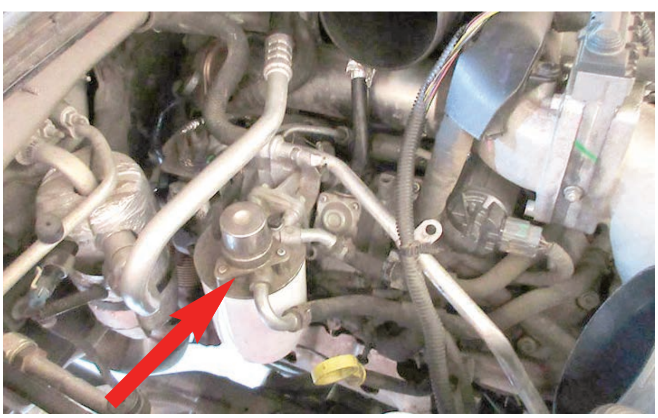
Fuel is transferred from the auxiliary fuel tank to the primary fuel tank in order to ensure all of the usable fuel volume is available to the fuel injection pump.

High Pressure Fuel Pump
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.

EARLY DURAMAX FUEL SYSTEMS

Duramax LB7 High Pressure Fuel Pump

Fuel pressure is regulated by a valve on the inlet of the fuel pump, controlled by the ECM. Excess fuel from the fuel injection pump returns to the fuel tank through the fuel return pipe and a fuel cooler.



Duramax LB7 Fuel Filter Assembly

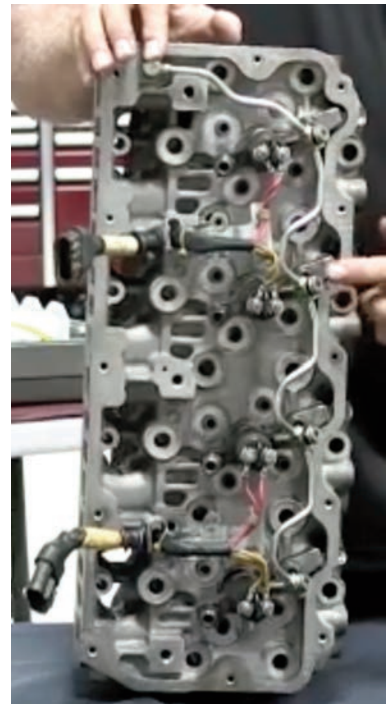
Fuel Filter Housing

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.

Fuel Feed and Return

The fuel feed pipe carries fuel to the fuel injector control module from the fuel tank. The fuel return pipe carries fuel from the fuel rail assemblies, located under the cylinder head cover as illustrated, back to the fuel tank.

The fuel exits the cylinder head from a small port on the cylinder head. The return port on the drivers' side



Duramax LB7 Cylinder Head Fuel Return Line

Duramax LB7 Cylinder Head Fuel Return Port

cylinder head is at the front and at the rear of the passenger side cylinder head. This is important to know if you intend on performing the return fuel flow test.

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 steel with sections of rubber hose covered with braiding.

EARLY DURAMAX FUEL SYSTEMS

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

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. Arrows are located on the assembly, indicating fuel flow into the filter and out.

A check ball is located within the fuel filter. This check ball seals the system when the engine is shut off. This helps keep a prime of fuel within the system, shortening cranking duration.

O-rings seal the connections in the fuel system. Fuel system O-ring seals are made of unique material. Service the O-ring seals with the correct service part.

Fuel Filter Housing Heater and Primer
The fuel filter housing also incorporates a fuel heater indicated by the wiring harness leading to the heater. A priming pump is located at the top of the assembly. The fuel filter priming pump can also be used as a great diagnostic tool if you have a long crank or no start condition.

Duramax LB7 Fuel Filter and Heater Housing

If you have a long crank or no start condition, have a helper crank over the engine and observe the primer pump at the top of the filter housing. If the pump compresses during cranking, this indicates a fuel restriction somewhere in the system.

Duramax LB7 Fuel Primer Fully Open

Duramax LB7 Fuel Primer Compressed

Fuel Filter Canister, WIF Sensor and Air Bleeder Screw
Attached to the housing is the screw on fuel filter canister. Replacement fuel filter canisters come in many different sizes, filtering capacity, manufacturers and quality.

EARLY DURAMAX FUEL SYSTEMS

When inspecting the fuel system for a restriction, don't dismiss the fuel filter canister if it appears to be new or just replaced.

A lower quality filter or a filter with limited filtering capacity can get filled with debris and plug in a few days if the system is contaminated.

Duramax LB7 Fuel Filter Canister & WIF Sensor

Higher quality filters have a higher quality element and the ability to filter a greater volume of fuel. It could be weeks or even months if the higher quality filter gets clogged causing a fuel restriction.

At the bottom of the filter is the canister, where the Water In Fuel (WIF) sensor is located. The WIF sensor has been a constant problem with the LB7. One of the major causes of leaks and failure of the WIF sensor is the number of times the sensor is removed from an old fuel filter canister and installed into the new filter canister.

Lower quality fuel filter canisters can sometimes have defects or the wrong size threads for the sensor.

Excessive removal and installation of the WIF sensor into a low-quality filter or damaged sensor threads can cause leaks and failure to the sensor.

For example, consider replacing the entire sensor if you find the sensor screws into the filter canister either too easy or too hard. The best way to avoid any problems we have discussed with the fuel filter canister or WIF sensor is to use OEM replacement parts when servicing the fuel filter assembly.

A plastic bleeder screw is located at the top of the filter housing. This bleeder screw is used to bleed air from the system. Keep an eye on this screw. The filter

Duramax LB7 Fuel Filter Housing Air Bleeder Screw

housing operates in a vacuum when the engine is not running. If the screw is damaged, loose, or the O-ring is missing or damaged, air can leak into the system, causing starting and driveability problems.

Fuel Junction Block, Fuel Rails and Feed Lines
The fuel junction block is located between the left and right fuel rail assemblies. The fuel junction block consists of the following components:
- The fuel rail pressure sensor
- The fuel pressure relief valve

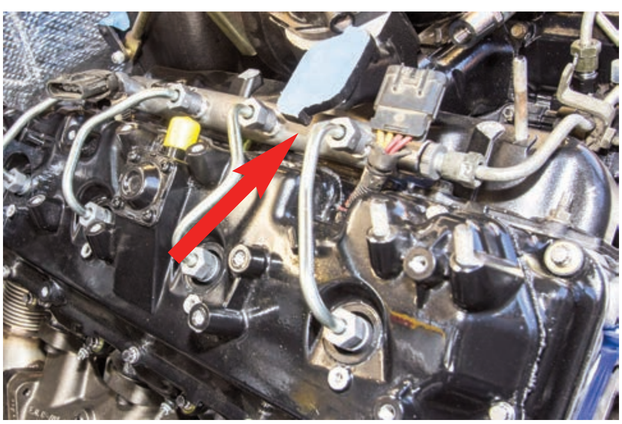
The fuel rail pressure sensor gives the ECM an indication of fuel pressure. The ECM uses this information to regulate fuel pressure, by commanding the fuel pressure regulator open or closed on the inlet of the fuel injection pump.

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.

EARLY DURAMAX FUEL SYSTEMS

Duramax LB7 Fuel Junction Block

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

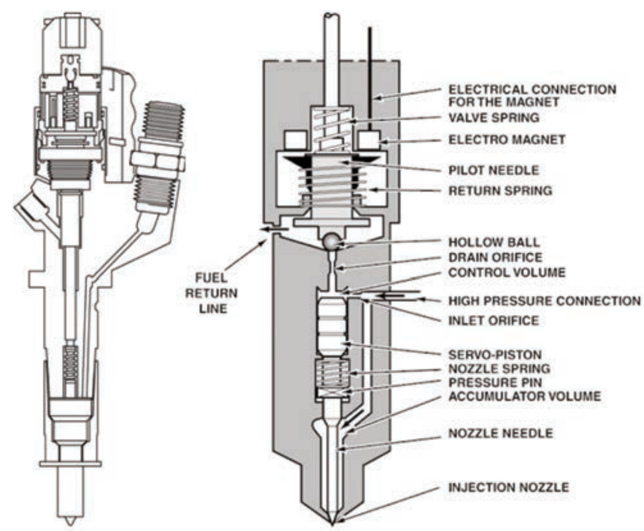


Duramax LB7 Fuel Rail Assembly

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

Duramax LB7 Fuel Injector Delivery Line

Duramax LB7 Fuel Injector



Duramax LB7 Fuel Injector (Cutaway)

Fuel Injectors and Injector Sleeves

The fuel injector is a solenoid device controlled by the Fuel Injection Control Module (FICM) that meters pressurized fuel to a single-engine cylinder. The fuel injectors are located under the rocker covers.

The 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.

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 engine's compression stroke.
When servicing the injector, you will need to drain the coolant from the engine because the injector fits into a sleeve, as illustrated above, that uses coolant to keep the injector cool.

EARLY DURAMAX FUEL SYSTEMS

Duramax LB7 Fuel Injector Sleeve

The two o-rings at the top of the sleeve are used as seals to keep the coolant from leaking into the combustion chamber. One of the main problems with this design is that when you remove or replace the injector, the entire sleeve will come out.You run the risk of coolant running into the cylinder and contaminating the system when this happens.

Always drain the coolant if you intend on removing or replacing the fuel injectors. Depending on the truck's mileage and the condition of the coolant, this could be an opportunity to sell a coolant service to the customer.

In high mileage engines, removing the injector sleeve can be problematic even if you have a special tool from GM.

For example, you can use a tap or threaded bolt inserted into the sleeve and remove it. Also, if you are replacing injectors in a high mileage engine, it is recommended that you replace the sleeves as well for good measure.

Tech Tip: Removing the injectors requires removing the valve cover to gain access. Use hand tools to remove the valve covers instead of air or power tools. The heads of these bolts can and do quickly get rounded if too much force is used.

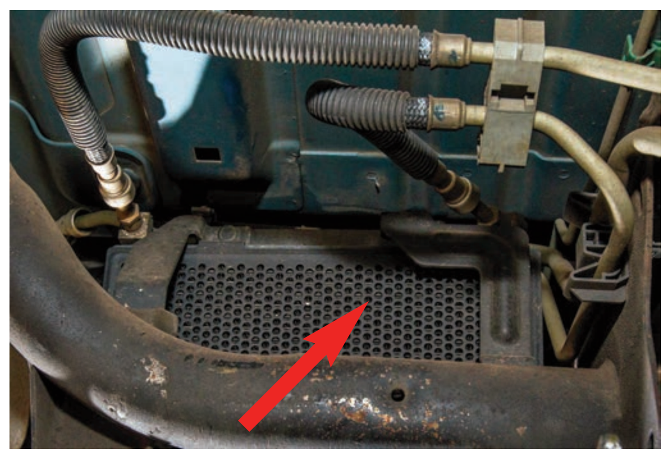
Also, if the sleeve has come out or been removed, make sure you replace the o-rings on the sleeve and ensure it is seated into the passage correctly.

Be sure to torque the injector hold down to the correct specification as this is the only bolt that secures both the injector and injector sleeve to the cylinder head.

If the injector sleeve is not fitted correctly or the injector has not been torqued to specification, coolant can leak into the cylinder causing significant problems.

Fuel Cooler

The fuel system cooler is located in front of the primary fuel tank. The fuel system cooler cools the fuel before it is returned to the fuel tank.



Duramax LB7 Fuel Cooler (Installed)

Fuel Injection Control Module (FICM)

The Fuel Injection Control Module (FICM) is located on a mounting bracket on the front passenger side of the engine.

The FICM was originally used to provide the high voltages and current that were necessary to operate the fuel injectors. The injectors on the LB7 variant need a trigger of approximately 93 volts at 18 amps to initiate the injection process, a higher current load and 12 amps is used to sustain the injection process.

The electronics used to perform these operations would get very hot requiring additional cooling.

Under normal operation, the FICM generates a considerable amount of heat. Diesel fuel flows through the FICM providing cooling.

EARLY DURAMAX FUEL SYSTEMS

Duramax LB7 FICM

The FICM will also provide a pre-heating condition to the diesel fuel in cold climate conditions.

The FICM reports information to the ECM using a dedicated communication BUS which is a two-wire system known as a Controller Area Network BUS (CAN-BUS). The ECM uses dedicated wires for each injector and uses electrical pulses through those wires to command the FICM telling it which injector(s) to fire.

Some of the most common fault issues result from the wire harness chafing around the mounting brackets. When the harness becomes worn and the exposed wires make contact with the brackets, the engine will begin to run rough, and multiple injector DTCs will set illuminating the MIL.

To fix this problem, remove the tie straps that hold down the wire harness to the bracket, inspect the wires for damage or wear and repair or replace as necessary.

In certain circumstances, the FICM will leak fuel from the wire harness connection. When this happens, the vehicle will suffer a no-start condition. A vacuum is created, drawing air and fuel through the connectors. This creates air pockets in the fuel.

Another significant problem with the FICM is the component's design and its location in relation to the fuel flow within the system. Fuel flows through the FICM in a "U" shaped channel. This U-shaped channel allows debris and asphaltenes to collect at the bottom of the channel, causing a fuel restriction. Furthering the problem, the fuel filter is located AFTER the FICM.

In later designs, the fuel filter is located BEFORE the FICM, and the U-shaped channel has been deleted, allowing the fuel to flow straight through the FICM.

EARLY DURAMAX FUEL SYSTEM SAMPLE TESTS

Below is an air leak diagnostic test for a 2004 Duramax LB7 engine. While this test is typical and representative of most Duramax engines except for the L5P, we recommend you perform the correct test for the engine variant you are working on

Air Leak Diagnostics (low pressure side)

1. Install the Vacuum Gauge to the fuel system service port on the right front side of the engine.
2. Remove the air duct from the air cleaner assembly to the turbo inlet.
3. Remove the generator for visibility of the fuel supply lines.
4. Prime the fuel system until 10 psi is indicated on the gauge. Use minimum of 10 pumps.
5. Check for external fuel leaks between the fuel filter assembly and the fuel injection pump.
6. If fuel is leaking externally, replace or repair the leaking component.
7. If no external fuel leaks are found, reprime the fuel system until 10 psi is indicated on the vacuum gauge.
8. If the fuel pressure drops from 10 psi to 2 psi in less than 1 minute, NO leak is detected.
9. If the fuel pressure drops from 10 psi to 2 psi in more than 1 minute, locate the leak in the low pressure side of the fuel system and repair as necessary.

Fuel Pressure Regulator

Fuel Pressure Regulator Graphing

1. Set up the scan tool in the following format:
    a. Select the Data Display on the scan tool.
    b. Select Engine Data 1.

EARLY DURAMAX FUEL SYSTEM SAMPLE TESTS

c. Select the More softkey 2 times.

d. Select the Live Plot softkey.

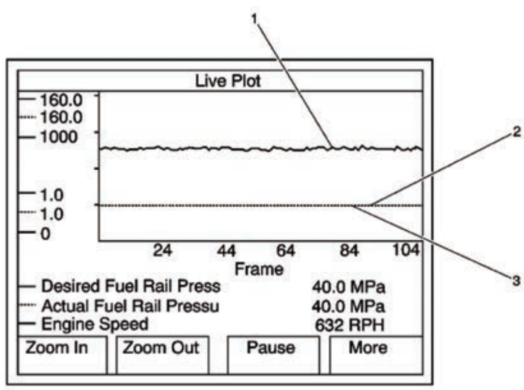
e. Select the Engine Speed, Actual Fuel Rail Pressure, and Desired Fuel Rail Pressure parameters by highlighting each parameter and depressing the ENTER softkey.

f. Select the Accept softkey.

g. Select the More softkey, then select the Change Min/Max softkey.

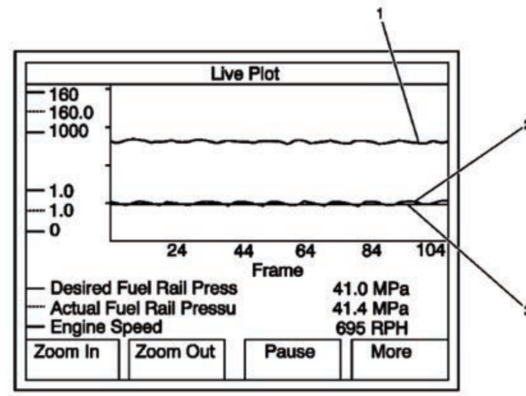
h. Select the More softkey, and adjust the parameters to the following Min/Max ranges:

2. The Engine Speed Min/Max range is 0 to 1000 RPM.
3. The Actual Fuel Rail Pressure Min/Max range is 1.0 to 160 MPa.
4. The Desired Fuel Rail Pressure Min/Max range is 1.0 to 160 MPa.
5. Start and idle the engine.



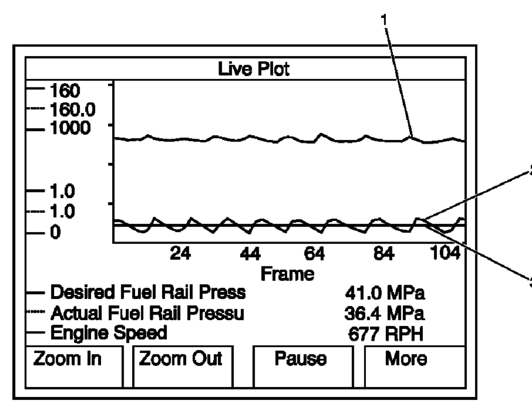
(1)	Engine Speed
(2)	Actual Fuel Rail Pressure
(3)	Desired Fuel Rail Pressure

Good Fuel Pressure Regulator Graph, 0 Miles



(1)	Engine Speed
(2)	Actual Fuel Rail Pressure
(3)	Desired Fuel Rail Pressure

Good Fuel Pressure Regulator Graph, 26K Miles



(1)	Engine Speed
(2)	Actual Fuel Rail Pressure
(3)	Desired Fuel Rail Pressure

Fuel Pressure Regulator Graph, Surging

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (AT)

Below is a fuel injector balance test for a 2004 Duramax LB7 engine. While this test is typical and representative of most Duramax engines except for the L5P, we recommend you perform the correct test for the engine variant you are working on

Fuel Injector Balance Test with Tech 2

Step 1 (With Automatic Transmission)
Did you perform the Diagnostic System Check – Engine Controls?
YES: Go to Step 2
NO: Perform the Diagnostic System Check on the Engine Control System and repair as necessary.

Step 2 (With Automatic Transmission)
Are any DTCs set other than P0300, P0301–P0308?
YES: Diagnose and repair DTCs as necessary and repeat the test.
NO: Go to Step 3

Step 3 (With Automatic Transmission)
Does the customer concern occur ONLY at idle or during tip-in acceleration off-idle?
YES: Go to Step 4
NO: Go to Step 6

Step 4 (With Automatic Transmission)
1. Start and run the engine until the engine coolant temperature is more than 82°C (180°F).
2. Turn OFF all accessories.
3. Hold the brake pedal in the fully applied position. A hiss will be noticeable when the brake is fully applied.
4. Place the transmission in Drive.
5. Idle the engine for more than 30 seconds.
6. Record the Balancing Rate Cyl.1–8 parameters from the scan tool while the engine is at idle speed.
7. Repeat above steps 2–6 with the transmission in Neutral.
Are all of the Balancing Rate parameters within the first specified range in Drive, and the second specified range in Neutral?
–6 mm^3 and +6 mm^3
–4 mm^3 and +4 mm^3
YES: Go to Step 6
NO: Go to Step 5

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (AT)

Step 5 (With Automatic Transmission)
Graph the Fuel Pressure Regulator. Refer to Fuel Pressure Regulator Graphing in this section.
Is the fuel pressure regulator graph normal?
YES: Go to Step 7
NO: Go to Step 9

Step 6 (With Automatic Transmission)
Important: The fuel Cylinder Power Balance Test must be performed under the conditions for which the concern occurred. The concern must be duplicated during the test.
Important: Do not operate the cruise control during this test. Cruise control reactivation after the test may cause a brief extreme increase in engine speed.
Observe the cylinder power contribution or other customer concern.
Perform the Cylinder Power Balance Test in Special Functions.
Do any of the cylinders indicate a different cylinder power contribution than the others, or lessen the customer concern?
YES: Go to Step 7
NO: System OK

Step 7 (With Automatic Transmission)
Important: A fuel injector leak into the combustion chamber may result in mechanical damage to the cylinder. If any fuel spray comes out of a glow plug hole during the compression test, replace the fuel injector of the affected cylinder.
Perform the Engine Compression Test.
Do any of the cylinders have low compression?
YES: Diagnose and repair cause of low compression. Repeat the test.
NO: Go to Step 8

Step 8 (With Automatic Transmission)
Important: Refer to Injection System Components in Engine Controls Component Views. Failure to correctly identify the cylinder positions may result in the replacement of the wrong fuel injector.
Replace the fuel injectors on the cylinders that had poor cylinder power contribution, high balance rates, or a noise/smoke change.
Did you complete the replacements?
YES: Go to Step 10
NO: Test complete.

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (AT)

Step 9 (With Automatic Transmission)
Replace the fuel pressure regulator. Refer to Fuel Pressure Regulator Replacement.
Did you complete the replacement?
YES: Go to Step 10
NO: Test complete.

Step 10 (With Automatic Transmission)
Operate the vehicle under the conditions in which the concern occurred.
Does the system operate normally, with no DTCs or symptoms?
YES: System OK
NO: Diagnose and repair DTCs according to GM test methods.

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (MT)

Step 1 (With Manual Transmission)
Did you perform the Diagnostic System Check–Engine Controls?
YES: Go to Step 2
NO: Perform the Diagnostic System Check on the Engine Control System and repair as necessary.

Step 2 (With Manual Transmission)
1. Start and run the engine until the engine coolant temperature is more than 82°C (180°F).
2. Turn OFF all accessories.
3. Hold the brake pedal in the fully applied position. A hiss will be noticeable when the brake is fully applied.
4. Idle the engine for more than 30 seconds.
5. Record the Balancing Rate Cyl.1–8 parameters from the scan tool while the engine is at idle speed.
6. Are at least 5 of the Balancing Rate parameters more than the specified value?
Specified value +4 mm^3
YES: Diagnose and repair the flywheel.
NO: Go to Step 3

Step 3 (With Manual Transmission)
Are any DTCs set other than P0300, P0301-P0308?
YES: Diagnose and repair DTCs as necessary and repeat the test.
NO: Go to Step 4

Step 4 (With Manual Transmission)
Does the customer concern occur ONLY at idle or during tip-in acceleration off-idle?
YES: Go to Step 5
NO: Go to Step 7

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (MT)

Step 5 (With Manual Transmission)
1. Start and run the engine until the engine coolant temperature is more than 82°C (180°F).
2. Turn OFF all accessories.
3. Hold the brake pedal in the fully applied position. A hiss will be noticeable when the brake is fully applied.
4. Idle the engine for more than 30 seconds.
5. Record the Balancing Rate Cyl.1–8 parameters from the scan tool while the engine is at idle speed.
6. Are all of the Balancing Rate parameters within the specified range?
Specified Range: –4 mm^3 and +4 mm^3
YES: Go to Step 7
NO: Go to Step 6

Step 6 (With Manual Transmission)
Graph the Fuel Pressure Regulator. Graph the Fuel Pressure Regulator. Refer to Fuel Pressure Regulator Graphing in this section.
Is the fuel pressure regulator graph normal?
YES: Go to Step 8
NO: Go to Step 10

Step 7 (With Manual Transmission)
Important: The fuel Cylinder Power Balance Test must be performed under the conditions for which the concern occurred. The concern must be duplicated during the test.
Important: Do not operate the cruise control during this test. Cruise control reactivation after the test may cause a brief extreme increase in engine speed.
Observe the cylinder power contribution or other customer concern.
Perform the Cylinder Power Balance Test in Special Functions.
Do any of the cylinders indicate a different cylinder power contribution than the others, or lessen the customer concern?
YES: Go to Step 8
NO: System OK

EARLY DURAMAX FUEL INJECTOR BALANCE TESTS (MT)

Step 8 (With Manual Transmission)
Important: A fuel injector leak into the combustion chamber may result in mechanical damage to the cylinder. If any fuel spray comes out of a glow plug hole during the compression test, replace the fuel injector of the affected cylinder.
Perform the Engine Compression Test.
Do any of the cylinders have low compression?
YES: Diagnose and repair cause of low compression and repeat the test.
NO: Go to Step 9

Step 9 (With Manual Transmission)
Important: Refer to Injection System Components in Engine Controls Component Views. Failure to correctly identify the cylinder positions may result in the replacement of the wrong fuel injector.
Replace the fuel injectors on the cylinders that had poor cylinder power contribution, high balance rates, or a noise/smoke change.
Did you complete the replacements?
YES: Verify repair by repeating the test.
NO: Go to Step 11

Step 10 (With Manual Transmission)
Replace the fuel pressure regulator.
Did you complete the replacement?
YES: Verify repair by repeating the test
NO: Go to Step 11

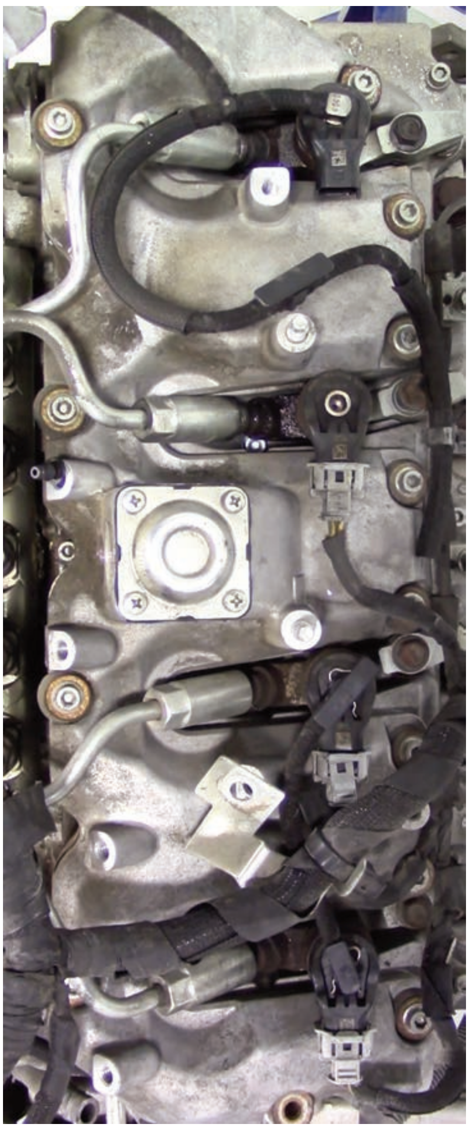
Step 11 (With Manual Transmission)
Operate the vehicle under the conditions in which the concern occurred.
Does the system operate normally, with no DTCs or symptoms?
YES: System OK
NO: Diagnose and repair the DTC or symptom and repeat the test.

NOTES

MAJOR CHANGES THROUGH THE YEARS

Injector Accessibility
GM solved the widespread injector issues that ravaged the LB7. Not only were the injector issues cumbersome to diagnose, repairing the faults was just as problematic.

This problem was solved by installing a newly designed injection system that was external to the cylinder head as illustrated below.

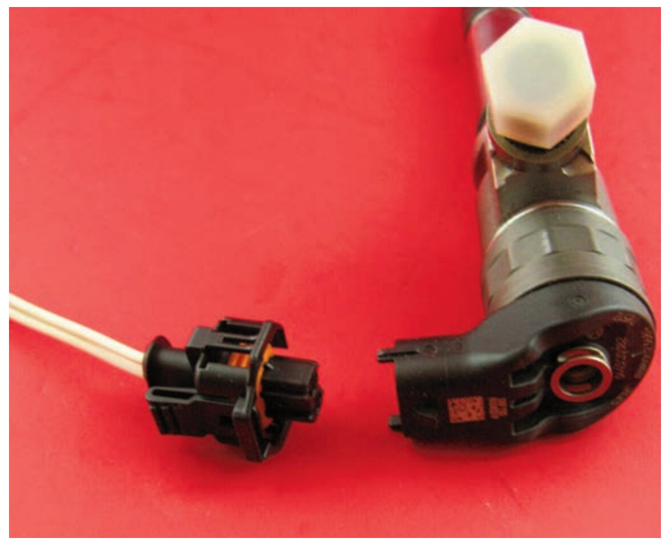


Injectors, Fuel Lines and Harness Accesibility

The re-design to gain access to the injectors was a huge accomplishment, but it comes with one drawback that you need to know about. The drawback is the new problem of injector harness chafing.

Vehicles that have been driven in severe conditions or with high mileage will suffer from injector harness chafing. The most common faults are short-to-ground conditions. You may also see high resistance on the injector output circuit.

Tracking the problem down can be tedious, but you can usually repair the fault without replacing the entire injector harness using a replacement pigtail connector, as illustrated below.



New Pig Tail Replacement Injector Harenss

The engine control module (ECM) supplies voltage to each fuel injector on the injector positive voltage control circuits.

The ECM energizes each fuel injector by grounding the control circuit of that fuel injector. The ECM monitors the status of the injector positive voltage control circuits and the fuel injector control circuits.

The injectors are separated into the following four groups:

- Group 1–DTC P2146 with injectors 1 and 4
- Group 2–DTC P2149 with injectors 6 and 7
- Group 3–DTC P2152 with injectors 2 and 5
- Group 4–DTC P2155 with injectors 3 and 8

MAJOR CHANGES THROUGH THE YEARS

Most common DTCs pertaining to chafed harnesses.

Fuel Injector Circuits	Short to Ground	High Resistance	Open	Short to Voltage
Fuel Injector Positive Voltage Control Group 1	P2146[2]	P2146	P0201, P0204[1]	P0201, P0204, P2146
Fuel Injector Positive Voltage Control Group 2	P2149[2]	P2149	P0206, P0207[1]	P0206, P0207, P2149
Fuel Injector Positive Voltage Control Group 3	P2152[2]	P2152	P0202, P0205[1]	P0202, P0205, P2152
Fuel Injector Positive Voltage Control Group 4	P2155[2]	P2155	P0203, P0208[1]	P0203, P0208, P2155
Fuel Injector 1 Control	P0201, P0204, P2146	P2146	P0201	P0201
Fuel Injector 2 Control	P0202, P0205, P2152	P2152	P0202	P0202
Fuel Injector 3 Control	P0203, P0208, P2155	P2155	P0203	P0203
Fuel Injector 4 Control	P0201, P0204, P2146	P2146	P0204	P0204
Fuel Injector 5 Control	P0202, P0205, P2152	P2152	P0205	P0205
Fuel Injector 6 Control	P0206, P0207, P2149	P2149	P0206	P0206
Fuel Injector 7 Control	P0206, P0207, P2149	P2149	P0207	P0207
Fuel Injector 8 Control	P0203, P0208, P2155	P2155	P0208	P0208
[1] Misfire DTCs may also set.				
[2] Injector DTCs may also set.				

Circuit and system testing
Important: If you cannot duplicate the condition, operate the vehicle within the conditions for running the DTC.

You may also operate the vehicle within the conditions you observed from the Freeze Frame/Failure Records.

1. Observe the Balancing Rate parameters with a scan tool. The normal reading should be between +4 mm^3 and –4 mm^3 at idle and between +6 mm^3 and – 6 mm^3 in the drive. With the engine running at idle, the Actual Fuel Rail Pressure should be close to the Desired Fuel Rail Pressure.

2. Engine running, observe the DTC information with a scan tool; DTCs P2146, P2149, P2152, or P2155 should not be set.

3. Operate the vehicle within the conditions for running the DTC; you may also operate the vehicle within the conditions you observed from the Freeze Frame/Failure Records data.

Fuel Injector Group DTC set
1. Turn OFF the ignition. Allow 60 seconds for the ECM to power down.

2. Disconnect the ECM connector.

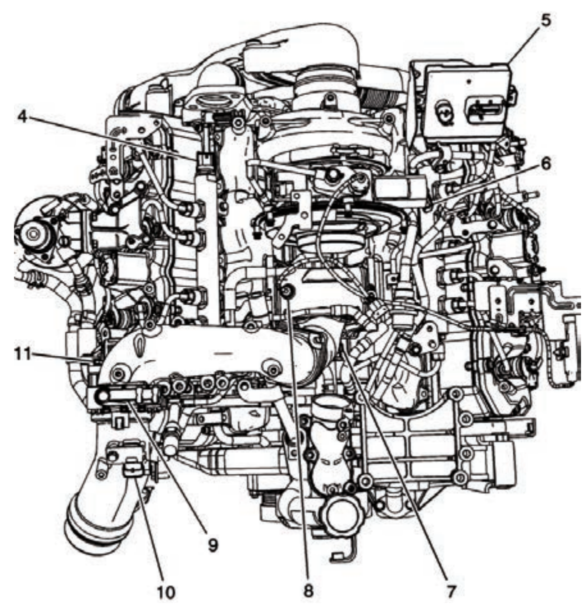
MAJOR CHANGES THROUGH THE YEARS

3. Connect a test lamp between the fuel injector positive voltage control circuit and battery voltage.
· If the test lamp illuminates, test the fuel injector positive voltage circuit for a short to ground.
· Test the fuel injector positive voltage control circuit and the fuel injector control circuit for high resistance.
· Test the affected fuel injector for high resistance.
· If all circuits test normal, replace the ECM.

Fuel Injector Group DTC and Fuel Injector DTCs set
1. Turn OFF the ignition. Allow 60 seconds for the ECM to power down.
2. Disconnect the ECM connector.
3. Connect a test lamp between the fuel injector positive voltage control circuit and a ground.
· If the test lamp illuminates, test the fuel injector positive voltage control circuit for short to voltage.
· Connect a test lamp between the affected fuel injector control circuit and battery voltage.
· If the test lamp illuminates, test both fuel injector control circuits of the affected group for a short to ground.
· Test the affected fuel injector for high resistance.
· If all circuits test normal, replace the ECM.

Enhanced Turbocharger
The turbocharger for this system has vane position control by the engine control module (ECM). The vanes are controlled to vary the amount of boost pressure. Thus, the boost pressure can be controlled independently of engine speed.

New Enhanced Turbocharger



1	Fuel Heater
2	Fuel Filter
3	Water In Fuel (WIF) Sensor
4	Fuel Rail Pressure (FRP) Sensor
5	Glow Plug Control Module (GPCM)
6	Fuel Rail Temperature (FRT) Sensor
7	Fuel Pressure Regulator
8	Intake Air Temperature (IAT) Sensor 2
9	Intake Air Heater (IAH) Module
10	Manifold Absolute Pressure (MAP) Sensor
11	Exhaust Gas Recirculation (EGR) Valve

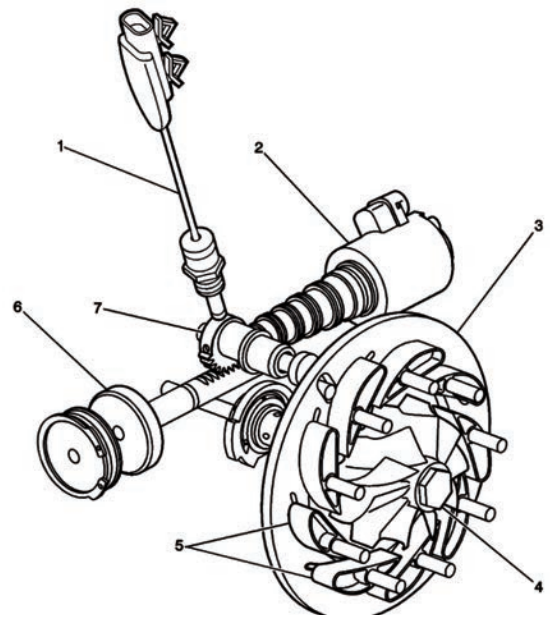
Turbocharger System Components and Locations (Courtesy GM Corporation)

There are nine controllable vanes in this turbocharger. The vanes mount to a unison ring that can change the vane angle. The ECM will vary the boost dependent upon the load requirements of the engine.

The turbocharger vanes are ordinarily open when the engine is not under load. However, the ECM will often close the turbocharger vanes to create back pressure to drive exhaust gas through the exhaust gas recirculation (EGR) valve as required.

In addition, the ECM may close the vanes at low load conditions to accelerate engine coolant heating at extremely cold temperatures. The ECM may also close the turbocharger vanes under exhaust braking conditions only with RPO K40.

MAJOR CHANGES THROUGH THE YEARS



1	Turbocharger Vane Position Sensor
2	Turbocharger Vane Position Control Solenoid Valve
3	Turbocharger Vane Position Unison Ring
4	Turbine Wheel
5	Turbocharger Vanes
6	Hydraulic Piston
7	Cam

Turbocharger Control System Components (Courtesy GM Corporation)

Turbocharger Control System Components
Turbocharger Vane Position Control Solenoid Valve
The vane position control solenoid valve (2) works with oil pressure to control the turbocharger vanes. The solenoid valve has a common control circuit and a high control circuit.

The engine control module (ECM) uses a pulse width modulation on both control circuits to control the solenoid valve. In addition, the ECM will control the solenoid valve to allow the engine oil pressure (EOP) to move a piston (6). This piston rotates the unison ring, thus controlling the engine boost depending upon engine load.

Turbocharger Vane Position Sensor
The vane position sensor (1) uses three circuits: a 5-volt reference circuit, a low reference circuit, and a signal circuit.

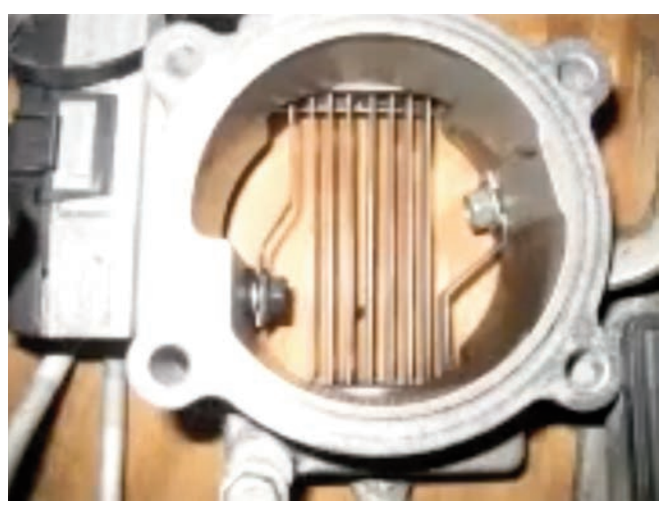
The engine control module (ECM) provides the sensor with 5 volts on the 5-volt reference circuit and a ground on the low reference circuit.

The movement of the vanes provides the ECM with a signal voltage from the TC sensor through the position sensor signal circuit. The voltage is low when the TC vanes are open and high when the TC vanes are closed.

Vane position sensor codes indicate sticky or stuck vanes, unison ring wear, VGT actuator failure, restricted oil supply, or a VGT position sensor failure.

The design of these turbos is nearly identical to 6.0l Powerstroke turbos known for this type of failure. The turbos may free up at higher rpm due to additional oil pressure/volume to drive the vane actuator piston. Sticking unison rings is more common than actuator or vane position sensor failures.

Intake Air Heater System
The intake air heater (IAH) is located in the air inlet tube and is used to warm the incoming air to start the engine and for proper cylinder combustion. The glow plug control module (GPCM) will command the IAH when the engine coolant temperature is below 40°C (104°F).



Intake Air Heater Assembly

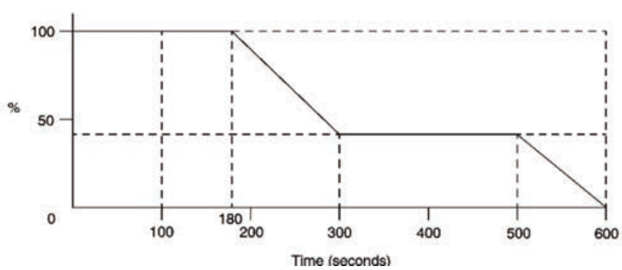
MAJOR CHANGES THROUGH THE YEARS

The GPCM commands ON the IAH through the command 1 circuit and the command two circuits. The command one signal is ON or OFF from the GPCM to the IAH. The command two circuits are a digital signal from the GPCM to the IAH. Without both signals, the IAH will not operate.

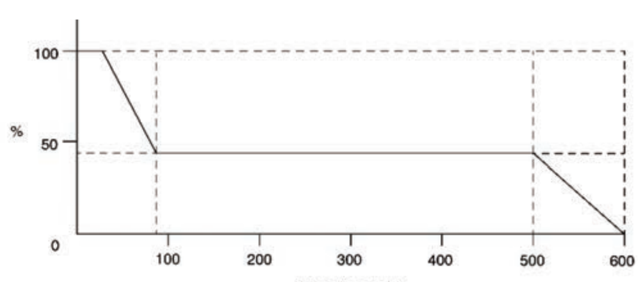
The feedback signal is digital and informs the GPCM of the status of IAH. The temperature, current, and voltage circuits are analog signals from the IAH to the GPCM.

The IAH will be commanded to 100 percent when the engine coolant temperature is below five °C (41°F) for 180 seconds after key up; then, it will ramp down to 42 percent after 180–300 seconds and hold it there until 300–500 seconds. After 500–600 seconds, the IAH will ramp down to 0 percent.

When the engine coolant is 10–40°C (50–104°F), the IAH is 100 percent for 30 seconds after key up then ramps down to 42 percent after 30–90 seconds and holds it there for up to 500 seconds, then it ramps down to 0 percent

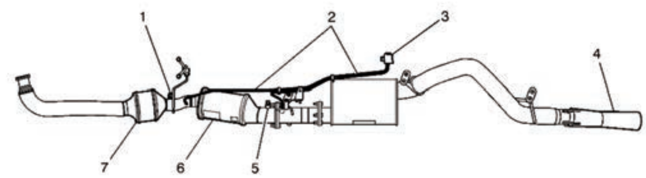


IAH Operation: Below 5°C at Ignition ON (Courtesy GM Corporation)



IAH Operation: 10–40°C at Ignition ON (Courtesy GM Corporation)

Diesel Particulate Filter (DPF) System
Diesel Particulate Filter Layout



1	Exhaust Gas Temperature (EGT) Sensor1
2	Differential Pressure Sensor (DPS) Pressure Lines
3	Differential Pressure Sensor (DPS)
4	Exhaust Cooler
5	Exhaust Gas Temperature (EGT) Sensor2
6	Diesel Particulate Filter (DPF)
7	Diesel Oxidation Catalyst (DOC)

Diesel Particulate Filter (DPF) System Layout (Courtesy GM Corporation)

Diesel Oxidation Catalyst
The diesel oxidation catalyst (DOC) has two functions. One function is to reduce emissions from exhaust gases from non-methane hydrocarbons and carbon monoxide (CO). The other function is to help start a regeneration event by converting the fuel-rich exhaust gases to heat.

Diesel Oxidation Catalyst (DOC)

MAJOR CHANGES THROUGH THE YEARS

The engine control module (ECM) monitors the functionally of the DOC by determining if the exhaust gas temperature (EGT) sensor 1 reaches a predetermined temperature during a regeneration event.

The DOC and the Diesel particulate filter (DPF) are downstream of the turbocharger and are two separate components under the vehicle.

Diesel Particulate Filter
The Diesel Particulate Filter (DPF) captures diesel exhaust gas particulates, preventing their release into the atmosphere. The DPF traps harmful particulates and pollutants that the combustion process has failed to burn off completely.

Diesel Oxidation Catalyst (DOC) Assembly and Substrate

Exhaust gas is forced through a filter substrate that removes the particulates from the exhaust gas. The exhaust gas enters the filter, but because every other filter cell 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. Then, the cleaned exhaust gas exits the filter through the adjacent cell. Finally, the DPF can reduce more than 90 percent of particulate matter.

Differential Pressure Sensor (DPS) and Pressure Lines
The differential pressure sensor (DPS) measures the pressure differential between the intake and outlet of the DPF.

Diesel Oxidation Catalyst (DOC) Assembly and Substrate

A high particulate loading condition is indicated when pressure difference increases above a pre-determined calibrated threshold. For example, the ECM will command a regeneration event to burn off the particulate matter in the filter.

For example, suppose the pressure differential increases across the exhaust filter without a regeneration event. In that case, the ECM will illuminate a DPF lamp or send a message to the driver information center (DIC) referring the customer to clean the exhaust filter.

MAJOR CHANGES THROUGH THE YEARS

To clean the exhaust filter, the operator must drive the vehicle under the conditions necessary for regeneration. If these lamps and messages are ignored, the ECM will eventually illuminate the MIL and revert to Reduced Engine Power, requiring 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 are connected before and after the EPF. Therefore, to provide the pressure sensor with accurate back pressure measurements, the DPS pressure lines should have a continuous downward gradient without 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 DPF.

Exhaust Gas Temperature (EGT) Sensor

Each EGT sensor is a variable resistor. When the EGT sensors are cold, the sensor resistance is low, and as the temperature increases, the sensor resistance increases. In addition, the ECM detects a high voltage on the signal circuit when sensor resistance is high. The ECM detects a lower voltage on the signal circuit when sensor resistance is low.

Proper EGTs at the inlet and outlet of the DPF are crucial for proper operation and for initiating the regeneration process.

A too high temperature in the DPF will cause the DPF substrate to melt or crack. In addition, the ECM monitors the DPF inlet and outlet temperatures to regulate DPF temperatures.

Normal Regeneration
Courtesy GM Corporation
Regeneration removes the captured particulates through incineration within the DPF. Elevated temperatures are created in the DOC through a calibrated strategy in the engine control system.

Regeneration occurs when the ECM calculates that the particulate level in the filter has reached a pre-determined calibrated threshold using many different factors such as; engine run time, mileage traveled, fuel used since the last regeneration, and data received from the exhaust differential pressure.

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. During regeneration, the exhaust gases reach temperatures above 550°C (1,022°F).

The ECM monitors the EGT sensors during regeneration. If the sensors indicate that regeneration temperatures exceed a pre-determined calibrated threshold, regeneration will be temporally suspended until the sensors return to an average temperature.

However, regeneration will be terminated if EGT temperatures fall below a standard pre-determined calibrated threshold. If the regeneration process is suspended or canceled, the ECM will set a DTC, and the MIL will become illuminated.

If a regeneration event is interrupted for any reason, it will continue within the following key cycle if the conditions are met for regeneration enablement. However, during normal regeneration, the customer should not experience a difference in performance to normal driving conditions.

The Duramax regen system operates stealthy by design. In typical operation the customer will not notice regeneration is occurring. The few things the operator may experience is a slightly higher idle speed, somewhere between 800 - 850 rpm and a drop in fuel economy. You may notice a hot smell when standing.

MAJOR CHANGES THROUGH THE YEARS

Service Regeneration
Courtesy GM Corporation

Caution: Tailpipe outlet exhaust temperature will be greater than 300°C (572°F) during service regeneration. 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's tailpipe.

2. Park the vehicle outdoors and keep people, other vehicles, and combustible material away during service regeneration.

3. Do not leave the vehicle unattended.

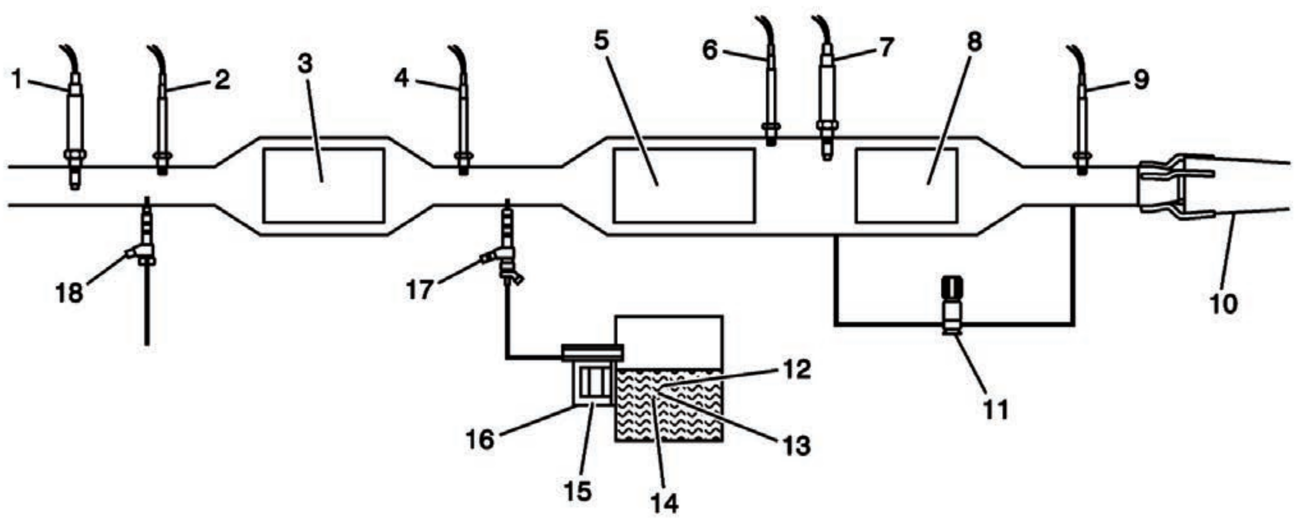
Caution: To avoid extremely elevated exhaust temperatures, inspect and remove any debris or mud build-up at the exhaust cooler located at the tailpipe.

Notice: Due to the elevated engine temperatures created while performing this procedure, it is imperative to keep the front of the vehicle in an open environment, with the hood open, away from any walls or buildings. This ensures proper airflow across the radiator.

A scan tool is an essential tool that is required for service regeneration. Commanding a service regeneration is accomplished using the output control function.

The vehicle will need to be parked outside the facility and away from nearby objects, such as other vehicles and buildings, due to the elevated exhaust gas temperature at the tailpipe during regeneration.

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.



1	NOx Sensor 1		10	Exhaust Cooler
2	EGT 1		11	DPF Differential Pressure Sensor
3	Diesel Oxidation Catalyst (DOC)		12	Reductant Heater (3)
4	EGT 2		13	Reductant Pressure Sensor
5	Selective Catalyst Reduction (SCR)		14	Reductant Level/Temperature Sensor
6	EGT 3		15	Reductant Purge Valve
7	NOx Sensor 2		16	Reductant Pump
8	Diesel Particulate Filter (DPF)		17	Reductant Injector
9	EGT 4		18	Hydrocarbon Injector (HCI)

Exhaust Aftertreatment System WIth SCR and DEF Systems

MAJOR CHANGES THROUGH THE YEARS

Exhaust Aftertreatment System Description
Selective Catalyst Reduction (SCR) Operation
While diesel engines are more fuel-efficient and produce less HC and CO than gasoline engines, they generate much higher levels of NOx.

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.

NOx Sensor

The second NOx sensor is located in the exhaust pipe downstream of the SCR and monitors NOx levels exiting the after-treatment system. In addition, the smart NOx sensors communicate with the ECM over the serial data line.

Diesel engines are controlled by the ECM in much the same way gasoline engines. Both use the ECM to maintain a proper air to fuel ratios under different driving conditions.

Gas applications use oxygen sensors to achieve this, and diesel applications use oxygen and NOx sensors to maintain a proper air to fuel ratio and calculate the amount of DEF required to reduce NOx levels.

The NOx sensors incorporate an electric heater to bring the sensors to operating temperature quickly. However, 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 affecting NOx sensor operation. Depending on engine temperature at startup, the delay can be less than a minute or as long as two minutes.

Typically, NOx sensor one will reach operating temperature faster than NOx sensor two as it's closer to the engine's hot exhaust. In addition, NOx sensor two may require up to 5 minutes to reach an operating temperature at idle or low engine speeds. 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 (NH3) that reacts with NOx to form nitrogen, CO2, and water vapor. Optimum NOx reduction occurs at SCR temperatures above 250°C (480°F).

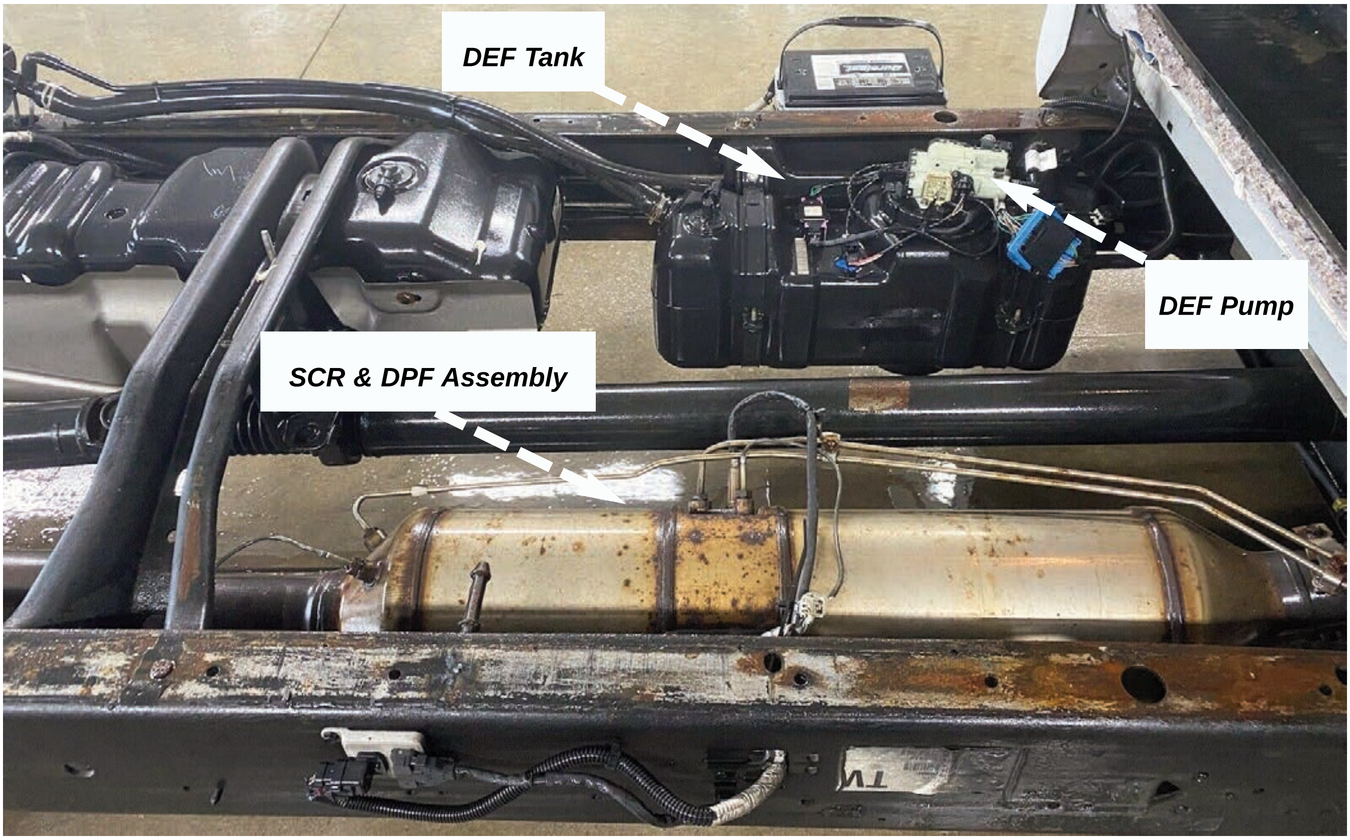
At temperatures below 250°C, the incomplete conversion of urea forms sulfates that can poison the catalyst. The ECM suspends DEF injection when exhaust temperature falls below a calibrated limit to prevent this poisoning.

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 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 usual driving conditions; however, SCR temperatures will increase when hauling a trailer.

The smart NOx sensors provide a serial data message to the ECM with information on exhaust oxygen levels.

MAJOR CHANGES THROUGH THE YEARS



Exhaust Aftertreatment System WIth SCR and DEF Systems (Typical)

Diesel Exhaust Fluid (DEF) System
Courtesy GM Corporation
The DEF system consists of the following components located at the DEF reservoir:

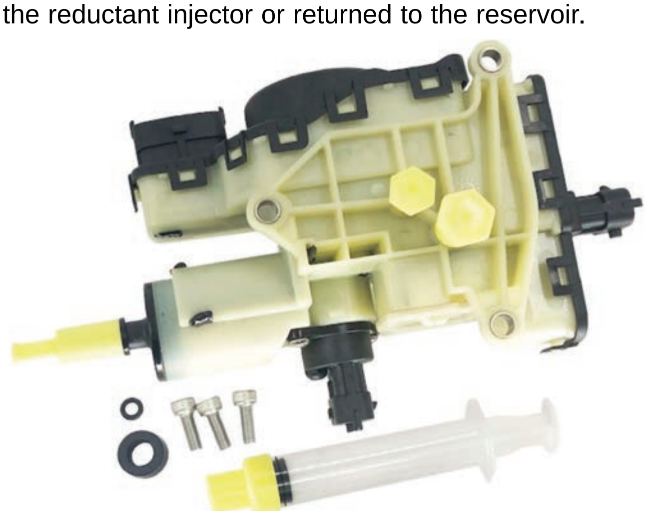
- An electrically-operated reductant pump
- A reductant purge valve
- A reductant pressure sensor
- An integrated reductant level sensor and reductant temperature sensor
- Reductant system heaters

The remaining DEF system component, an electrically-controlled reductant injector, is external to the reservoir.

The onboard reservoir holds approximately 19 liters (5 gallons) of DEF. An ECM-controlled pump within the reservoir supplies pressurized DEF to the reductant injector upstream of the SCR.

A smart DEF level sensor within the reductant reservoir sends the ECM a serial data message indicating the 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.



DEF Pump

MAJOR CHANGES THROUGH THE YEARS

DEF Injector

In the ordinarily de-energized state, the reductant purge valve directs the 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 to purge the supply line of DEF.

The ECM also commands the reductant injector to 100% to prevent a 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 control the reductant supplied to the SCR accurately.

For example, suppose more reductant is supplied to the SCR than is needed for a given NOx level. In that case, the excess reductant results in ammonia slip where significant levels of ammonia exit the SCR. Since the NOx sensors cannot differentiate between NOx and ammonia, ammonia slip will cause NOx sensor 2 to detect higher NOx levels than exist.

Cold Weather Operation

As reductant will freeze at temperatures below 0°C (32°F), there are three reductant heaters. Reductant heater 1 is in the reductant reservoir, reductant heater two 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 to determine if the reductant temperature is below it's 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.

Reductant pump operation is disabled for a calibrated amount of time to allow the heaters 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

DEF Heater

the reservoir to speed thawing. In addition, the ECM looks for an increase in the reductant temperature to verify that the reductant reservoir heater is working.

NOTES

L5P OVERVIEW

Duramax L5P F - Courtesy GM Corporation

OVERVIEW

Courtesy GM Corporation

The next-generation Duramax 6.6L, RPO code L5P, went on sale in 2017. This next-generation Duramax 6.6L engine is a complete redesign and offers more horsepower and torque than previous variants. Horsepower was SAE-certified at 445 (332 kW), and torque was 910 lb.-ft. (1,234 Nm). With a 19 percent increase in max torque over the previous Duramax 6.6L, the redesigned turbo-diesel's performance is quieter and smoother for greater refinement.

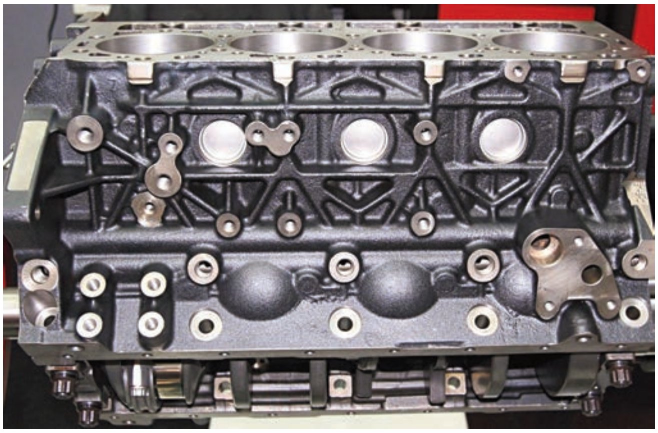
The new L5P Duramax 6.6L shares essentially only the bore and stroke dimensions of the current engine and incorporates a new, GM-developed control system. The Duramax's signature low-rpm torque production hasn't changed and still offers 90 percent of peak torque at a low 1,550 rpm and sustains it through 2,850 rpm.

L5P technical highlights:

* Brand new compact graphite iron block which is stronger and lighter.
* Induction hardened cylinder walls to improve piston ring seal.
* 5 nodular main bearings.
* 4 bolt crossed drilled mains.
* Cracked connecting rods with high tensile strength bolts.
* 6.6L (403 CID).
* 4.055 bore X 3.897 stroke. This lager bore will help increase air flow.
* 32V V8 engine with OHV.
* The L5P utilizes a new stronger yet lighter cylinder block and cylinder heads.
* New stronger rotating and reciprocating assembly.
* Increased oil and coolant flow capacity.
* New EGR system with single cooler and integrated bypass.
* New electrical actuated/electronically controlled turbo charging system.
* The L5P creates 445 hp @ 2,800 rpm and 910 lb-ft @ 1,600 rpm.
* All new advanced solenoid fuel system.
* All new electronic controls
* New full length damped steel oil pan that contributes to quietness.
* New rocker cover fuel system acoustical treatments.
* B20 bio diesel compatibility.

The new vehicle air intake system, distinguished on the Silverado HD by a daring new hood scoop, drives cool, dry air into the engine for sustained performance and cooler engine temperatures during difficult conditions, such as trailering on steep grades. Cooler air helps the engine run better under load, significantly when engine and transmission temperatures rise quickly. That allows the Duramax to maintain more power and vehicle speed when trailering in the most demanding conditions.

L5P OVERVIEW



Duramax L5P Cylinder Block

As with previous versions, the new Duramax block features a strong cast-iron foundation known for its durability, with induction-hardened cylinder walls and five nodular iron main bearings. It retains the same 4.05-inch (103mm) and 3.89-inch (99mm) bore and stroke dimensions as the current engine, retaining Duramax's familiar 6.6L (403 cu.-in./6,599 cc) displacement.

Duramax L5P (Left), LML (Right)

A deep-skirt design and four-bolt, cross-bolted main caps help ensure the block's strength and enable a more accurate location of the rotating assembly. A die-cast aluminum lower crankcase also strengthens the engine block and serves as the lower engine cover while reducing its overall weight.

The new engine block incorporates larger-diameter crankshaft connecting rod journals than the current engine, enabling the placement of a stronger crankshaft and increased bearing area to handle higher cylinder loads.

An enhanced oiling circuit with higher flow capacity and a dedicated feed for the turbocharger provides increased pressure at the turbo and faster oil delivery. Larger piston-cooling oil jets at the bottom of the cylinder bores spray up to twice the amount of engine oil into oil galleries under the crown of the pistons, contributing to lower engine temperature and greater durability.

A new, two-piece oil pan contributes to the new Duramax's quieter operation. It consists of a laminated steel oil pan with an upper aluminum section. The aluminum section provides strength-enhancing rigidity for the engine. Still, a pan made entirely of aluminum would radiate more noise, so the laminated steel lower section is added to dampen noise and vibration.

A tough, forged micro-alloy steel crankshaft anchors the new Duramax's stronger rotating assembly. Cut-then-rolled journal fillets contribute to its durability by strengthening the junction where the journals — the round sections on which the bearings slide — meet the webs that separate the main and rod journals.

The connecting rods are stronger, too, and incorporate a new 45-degree split-angle design to allow the larger-diameter rod bearings to pass through the cylinder bores during engine assembly. They're forged and sintered with a durable powdered metal alloy, with a fractured-cap design enabling more precise cap-to-rod fitment.

A new, stronger cast-aluminum piston design tops off the rotating assembly. It features a taller crown area and a remelted combustion bowl rim for greater strength. Remelting is an additional manufacturing process for aluminum pistons in which the bowl rim area is reheated after casting and pre-machining, creating a much finer and more consistent metal grain structure that greatly enhances thermal fatigue properties.

Additionally, the Duramax's pistons don't use pin bushings, reducing reciprocating weight to help the engine rev quicker and respond faster to throttle changes.

L5P OVERVIEW

Lightweight cylinder heads, solenoid injectors
The redesigned engine retains the Duramax's signature first-in-class aluminum cylinder head design, with six head bolts per cylinder and four valves per cylinder. The aluminum construction helps reduce the engine's overall weight, while the six-bolt design provides exceptional head-clamping strength — a must in a high-compression, turbocharged application.

A new aluminum head casting uses a new double-layer water core design that separates and arranges water cores in layers to create a stiffer head structure with more precise coolant flow control. The heads' airflow passages are also heavily revised to enhance airflow, contributing to the engine's increased horsepower and torque.

The Duramax employs a common-rail direct injection fuel system with new high-capability solenoid-type injectors. High fuel pressure of 29,000 psi (2,000 bar) promotes excellent fuel atomization for a cleaner burn that promotes reduced particulate emissions.

The new injectors also support up to seven fuel delivery events per combustion event, contributing to lower noise, greater efficiency and lower emissions. Technology advancements enable less-complex solenoid injectors to deliver comparable performance to piezo-type injectors.

Electronically controlled, variable-geometry turbocharging system
A new electronically controlled, variable-vane turbocharger advances the Duramax's legacy of variable-geometry boosting. Compared to the current engine, the system produces higher maximum boost pressure — 28 psi (195 kPa) — to help the engine make more power, and revisions to enhance the capability of the exhaust-brake system.

Along with a new camshaft profile and improved cylinder head design, the Duramax's new variable-vane turbocharger enables the engine to deliver more power with lower exhaust emissions. It uses a more advanced variable-vane mechanism, allowing a 104-degree F (40 C) increase in exhaust temperature capability.

The self-contained mechanism decouples movement from the turbine housing, allowing operation at higher temperature. That enables the engine to achieve higher power at lower cylinder pressure. Additionally, it has lower internal leakage, allowing more exhaust energy to be captured during exhaust braking.

The integrated exhaust brake system makes towing less stressful by creating added backpressure in the exhaust, resulting in negative torque during deceleration and downhill driving, enhancing driver control and prolonging brake pad life.

Venturi Jet Drain Oil Separator
A new Venturi Jet Drain Oil Separator employed with the Duramax 6.6L is the first of its type in the segment and is designed to ensure oil control in sustained full-load operation.

The totally sealed system collects the fine mist of oil entrained in the blow-by gas and uses a small portion of the boosted air generated by the turbocharger to pump the collected oil back to the engine oil sump for re-use by the engine.

Less sophisticated systems are not able to return this oil during full-load operation, which can result in oil carryover into the cylinders during combustion.

Cold Start System
The new Duramax also provides outstanding cold-weather performance, with microprocessor-controlled glow plugs capable of gas-engine-like starting performance in fewer than 3 seconds in temperatures as low as -20 degrees F (-29 C) without a block heater.

The system is enhanced with ceramic glow plugs and automatic temperature compensation — a first-in-class feature providing improved robustness and capability.

The automatic temperature compensation assesses and adjusts the current to each glow plug for every use, providing optimal temperature for cold start performance and durability.

Electronic throttle valve and cooled EGR
Unlike a gasoline engine, a diesel engine doesn't necessarily require a throttle control system. The Duramax 6.6L employs an electronic throttle valve to regulate intake manifold pressure in order to increase exhaust gas recirculation (EGR) rates.

It also contributes to smoother engine shutdown. Additionally, a cooled exhaust gas recirculation (EGR) system enhances performance and helps reduce

L5P OVERVIEW

emissions by diverting some of the engine-out exhaust gas and mixing it back into the fresh intake air stream, which is fed through the cylinder head for combustion. This lowers combustion temperatures, improving emissions performance by reducing NOx formation.

The exhaust is cooled in a unique heat exchanger before it's fed into the intake stream through a patented EGR mixing device, further improving emissions and performance capability.

An integrated bypass allows non-cooled exhaust gas to be fed back into the system to help the engine more quickly achieve optimal operating temperature when cold.

B20 Biodiesel Capability
The new Duramax 6.6L is capable of running on B20 biodiesel, a fuel composed of 20 percent biodiesel and 80 percent conventional diesel. B20 helps lower carbon dioxide emissions and lessens dependence on petroleum. It is a domestically produced, renewable fuel made primarily of plant matter — mostly soybean oil.

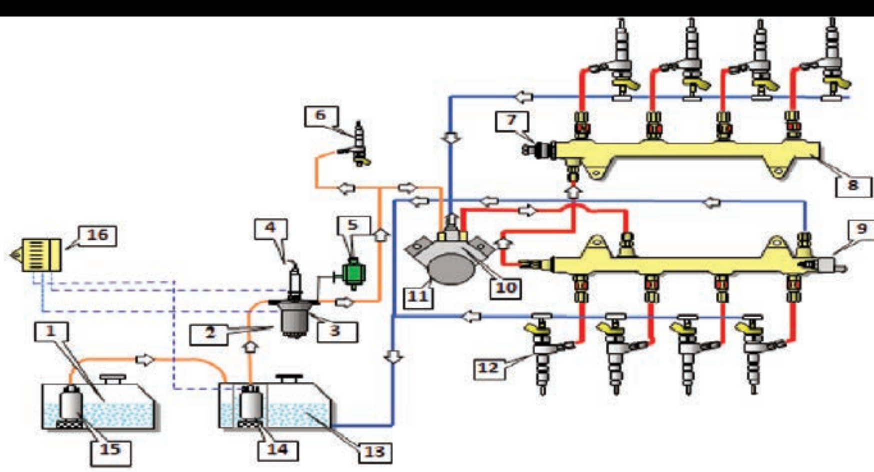
Manufacturing
The new Duramax 6.6L turbo-diesel engine is produced with locally and globally sourced parts at the DMAX Ltd. (GM's joint venture with Isuzu) manufacturing facility in Moraine, Ohio.

Allison 1000 Automatic Transmission
The proven Allison 1000 six-speed automatic transmission is matched with the new Duramax 6.6L. A number of refinements have been made to accommodate the engine's higher torque capacity, including a new torque converter.

The Allison 1000's technologically advanced control features, such as driver shift control with manual shift feature and a patented elevated idle mode cab warm-up feature, haven't changed. Also, the Tow/Haul mode reduces shift cycling for better control and improved cooling when towing or hauling heavy loads.

There's also a smart diesel exhaust brake feature that enhances control when descending steep grades.

L5P FUEL SYSTEM



Number	Component		Number	Component
1	Secondary Fuel Tank (if equipped)		9	Fuel Rail Pressure Regulator2
2	Fuel Filter with Water in Fuel Sensor		10	Fuel Pressure Regulator1 (Located in Fuel Injection Pump)
3	Fuel Heater		11	Fuel Injection Pump
4	Fuel Temperature Sensor		12	Fuel Injectors
5	Fuel Pressure Sensor		13	Primary Fuel Tank
6	Exhaust Aftertreatment Fuel Injector (if equipped)		14	Brushless 3–Phase Fuel Pump
7	Dual Fuel Rail Pressure Sensor (Contains Fuel Rail Pressure Sensor1 and Fuel Rail Pressure Sensor2)		15	Fuel Transfer Pump (if equipped)
8	Fuel Rail Assembly		16	Fuel Pump Driver Control Module

Duramax L5P Fuel System Diagram

L5P FUEL SYSTEM

Duramax L5P Primary Fuel Tank

The Fuel Tank
The primary fuel tank and secondary fuel tank (if equipped) store the fuel supply. A fuel transfer pump is located in the secondary fuel tank (if equipped) and is used to transfer fuel to the primary tank.

The primary fuel tank contains a 3–phase brushless fuel pump and is controlled by the fuel pump driver control module in conjunction with the engine control module. Fuel is pumped from the primary fuel tank to the fuel filter assembly through the fuel feed line.

The fuel filter assembly consists of a fuel filter/water separator assembly, fuel heater, fuel temperature sensor, and a water in fuel (WIF) sensor.

Fuel flows out of the fuel filter assembly through the rear fuel feed pipe to the exhaust after-treatment fuel injector (if equipped) and past the fuel pressure sensor to the fuel injection pump.

High-pressure fuel is supplied to the fuel injectors through the high-pressure fuel line to the fuel rails and fuel injector lines. The high-pressure side of the fuel system is controlled by the ECM and two fuel pressure regulators. Excess fuel returns to the fuel tank through the fuel return pipes.

The Fuel Pump
The fuel pump is mounted in the primary fuel tank module. The engine control module (ECM) supplies voltage to the Fuel Pump Driver Control Module for 30 sec when the ignition is turned on and continuously when the engine is running.

Duramax L5P Fuel Pump

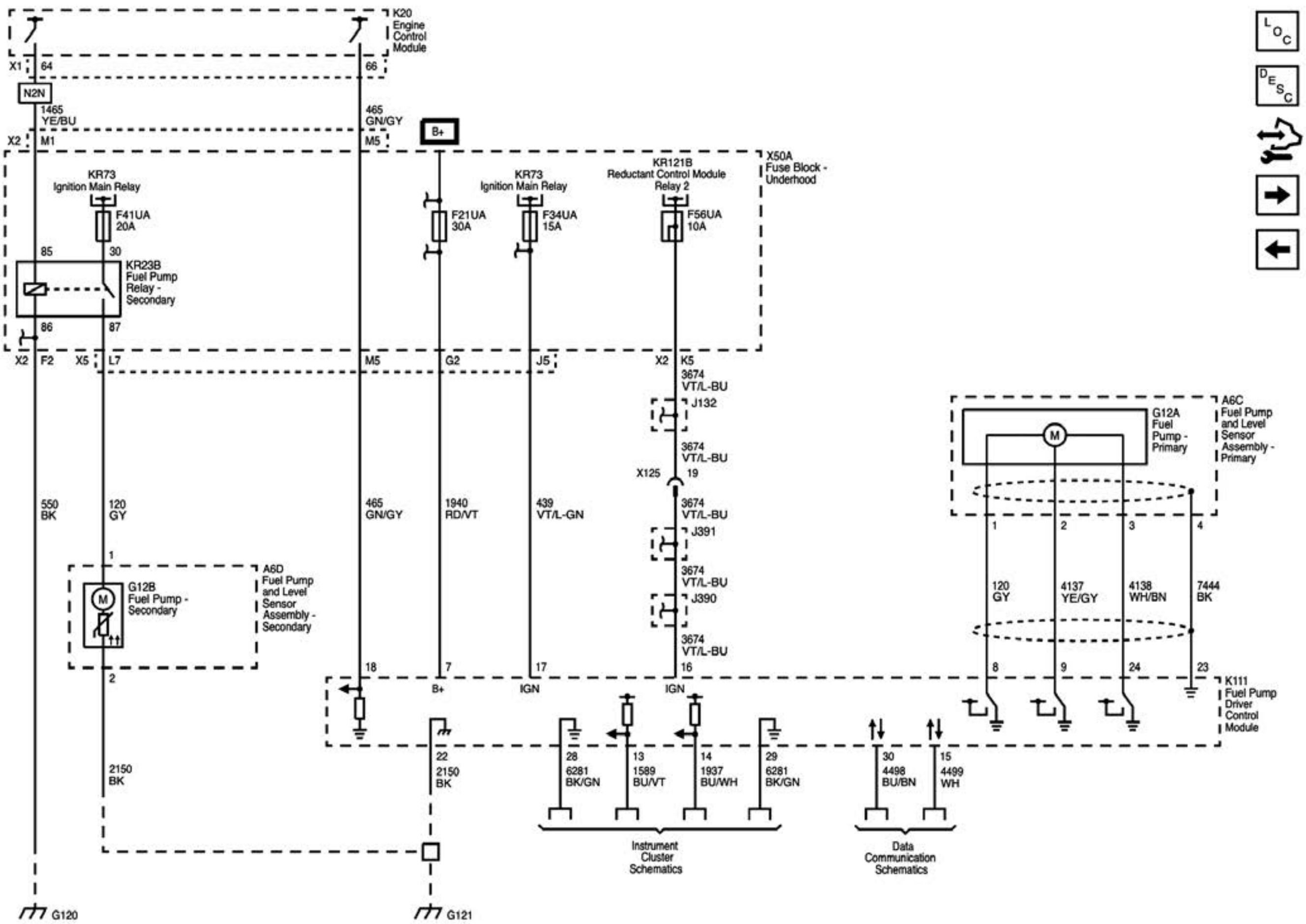
While this voltage is being received, the ECM sends a serial data signal to the fuel pump driver control module containing the desired fuel pump speed.

The fuel pump driver control module actuates the brushless fuel pump utilizing a three-phase signal and controls the fuel pump speed according to serial data signals received from the ECM containing the desired fuel pump speed.

During a cold start, to warm the fuel, the high-pressure pump operates at the total output, and the pressure in the rail is regulated by the fuel pressure regulator 2. This mode is also active during fuel injection cut-off.

The fuel return line can flow up to 230 l/h (60.8 g/h) when in this mode.

L5P FUEL SYSTEM



Duramax L5P Fuel Pump Wiring Diagram (Courtesy GM Corp.)

Fuel Feed and Return Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel filter/heater, exhaust aftertreatment fuel injector, and fuel injection pump. The fuel return pipe carries fuel from the fuel rail assemblies back to the fuel tank.

Fuel Filter Assembly

The fuel filter assembly is located near the left frame rail and contains the following components:

- Fuel Filter/Water Separator
- Fuel Heater
- Fuel Temperature Sensor
- Water in Fuel Sensor

Fuel Filter/Water Separator

The paper filter element traps particles in the fuel that may damage the fuel injection system.
The fuel filter canister is designed to allow trapped water particles to settle at the bottom of the filter assembly.

Duramax L5P Fuel Filter Assembly

Fuel Heater

The engine control module (ECM) commands the fuel heater. When the fuel temperature is below the calibrated level, the ECM will command the fuel heater relay ON. When the relay is ON, battery voltage is supplied to the fuel heater to operate in cold weather.

L5P FUEL SYSTEM

Duramax L5P Fuel Cooler

Fuel Cooler

The fuel cooler is used to cool the fuel and reduce asphaltenes. The more pressure generated from these higher horsepower engines, the more heat is generated. One great way to dissipate the heat is to cool the fuel before delivery.

The fuel cooler is located underneath the truck along the frame rail. Depending on how the customer uses the vehicle, it can be prone to plugging, primarily if the truck is used primarily in off-road conditions. When the fuel cooler gets plugged, its ability to cool the fuel is greatly diminished. Once this happens, asphaltenes can form, plugging the DPF and SCR components.

Inspecting the fuel cooler should be a standard part of your service routine every time a Duramax-equipped truck enters your service bay.

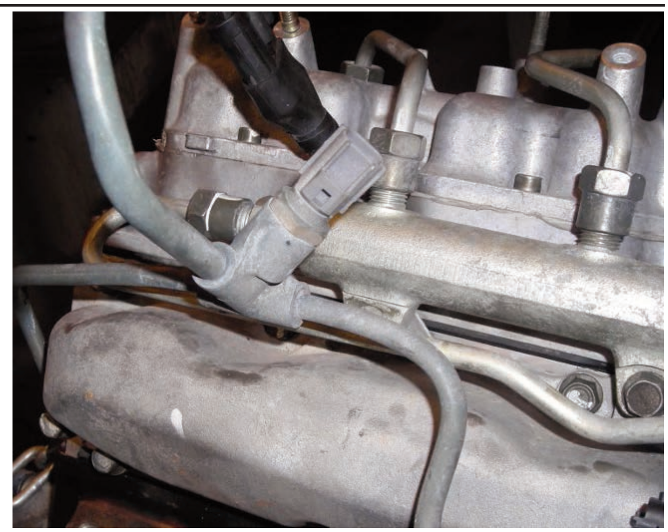
Fuel Temperature Sensor

The fuel temperature sensor is a thermistor located in the fuel filter assembly. The ECM monitors the fuel temperature sensor through the fuel pump driver control module to calculate the temperature of the fuel entering the fuel injection pump.

Water in Fuel Sensor

The water in the fuel sensor is a sensor that monitors for the presence of diesel fuel and water. When water is present, the fuel pump driver control module detects low voltage on the signal circuit and sends a message to the ECM.

In addition, the ECM sends a serial data message to the instrument panel cluster to display the WATER IN FUEL SERVICE REQUIRED message.



Duramax L5P Fuel Temperature Sensor

Fuel Pressure Regulators 1 & 2

The L5P uses two fuel pressure regulators. Both regulators are pulse width modulated and controlled by the ECM. Fuel pressure regulator one is located within the high-pressure fuel pump and regulates the quantity of fuel entering the high side of the pump.

Fuel pressure regulator one is located in the fuel injection pump and meters the amount of fuel that enters the high-pressure side of the pump. The fuel moves to the fuel rail through a high-pressure steel line from the high-pressure pump. The fuel rail distributes high-pressure fuel to all eight fuel injectors.

Fuel pressure regulator two is located on the rear of the driver's side fuel rail and regulates the amount of fuel returned to the fuel tank. The ECM varies the pulse width modulated voltage to the fuel pressure

L5P FUEL SYSTEM

regulator two to relieve excessive fuel pressure, which returns to the fuel tank. When the ignition is Off, fuel pressure regulator two opens to bleed off the pressure in the fuel rail.

Fuel Pressure Sensor
The fuel pressure sensor is located in the fuel feed pipe. The fuel pressure sensor monitors the fuel pressure in the fuel line and sends inputs to the ECM.

Duramax L5P Fuel Pressure Sensor

The ECM monitors the voltage signal from the fuel pressure sensor. The sensor provides a fuel pressure signal to the ECM, which is used to provide fuel pressure control.

Having two fuel pressure sensors is beneficial in redundancy and diagnostically. You now have two PIDs to look at on your scan tool. As the fuel pressure changes across the fuel rails, the readings on the scan tool will move in opposite directions from one another.

Much like Accelerator Pedal Position (APP) sensors, the voltages will be opposite each other. This gives you the ability to view the voltages of the sensors on the scan tool and see if they correlate with each other correctly.

Fuel Injection Pump
The fuel injection pump is a mechanical high-pressure pump. The fuel injection pump is located at the front of the engine below the intake manifold. The fuel is pumped to the fuel rails at a specified pressure regulated by two fuel pressure regulators.

Fuel Injection Timing
The engine control module (ECM) can learn injector timing performance. When the engine is at operating

Duramax L5P High Pressure Fuel Pump

temperature, throttle closed. In deceleration fuel cut-off mode, the ECM will pulse each injector individually and measure the changes in rotational speed of the crankshaft using the input from the crankshaft position sensor. The ECM will run this diagnostic at each injector's fuel rail pressure operating point. The ECM stores the injector timing value.

Fuel Injectors
The fuel injectors are located above each cylinder and deliver fuel directly into the cylinder. The fuel injector is a fuel delivery device controlled by the ECM. The ECM uses inputs from other driveability sensors and uses this data to meter pressurized fuel into each cylinder.

Duramax L5P Fuel Injector

Fuel from the tip of the fuel injector is sprayed directly into the combustion chamber during the engine's

L5P FUEL SYSTEM

compression stroke. Each injector has a high-pressure fuel pipe from the fuel rail and a return line.

A known issue with these injectors is what is known as Injector Fretting. Injector fretting occurs when electrical connectivity is lost on the two terminals at the injector and the injector connector to the wiring harness.

This loss of connectivity creates an ozone pocket between the connectors, thus diminishing the electrical signal supplied by the ECM to drive the injectors.

Many technicians see this as a problem with the injector and replace it accordingly. However, this may not always be the case. If the problem is fretting, you can use an updated harness and connector to fix the problem. The connectors on the replacement harness are gold plated, giving a better connection.

You can replace the injector only to find you have the same problem coming back to your service bay. Make sure you determine if the problem is with the injector or injector fretting.

Fuel Injection Quantity
In the calibration/controls community, this diagnostic is called the Fuel Setpoint Adaptation (FSA). This algorithm is used to estimate the actual injected fuel quantity.

This estimated quantity is used to correct ECM set points for exhaust gas recirculation (EGR), Boost Pressure, Fuel Rail Pressure, etc. The goal of FSA is to account for injectors that drift during the vehicle's lifetime.

The algorithm estimates the real injected fuel quantity using input from the mass airflow (MAF) sensor & nitrogen oxides (NOx) sensor 1 to determine the air/fuel ratio.

For example, suppose airflow parameters are incorrect due to leaks. In that case, blockages, malfunctioning EGR, faulty MAF sensor/NOx sensor one signals, or fuel injectors that are not performing as intended, a skewed air-fuel ratio could negatively affect the FSA.

FUEL TESTING

Specific gravity fuel testing.
How do we know the customer put the correct fuel in the tank? Maybe someone mistakenly added gasoline to the tank.

Water in fuel testing.
There could be water in the fuel. Diesel fuel is not only a fuel that will ignite in a combustion chamber, but it is also an excellent lubricant. So how well do you think diesel fuel contaminated with water will lubricate the engine? Not too well, that is for sure.

What causes Asphaltenes.
Asphaltenes are formed when diesel fuel is heated under high pressure through today’s high-pressure fuel injection systems.

These systems operate at about 30,000 PSI which is approximately six times the pressure of the previous conventional fuel injection systems.

The drastic increase in pressure combined with temperatures that can easily exceed 200 degrees act to cook the fuel and create asphaltenes – small pieces of tar about 2 microns in size.

These asphaltenes turn the fuel a dark brown and can congregate and clog your fuel filters. They also can make up a significant part of the dark sludge that you see in many fuel storage tanks.

The solids form a layer of sticky, gummy slime that grows over time and eventually must be removed.

It is worth noting that many of us can initially mistake asphaltenes for “algae” or microbial growth that can also clog our fuel filters. Not until we have already treated the fuel with an EPA registered biocide unsuccessfully is it apparent that the problem is not what we thought but is instead asphaltenes.

DEF testing.
Testing the Diesel Exhaust Fluid (DEF) is critical, especially if you have an SCR problem. Usually stored near the fuel tank, it only takes a few extra minutes to ensure you are not chasing your tail.

FUEL TESTING

What type of problems will we see caused by poor fuel quality or fuel contamination? The answer is many. Components that could be damaged by poor quality or contaminated fuel include;

* Low-pressure fuel pump.
* Fuel filters and strainers.
* High-pressure fuel pump.
* Fuel rails.
* Injectors.
* Pressure control valves.
* Fuel coolers.
* Fuel pressure sensors or switches.
* Lines including return lines.

These components can fail due to poor fuel quality and/or contamination, and all of them are very expensive to repair or replace. For this reason, we test the fuel and get it out of the system if it fails the diagnostic process.

Symptoms of fuel contamination;

* The engine will crank but will not start.
* The engine will not crank.
* The engine will start, but the cranking duration is extended.
* Engine misfires.
* Knocking from the engine.
* Excessive smoke from the exhaust system.
* Multiple assorted DTCs.
* Multiple failures of injection components.

The best place to get the fuel sample is at the truck's water drain. A high-quality primary fuel filter should stop most water and contamination. This should be a place to get a critical sample.

Even a high-quality filter, if exposed to various contaminants and compounds and service intervals, may allow some system damaging items to pass like DEF fluid.

Once you have taken a sample, you are ready to test the fuel for API/Specific Gravity and contamination. First, we can test for the specific gravity of the fuel. Keep in mind that there is not one diesel fuel that will work year-round for all climates. As you can see in the illustration Below, there are three types of diesel fuel noted along with their estimated API and specific gravities.

If the temperature is really cold in your area, you will want to use a type 1 diesel fuel. Use of type 1 diesel fuels will avoid gelling and aid in easier starting in cold weather. Fuel economy and power will suffer, but the vehicle will start reliably.

In most areas, during the winter, you will find the winter blend diesel fuel. The winter blend will give not only good starting capability but also decent fuel mileage and power.

Type 2 diesel fuel should not be used in colder climates as gelling is quite common. In warmer climates, this diesel fuel will give a great performance as well as fuel mileage.

As you can see in the chart, there are two standards of gravity. There is the American Petroleum Industry (API) and the specific gravity. Both can be measured with a hydrometer. Just make sure the hydrometer you buy or use is calibrated for the purpose you are using it for.

API Gravity	Specific Gravity	
42	.816	Type 1 Diesel fuel
41	.820	
40	.825	
39	.830	
38	.835	Winter Blend Diesel
37	.840	
36	.845	
35	.850	
34	.855	
33	.860	
32	.865	Type 2 Diesel
31	.871	
30	.876	

Fuel API Correction Chart
API Gravity Corrected to 60°F
(Measured Fuel Temperature °F)

Measured °API Gravity	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°
	°API Gravity At 60°F															
29°	33	32.5	32	31	30	30	29	28	28	27	26.5	26	25	24.5	24	23.5
30°	34	33.5	33	32	31.5	31	30	29	29	28	27.5	27	26	25.5	25	24.5
31°	35	34.5	34	33	32.5	32	31	30	30	29	28.5	28	27	26.5	26	25
32°	36	35.5	35	34	33.5	33	32	31	30.5	30	29	29	28	27.5	27	26
33°	37	36.5	36	35	34.5	34	33	32	31.5	31	30	29.5	29	28.5	28	27
34°	38.5	38	37	36	35.5	35	34	33	32.5	32	31	30.5	30	29	29	28
35°	39.5	39	38	37	36.5	36	35	34	33.5	33	32	31.5	31	30	29.5	29
36°	41	40	39	38	37.5	37	36	35	34.5	34	33	32.5	32	31	30.5	30
37°	42	41	40	39	38.5	38	37	36	35.5	35	34	33.5	33	32	31.5	31
38°	43	42	41	40.5	39.5	39	38	37	36.5	36	35	34.5	34	33	32	32
39°	44	43	42	41.5	40.5	40	39	38	37.5	37	36	35	34.5	34	33	32.5
40°	45	44	43	42.5	41.5	41	40	39	38.5	38	37	36	35.5	35	34	33.5
41°	46	45	44.5	43.5	42.5	42	41	40	39.5	39	38	37	36.5	36	35	34.5
42°	47	46	45.5	44.5	44	43	42	41	40.5	39.5	39	38	37.5	37	36	35
43°	48.5	47.5	46.5	45.5	45	44	43	42	41.5	40.5	40	39	38	37.5	37	36
44°	49.5	48.5	47.5	46.5	46	45	44	43	42	41.5	41	40	39	38.5	38	37

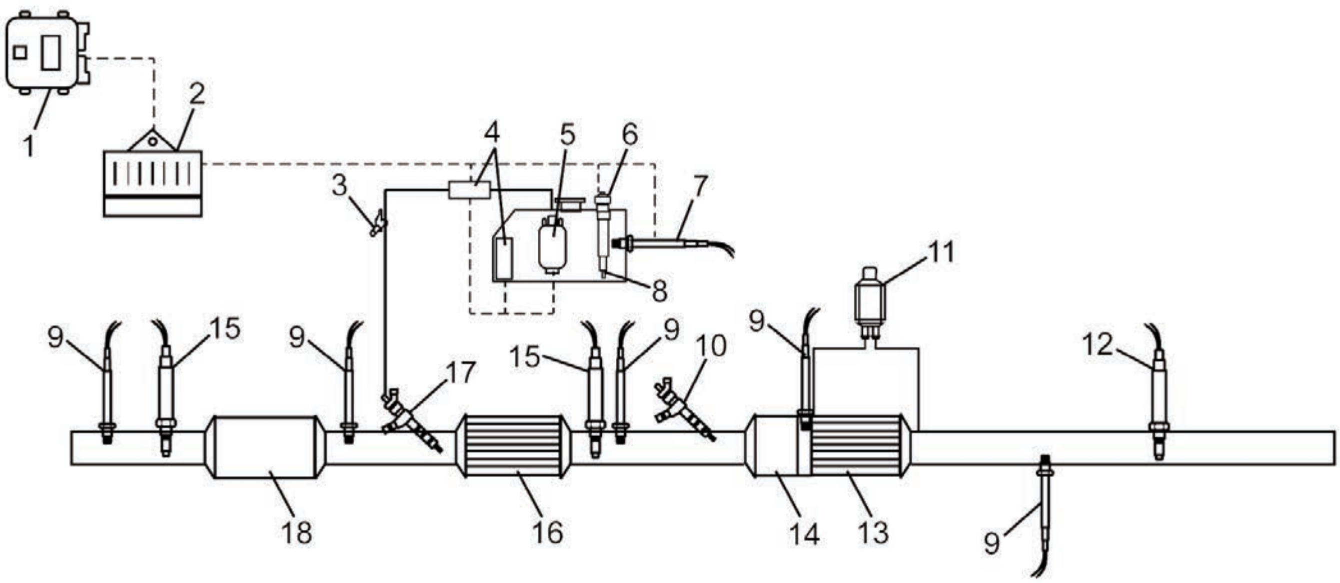
Diesel Fuel API Specific Gravity and Correction Chart

FUEL TESTING

The lower the number, the better the fuel economy and power. If the fuel does not test in this range, it is not diesel fuel.

Real-life great numbers in summer would be 32 to 35. Winter blend 35 to 38. Type 1 diesel no higher than 42. For more on fuel testing, visit https://aviondemand.com/

L5P EXHAUST AFTERTREATMENT SYSTEM



Number	Component
1	ECM w/Baro Sensor
2	Reductant Control Module, CAN Interface
3	DEF Pressure Sensor
4	DEF Heaters — to Reductant Control Module
5	DEF Pump — to Reductant Control Module
6	DEF Continuous Level Sensor — to Reductant Control Module
7	DEF Temperature Sensor — to Reductant Control Module
8	DEF Quality Sensor — to Reductant Control Module
9	Exhaust Gas Temperature Sensor

Number	Component
10	HC Injector
11	DPF Differential Pressure Sensor
12	PM Sensor, CAN Interface
13	DPF
14	DOC
15	NOx Sensor — CAN Interface
16	SCR
17	DEF Injector
18	Close Coupled DOC

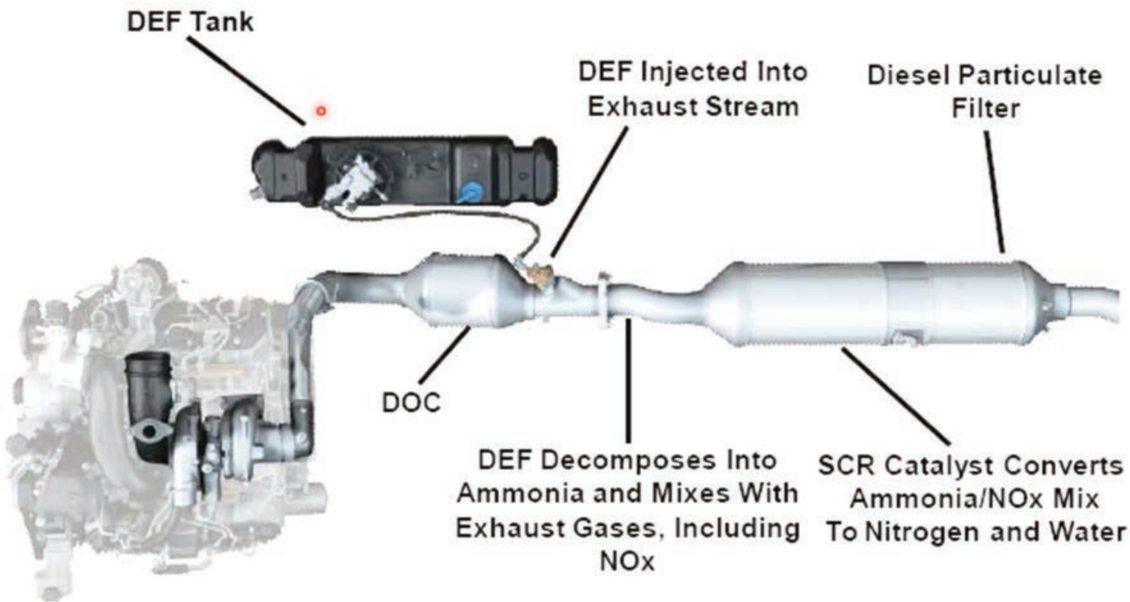
Duramax L5P Exhaust Aftertreatment System DIagram (Courtesy GM Corp.)

System Overview
The diesel exhaust after-treatment system is designed to reduce the levels of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and particulate matter (PM), remaining in the vehicle’s exhaust gases.

Typically, NOx and PM are controlled by separate after-treatment components. For example, NOx is controlled by a Selective Catalytic Reduction (SCR) converter combined with precise injections of Diesel Exhaust Fluid (DEF). In contrast, PM is controlled by a diesel particulate filter (DPF). Combining after-treatment system components can reduce packaging volume and manufacturing costs. One way of doing this is to coat the SCR catalyst on the DPF to form an SCR-coated DPF, also known as a Selective Catalytic Reduction on Filter (SCRoF).

Reducing these pollutants to acceptable levels is achieved through a four-stage process:
1. A close-coupled diesel oxidation catalyst (DOC) stage
2. A selective catalyst reduction (SCR) stage
3. A diesel oxidation catalyst (DOC) stage
4. A diesel particulate filter (DPF) stage

L5P EXHAUST AFTERTREATMENT SYSTEM



Duramax L5P Exhaust Aftertreatment System DIagram (Courtesy GM Corp.)

In stage 1, the close-coupled DOC removes exhaust HC and CO through an oxidation process. After stage 1, reductant, also known as diesel exhaust fluid (DEF) or urea, is injected into the exhaust gases before entering the SCR stage. Within the SCR, NOx is converted to nitrogen (N2), carbon dioxide (CO2), and water vapor (H20) through a catalytic reduction fueled by the injected reductant.

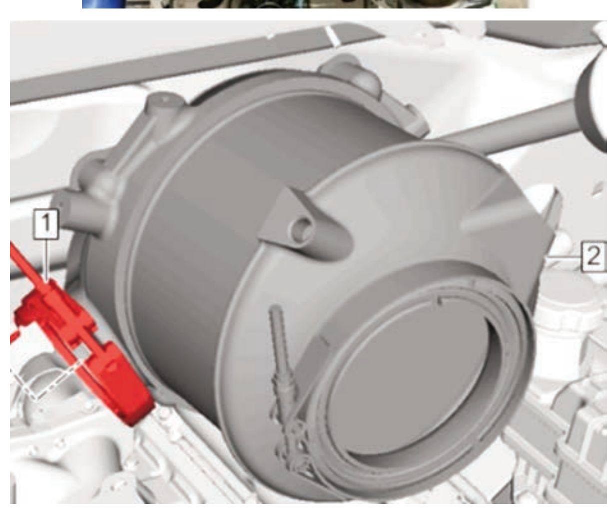
The exhaust then enters a second DOC. In the final or stage 4 process, particulate matter consisting of tiny particles of carbon remaining after combustion are removed from the exhaust gas by the large surface area of the DPF.

Diesel Oxidation Catalyst (DOC)

The DOC functions much like the catalytic converter used with gasoline-fueled engines. As with all catalytic converters, the DOC must be hot to effectively convert the exhaust HC and CO into CO2 and H2O.

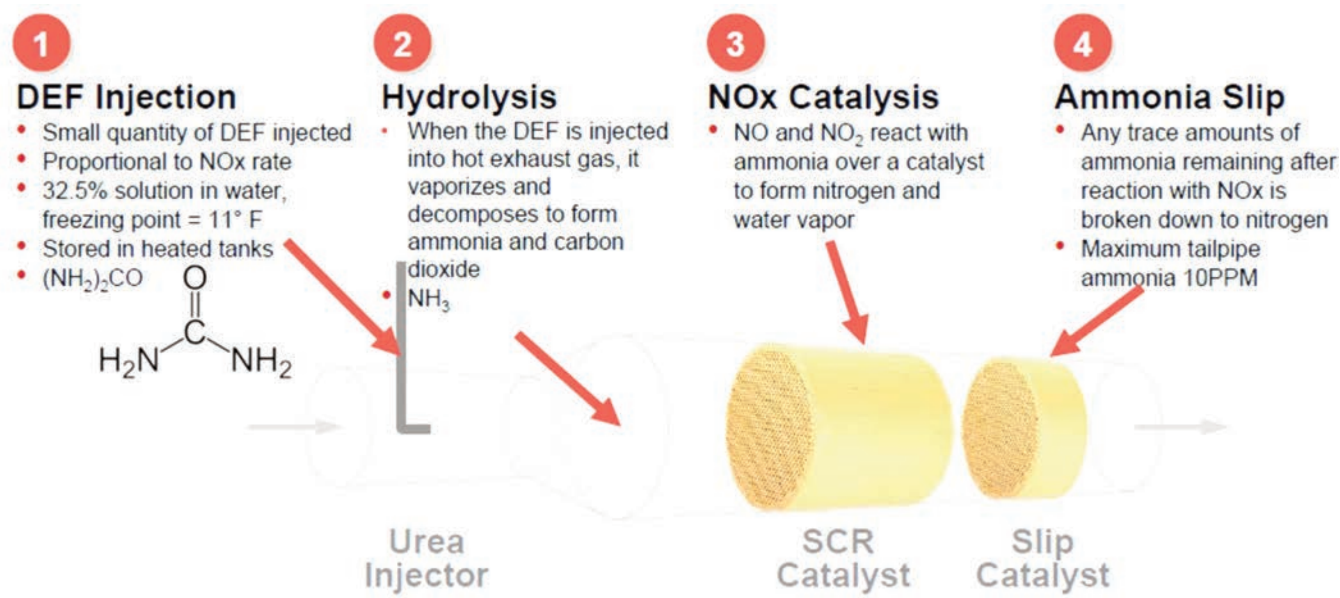
However, the exhaust gases are not hot enough to create temperatures within the DOC high enough to support complete HC and CO conversion on cold starts. The temperature at which complete conversion occurs is known as light-off.

Proper DOC function requires the use of ultra-low sulfur diesel (ULSD) fuel containing less than 15 parts-per-million (ppm) sulfur. Levels above 15 ppm will reduce catalyst efficiency and eventually result in poor driveability and set one or more DTCs.



Duramax L5P DOC

L5P EXHAUST AFTERTREATMENT SYSTEM



Duramax L5P Exhaust Aftertreatment System Process

Selective Catalyst Reduction (SCR)
Diesel engines are more fuel-efficient and produce less HC and CO than gasoline engines; however, they generate much higher levels of NOx.

To meet the current NOx limits, an SCR catalyst and reductant are used to convert NOx into N2, CO2, and H2O. Diesel Oxidation Catalyst (DOC): In addition to reducing emissions, the DOC also generates the exhaust heat needed by the SCR to function correctly.

Exhaust gas temperature sensors are located upstream and downstream of the DOC. By monitoring the temperature differential between these sensors, the ECM can confirm DOC light-off.

Light-off is confirmed by a DOC output temperature more significant than its input temperature. The after-treatment system increases exhaust temperatures by injecting diesel fuel into the exhaust gases entering the DOC to generate the high exhaust temperatures needed for regeneration.

This is accomplished utilizing a hydrocarbon injector (HCI) upstream of the DOC in the exhaust system.

Diesel Particulate Filter (DPF)
The DPF captures diesel exhaust gas particulates, also known as soot, preventing their release into the atmosphere.

Duramax L5P DPF

This is accomplished by forcing particulate-laden exhaust through thousands of porous cells through a filter substrate. 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 through the porous walls of the inlet cells into the adjacent outlet cells trapping the particulate matter (PM).

In addition, the DPF can remove more than 90% of particulate matter or soot carried in the exhaust gases.

Particulate Matter Sensor
The PM sensor determines the number of particulates (soot) in the diesel exhaust gas exiting the tailpipe by monitoring the collection efficiency of the DPF and aiding in OBD-II emission diagnostics. The PM sensor is similar to the heated oxygen sensor with a ceramic element and includes an individually calibrated control unit.

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The PM sensor sensing element includes:
- Two comb-shaped inter-digital electrodes.
- A heater.
- A positive temperature coefficient (PTC) resistor for temperature measurement.

The operation of the PM sensor is based on the electrical conductivity characteristic of the soot.

As the exhaust gas flows over the sensing element, soot is absorbed in the combs between the electrodes, eventually creating a conductive path. When the path is formed, it generates a current based on the voltage being applied to the element.

The measurement process continues until a preset current value is reached. The sensor operates on a “regenerative” principle to avoid misleading readings.

The soot is cleaned off by heating the element to burn the carbon before the measurement phase begins. The amount of regenerations is based on vehicle strategy.

The cumulative PM sensor current readings are used to determine the amount of soot concentration in the exhaust gas and determine the collection efficiency of the DPF and if regeneration is needed.

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The amount of regenerations is based on vehicle strategy; when the amount of regeneration is reached, the cumulative current readings are used to determine the amount of soot concentration in the exhaust gas and thus the collection efficiency of the DPF.

- **ECM calculates DPF load in grams**
- **Looks @ DPF voltage & calculates flow**

DPF Differential Pressure Sensor	1.02	V
Calculated DPF Flow	85	m³/h
DPF Soot Accumulation	11	g

Duramax L5P DPF Scan Tool Data

The PM sensor is operated in 3 successive modes:
1. Standby mode after power-up to ensure protective heating. On power-up, the control unit starts the heating process to avoid condensation of liquids on the sensing element.

The presence of liquid can cause thermal shock during the heating process, resulting in damage to the ceramic element. Regeneration is not initiated until the dew point temperature has been exceeded.

2. Regeneration mode is conducted before each measurement to ensure a soot-free sensing element. Before starting measurements, absorbed soot is burned off the sensing element by heating it; this ensures each measurement starts at the same condition.

Regeneration is conducted for a pre-determined period based on soot level.

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3. Measurement mode is when soot is actively collected on the sensing element. The sensor heater is deactivated during measurement, so the temperature on the element is equivalent to that of the exhaust gas.

Voltage is applied until a preset 12 micro-amp current threshold is achieved due to increasing current as the soot builds upon the element. The time from the end of the regeneration to reach the threshold is used to calculate the soot concentration in the exhaust gas.

Exhaust Aftertreatment Fuel Injector (if equipped)
The exhaust aftertreatment fuel injector, also known as the indirect fuel injector is located on the passenger side frame rail. The exhaust aftertreatment fuel injector is used to inject fuel into the exhaust system to generate the required heat needed by the diesel oxidation catalyst to function properly.

Duramax L5P Exhaust Aftertreatment Fuel Injector

Normal DPF Regeneration
Over time, the soot trapped on the cell walls acts to restrict exhaust flow through the DPF reducing its effectiveness and 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 (100%), as signaled by the increased pressure drop across the DPF, the ECM commands a regeneration event to burn off the collected soot during regular 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. Under normal operating conditions, the normal DPF regeneration is initiated after approximately 36 gallons of fuel used, or a maximum distance traveled of 911 km (560 miles.)

To initiate a regular DPF regeneration event, the ECM commands additional fuel via the hydrocarbon injector to create the additional exhaust heat in the DOC necessary to promote regeneration and burn-off the collected soot.

During regeneration, exhaust temperatures may exceed 640°C (1,184°F) due to the rapid catalytic combustion of soot within the DPF.

Conversely, exhaust temperatures may be too low to promote proper regeneration under low engine speed or light loads. For example, to protect the DPF catalyst from thermal damage due to excessive soot combustion or sulfate poisoning at low temperatures, the ECM monitors EGT sensors upstream and downstream of the DPF during regeneration.

Suppose the vehicle is slowed to idle speed during a normal DPF regeneration. In that case, the engine may maintain an elevated idle of 900 RPM until the DPF is cooled to a calibrated temperature.

If the EGT sensors indicate that regeneration temperatures have exceeded a calibrated threshold, regeneration will be temporarily suspended until the sensors return to an average temperature.

However, 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 regular regeneration cycles. Periodic regeneration prevents soot buildup from

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reaching a level where its burn-off could produce damaging high temperatures within the DPF. In addition, 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 DPS detects the high-pressure drop across the DPF, 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's manual diesel supplement describes how the operator should drive the vehicle to enable normal regeneration.

Service Regeneration
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.

In addition, the technician canceled the service regeneration or aborted by the ECM when it detected unexpected conditions. The ECM commands additional fuel via post-injection to create the additional exhaust heat in the DOC necessary to promote regeneration and burn-off the collected soot.

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.

Fuses	Usage
7	Powertrain sensor
8	—
9	Diesel exhaust fluid control
10	Fuel heater
11	Smart sensors
12	SCRPM
13	100 watt pump/—

Relays	Usage
1	Diesel exhaust fluid control
2	Fuel heater
3	100 watt pump (LD)
4	Powertrain sensor (LD)
5	Cooling fan clutch (HD)
6	Powertrain sensor (HD)

Duramax L5P DEF Electrical Junction Box

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- 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.
- Ensure the tailpipe 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 and outlet of the particulate filter. Optimum particulate filter temperature is crucial for emission reduction and ensuring complete regeneration.

Excessive particulate filter temperatures could damage the ceramic substrate. In addition, the ECM monitors the inlet and outlet exhaust gas temperature sensors to maintain the particulate filter at its optimum temperature.

Diesel Exhaust Fluid (DEF) System
The DEF system consists of the following components located at the reductant reservoir:

- An electrically-operated reductant pump
- An integrated reductant level sensor and reductant temperature sensor
- Reductant control module
- Reductant quality sensor
- Reductant system heaters

Duramax L5P DEF Tank

The remaining reductant system component, an electrically-controlled reductant injector, is external to the reservoir.

The onboard reservoir holds approximately 26 liters (7 gallons) of reductant. A pump within the reservoir supplies pressurized reductant to the reductant injector upstream of the SCR.

A reductant level sensor within the reductant reservoir provides the reductant control module a signal indicating the reductant level.

The reductant pressure sensor provides the reductant control module with a voltage signal proportional to the reductant pressure generated by the reductant pump. The reductant control module varies the duty cycle of the pump voltage to maintain reductant pressure within a calibrated range.

DEF Gauge Indication	Approximate minimum volume of DEF that can be added *
E 1/2 F	0 L (0 gal)
E 1/2 F	2 L (0.5 gal)
E 1/2 F	4.5 L (1 gal)
E 1/2 F	7 L (2 gal)
E 1/2 F	10 L (2.5 gal)
E 1/2 F	12.5 L (3.5 gal)
E 1/2 F	15 L (4 gal)
E 1/2 F	18 L (4.5 gal)

* Final gauge reading after fill may not illuminate all segments

Duramax L5P DEF Level Indicator

When the ignition is turned Off, the reductant pump is run in reverse for about 45 seconds to purge the reductant supply line. There is a one-minute delay between ignition off and the start of the purge to allow the exhaust system to cool to prevent hot exhaust gas from being drawn into the reductant line.

The ECM also commands the reductant injector to open 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.

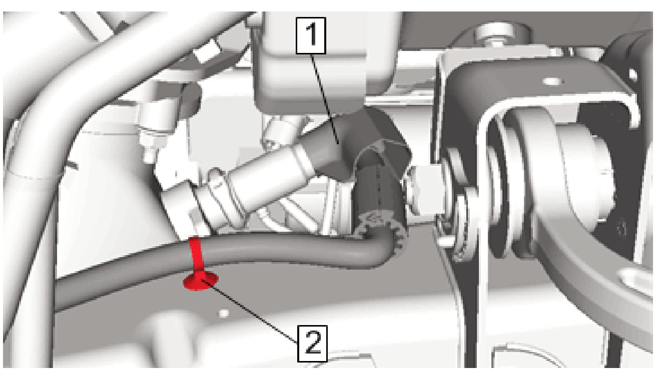
L5P EXHAUST AFTERTREATMENT SYSTEM

DEF Pressure Sensor Transfer Function		
DEF Pump Pressure (PSI) = 29 * Voltage - 14.5		
Volts	Pressure, MPa (gauge)	Pressure, psi (gauge)
5.00	0.8	116
4.50	0.8	116
3.50	0.6	87
2.50	0.4	58
1.00	0.1	14
0.500	0.0	0
0.250	0.0	0

Duramax L5P DEF Pressure Sensor Transfer Function Specifications

Feedback from NOx sensors 1 and 2 allow the ECM to control the reductant supplied to the SCR accurately. For example, suppose more reductant is supplied to the SCR than is needed for a given NOx level.

In that case, the excess reductant results in ammonia slip where significant levels of ammonia exit the SCR. Since the NOx sensors cannot differentiate between NOx and ammonia, ammonia slip will cause NOx sensor 2 to detect higher NOx levels than exist.



Duramax L5P DEF Injector Location

Cold Weather Operation
As reductant will freeze at temperatures below 12°F (-11°C), there are two reductant heaters. Reductant heater 1 is in the reductant reservoir and reductant heater two is in the supply line to the reductant injector.

The reductant control module monitors the reductant temperature sensor within the reservoir to determine if the reductant temperature is below its freeze point. If the module determines that the reductant may be frozen, it energizes the reductant heaters.

Reductant pump operation is disabled for a calibrated amount of time to allow the heaters to thaw the frozen reductant.

Once the thaw period expires, the module energizes the reductant pump to circulate warm reductant back to the reservoir to speed thawing.

In addition, the ECM looks for an increase in the reductant temperature to verify that the reductant reservoir heater is working.

Urea Quality and Specifications
Diesel Exhaust Fluid (DEF) combines deionized water and urea that transform harmful nitrous oxide emissions into harmless water and gas.

These systems exist on most modern diesel pickups, diesel cars, semi-trucks, and farm equipment. Appropriately used, DEF is a good thing—but misused, it can cause serious (and costly) problems.

L5P EXHAUST AFTERTREATMENT SYSTEM

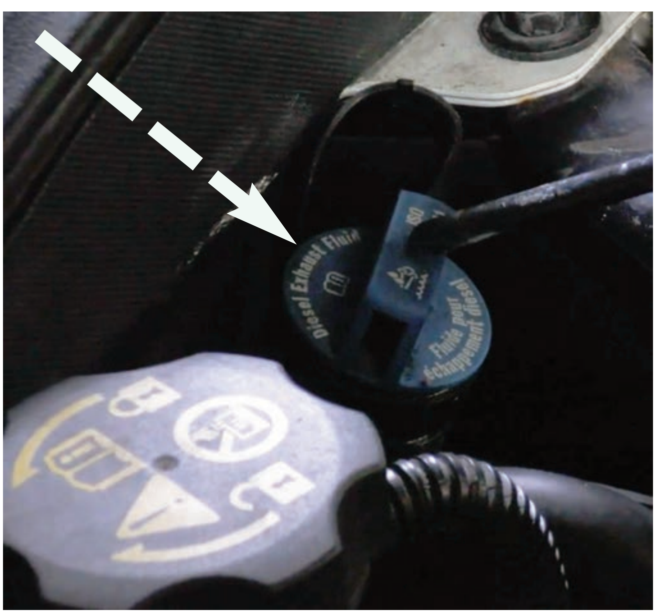
Every day, technicians and service advisers at dealerships and independent shops get customer calls regarding fuel contamination on diesel-powered vehicles. One of the most common is the use, or misuse, of DEF.

The most common issues seen are;
- Mistakenly add DEF directly into the diesel fuel tank.
- DEF contamination.
- Improperly handling DEF.

Any one of the three can be a potential issue that can cause damage to the engine. However, you and the customer can limit the vehicle's exposure and damage with some training and caution. Realization of two different tanks for two different fluids.

DEF should never be mixed with the diesel fuel tank's diesel fuel. DEF has its tank and its filling port. The DEF tank and the diesel tank are close on some vehicles and can be confused.

The DEF filling port is located in the engine bay next to the coolant fill bottle. Do not confuse the two!



Duramax L5P DEF Fill Location

The DEF port will be much smaller than the diesel filler port. If you have a concern where you believe DEF has been added to the diesel fuel tank, drain the tank and purge the fuel system immediately.

DEF added directly in the diesel fuel tank can cause tens of thousands of dollars of damage if left un-repaired.

DEF Contamination.
For DEF to work correctly, it's purity is critical. Unfortunately, DEF is highly susceptible to contamination.

Inspect the DEF filler cap for dirt, dust, crystallization, and any other forms of contaminant. It is effortless for these particles to enter the filler port and contaminate the entire system.

Typical Chemical and Physical Analysis

Parameter	Typical
Urea Concentration	32.5 +/- 0.7%
Specific gravity at 20° C	1.087 – 1.093 kg/m3
Refractive index at 20° C	1.3814 – 1.3843
Free Ammonia (alkalinity)	0.2% max
Biuret	0.3% max
Formaldehyde	None
Insoluble matter	20 ppm max
Phosphates	0.5 ppm max
Calcium	0.5 ppm max
Iron	0.5 ppm max
Copper	0.2 ppm max
Zinc	0.2 ppm max
Chromium	0.2 ppm max
Nickel	0.2 ppm max
Aluminum	0.5 ppm max
Magnesium	0.5 ppm max
Sodium	0.5 ppm max
Potassium	0.5 ppm max
Water quality	Demin—ISO 3696 applicable

Physical Properties of DEF Fluid

Ensure the customer and your technicians know to clean around the cap and filler port BEFORE removing the cap and adding DEF.

The best way to monitor and test the concentration of DEF is to use a digital refractometer similar to the ones used for testing engine coolant. The ideal concentration of DEF is between 32.5% - 37.0% urea.

A telltale sign this ratio is off and/or DEF is contaminated is excessive DEF consumption, malfunctions with the Selective Catalytic Reduction (SCR) system, or even engine shutdown.

L5P EXHAUST AFTERTREATMENT SYSTEM

Avoiding these problems with DEF contamination can be as simple as talking to the customer and your technicians and explaining the importance of cleaning around the DEF filler cap and port.

Also, explain to them the importance of storing DEF in its container or in a container that has never been used to store any other liquids, materials, or additives.

Proper Handling and Storage of DEF.
DEF should be stored away from direct sunlight and in plastic totes or stainless steel lockers in its container. Ensure the storage area is a cool, dry area indoors. Follow the DEF manufacturer's instructions for storage.

DEF will degrade over time but can last up to two years if stored correctly. DEF will freeze at temperatures below 12°F (-11°C), and turn into a slushy fluid. However, you can still use this slushy mix if tested and found to meet the manufacturer's specifications.

DEF has a shelf life of approximately 24 months, but when exposed to sunlight or prolonged exposure to temperatures warmer than 75°F (23.8°C), the nitrogen in DEF begins to volatilize into ammonia gas and can reduce shelf life. Once volatilized, it will not go back into suspension and the percentage of urea in the product decreases to less than the optimum 32.5%.

DEF Refractometer Testing

Fresh DEF has a slightly pungent smell of ammonia. After extended exposure to temperatures warmer than 75°F (23.8°C), the ammonia scent grows stronger, indicating nitrogen has vaporized, changing the urea-to-water ratio of the product.

Because DEF is highly reactive to many metals, DEF must be stored in stainless steel, polypropylene, or high-density polyethylene (HDPE) storage tanks. All pumps, valves, and fittings must be DEF compatible and used only to transfer DEF.

If DEF is stored somewhere cold, ensure you have a container that will allow the DEF to expand. Once the temperature gets into the freezing range, DEF will expand by at least 7%.

Other tips.
- Change DEF filters regularly following the vehicle manufacturer's service interval.
- If the DEF tank runs empty, the DEF needed lamp on the instrument cluster will illuminate. If left unattended, the engine performance will degrade, go into limp-in-mode or even shut off altogether; do not ignore the lamp!
- It is always good practice to keep the DEF tank topped off, and DEF tanks that run low can build up condensation, contaminating the fuel system causing severe damage over time.

DEF testing.
Testing the Diesel Exhaust Fluid (DEF) is critical, especially if you have an SCR problem. Usually stored near the fuel tank, it only takes a few extra minutes to ensure you are not chasing your tail.

What type of problems will we see caused by poor fuel quality or fuel/DEF contamination? The answer is many.

Components that could be damaged by poor quality or contaminated fuel include;
* Low-pressure fuel pump.
* Fuel filters and strainers.
* High-pressure fuel pump.
* Fuel rails.
* Injectors.
* Pressure control valves.
* Fuel coolers.
* Fuel pressure sensors or switches.
* Lines including return lines.

These components can fail due to poor fuel quality and/or contamination, and all of them are very expensive to repair or replace. For this reason, we test the fuel and get it out of the system if it fails the diagnostic process.

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Symptoms of fuel contamination;
* The engine will crank but will not start.
* The engine will not crank.
* The engine will start, but the cranking duration is extended.
* Engine misfires.
* Knocking from the engine.
* Excessive smoke from the exhaust system.
* Multiple assorted DTCs.
* Multiple failures of injection components.

Glow Plug System
As you all know, diesel engines ignite fuel differently from gasoline engines. While a gasoline engine uses air and fuel compressed by the piston and ignited by the spark plug, diesel engines use air and fuel alone. Ignition is caused by the heat created by the process of compression.

Duramax L5P Glow Plugs

A charge of fuel is sprayed into the cylinder, and ignition occurs. Eight glow plugs are used as an aid to starting. If for some reason you need to replace the glow plugs or a glow plug, you MUST replace the glow plug with a NEW glow plug.

Ever since emission devices have been required on modern diesel engines, delete kits have been there to get rid of them. In today's world, delete kits are available for every emission part on the vehicle, including the glow plugs.

The problem with deleting the glow plugs, other than being illegal and voiding the warranty, is that deleting them can eventually cause problems with the vehicle. Glow plugs heat the cylinder quickly, enabling the emission components to work quicker.

However, if the glow plugs aren't there to heat the cylinder, the emission components have to work harder to clean the exhaust gasses.

As a result, the harder the emission components work, the more likely they will either clog up faster or wear out prematurely. In short, it is not a good idea to delete ANY component of the emission system. However, deleting components of the emission system can void the warranty on the vehicle and is illegal in some states.

The glow plug control module accomplishes control of the glow plugs. The nominal voltage for the glow plugs is 5.4 volts. When the ignition is turned On, the glow plug control module applies 7.2 V for 2.2 s, then 5.7 V for 0.8 s, and then 5.4 V until 1200°C (2192°F) is reached. The maximum voltage of the system is 10 V.

While the engine is running, the voltage will vary between 4.7 – 10 V when in closed-loop control to maintain a glow plug temperature that ranges from 1150° – 1180°C (2102° – 2156°F). The temperature and the power consumption are controlled between the engine control module (ECM) and the glow plug control module within a wide range to suit the engine's preheating requirements. Each glow plug is energized individually.

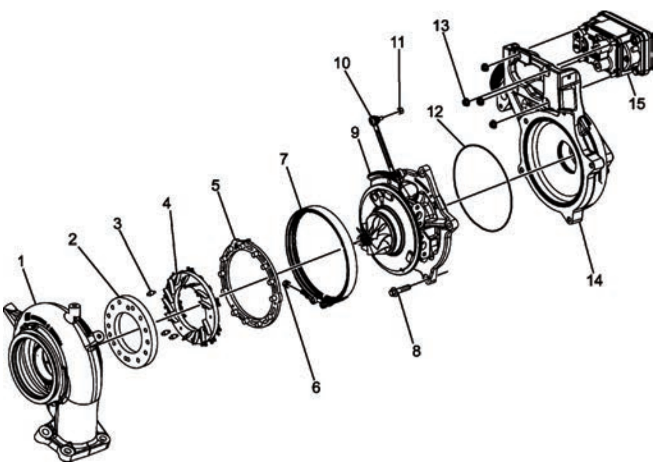
This capability yields more optimum heat times for the glow plugs; thus pre–glow times can be kept to a minimum for a short wait to crank times and maximum glow plug durability. A DTC will be set if there is a glow plug system fault.

A typical functioning system operates as follows:
· Turn the ignition On with the engine Off and at room temperature.
· The glow plugs turn On, and 7.2 V is applied for 2.2 s, then 5.7 V for 0.8 s, and then 5.4 V to reach 1200°C (2192°F).
· The glow plug wait lamp is ON for 1 second during cold start.
· The glow plug wait lamp may not illuminate during a warm engine start.
· If the engine is cranked during or after the above sequence, the glow plugs may cycle On and Off after the ignition switch is returned from the start position to the run position, whether the engine starts or not. The engine does not have to be running to terminate the glow plug cycling.

L5P EXHAUST AFTERTREATMENT SYSTEM

The glow plug's initial ON time will vary based on the system voltage and temperature. Lower temperatures cause longer On times.

Turbocharger System
The L5P uses a new Borg Warner single stage variable geometry turbocharger (VGT). This turbocharger is water cooled and is capable of producing 220 kPa (31.9 psi) boost pressure. The turbocharger pumps compressed air into the combustion chambers.



ID	COMPONENT		ID	COMPONENT
1	TURBINE HOUSING		9	CORE ASSEMBLY
2	LOWER VANE RING		10	LINKAGE ASSEMBLY
3	VANE RING ASSEMBLY SPACER		11	LINKAGE ASSEMBLY NUT
4	UPPER VANE RING ASSEMBLY		12	COMPRESSOR HOUSING O-RING
5	ADJUSTING RING ASSEMBLY		13	ACTUATOR NUT
6	V-BAND NUT		14	COMPRESSOR HOUSING
7	V-BAND		15	ACTUATOR
8	COMPRESSOR HOUSING BOLT			

Duramax L5P Borg Warner Turbocharger (Courtesy GM Corp.)

Along with this compressed air, a greater quantity of fuel is also injected into the combustion chamber. The turbine spins as exhaust gas flows out of the engine and over the turbine blades, and turns the compressor wheel at the other end of the turbine shaft, pumping more air into the intake system. The combination of the two increases total horsepower supplied to the drivetrain.

The turbocharger is controlled by the ECM. The ECM will command the vane position actuator via a Controller Area Network (CAN). The actuator uses a brushless motor located at the top of the turbocharger.

Duramax L5P Turbocharger Actuator

The actuator is connected to the vanes by a linkage rod. The vanes are used to adjust the amount of boost pressure and can also control the boost pressure independent of the engine speed. The vanes are mounted to a unison ring which rotates to change the angle of the vanes. The ECM commands the vane angle and adjusts the boost pressure depending on the load applied to the engine.

The turbocharger vanes are fully open when the actuator arm is in the vertical top rest position. The turbocharger vanes are fully closed when the actuator arm is in the horizontal bottom of the travel position.

The turbocharger vanes are generally open when the engine is not under load. However, the ECM will often close the turbocharger vanes to create back pressure to drive exhaust gas through the Exhaust Gas Recirculation (EGR) valve as required.

In addition, the ECM may close the vanes at low load conditions to accelerate engine coolant heating at extremely cold temperatures.

The turbocharger is also utilized as a component of the exhaust brake system if equipped. Under certain conditions, the ECM will automatically close the turbocharger vanes to build back pressure in the exhaust, reducing engine speed and slowing the vehicle without applying the brakes.

L5P EXHAUST AFTERTREATMENT SYSTEM

During regeneration, the ECM will vary the turbocharger vanes to assist with the exhaust system warm-up and maintain proper engine exhaust temperatures needed to regenerate the Diesel Exhaust Particulate Filter (DPF) properly.

Each time the ignition is turned off, the turbocharger vane position actuator performs a learning procedure. The actuator arm sweeps the turbocharger vanes from fully open to close to obtain a count value. This value is compared to the previous value to ensure proper vane position. Following the learning to sweep, the actuator sweeps the vanes two more times to clean off combustion soot.

NOTES

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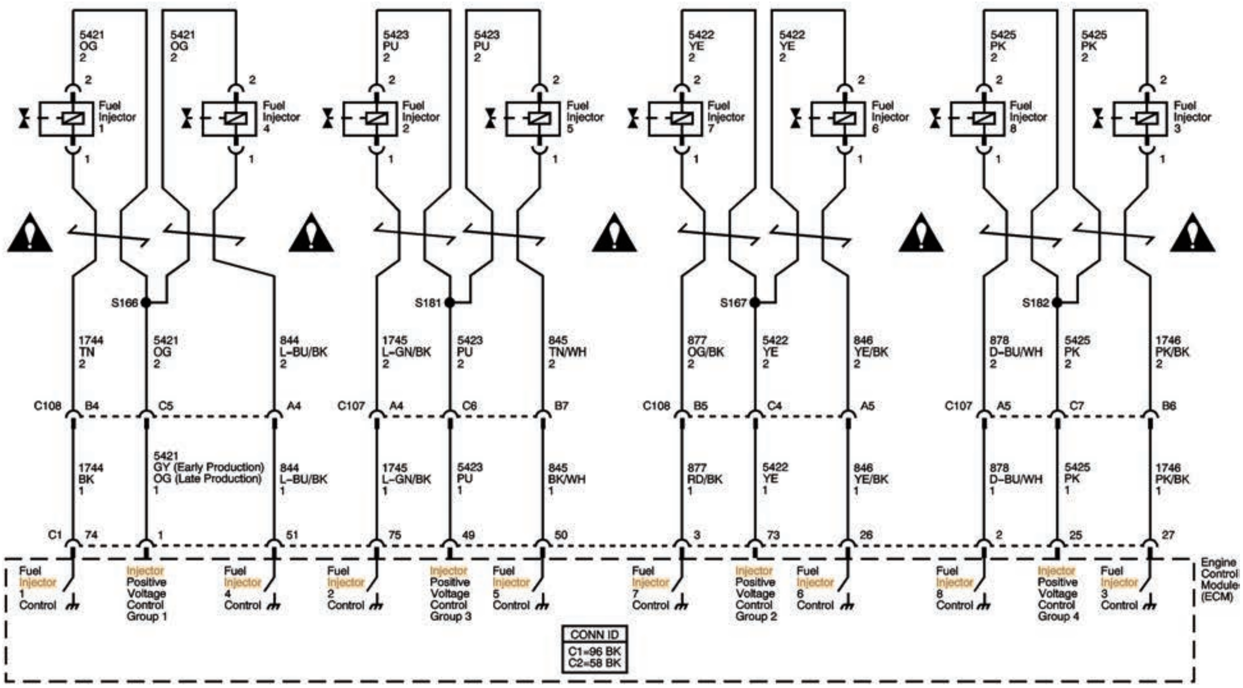
NEW STYLE INJECTORS



New Style Injector Wiring DIagram - Courtesy GM Corporation

Illustrated above is a wiring schematic of the injector circuit on a 2006 Chevrolet Silverado 2500 HD with a 6.6L Duramax engine. As you can see at the feed point of the injectors, two injectors share the same feed point. In the years prior to 2006, four injectors shared the same feed point.

Since two injectors will share the same feed point, it is not uncommon that, if you have an electrical problem with an injector, you find you have a problem with both injectors using the same feed point.

Several diagnostic and service points are important to note. First, chafing of any of these wires can cause electrical faults and failures to the injectors. Chafing happens when the injectors have been replaced improperly, modifications have been made to the engine outside of OEM specifications or proper repair procedures have not been followed.

The injectors are separated into the following four groups:

- Group 1–DTC P2146 with injectors 1 and 4
- Group 2–DTC P2149 with injectors 6 and 7
- Group 3–DTC P2152 with injectors 2 and 5
- Group 4–DTC P2155 with injectors 3 and 8

Fuel Injector Group DTC set.

1. Turn OFF the ignition. Allow 60 seconds for the ECM to power down.
2. Disconnect the ECM connector.
3. Connect a test lamp between the fuel injector positive voltage control circuit and battery voltage.

· If the test lamp illuminates, test the fuel injector positive voltage circuit for a short to ground.
· Test the fuel injector positive voltage control circuit and the fuel injector control circuit for high resistance.
· Test the affected fuel injector for high resistance.
· If all circuits test normal, replace the ECM.

Fuel Injector Group DTC and Fuel Injector DTCs set.

1. Turn OFF the ignition. Allow 60 seconds for the ECM to power down.
2. Disconnect the ECM connector.
3. Connect a test lamp between the fuel injector positive voltage control circuit and a ground.

· If the test lamp illuminates, test the fuel injector positive voltage control circuit for short to voltage.
· Connect a test lamp between the affected fuel injector control circuit and battery voltage.
· If the test lamp illuminates, test both fuel injector control circuits of the affected group for a short to ground.

NEW STYLE INJECTORS

· Test the affected fuel injector for high resistance.
· If all circuits test normal, replace the ECM.

Another change implemented in 2006 is the use of Injector Quantity Adjustment (IQA), codes for the injectors. IQA codes are programmed into the GPCM and the ECM.

These IQA codes are used to determine the flow each injector can supply and are programmed into the entire fuel map.

Each injector has a unique flow quantity and code that the ECM and GPCM use to control the fuel metering, making the fuel delivery more precise, increasing injector efficiency and improved emissions.

Any time an injector is replaced, the IQA code must be programmed into the ECM and the GPCM (if available). If the IQA codes are missing from either or both, the following DTCs will set in the ECM's memory.

P160C - IQA code missing from GPCM.
P268A - Sets if IQA missing from ECM.

HEAD GASKETS

Measuring Piston Protrusion

Earlier Duramax variants have had a history of cylinder head gasket issues. If you work on these engines long enough, you will surely experience replacing head gaskets.

Unfortunately, many technicians pick the thickest gasket available to avoid any clearance issues.

If you have had the experience of replacing a head gasket on the earlier Duramax variants, you have undoubtedly found there are three thicknesses of gaskets available.

This is because you, the technician, are expected to measure for cylinder head warpage and piston protrusion, then select the correct thickness of gasket for your situation.

Using the wrong thickness of the gasket can, at the very least, diminish engine performance and, at worst, damage the engine severely.

The cylinder head gaskets are side specific, meaning the left and right bank gaskets are not interchangeable.

If the incorrect gasket is installed, lubricant and coolant passages will be blocked off, causing severe damage. Keep a close eye on this as not to damage or destroy the engine.

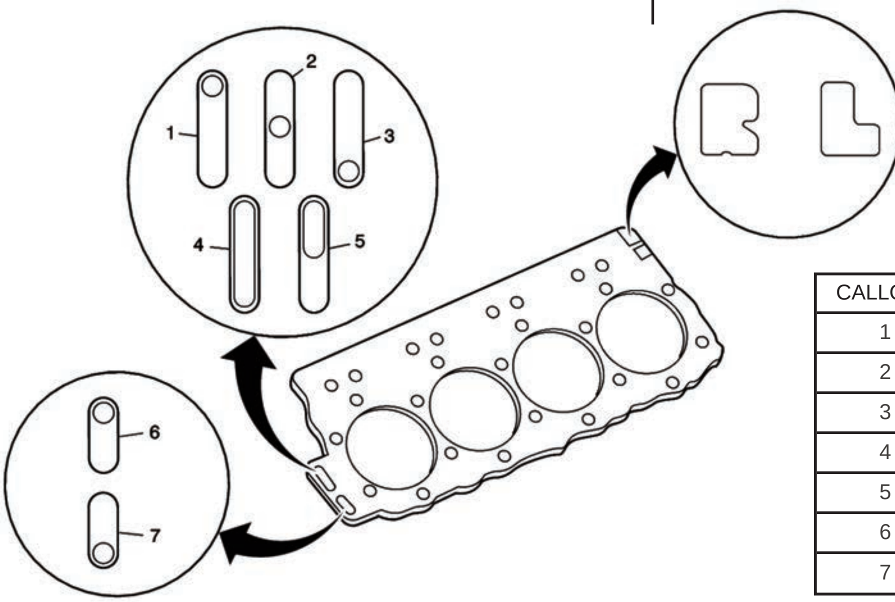
Measure piston protrusion to confirm you are picking the correct gasket. Also, always check both sides as they are not always the same.

Use a dial indicator on the deck surface and check the piston in two different locations on each bank.

HEAD GASKETS

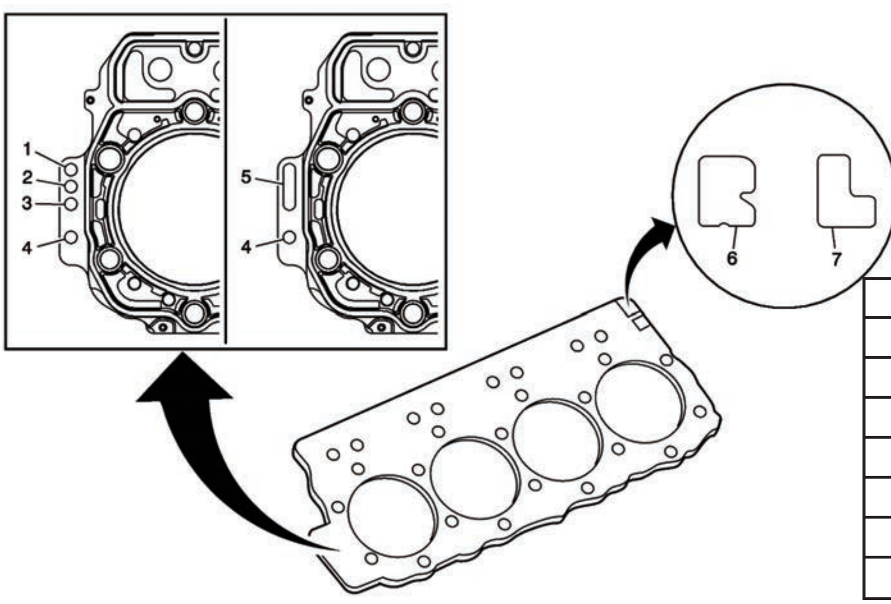
The last step is to place the pointer right above the piston pin centerline to prevent inaccurate readings due to the piston rocking in the cylinder bore. Rotate the engine through (TDC) while noting the maximum reading on the dial indicator.

Continue this process for each cylinder to get the maximum protrusion value for each bank of cylinders. Next, determine your gasket options using the information below.



CALLOUT	IDENTIFIER
1	Grade A
2	Grade B
3	Grade C
4	Block Over-Bored
5	Block Over-Bored and Deck Milled
6	Right
7	Left

Cylinder Head Gasket (First Design) - Courtesy GM Corporation



CALLOUT	IDENTIFIER
1	Grade A
2	Grade B
3	Grade C
4	Right Bank Only
5	Block Over-Bored
6	Right
7	Left

Cylinder Head Gasket (Second Design) - Courtesy GM Corporation

HEAD GASKETS

Cylinder Head Gasket Grade	Ti Max (Piston Projection)		Compressed Gasket Thickness	
	Metric (mm)	English (in)	Metric (mm)	English (in)
Grade A	0.223–0.274	0.0088–0.0108	0.90–1.00	0.0354–0.0394
Grade B	0.274–0.325	0.0108–0.0128	0.95–1.05	0.0374–0.0413
Grade C	0.325–0.376	0.0128–0.0148	1.00–1.10	0.0394–0.0433
Block Over-Bored 0.010–0.030 in (0.254–0.762 mm)	0.223–0.376	0.0088–0.0148	1.00–1.10	0.0394–0.0433
Block Over-Bored 0.010–0.030 in (0.254–0.762 mm) and Deck Milled 0.008 in (0.203 mm)	0.4257–0.5777	0.0168–0.0228	1.25–1.35	0.0492–0.0532

TURBOCHARGER DIAGNOSTICS

GM TSB #03-06-93-001D: Diagnostic Information on Turbocharger Malfunction Due to Lack of Engine Oil for LBZ, LB7, LLY and LMM Duramax Diesel Engine - (Oct 9, 2008).

Subject:	Diagnostic Information on Turbocharger Malfunction Due to Lack of Engine Oil for LBZ, LB7, LLY or LMM Duramax™ Diesel Engine
Models:	2001–2009 Chevrolet Silverado
	2003–2009 Chevrolet Kodiak C4500-C5500 Series
	2006–2009 Chevrolet Express
	2001–2009 GMC Sierra
	2003–2009 GMC TopKick C4500-C5500 Series
	2006–2009 GMC Savana
	with 6.6L Duramax™ V8 Diesel Engine (VINs D, 1, 2, 6 — RPOs LBZ, LB7, LLY, LMM)

This bulletin is being revised to add model years. Please discard Corporate Bulletin Number 03-06-93-001C (Section 06 — Engine/Propulsion System).

Notice: Before installing a new turbocharger, clean any debris or excessive oil from the charge air cooler and intake system in order to prevent damage to the new turbocharger or an engine overspeed condition.

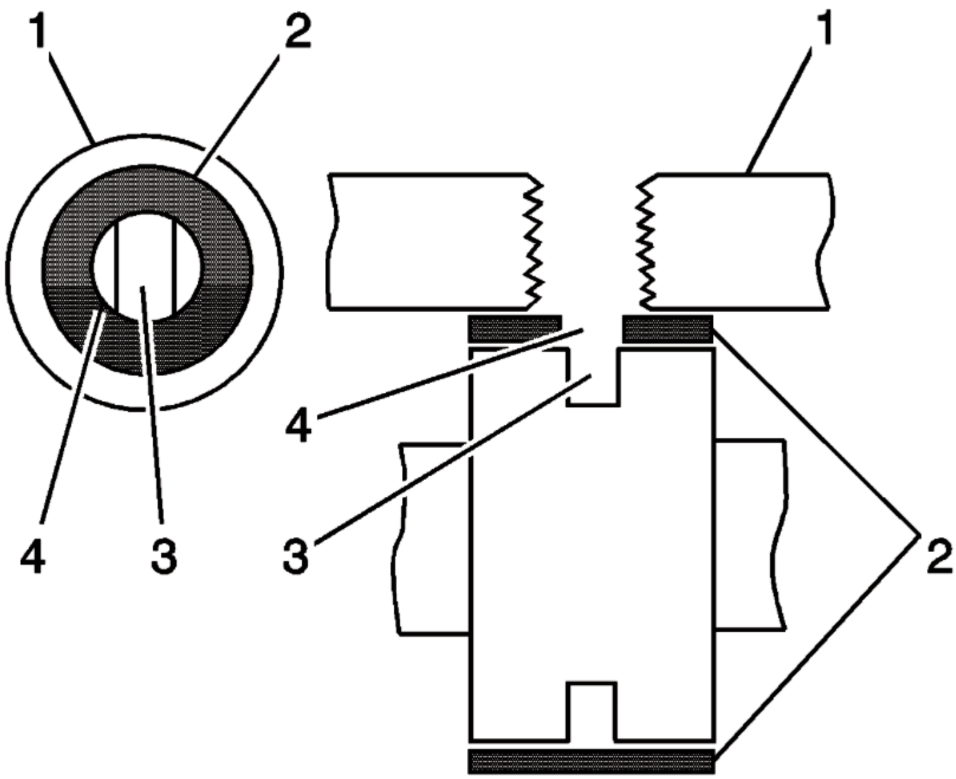
Spun Camshaft Bearing
If a turbocharger performance concern is thought to be caused from a deficiency of engine oil, the camshaft bearing should be checked. The number 4 camshaft bearing bore feeds the turbocharger engine oil supply hose.

If this camshaft bearing spins in the bore, the turbocharger will be deprived of engine oil. This will cause a performance concern with the turbocharger. Incorrect diagnosis of this condition will result in a repeat performance concern with the turbocharger.

TURBOCHARGER DIAGNOSTICS

Camshaft Bearing Inspection
If the turbocharger has to be replaced, perform the following procedure in order to verify the condition of the number 4 camshaft bearing before installing a new turbocharger.

1. Remove the turbocharger. Refer to Service Information (SI) procedures for Turbocharger Replacement.
2. Remove the turbocharger oil supply hose.



3. Visually inspect for correct alignment of the number 4 camshaft bearing oil hole (Refer to illustration callout 4) through the turbocharger oil supply hole in the block (Refer to illustration callout 1). The camshaft journal oil groove (Refer to illustration callout 3) should be visible through the camshaft bearing oil hole (Refer to illustration callout 4).

4. Turn the engine over by hand a 1/2 turn. The camshaft journal oil groove (Refer to illustration callout 3) should still be visible through the camshaft bearing oil hole (Refer to illustration callout 4) as the engine is turned.

5. If the camshaft bearing (Refer to illustration callout 2) has spun, the camshaft bearing oil hole (Refer to illustration callout 4) will either not be visible at all or it will be misaligned with the turbocharger oil supply hole during the inspection procedure. In the event of a spun camshaft bearing, the engine must be replaced.

Restricted Turbocharger Oil Supply Hose
If a lack of oil is suspected, the turbocharger oil supply hose should also be checked for damage. The turbocharger oil feed line is a high pressure plastic tube that is protected by a stainless steel braided covering. If it is twisted at all or bent too far during turbocharger removal, the plastic line may fold and kink. The kink may cause an oil flow restriction. If the plastic pipe does kink, it will not return back to its normal size and shape. The damage may not be obvious upon inspection because the braided steel covering will hide the deformity.

TURBOCHARGER DIAGNOSTICS

LB7 Turbocharger Replacement
During turbocharger removal on the 6.6L LB7 engine, the turbocharger oil feed line can be pulled directly away from the turbocharger body in a perpendicular fashion. Care must be taken to avoid excessive bending of the line.

LBZ, LLY or LMM Turbocharger Replacement
During repairs on the 6.6L LBZ, LLY or LMM engine, the EGR cooler does not allow enough perpendicular movement of the line to clear the turbocharger for removal. However, the line can be pushed straight forward of the turbocharger with less risk of kinking the line. Assistance may be required to keep the lines clear of the turbocharger during removal or installation.

Notice: Do not twist the turbocharger oil supply line. Twisting of the line will result in the collapse and deformation of the plastic line, restricting oil flow and causing turbocharger performance concerns.

GM bulletins are intended for use by professional technicians, NOT a "do-it-yourselfer". They are written to inform these technicians of conditions that may occur on some vehicles, or to provide information that could assist in the proper service of a vehicle. Properly trained technicians have the equipment, tools, safety instructions, and know-how to do a job properly and safely. If a condition is described, DO NOT assume that the bulletin applies to your vehicle, or that your vehicle will have that condition. See your GM dealer for information on whether your vehicle may benefit from the information.	ASE	WE SUPPORT VOLUNTARY TECHNICIAN CERTIFICATION

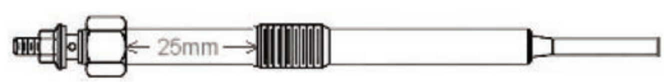
GLOW PLUG ISSUES

Throughout the years, the Duramax engine has used three different types of glow plugs. Starting with the LB7, the glow plugs were gold in color and the threads start at approximately ¼" below the hex head of the plug. The plugs also have an operating voltage of 11.0 volts.

Glow Plug Design Prior to 2006

The glow plugs used in the LLY were similar in shape and thread size as well as location but were silver in color and the plugs operated at 4.7 volts.

Starting in 2006 with the LBZ variant, the glow plugs have the threads starting at approximately 1.0" below the hex head and the plug operated at 4.7 volts.



Glow Plug Design Prior to 2006

Glow plugs sit within each engine cylinder and have a metal tip at the end of them. During the ignition process, the tip of the glow plugs is provided electrical current to create heat within the cylinder.

Fuel injectors then spray fuel directly onto the tip of the glow plug, which ignites the fuel, creating ignition when the engine usually is not warm enough itself.

In the 2006 year models, both the LLY and LBZ Duramax engines had glow plug failure issues. The glow plugs are powered by a glow plug control module which sends the electrical current to heat them.

Later models had problems with the GPCM. First, the GPCM would overload the plugs with electrical current. This caused the tips of the glow plugs to overheat to

GLOW PLUG ISSUES

the breaking point. If the tip breaks off, it will inevitably enter the combustion chamber, causing catastrophic damage to the engine.

Lucky for the vehicle owner and us, this problem was caused by incorrect or corrupt programming of the GPCM. To fix this issue, you will need to perform a re-flash of the GPCM with the most current calibration from GM. See GM TSB below Cortesy GM Corporation;

#06522: Product Emission-Engine Glow Plug System Concern-Reprogram Glow Plug Control Module - (Mar 24, 2006)

Subject:	06522 — Engine Glow Plug System Concern – Reprogram Glow Plug Control Module
Models:	2006 CHEVROLET SILVERADO, EXPRESS, KODIAK
	2006 GMC SIERRA, SAVANA, TOPKICK
	EQUIPPED WITH 6.6L V8 (RPO LLY – VIN 2 OR RPO LBZ – VIN D) DURAMAX DIESEL ENGINE

Condition
Certain 2006 Chevrolet Silverado, Express, Kodiak; and 2006 GMC Sierra, Savana, Topkick model trucks equipped with a 6.6L V8 (RPO LLY – VIN 2 or RPO LBZ – VIN D) Duramax Diesel engine, may have a condition in which the engine glow plugs are overstressed electronically, causing glow plug failure and engine damage in some cases.

Correction
Dealers are to reprogram the Glow Plug Control Module (GPCM).

Vehicles Involved
Involved are certain 2006 Chevrolet Silverado, Express, Kodiak; and 2006 GMC Sierra, Savana, Topkick model trucks equipped with a 6.6L V8 (RPO LLY – VIN 2 or RPO LBZ – VIN D) Duramax Diesel engine and built within these VIN breakpoints:

Year	Division	Model	From	Through
2006	Chevrolet	Silverado	6E100002	6E232880
			6F100001	6F218045
2006	Chevrolet	Express	61100002	61221358
2006	Chevrolet	Kodiak	6F400002	6F422129
2006	GMC	Sierra	6E100003	6E232523
			6F100002	6F216758
2006	GMC	Savana	61100022	61221125
2006	GMC	TopKick	6F400010	6F904910

GLOW PLUG ISSUES

If you suspect this problem with the GPCM installed on the vehicle you are working on, the first thing you should do is check to see if the GPCM has the most current calibration using your scan tool. Doing this can prevent you from condemning a good GPCM without knowing if the GPCM has been re-flashed correctly.

Glow Plug Failure Symptoms

- Hard starting/difficulty starting (especially in cold weather)
- Rough idling
- Cylinder misfires
- Glow plug engine light
- Black smoke coming from the exhaust

FUEL PRESSURE RELIEF VALVE

Failure in fuel pressure, whether high pressure or low pressure, can cause driveability problems and hard start and no-start conditions. The Fuel Pressure Relief Valve (FPRV) operates much like the temperature/pressure valve on your home's water heater. The valve is there to protect the entire system but should only activate if there is a failure in pressure control.

The valve will not activate when the fuel system is operating under normal fuel pressures. However, no fuel should ever leak or escape past this valve unless a condition within the fuel system causes an over-pressurization of the fuel.

Higher demand in fuel flow can cause pressure cycling either from a restriction in the system or an increase in demand from a performance tune programmed into the ECM. When this happens, the ECM has difficulty commanding the same fuel flow.

The pressure oscillates from a condition under the desired pressure to a condition that is over the desired pressure. At some point, pressure will build to the point where the FPRV performs its job by discharging fuel to relieve the fuel pressure.

The discharged fuel is hot and will weaken the spring within the valve. Once the spring within the valve fails, the engine will have a complicated or impossible time creating the correct amount of fuel pressure to run the engine correctly.

If the fuel pressure stays within standard operating specifications, you won't have any issues. To keep the system operating normally, the ECM will need to maintain the correct fuel flow so pressure cycling will not occur.

A key to this is having clean fuel filters free of debris that may restrict fuel flow. Some owners will also have a lift pump installed, if not already equipped, to maintain fuel pressure to the low side of the fuel system.

Some devices such as Race Valves or Shim Mods are available to stabilize the fuel flow at higher pressure than the OEM recommends. Installation of these items is not recommended. Below is a selection from a GM Product Information (PI) Bulletin.Courtesy GM

Important: General Motors does not support or endorse the use of devices or modifications that, when installed, increase the engine horsepower and torque. Important: For further information on aftermarket Power-Up Kits, refer to February 2006 Emerging Issues Course Number 10206.02D. In Canada, information on aftermarket Power-Up Kits is covered in the April 2006 TAC TALK program.

Aftermarket power-up devices are non-approved by General Motors. These devices are usually piggy-backed in the main engine harness or remain connected to the diagnostic connector to upload the calibration to the ECM.

Recent warranty reviews of returned engines show engine breakdown or non-function due to power-up devices that are utilized for increased horsepower and torque.

The following information will assist technicians in identifying overpower engine breakdown or non-function due to aftermarket power-up devices vs. non overpower engine breakdown or non-function.

FUEL PRESSURE RELIEF VALVE

Non-GM parts can alter the design of the vehicle. GM dealers need to be aware of the quality of parts being installed on vehicles. If failure occurs as a result of installation of sub-par parts, warranty coverage may be denied.

Installed Power-Up Kit
Aftermarket power-up kits have become a very popular add on for performance-minded customers. These devices can add horsepower and torque and can add additional stress to the engine.

These aftermarket calibrations take the Duramax™ powertrain outside of its design torque and horsepower rating. They do this by altering air/fuel ratios and injector timing, resulting in excessive cylinder pressure and temperature.

When these calibrated parameters are altered, it will upset the design balance and can lead to a reduction of engine life expectancy.

Generally, in inspection of Duramax™ engine failure due to power-up failures, two or more cylinders will be affected.

Installed Power-Up Kit

- *Once installed, the calibration may mask itself with the factory original calibration ID and may remain the same. Refer to the latest version of Corporate Bulletin Number #08-06-04-006 - Information on Identifying Non-GM Calibration Usage for LMM Duramax™ Diesel Engine.*
- *A Tech 2® will not positively enable you to identify the use of a power-up device.*
- *Some companies that offer power-up devices claim increases of 150 or more horsepower and 300 or more lb/ft pounds of torque.*
- *A vehicle that is used to the power-up device potential 100% of the time will see earlier engine wear and breakdown.*
- *A vehicle that takes advantage of additional power, but on a less frequent basis, may not see premature engine wear and breakdown until later in the engine's life.*
- *A vehicle not pushed to its limits of the power-up device often may not encounter premature wear and breakdown until after the engine is out of warranty.*

BLOCK OFF PLUGS

Block Off Plugs

When a Duramax engine will not start, one of the very first things to check is the fuel rail pressure. If the pressure is less than 2,500 psi, one of the most likely causes is a defective injector that is returning excess fuel back to the tank.

A return flow volume test will verify if excessive return flow is the problem. This block off plug is then used to identify the individual cylinder that is at fault.

The injection line is removed for one cylinder at a time and the cap installed on the fuel rail in place of the injection line.

When the cylinder with the offending injector is capped, the rail pressure will rise and the truck will start. In some cases, you will need several caps to isolate the problem injector.

This is because several injectors that return slightly too much fuel can have the same effect as a single injector with extremely excessive return flow.

These block off plugs are available in quantity through the aftermarket. You may want to think about buying multiple sets as this tool can be used across other diesel platforms such as Powerstroke and Cummins. Be advised, the size required across platforms may vary so be sure to do your research before buying.

AIR LEAK EQUIVALENCY TESTING

Bulletin No.: PIP4932D

Date: Dec-2015

Service Bulletin

PRELIMINARY INFORMATION

Subject: Diagnostic Tip - Duramax Diesel Airflow Leak Equivalency Ratio Or Induction System Leak Indication And P0101

Models: 2007-2016 Chevrolet Express, Kodiak, Silverado 2007-2016 GMC Savana, Sierra, Topkick Equipped with the 6.6L Duramax Diesel Engine RPO code LGH, LML, and LMM

This PI was superseded to update Recommendation/Instructions and Model Years. Please discard PIP4932C.

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

Condition/Concern A dealer may have encountered a customer concern of a SES light on and DTC P0101 has been found.

During diagnosis of P0101 the dealer technician will be directed to monitor the Airflow Leak Equivalency Ratio (ALER for 2007 - 2013) or Induction System Leak Indication (ISLI for 2014 - 2016). This ratio will help decide where to start looking for an air intake leak.

Recommendation/Instructions Complete the current SI diagnostics for any symptoms or DTCs found. If during diagnosis the tech has found that the ALER/ISLI is above or below the specification the tech will have to carefully check for leaks in the air intake. Below is a description of where to look depending on the actual ALER/ISLI reading

Note: There can be no modifications to air intake, exhaust, ECM calibrations, or MAF sensor to utilize these diagnostics.

Note: The EGR valve position must be at 0% or commanded to 0% for the ALER/ISLI to be used to determine a potential location of a leak. If the EGR position is not at 0%, using the ALER/ISLI is not valid

Note: The specification for ALER/ISLI is different depending on the engine in the vehicle. Please make sure the correct specification is being used from the description below.

If the ALER reading (with EGR position at 0%) is less than 0.86:1 for a 2007-2010 LMM engine: Inspect for anything which could result in an unexpected rise in measured airflow.

This would include leaks in the boosted side of the Turbo (not including the EGR valve) or a shifted/skewed MAF sensor.

In rare cases, an aftermarket low restriction exhaust system could also cause low readings. If the ALER reading (with EGR position at 0%) is greater than 1.20:1 for 2007-2010 LMM engine: Inspect for anything which could result in an unexpected drop in measured airflow.

This would include leaks in the unboosted side of the Turbo (between the MAF sensor and turbo), a shifted/skewed MAF sensor, damaged Turbo, exhaust leaks between the exhaust ports and the turbo, or a leaky EGR valve when closed. If the ALER/ISLI reading (with EGR position at 0%) is less than 0.90:1 for a 2010-2016 LGH or LML engine: Inspect for anything which could result in an unexpected drop in measured airflow.

This would include leaks in the unboosted side of the Turbo (between the MAF sensor and turbo), a shifted/skewed MAF sensor, damaged Turbo, exhaust

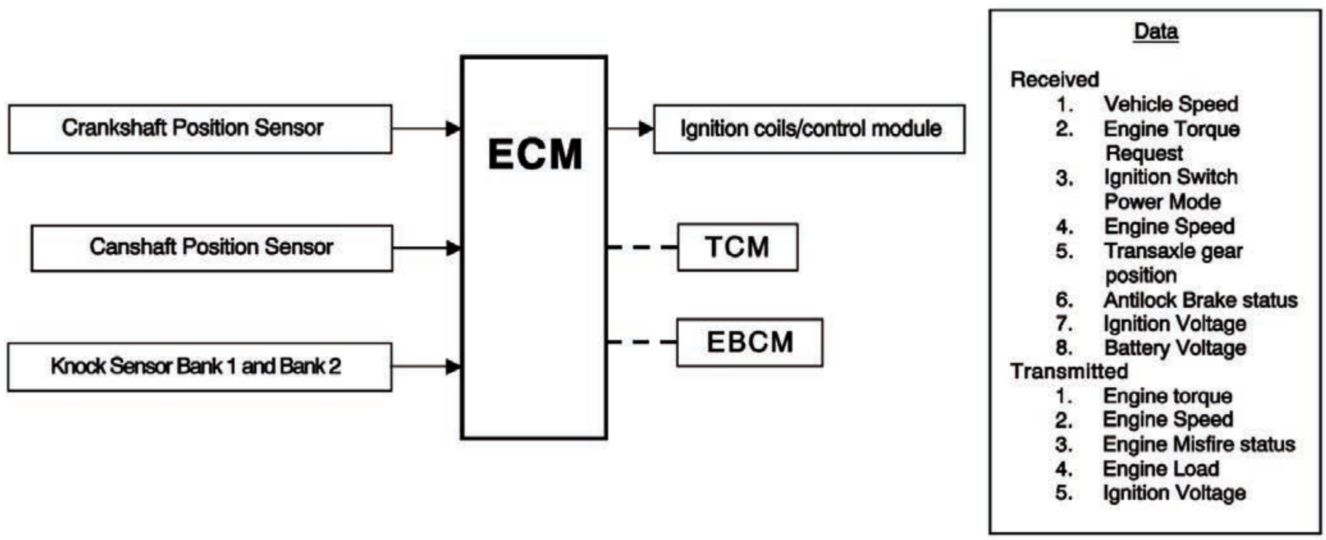
AIR LEAK EQUIVALENCY TESTING

leaks between the exhaust ports and the turbo, or a leaky EGR valve when closed If the ALER/ISLI reading (with EGR position at 0%) is greater than 1.10:1 for a 2010-2016 LGH or LML engine: Inspect for anything which could result in an unexpected rise in measured airflow.

This would include leaks in the boosted side of the Turbo (not including the EGR valve) or a shifted/skewed MAF sensor. In rare cases, an after-market low restriction exhaust system could also cause high readings.

Use the current SI procedure for Charge Air Cooler Diagnosis (Induction System Smoke Test), Charge Air Cooler Diagnosis (Full System Air Leak Test), or Charge Air Cooler Diagnosis (Charge Air Cooler Air Leak Test) as needed.

CKP AND CMP DTCS



CKP/CMP Reporting Structure to the ECM

The Camshaft Position (CMP) sensor and the Crankshaft Position (CKP) sensor work in unison to help the ECM control ignition, fuel delivery and sometimes timing.

Both consist of a tone ring or reluctor which passes over a magnetic sensor generating a voltage signal. This voltage signal is used by the ECM to determine the position of the crankshaft and camshaft.

The crankshaft position (CKP) sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of the reluctor wheel on the crankshaft.

The reluctor wheel is spaced at 60-tooth spacing, with 2 missing teeth for the reference gap. The reference gap is used to identify the crankshaft position at each start-up.

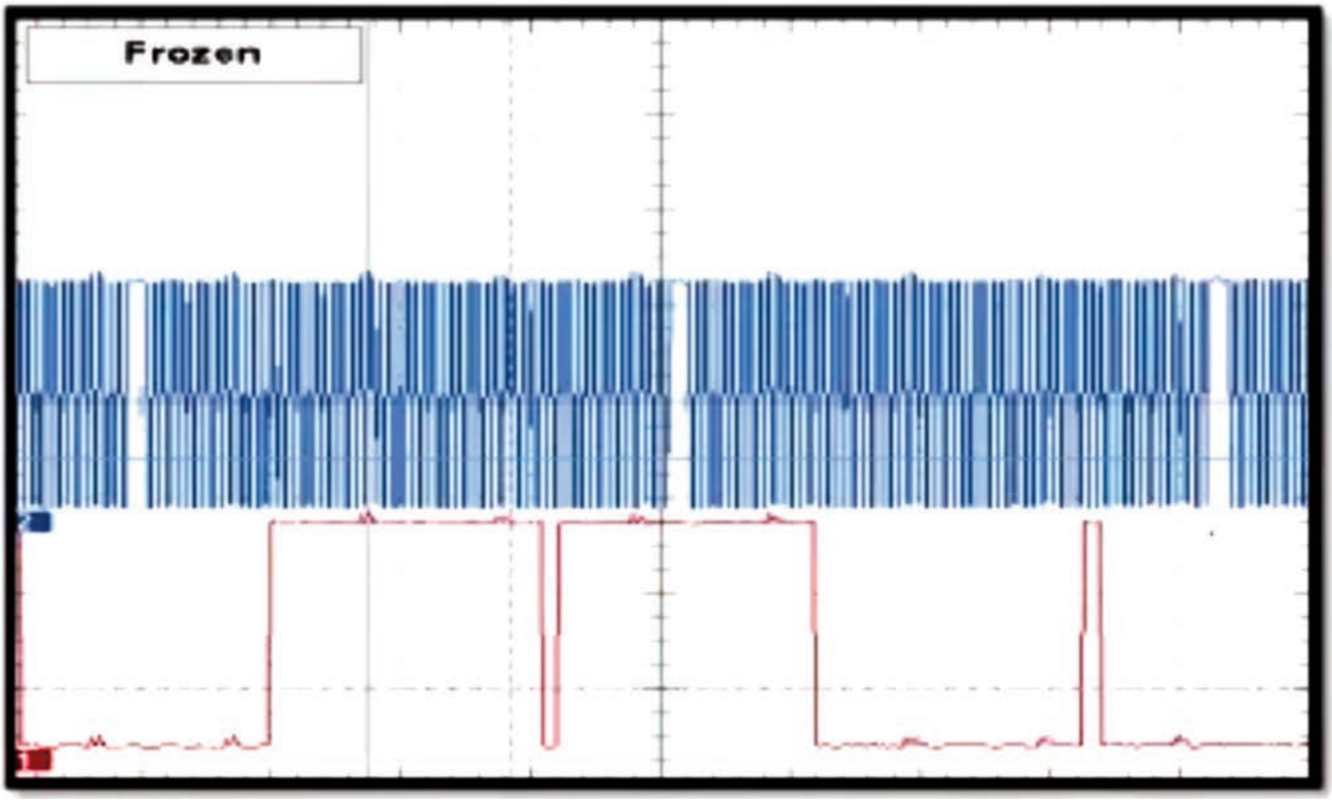
The CKP sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution.

The CKP sensor sends a digital signal to the ECM as each tooth on the reluctor wheel rotates past the CKP sensor. The ECM uses each CKP signal pulse to determine crankshaft speed position.

This information is then used to determine the optimum ignition and injection points of the engine. The ECM also uses CKP sensor output information to determine the camshaft relative position to the crankshaft, to control camshaft phasing, and to detect cylinder misfire.

The camshaft position (CMP) sensor detects magnetic flux changes between the four narrow and wide tooth slots on the reluctor wheel.

CKP AND CMP DTCS



CKP/CMP Reporting Structure to the ECM

The CMP sensor provides a digital ON/OFF DC voltage of varying frequency per each camshaft revolution.

The ECM will recognize the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression and which is in exhaust. The information is then used to determine the correct time and sequence for fuel injection and ignition spark events.

P0016
DTC P0016 concerns the camshaft and crankshaft. If the CKP and/or CMP reports a fault to the ECM, it could mean the two shafts are out of synchronization. The ECM will set DTC P0016 illuminating the MIL alerting the driver.

Symptoms may include the following;
- Illuminated MIL.
- The engine may run rough or have reduced performance.
- Engine cranks but does not start.
- Engine may start but run poorly.
- An audible rattle may be noticeable near the harmonic balancer indicating a damaged tone ring.

Causes may include the following;
- Stretched or damaged timing chain.
- Faulty CKP.
- Faulty CMP.
- Damaged CMP or CKP reluctor wheel.
- Damaged, chafed or loose wires or connections.
- Damaged timing chain tensioners or guides.
- Damaged PCM or the PCM is in need of a software update.
- Low engine oil level.

Inspection and diagnosis

Visually inspect the CMP and CKP sensors for damage. Inspect the wiring harnesses for chafing, damage or loose connections. If a fault is detected, repair or replace the sensors, harnesses or connections as necessary and retest to verify the repair.

CKP AND CMP DTCS

If the problem still exists, inspect the tone rings for proper alignment and/or damage. If damage or loose, repair or replace as necessary and retest to verify the repair.

Connect a scan tool to the vehicle and monitor the CMP and CKP waveforms. If the signals appear to be normal, inspect the timing chain for proper alignment. If the timing chain is out of alignment, inspect for a damaged tensioner that may have allowed the chain to slip one or multiple teeth.

Also inspect the chain for excessive stretch. Repair or replace components as necessary and retest to verify the repair.

Other CMP/CKP sensor DTCs include P00147, P0018, P0019, P0335, P0336, P0337, P0338, P0339, P0385, P0386, P0387, P0388 and P0389.

DIESEL PARTICULATE EMISSIONS

Diesel Particulate Filter Pressure (DPFPS) Sensor

The Diesel Particulate Filter Pressure (DPFPS) sensor is used to monitor the soot loading of a particulate filter on the Duramax. The signal of the sensor is not sufficient to determine an optimized timing for regeneration of the DPF.

It is part of a soot loading model that should be calculated permanently by the ECU. The sensor helps to determine the content of ashes remaining permanently in the filter.

The soot loading model should be calculated in the background with the differential pressure as one of several inputs.

Further input values are:
- Engine load.
- Exhaust Gas Temperature (EGT).
- Backpressure.

The triggering of the regeneration only based on the sensor signal is not recommended due to the following reasons:
- Increase of tolerances at high and low temperatures.
- Signal drift over lifetime.
- Filter overload (if sensor is failing or fails).

The arithmetic soot loading model triggers the filter regeneration. Additionally, time controlled regeneration should be implemented as a back-up system to avoid filter overloading in any case.

44 grams – 100% Soot Loading
- **Active regeneration is commanded.**

54 grams – 125% Soot Loading
- **Clean filter lamp illuminates.**
- **Vehicle needs to be operated above 30 mph for at least 20 to 30 minutes.**

70 grams – 160% Soot Loading
- **DTC P2463 sets.**
- **Reduced engine power.**
- **Service regeneration required.**

87 grams – 200% Soot Loading
- **DTC P244B Sets.**
- **Reduced engine power.**
- **Driving regeneration is inhibited.**
- **Service regeneration or DPF replacement is required.**

During regeneration of an overloaded filter extremely high temperatures easily melt ceramic of metal filter systems.

DIESEL PARTICULATE EMISSIONS

The remaining ashes after regeneration cycles can be determined with the differential pressure sensor.

The soot loading model can then be adjusted to the increasing ash content. The installation place of the sensor has to ensure that the gas temperature never exceeds 130°C.

Cooling loops or prolonging the tube system helps to adjust the temperature management. The sensor has a very quick response time. An alternative application is monitoring the charger pressure for small chargers.

Particulate filter pressure	5.0 kPa
DPF pressure sensor	1.70 volts
DPF soot mass	80 g
DPF indicator command	ON
DPF regeneration status	Active
DPF regeneration inhibit reason	None
Engine run time since last DPF regeneration	8.92 Hours
Fuel used since last DPF regeneration	73.0 liters
Distance since last DPF regeneration	340.Miles
DPF regenerations completed	1

DPF Scan Tool Data Screen Capture

Illustrated above is a screen capture of scan tool data relating to the DPF. If we take a closer look, we can see the DPF soot mass is at 80 grams and the vehicle is in ACTIVE regeneration status.

The engine has run 8.92 hours and traveled 340 miles since the last regeneration. This capture also tells us the vehicle has completed one regeneration within the time period specified in the screen capture.

This illustrates how often this particular vehicle has gone into regeneration. Excessive regeneration could indicate a problem with fuel, exhaust as well as a problem with aftermarket tuning devices.

How Regeneration Should Occur
Soot is generated during the normal operation of a diesel engine. The DPF traps this soot during engine operation not allowing it to escape into the environment.

The regeneration process allows the vehicle to clean the DPF increasing its ability to trap more soot.

The ECM uses the following inputs to determine when a regeneration is needed and when it should occur;

- After approximately 36 gallons (136 L) of fuel used since the last regeneration.
- A maximum distance of 800 miles (1287 km) have been traveled since the last regeneration.
- A pre-determined number of engine hours since the last regeneration.
- A calculated or measured soot mass of 100% in the particulate filter.

When any of the above criteria are met, the ECM will perform a regeneration as soon as all the correct conditions are met.

If the ECM cannot perform a regeneration, the ECM will only look at the soot mass to determine to display the Continue Driving DIC message or to set DTC P2463.

DIESEL PARTICULATE EMISSIONS

The ECM uses the following criteria to perform a regeneration:

- Vehicle in Drive
- BARO sensor 1 is more than 51 kPa (7.4 PSI)
- Engine speed between 500 and 4000 RPM
- Exhaust Gas Temperature Sensor 1 between 100 and 725 C
- Exhaust Gas Temperature Sensor 2 between 95 and 750 C
- Exhaust Gas Temperature Sensor 3 between 0 and 750 C
- Exhaust Gas Temperature Sensor 4 between 60 and 750 C
- Exhaust Gas Temperature Sensor 4 between 60 and 850 C
- Engine Coolant Temperature between 50 and 140 C
- Intake air temperature between -70 and 250 C
- Fueling from -1 to 165mm3
- Vehicle speed from -1 to 160 km/hr
- No active DTC related to EGR, Indirect injector, or Throttle (boost)

The vehicle does not have a soot level sensor to determine how much soot is in the DPF. It uses algorithms to calculate the soot mass.

Factors that contribute to generating high levels of soot include:

- Charge air cooler (CAC) and Air induction system leaks.
- A restricted air filter.
- Exhaust system leaks that may cause inaccurate Exhaust Gas Temperature sensor or Exhaust Pressure Differential sensor values.
- Failed, intermittent, improperly installed, incorrectly wired or loose Exhaust Gas Temperature sensors may cause inaccuracies in the soot model. Look at all temperature sensors when the vehicle is cold to verify that they read close to each other.
- Improperly routed differential pressure lines. The exhaust differential pressure line should have a continuous downward gradient without any sharp bends or kinks from the sensor to the DPF.
- Leaks or internal restrictions from the Exhaust Pressure Differential sensor lines.
- A skewed or shifted Exhaust Pressure Differential sensor will cause inaccuracies in the soot model.
- A cracked or damaged MAF sensor housing.
- A skewed, stuck in range, or slow responding MAF sensor. Inspect the MAF sensor for contamination.
- Indirect Fuel Injector leaking or restricted.
- Externally damaged or worn components.
- Loose or improperly installed components.
- Water in fuel contamination.
- Engine mechanical condition, such as low compression.
- Vehicle Modifications

NOTES