Duramax 6600 (LMM) Diesel Particulate Filter Operation and Diagnosis

Course #16342.01B

GM TRAINING

GM Service Technical College

GM Service Know-How

Caution

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

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

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

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

The service manuals contain Cautions and Notices that must be observed carefully in order to reduce the risk of injury. Improper service may cause vehicle damage or render the vehicle unsafe. The Cautions and Notices are not all-inclusive. General Motors cannot possibly warn of all the potentially hazardous consequences that may result by not following the proper service procedures.

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

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

Foreword

This course describes the technological enhancements that the Duramax 6600 engine and exhaust system received for the 2007i model year.

The Duramax Diesel 6.6L V8 provides class-leading output, exclusive durability enhancing features and superior noise and vibration control for GM's heavy-duty pickups, commercial vans, and medium-duty trucks. This 90-degree turbodiesel V8 combines the best design and manufacturing elements of General Motors Powertrain worldwide.

The 6.6 liter Duramax engine has been continuously refined each year since its introduction in the 2001 Chevrolet Silverado and GMC Sierra pickups. For the 2004 through 2006 model years, the engine received extensive modifications that were aimed at increasing torque output and reducing exhaust emissions while maintaining the engine's fuel economy. Early in the 2006 Model Year, structural changes to the block and connecting rods increased the strength of the engine, allowing calibration changes that increased output for the applications in the Chevrolet Silverado and GMC Sierra pickups to the current horsepower and torque levels (see specifications).

The 2007 Duramax LMM model year updates, as covered in this course, are aimed specifically at reducing exhaust emissions so that the engine complies with EPA regulations set forth in the agency's 2007 Highway Rule. Engine air intake, fuel system, and electronic control system calibrations, and exhaust system components are re-engineered so that the engine can benefit from the the significant emissions reductions that are achieved through the use of Ultra Low Sulfur Diesel fuel in combination with state of the art exhaust after treatment technology.

The Duramax diesel engine will remain as an option for all current Chevrolet and GMC applications: TopKick/Kodiak medium duty trucks, Express/Savana vans, and Silverado/Sierra HD pickup trucks.

The lower output fleet version of the Duramax is discontinued for 2007i.

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1. Introduction

Introduction

Diesel Engine Beginnings

In 1893, Paris-born engineer and inventor Rudolf Diesel published a paper entitled “The Theory and Construction of a Rational Heat Engine.” The paper described an engine in which air in a cylinder is compressed by a piston to a very high pressure, causing a high temperature. During the compression stroke, fuel is injected into a combustion chamber at the top of the cylinder and is ignited by the heat of the compressed air. Unlike the earlier Otto internal combustion engine, the Diesel invention required no electric spark. While he was involved in a number of patent disputes, Diesel prevailed and the compression ignition internal combustion engine he invented still bears his name today (figure 1-1).

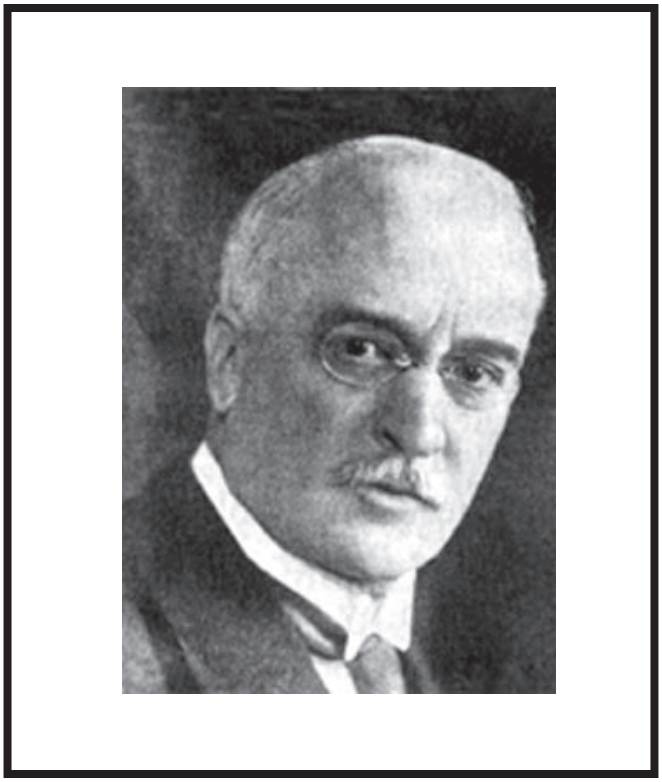


Figure 1-1, Rudolf Diesel

The earliest diesels were large stationary engines designed to operate on a variety of fuels, including powdered coal dust and vegetable oil. In 1898, the first such engine to be used in the United States was installed in a St. Louis brewery. In the 1920’s, fuel injection systems were perfected that permitted diesel engines to become portable enough to be used in on-road vehicles. As the engines continued to develop over the years, diesels came to be recognized for their superior power output, fuel efficiency and relative economy of operation. Large and small diesel-powered vehicles, including trucks, busses and locomotives, have become the mainstay of the United States transportation industry. Diesel is the dominant power source for heavy duty agricultural and construction machinery as well as commercial marine vessels and power generators.

Modern engines have all but eliminated the size, weight, noise, vibration and sensitivity to cold weather disadvantages often associated with the diesel engine. They are smaller, lighter, operate much more quietly and smoothly, and use sophisticated electronics that ensure optimum starting and performance under a wide variety of operating conditions.

The principal drawback that has remained is the diesel engine’s disadvantage of emitting significant amounts of particulate matter (PM) and oxides of nitrogen (NOx), and lesser amounts of hydrocarbon (HC), carbon monoxide (CO), toxic air pollutants and odors. This situation is about to change.

Figure 1-2, **Smog**

Pollution From Diesel Exhaust

Diesel Fuel and Exhaust

Most of the diesel fuel currently used in the United States is refined from petroleum. Distilled from crude oil, the main components of diesel are known as middle distillates because they are heavier than gasoline but lighter than lube oil. Kerosene is in the same middle distillate class. Most of today's diesel engines are designed to operate on ASTM No. 2-D grade diesel fuel. Diesel fuel has higher energy content per gallon than gasoline but its higher density also produces more combustion emissions than gasoline.

Soot or Particulate Matter

Soot particles may come directly from the exhaust tailpipe or they can also form when emissions of nitrogen oxide and various sulfur oxides chemically react with other pollutants suspended in the atmosphere. Such reactions result in the formation of ground-level ozone, more commonly known as smog. Smog is the most visible form of what is generally referred to as particulate matter (figure 1-2).

Particulate matter refers to tiny particles of solid or semi-solid material suspended in the atmosphere. This includes particles between 0.1 micron and 50 microns in diameter. The heavier particles, larger than 50 microns, typically tend to settle out quickly due to gravity. Particles smaller than 0.1 micron tend to act like molecules. Particulates are generally categorized as follows:

- **TSP**: Total Suspended Particulate refers to all particles between 0.1 - 50 microns. Up until 1987, the EPA standard for particulates was based on levels of TSP.
- **PM10**: Particulate matter of 10 microns or less (approximately 1/6 the diameter of a human hair). EPA has a standard for particles based on levels of PM10.
- **PM2.5**: Particulate matter of 2.5 microns or less (approximately 1/20 the diameter of a human hair), also called "fine" particles. In July 1997, the EPA approved a standard for PM2.5.

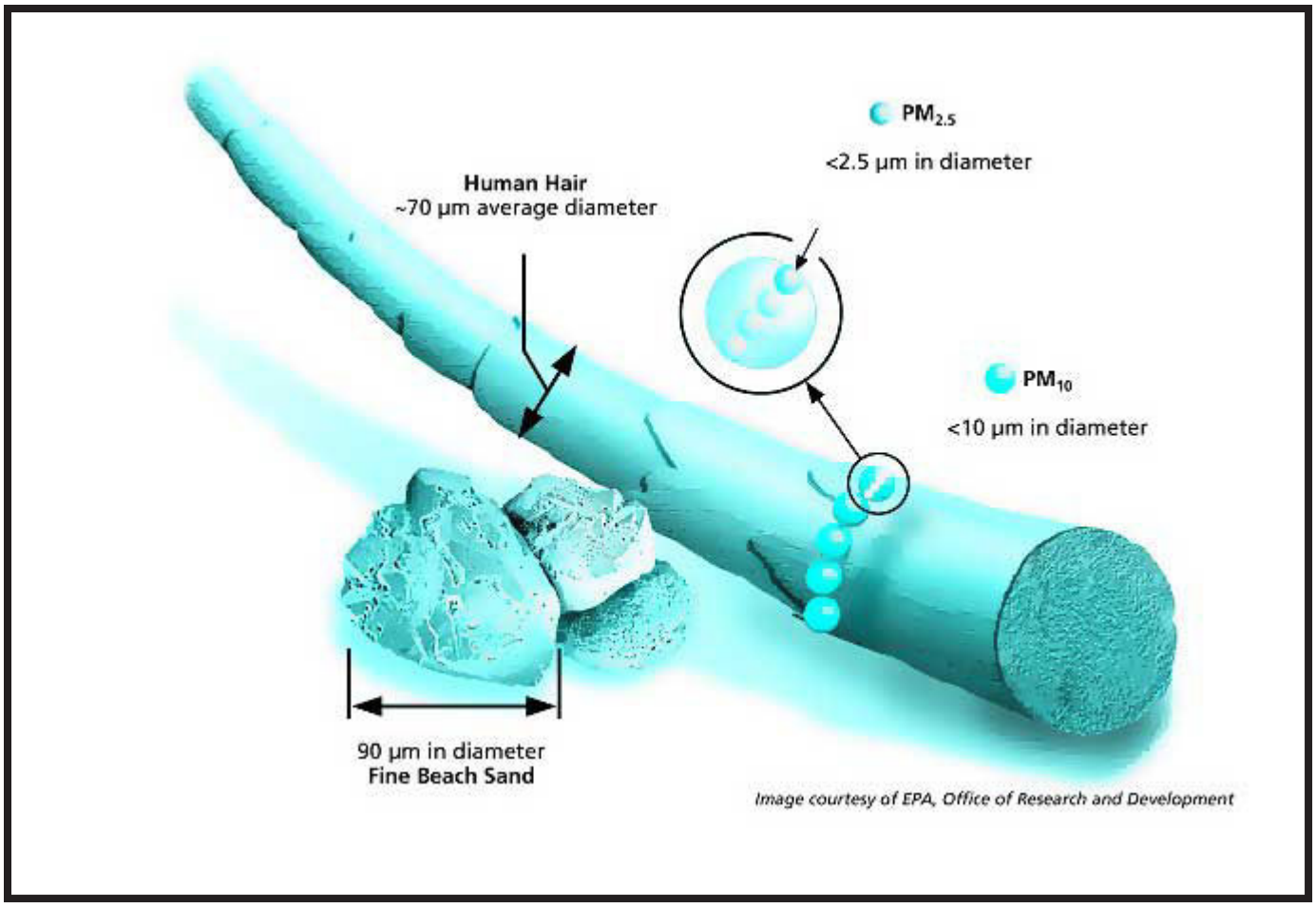


Figure 1-3, Particulate Matter Sizes

In general soot particles produced by diesel combustion fall into the categories of fine, that's less than 2.5 microns and ultra fine; less than 0.1 microns. Ultra fine particles make up about 80-95% of soot (Figure 1-3).

The US Environmental Protection Agency (EPA) announced new, revised National Ambient Air Quality Standards (NAAQS) for fine and coarse particle matter, referred to as $PM_{2.5}$ and PM_{10}, respectively (fine particles are 2.5 micrometers in diameter and smaller; inhalable coarse particles have diameters between 2.5 and 10 micrometers).

The main provisions of the new rule are:

- The EPA has strengthened its previous daily $PM_{2.5}$ standard, from 65 µg/m^3 to 35 µg/m^3.
- The current annual $PM_{2.5}$ standard remains unchanged at 15 µg/m^3.
- The existing daily PM_{10} standard remains at 150 µg/m^3.
- The annual PM_{10} standard has been revoked; the available evidence does not suggest an association between long-term exposure to coarse particles at current ambient levels and health effects, said the EPA.

States must meet the revised standards by 2015, with a possible extension to 2020, depending on local conditions and the availability of controls. Later this month, EPA will issue guidance on monitoring fine and coarse particle pollution.

Notes

2. US Environmental Legislation

US Environmental Protection Agency Legislation

Clean Air Act

In October 1993, the 1990 Clean Air Act Amendments required that diesel fuel for “on highway” vehicles contain no more than 0.05 percent sulfur by weight.

Before this rule was applied, diesel fuel typically contained 0.2 to 0.4 percent sulfur by weight.

2007 Highway Rule

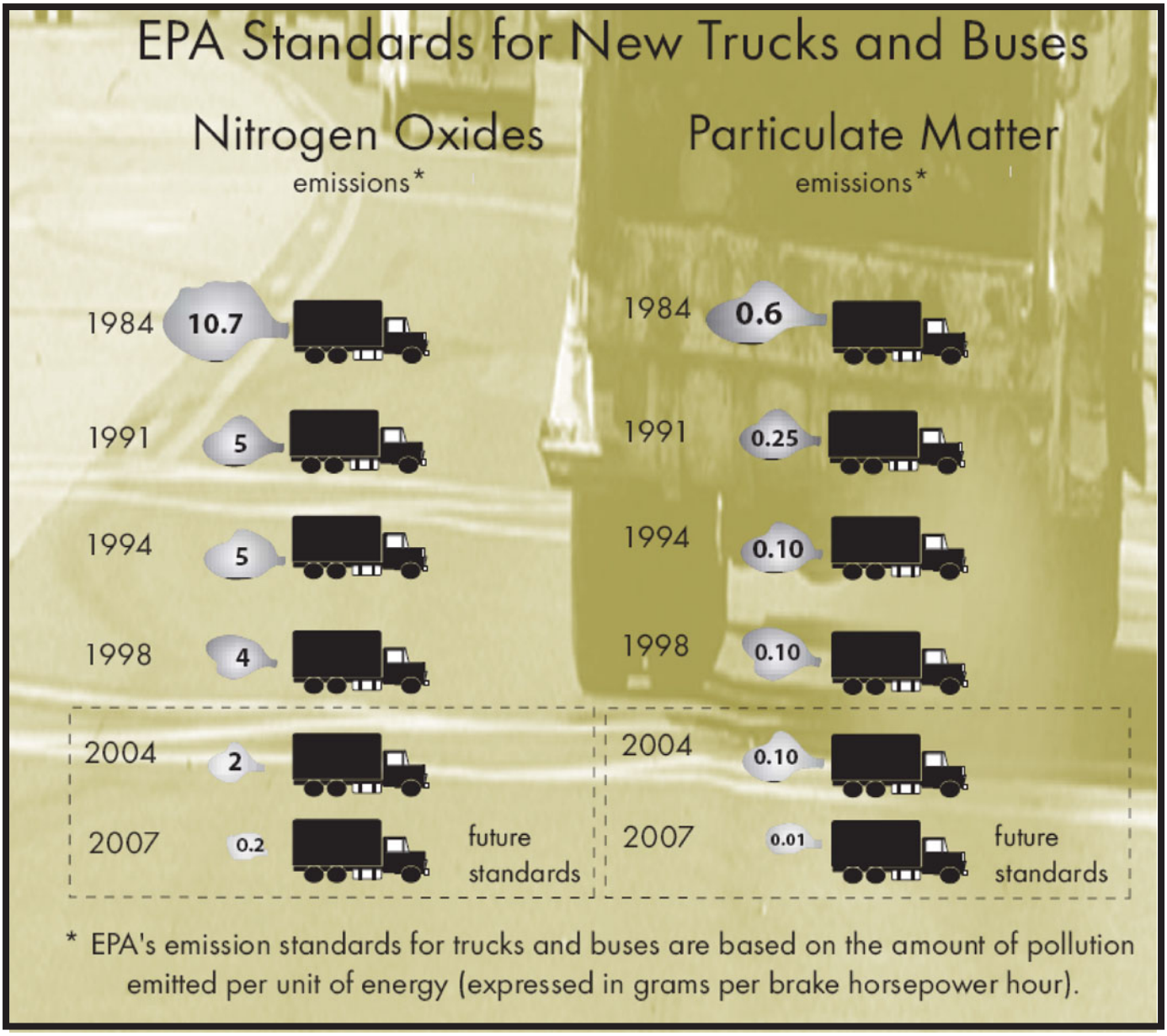
During 2007 and in subsequent model years, all diesel engines built for use on United States highways must comply with updated Federal emissions regulations contained in the “2007 Highway Rule.” The following is an excerpt from the official EPA ruling.

In 2000, EPA moved forward on schedule with its rule to make heavy-duty trucks and buses run cleaner, and the Highway Diesel Rule (the “2007 Highway Rule”), was finalized in January 2001. Beginning with the 2007i model year, the harmful pollution from heavy-duty highway vehicles will be reduced by more than 90 percent.

Sulfur in diesel fuel must be lowered to enable modern pollution-control technology to be effective on these trucks and buses. EPA will require a 97 percent reduction in the sulfur content of highway diesel fuel from its current level of 500 parts per million (low sulfur diesel, or LSD) to 15 parts per million (ultra-low sulfur diesel, or ULSD). Refiners began producing the cleaner-burning diesel fuel, ULSD, for use in highway vehicles beginning June 1, 2006. ULSD enables advanced pollution control technology for cars, trucks, and buses so that engine manufacturers can meet the 2007 emission standards. Engine manufacturers have the flexibility to meet the new standards through a phase-in approach between 2007 and 2010. The program also includes various flexible approaches, including additional time for some refiners and special provisions for small refiners.

Once this action is fully implemented:

- 2.6 million tons of smog-causing nitrogen oxide emissions will be reduced each year.
- Soot or particulate matter will be reduced by 110,000 tons a year.
- An estimated 8,300 premature deaths, 5,500 cases of chronic bronchitis and 17,600 cases of acute bronchitis in children will also be prevented annually.
- An estimated 360,000 asthma attacks and 386,000 cases of respiratory symptoms in asthmatic children will help be avoided every year.
- 1.5 million lost work days, 7,100 hospital visits and 2,400 emergency room visits for asthma will be prevented.



Summary of EPA Regulations

In the current regulations, the EPA has adopted a two pronged approach in its program to combat diesel pollution and obtain gasoline-like emissions standards from diesel powered vehicles. The two facets can be summarized as follows:

1. Emissions

All diesel engines produced, starting January 1, 2007, must comply with the new regulations that require the reduction of nitrogen oxide or NOx and hydrocarbons by 50% and particulate matter by 90+% over the current 2004 emission standards. Further reductions will be required by 2010.

2. Fuel

The EPA 2007 Highway Rule requires a full 97 percent reduction in the sulfur content of highway diesel fuel. The current Low Sulfur Fuel, or LSF, contains sulfur in a concentration of up to 500 parts per million. The new Ultra-Low Sulfur Diesel, or ULSD, only contains up to 15 parts per million.

According to the EPA, some case studies show that the use of ULSD alone can reduce particulate matter emissions by between 10 and 20 percent. However, of greater significance is that these clean fuels enable the use of advanced after-treatment technologies on new engines.

Notes

3. 2007 Fuel Regulations

2007 Fuel Regulations

Under 2007 EPA Highway Rule regulations, the petroleum refining industry was given a June 1, 2006, deadline to comply with limitations on the sulfur content of highway diesel fuel. Sulfur in diesel fuel negatively affects the reliability, durability and emissions performance of diesel particulate filters.

ASTM Standards for Diesel Fuel

The American Society of Testing and Materials, or ASTM, is the recognized standard-setting body for fuels and additives in the United States. ASTM standard D 975 designates Ultra low sulfur fuel as S15.

Sulfur Content

Since the 1990's, fuel quality has been increasingly more regulated by the US EPA under the authority of the Clean Air Act. In the context of the increasingly more stringent diesel emission standards, the most important fuel property regulated by the EPA became the sulfur content. Historically, the sulfur content in diesel fuels for highway and nonroad vehicles was limited to 0.5% (wt.) by ASTM specifications. The milestones in US environmental regulations limiting sulfur levels in diesel fuels can be summarized as follows:

Highway Diesel Fuel

- **500 ppm:** Sulfur limit of 500 ppm = 0.05% (wt.) became effective in October 1993. This fuel, commonly referred to as the *low sulfur* diesel fuel, was introduced to facilitate sulfate particulate emission reductions, which were necessary for meeting the 1994 emission standards for heavy-duty highway engines.
- **15 ppm:** Diesel fuel of maximum sulfur level of 15 ppm will be available for highway use beginning in June 2006. This fuel, referred to as the ultra low sulfur diesel (ULSD), was legislated by the EPA to enable catalyst-based emission control devices, such as diesel particulate filters and NOx adsorbers, which will be necessary for meeting the 2007-2010 emission standards for heavy-duty engines, as well as the Tier 2 light-duty standards.

Nonroad Diesel Fuels

- **500 ppm:** Sulfur limit of 500 ppm becomes effective in June 2007 for nonroad, locomotive and marine fuels.
- **15 ppm:** Sulfur limit of 15 ppm (ULSD) becomes effective in June 2010 for nonroad fuel, and in June 2012 for locomotive and marine fuels. The ULSD has been legislated for nonroad engines to enable advanced emission control systems for meeting the Tier 4 nonroad emission standards.

As of December 1, 2010, ONLY ULSD fuel will be available for highway use nationwide. Burning 500 parts per million LSF diesel in 2007 and a half and later model year diesel-powered cars, vans, trucks and buses is illegal and punishable with civil penalties.

California Regulations

In 1998, the California Air Resources Board (CARB) designated diesel exhaust a toxic air contaminant. In an effort to reduce the public's exposure to diesel particulate matter (PM) and nitrogen oxide (NOx) emissions, the state developed a comprehensive Diesel Risk Reduction Plan, which calls for reducing diesel PM 75 percent by 2010 and 85 percent by 2020 (from the base year 2000). The sale of Ultra Low Sulfur Diesel fuel is mandatory in all California highway fuel retail outlets by September 2006. Some California refiners have been producing ULSD for several years.

Figure 3-1, Vans

Figure 3-2, HD Pickups

Figure 3-3, Medium Duty Trucks

2007 Highway Rule and GM Trucks

The following is a summary of how the EPA legislation what all of this means for upcoming Chevrolet and GMC light and medium duty diesel powered vehicles (figure 3-1, figure 3-2, and figure 3-3).

All Duramax-equipped vehicles prior to the 2007 LMM can use either ULSD or LSF diesel.

2007 Duramax (RPO LMM-eighth digit of the VIN is a 6) diesel vehicles require the use of ULSD for proper operation of the particulate matter emission control system.

The vehicle owners' manuals will indicate which fuel a vehicle is required to use.

Fuel Labels

Vehicles that require ULSD fuel must have specific labels on the dashboard and near the fuel inlet indicating that they must be fueled with ULSD fuel (figure 3-4).

Federal regulations also require the labeling of all diesel fuel pumps to specify the type of fuel dispensed by each pump (figure 3-5).

A General Motors technical service bulletin, number 06-06-04-041, has been released addressing Ultra Low Sulfur Diesel Fuel and Warning Labels Found On Fuel Station Pumps.

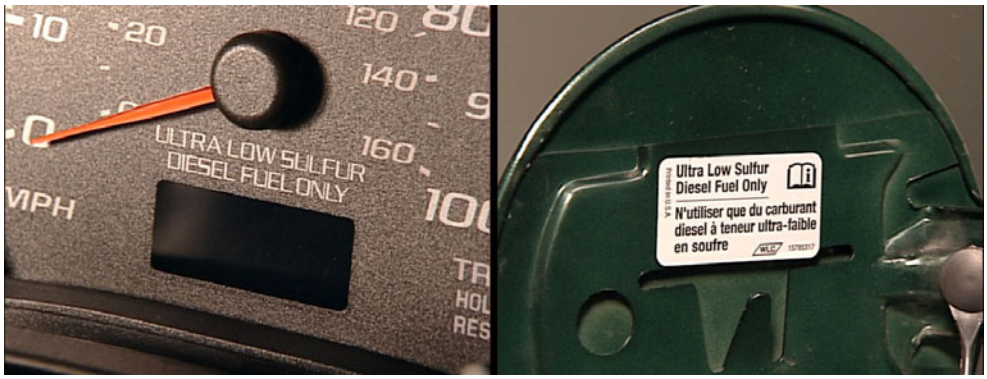


Figure 3-4, Vehicle Fuel Labels

Figure 3-5, Fuel Pump Labels

Service Stations

The EPA does not require service stations and truck stops to sell ULSD fuel, so it's possible that some retailers may choose to provide only LSF until closer to the 2010 mandate. In the meantime, dual fuels will be available at some facilities, while ULSD fuel might not be available initially at every service station or truck stop.

Off-Highway and Dyed Fuel

Colored dye is added to diesel fuel to indicate its tax-exempt status. The dye is NOT an indication of a fuel's sulfur content. Typically, non-highway diesel fuel is dyed red. Under the highway rule, non-highway diesel fuel is not required to meet the 15 parts per million ULSD requirement until 2010, except in California.

ULSD compliance dates for non-highway fuels in California are: June 1, 2006 for refiners and importers July 15, 2006 downstream from refineries through fuel terminals and September 1, 2006 for retail outlets.

The important point is that, regardless of its color, any fuel that has more than 15 PPM sulfur content will damage the DOC and/or the DPF in the exhaust system of the Duramax LMM.

3. 2007 Fuel Regulations

DOC Poisoning

The use of LSF in 2007i ULSD diesel engines will cause phosphorus in the exhaust to form deposits on the catalyst and eventually poison the DOC. When catalyst poisoning occurs the DOC:

- Does not function (burn hydrocarbons)
- DOC “not active” DTC P0420 sets
- MIL illuminates

Under these circumstances, DOC replacement is necessary because the catalyst material will neither convert harmful emissions, nor increase exhaust temperature with the efficiency with which it was designed. Catalyst poisoning may also cause DPF to plug with soot, resulting in reduced engine performance and DTCs.

Number 1-D Grade Fuel

ASTM Number 1 ULSD fuel with a sulfur content of no more than 15 parts per million may be used to improve cold weather performance when temperatures stay below -18°C (0°F). Continued use of number 1 grade fuel under temperate operational conditions is not recommended as it will reduce the fuel economy and power output of the engine.

In Canada, Diesel Type “A” fuel is blended for better cold weather starting.

Biodiesel

Biodiesel is a fuel that can be manufactured from vegetable oils, or even recycled fats and grease. Most biodiesel in the US is currently obtained from soy beans. The concept of using plant-derived oil to power a diesel goes back to the earliest development of the engine. When Rudolf Diesel demonstrated his namesake invention at the Paris Exhibition Fair in 1898, the engine was fueled by peanut oil. Today, biodiesel can play a role in reducing harmful emissions and improving air quality. In September 2006, the US EPA proposed a “Renewable Fuels Standard” (RFS) Program that would require that 3.71% of all the gasoline sold or dispensed to US motorists in 2007 be renewable fuel. Under the program, biodiesel, like ethanol, would be also eligible for renewable fuel credits. The EPA estimates use of biodiesel would increase from 0.025 billion gallons in 2004 to 0.3 billion gallons in 2012.

GM’s 2007 Duramax owner’s manual supplement states that It is acceptable to use diesel fuel containing up to 5% biodiesel or “B5” as it is also known. Check the current owner's manual for the most recent fuel recommendations.

Diesel Fuel in Canada and Mexico

Environment Canada’s “Sulphur in Diesel Fuel Regulations” are designed to ensure cross border compatibility. Regulation requiring ultra-low sulfur diesel fuel in Mexico beginning in September 2008 has not been finalized at this time.

4. 2007i Duramax 6600 LMM

2007i Duramax 6600 LMM

The Duramax Diesel 6600, RPO LMM will debut in the first quarter of 2007 when it will replace the current LLY and LBZ RPO engine codes (figure 4-1).

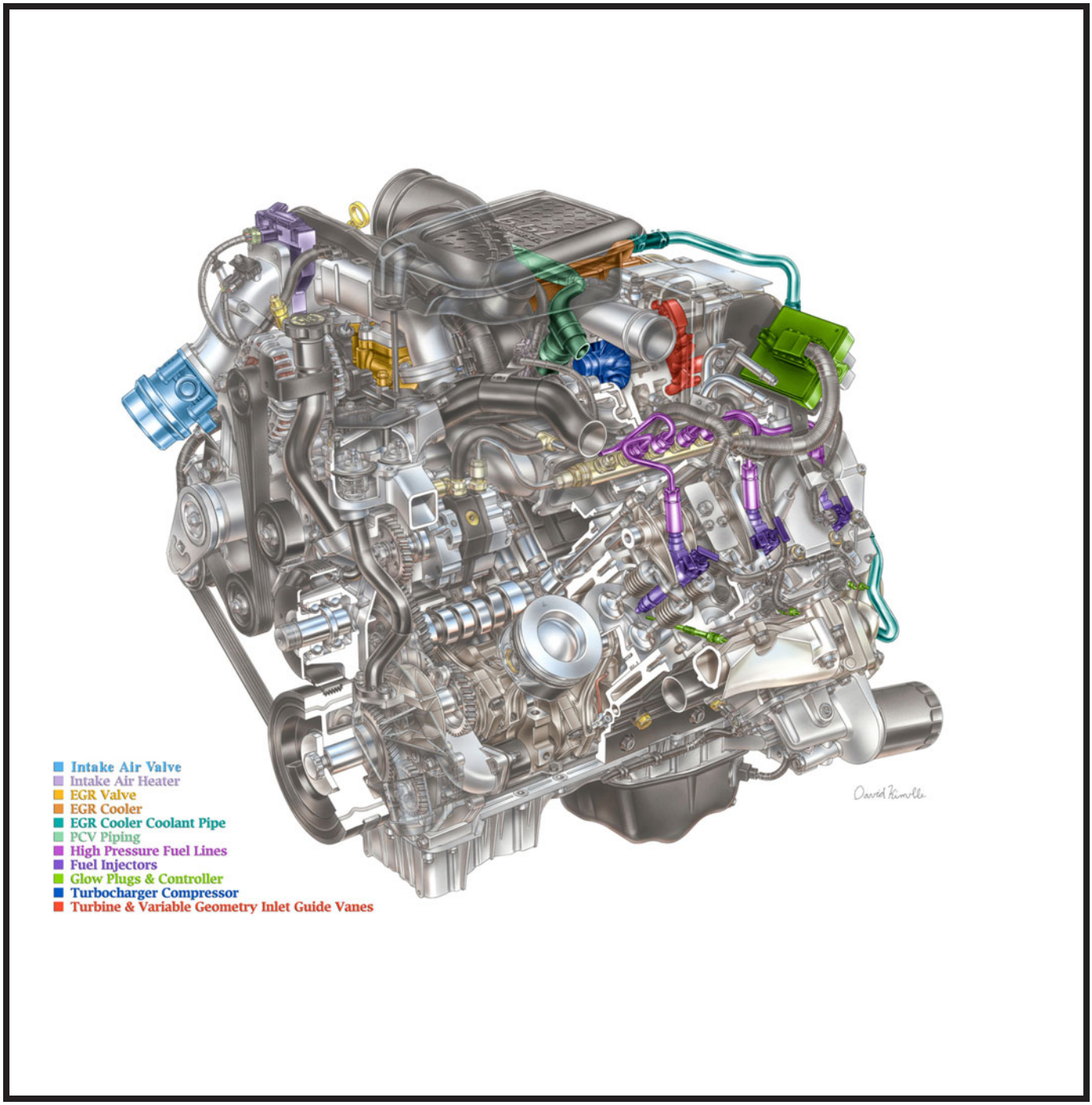


Figure 4-1, Duramax Diesel 6600, RPO LMM

4. 2007i Duramax 6600 LMM

Duramax (RPO LMM) Specifications

2007i Duramax Diesel 6.6L V8 Turbo (LMM)	
Type: Displacement: Compression ratio: Valve configuration: Assembly site: Valve lifters: Firing order: Bore x stroke: Fuel system:	Duramax 6.6L V8 turbo-diesel 6599cc 16.8:1 overhead valves (4 valves per cylinder) Moraine, Ohio mechanical roller 1 - 2 - 7 - 8 - 4 - 5 - 6 - 3 103 x 99mm direct injection diesel with high pressure common rail
Applications:	**Horsepower: hp (kW)**
Chevrolet Silverado HD GMC Sierra HD	365 hp (272 kW) @ 3200 rpm
Chevrolet Kodiak Medium Duty (LYE option) GMC TopKick Medium Duty (LYE option)	330 hp (246kW) @ 3000 rpm
Chevrolet Kodiak Medium Duty (LRX option) GMC TopKick Medium Duty (LRX option)	300 hp (224 kW) @ 3000 rpm
Chevrolet Express GMC Savana	250 hp (186 kW) @ 3200 rpm
Applications:	**Torque:lb-ft. (Nm)**
Chevrolet Silverado HD GMC Sierra HD	660 lb-ft. (895 Nm) @ 1600 rpm
Chevrolet Kodiak Medium Duty (LYE option) GMC TopKick Medium Duty (LYE option)	620 lb-ft. (841 Nm) @ 1600 rpm
Chevrolet Kodiak Medium Duty (LRX option) GMC TopKick Medium Duty (LRX option)	520 lb-ft. (705 Nm) @ 1600 rpm
Chevrolet Express GMC Savana	460 lb-ft. (624 Nm) @ 1600 rpm
Fuel shut off: Emissions controls: Additional features:	3250 rpm Kodiak and TopKick (Medium Duty) 3450 rpm Silverado and Sierra (Heavy Duty), Express and Savana cooled exhaust gas recirculation, catalytic converter, diesel particulate filter (DPF) & Intake throttle 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

Figure 4-2, Duramax (RPO LMM) Specifications

Duramax LMM (VIN 6) Emissions Reduction Strategies

To comply with EPA regulations, the 2007 Duramax LMM engine incorporates internal and external hardware modifications as well as significant electronic software calibration updates.

A number of engineering approaches can be utilized to reduce exhaust emissions from diesel engines. These most common strategies can be categorized into three general areas as follows:

a. Fuel delivery

b. Air intake

c. After treatment

Fuel Delivery

Fuel Injection Updates

Fuel delivery improvements typically include updating electronic control calibrations and fuel injectors to optimize fuel injection pressure, injection timing and spray location. The goal is to burn fuel with maximum efficiently without temperature spikes that can increase NOx emissions.

The 2006 Duramax 6600 LBZ was optimized for low NOx emissions with its state of the art common-rail system and solenoids that allow individual injection timing for precise control of fuel delivery at each injector (figure 4-3).

The 2007i Duramax LMM engine receives redesigned fuel injectors. The injector nozzles now have six spray holes instead of seven. This new nozzle is optimized for operation with the modified injection pulse timing strategies used for the exhaust after-treatment system (figure 4-4).

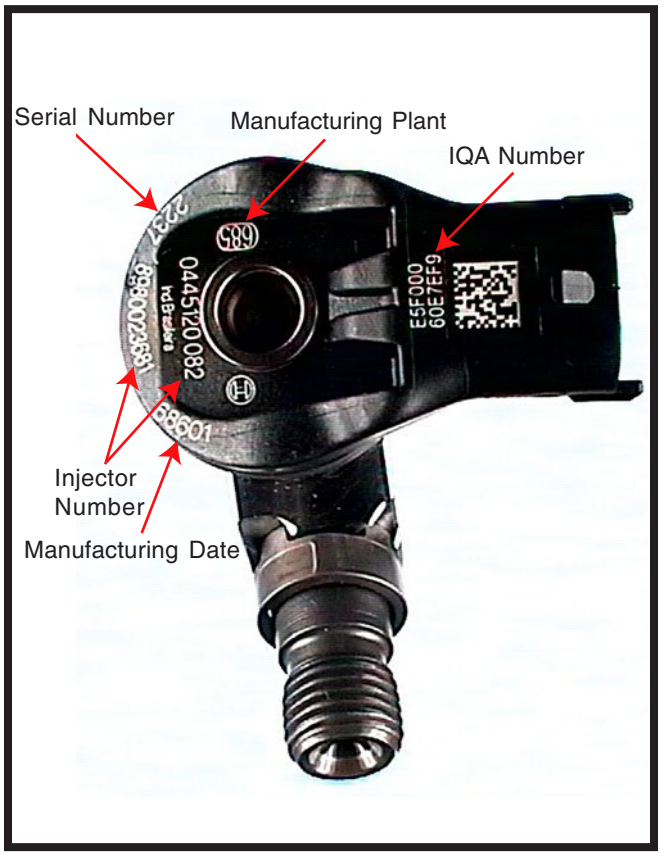


Figure 4-3, Duramax LMM Fuel Injector

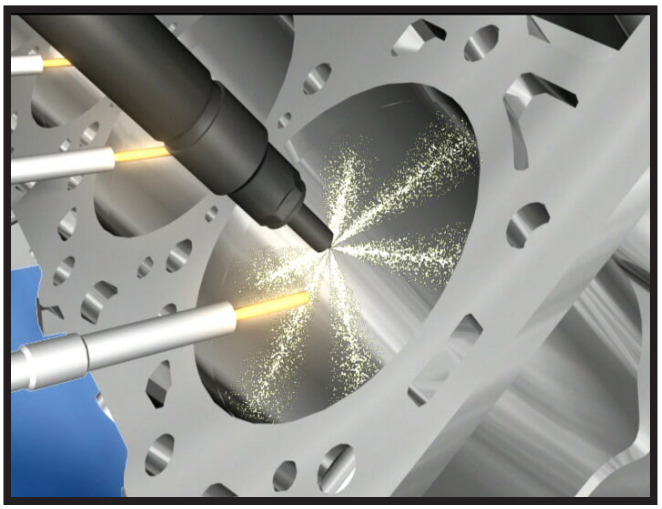


Figure 4-4, Injector Spray

Air Intake

Turbocharger

The Duramax LMM air intake system is also optimized for low emissions output.

The compressor and turbine on the LMM turbocharger have been modified to provide maximum efficiency in conjunction with the unit's variable vane positioning.

Air Intake Valve

For 2007i, a throttle-style valve is added to the LMM intake, just ahead of the existing intake air heater. The ECM uses the air intake valve to control the volume of intake air during regeneration, EGR operation and rich idle (figure 4-5).

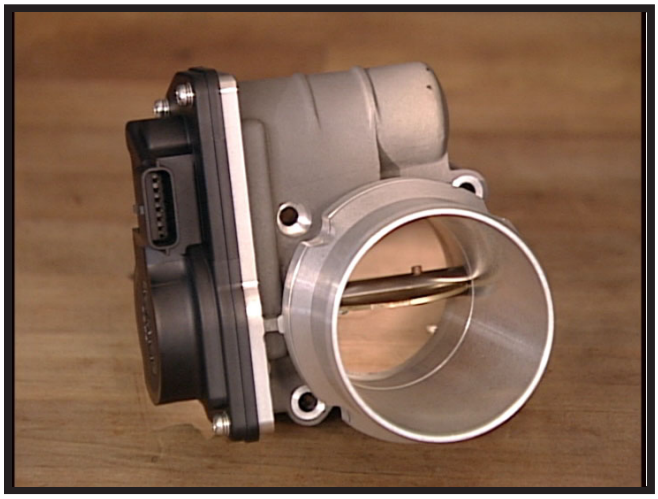


Figure 4-5, Air Intake Valve

Exhaust Gas Recirculation

The 2007i Duramax exhaust gas recirculation or EGR system has an increased capacity cooler to further reduce the NOx emission levels caused by high combustion temperatures.

5. LMM Exhaust After-Treatment

LMM Exhaust After-Treatment System

The most significant exhaust emissions reductions for 2007i model year diesel-powered vehicles are achieved through the use of exhaust after treatment systems incorporating the Diesel Particulate Filter system (figure 5-1).

Visually the 2007i Duramax exhaust system can be readily distinguished by its two most prominent components, namely the Diesel Oxidation Catalyst and the Diesel Particulate Filter (DPF), also referred to as an Exhaust Particulate Filter. The DOC/DPF combination is the primary means of reducing particulate matter emissions from 2007i vehicles.

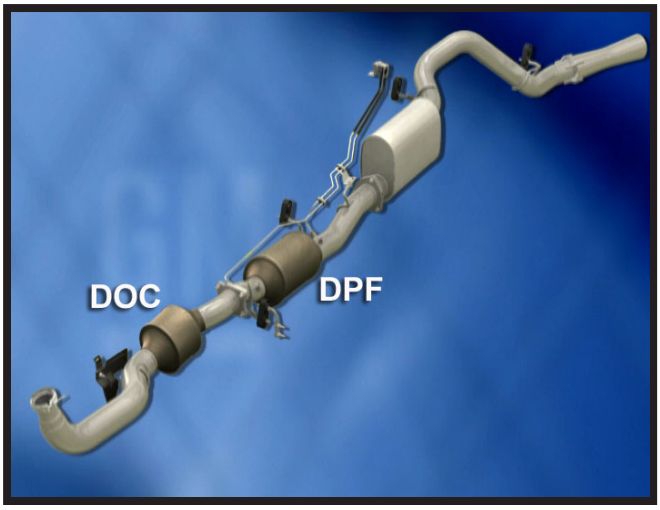


Figure 5-1, Typical Duramax DPF System Configuration

Diesel Oxidation Catalyst (DOC)

Diesel Oxidation Catalysts, or DOCs, as they are commonly known, have been used for many years to reduce harmful emissions from heavy-duty off-road machinery (figure 5-2).

The central component of the DOC is a flow-through honeycomb-style substrate structure that is washcoated with a layer of catalyst materials, similar to those used in a gasoline engine catalytic converter. These materials include the precious metals Platinum and Palladium as well as other base metals catalysts.

Figure 5-2, Diesel Oxidation Catalyst (DOC)

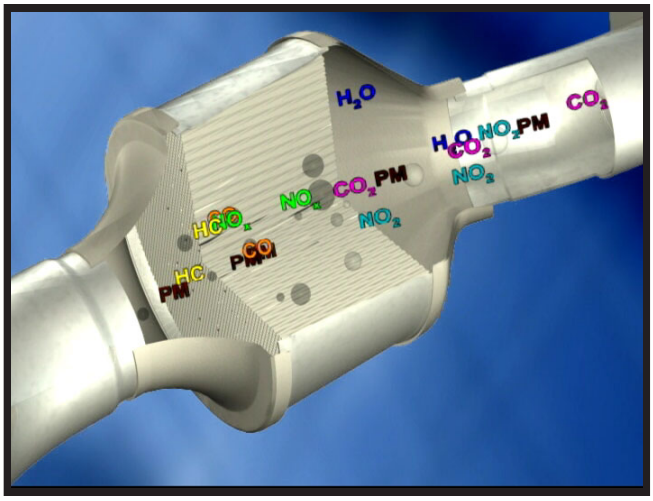


Figure 5-3, DOC Operation

Catalysts chemically react with exhaust gas to convert harmful nitrogen oxide into nitrogen dioxide, and to oxidize absorbed hydrocarbons. The chemical reaction acts as a combustor for the unburned fuel that's characteristic of diesel compression ignition. The main function of the DOC is to start a regeneration event by converting the fuel-rich exhaust gases to heat.

As a secondary effect, the DOC effectively reduces carbon monoxide, hydrocarbons, both gaseous and liquid, odor causing compounds such as aldehydes and sulfur, and the soluble organic fraction of particulate matter (figure 5-3).

During a regeneration event the Catalyst System Efficiency test will run. The engine control module (ECM) monitors this efficiency of the DOC by determining if the exhaust temperature sensor (EGTsensor 1) reaches a predetermined temperature during a regeneration event.

Diesel Exhaust Particulate Filter (DPF)

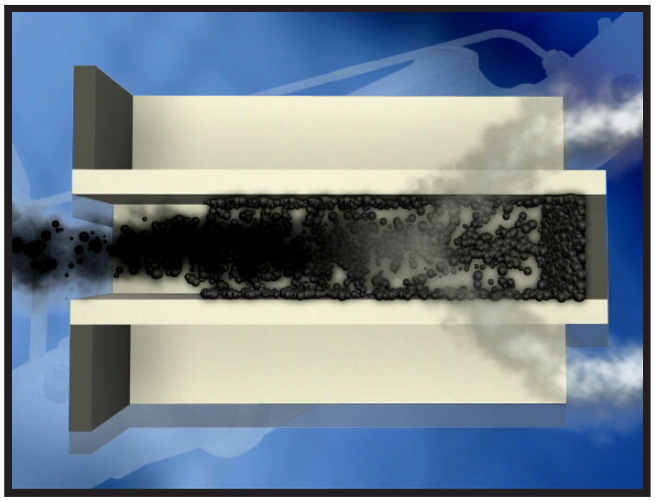


Figure 5-4, DPF Channels Trap Particulate Matter

The heated exhaust gas from the DOC flows into the Diesel Particulate Filter (DPF), which captures diesel exhaust gas particulates (soot) to prevent their release into the atmosphere. This is accomplished by forcing particulate-laden exhaust through a porous cell which, like the DOC, also has a silicon carbide substrate with honeycomb cell type channels. The channels are washcoated with catalyst materials similar to those in the DOC filter.

The main difference between the DPF and a typical catalyst filter is that the entrance to every other cell channel in the DPF substrate is blocked at one end. The channels that have open entrances are blocked at the exit end and vise versa. So, instead of flowing directly through the channels, the exhaust gas is forced through the porous walls of the blocked channels and exits through the adjacent open-ended channels (figure 5-4). This type of filter is also referred to as a "wall-flow" filter.

Soot particulates in the gas remain trapped on the DPF channel walls where, over time, the build up of trapped particulate matter will begin to clog the filter. The filter must therefore be purged periodically to remove accumulated soot particles. The process of purging soot from the DPF is described as regeneration. See DPF Regeneration for details.

Exhaust Gas Temperature Sensors (EGT Sensor 1 and EGT Sensor 2)

There are two exhaust gas temperature sensors that function in much the same way as engine temperature sensors (figure 5-5). EGT sensor is positioned between the DOC and the DPF where it can measure the temperature of the exhaust gas entering the DPF. EGT Sensor 2 measures the temperature of the exhaust gas stream immediately after it exits the DPF (figure 5-6).

The engine control module (ECM) monitors the signals from the EGT sensors as part of its calibrations to control DPF regeneration. The ECM supplies a biased 5-volts to the signal circuit and a ground on the low reference circuit to EGT Sensor 1. When the EGT Sensor 1 is cold, the sensor resistance is high. As the temperature increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the signal circuit. With lower sensor resistance the ECM detects a lower voltage on the signal circuit. Proper exhaust gas temperatures at the inlet of the DPF are crucial for proper operation and for initiating the regeneration process. Too high a temperature at the DPF will cause the DPF substrate to melt or crack. Regeneration will be terminated at temperatures above 800°C (1472 °F). With too low a temperature, self-regeneration will not fully complete the soot-burning process.

Figure 5-5, Exhaust Gas Temperature Sensor (EGT)

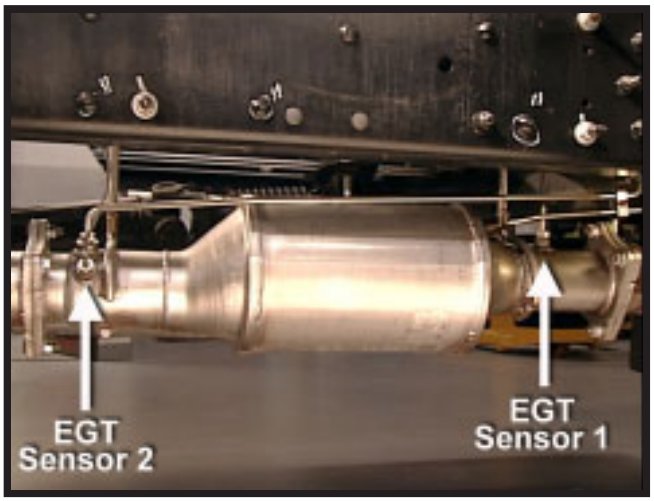


Figure 5-6, EGT Sensor 1 and EGT Sensor 2 (Medium Duty)

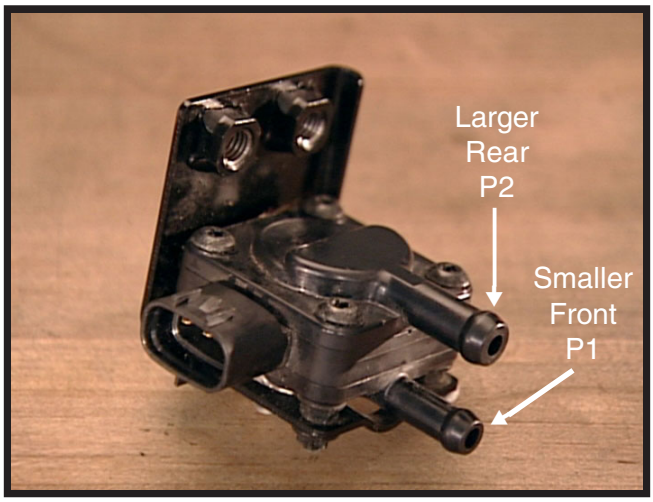


Figure 5-7, Differential Pressure Sensor

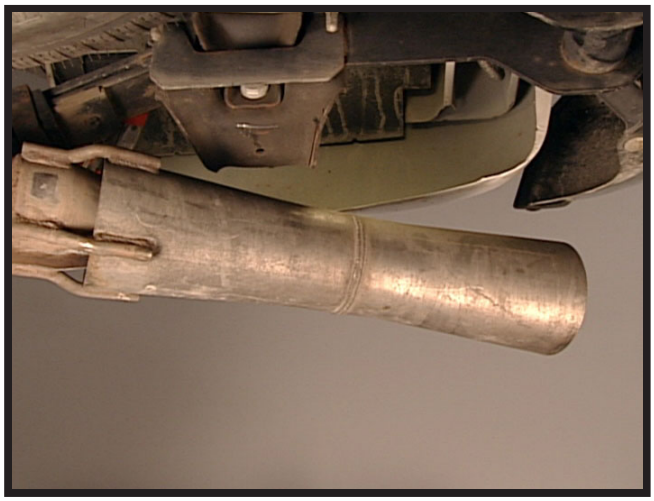


Figure 5-8, Tailpipe Exhaust Air Cooler Silverado/Sierra

DPF Differential Pressure Sensor (DPS)

The DPF Differential Pressure Sensor (DPS) (figure 5-7) has two pressure sample lines: one line is attached before and the other is located just after the DPF. The exact location of the DPS varies by vehicle model type (medium duty, pickup or van).

By measuring P1 exhaust supply pressure from the DOC, and P2, post DPF pressure, the ECM can determine differential pressure, also referred to as “delta” pressure, across the DPF. Data from the DPF Differential Pressure sensor is a critical part of the ECM’s calibrations for controlling DPF exhaust system operation.

Exhaust Air Cooler

Another new component on the exhaust system is the exhaust air cooler, located at the end of the tailpipe (figure 5-8). The cooler is simply a length of tubing with a narrower center section that acts as a venturi. The cooler is attached to the tailpipe with a bracket that provides a gap between the two.

As hot exhaust rushes past the gap, the venturi effect draws surrounding air into the cooler and reduces the exhaust temperature. The cooler significantly lowers exhaust temperature at the tailpipe from a potential 420 to 430°C (788 to 806°F) to approximately 270°C (518°F).

6. Diesel Particulate Filter

Diesel Particulate Filter Regeneration

Soot particulates in the gas remain trapped on the DPF channel walls where, over time, the build up of trapped particulate matter will begin to clog the filter. The filter must therefore be purged periodically to remove accumulated soot particles. The process of purging soot from the DPF by incineration is described as regeneration (figure 6-1).

When the temperature of the exhaust gas is increased sufficiently, the heat incinerates the soot particles trapped in the filter, leaving only residual ash from the engine's combustion of lubrication oil. The filter is effectively renewed.

The primary reason for soot removal is to prevent the build up of exhaust back pressure. Excessive back pressure increases fuel consumption, reduces power output and can potentially cause engine damage.

There are a number of operational factors that can trigger the Duramax LMM engine control module to initiate a DPF regeneration sequence.

The ECM monitors:

- Distance since last DPF Regeneration
- Fuel used since last DPF Regeneration
- Engine run time since last DPF Regeneration
- Exhaust differential pressure across the DPF

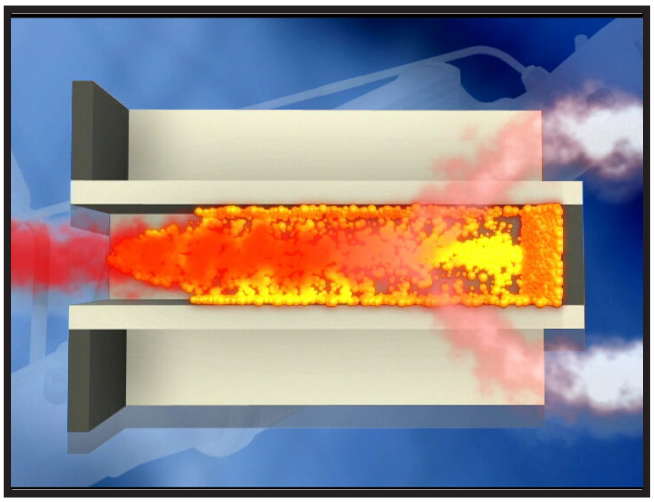


Figure 6-1, DPF Regeneration-Soot Incineration

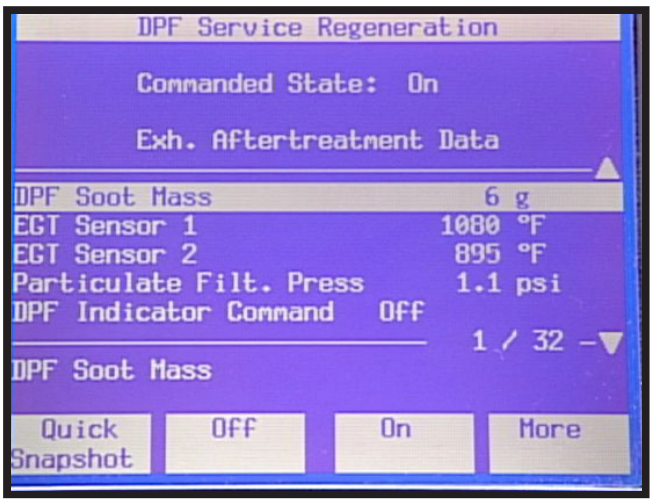


Figure 6-2, Soot Mass on Scan Tool

Soot Model

The ECM programming contains what's known as a "Soot Model", or algorithm, which uses all of these data parameters in addition to EGT sensor data to calculate how much soot has accumulated in the DPF. The calculated soot mass accumulation, measured in grams, can be displayed on the scan tool (figure 6-2).

6. Diesel Particulate Filter

Ash Loading

Ash is a non combustible byproduct from normal oil consumption. Ash accumulation in the DPF will eventually cause a restriction in particulate filter. Regeneration will not burn off the ash, only particulate matter is burned off. To service an ash loaded DPF, the DPF will need to be removed from the vehicle and cleaned or replaced. Low Ash content engine oil (CJ-4 API) is required for vehicles with the DPF system.

CJ-4 Engine Lubrication Oil

There are also new standards relating to diesel engine lubrication oil. For the 2002 model year, CI-4 engine oil was introduced for use in high-speed, four-stroke engines designed to meet 2004 exhaust emission standards and to sustain engine durability. For 2007 model year DPF-equipped vehicles, new API CJ-4 oils have been released to provide the lower ash content required by the new emission systems.

All current oil API categories, including API CF-4,
CG-4, CH-4, CI-4, and CI-4 PLUS are **NOT** forward compatible with API CJ-4 due to the chemical limits for ash, phosphorous and sulfur defined by API CJ-4. For example CI-4 oil contains up to 1.5% ash content by weight. The new CJ-4 oil is limited to 1% ash content. CJ-4 is designed to be backward compatible with all prior Duramax applications.

The oil that's consumed during normal engine operation is a significant factor in Diesel Particulate Filter operation and performance. If API CI-4 oil is used in a DPF-equipped vehicle, the service interval for the DPF could be shortened. That's because the higher ash content of the CI-4 oils will result in greater ash accumulation in the DPF. Remember, the regeneration process combusts particulate matter but the ash residue remains in the filter.

DPF Regeneration Process

A number of engine components are required to function together for the regeneration process to be performed.

ECM Fuel Injection Controls

ECM controls that impact DPF regeneration include late post injections, engine speed and adjusting fuel pressure (figure 6-3). Adding late post-injection pulses provides the engine with additional fuel to be oxidized in the DOC. This increases exhaust temperatures entering the DPF to 500°C (932°F) and higher. The contribution to exhaust heat from Injector control post injections is approximately 45%.

The intake air valve (figure 6-4) acts as a restrictor that reduces air entry to the engine which increases engine operating temperature. The contribution of the Intake Air Valve's to increasing engine heat is approximately 35%.

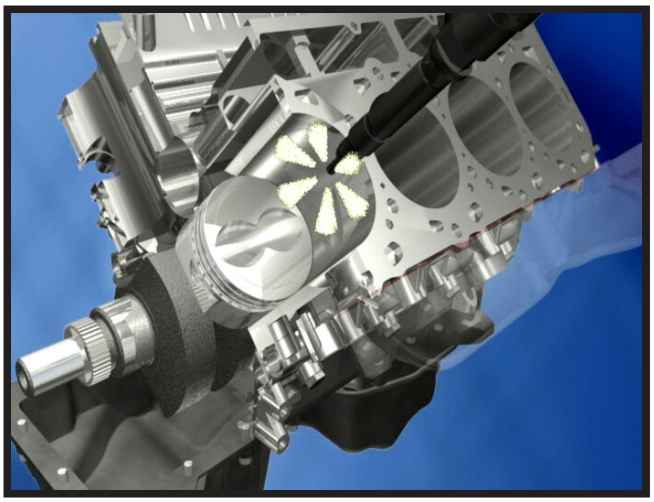


Figure 6-3, Late Post Injection

Air Intake Heater

The Intake Air Heater may also be activated to warm intake air during regeneration.

Turbocharger

The variable vane turbocharger also plays a role in achieving regeneration temperatures by reducing or increasing boost depending on engine load. The turbocharger's contribution to increasing engine heat is about 10%.

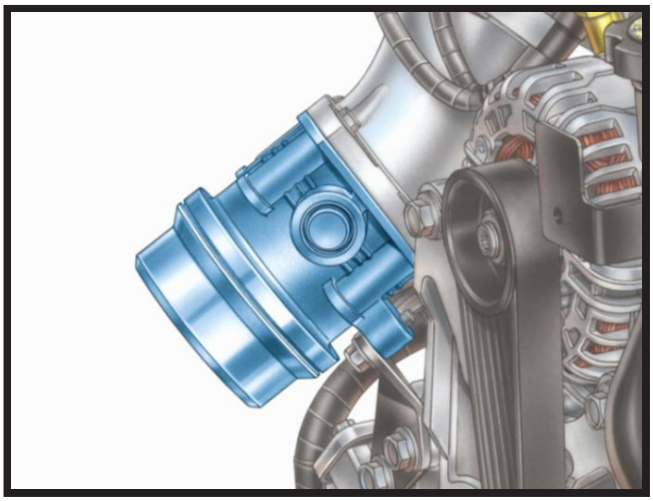


Figure 6-4, Air Intake Valve

6. Diesel Particulate Filter

Types of DPF Regeneration

DPF Regeneration can be initiated in a number of ways, depending on the vehicle application and operating circumstances. The two main regeneration types are passive and active.

Passive Regeneration

During normal vehicle operation when driving conditions produce sufficient load and exhaust temperatures, passive DPF regeneration may occur. This passive regeneration occurs without input from the ECM or the driver. A passive regeneration may typically occur while the vehicle is being driven at highway speed or towing a trailer.

Active Regeneration

Active regeneration is commanded by the ECM when it determines that the DPF requires it to remove excess soot build up and conditions for filter regeneration have been met. Active regeneration is transparent to the operator.

The vehicle needs to be driven at speeds above 30 mph for approximately 20-30 minutes for a full regeneration to complete. During regeneration, the exhaust gases reach temperatures above 550°C (1022°F). If a regeneration event is interrupted for any reason, it will continue where it left off (including the next drive cycle) when the conditions are met for regeneration. Active regeneration is for the most part transparent to the customer.

There are times when regeneration is required, but the vehicle's operating conditions do not meet the ECM's requirements, such as on a delivery vehicle that is driven on frequent short trips or subjected to extended idling conditions. In such cases, the ECM turns on a "regeneration required" indicator to notify the vehicle operator, that the filter requires cleaning.

– NOTE –
Due to the added fuel injection pulses and late fuel injection timing, an increase in fuel consumption may be noticed on the Driver Information Center (DIC) during the regeneration time period.

DPF Communications

Each of the three GM vehicle platforms featuring the 2007 Duramax LMM option has a different DPF communications set up.

2007i Chevrolet Silverado HD and GMC Sierra HD pickups

DPF communications in these vehicles is through the Driver Information Center, or DIC. The message “CLEAN EXHAUST FILTER” appears when the ECM determines soot levels are over 125% regeneration is required. The message remains on the DIC display until after regeneration has been completed (figure 6-5).

Figure 6-5, Regeneration Required Lights

2007i Chevrolet Express and GMC Savana Vans

The 2007 Chevrolet Express and GMC Savana vans have a CLN EXH FILTER (Clean Exhaust Filter) light that illuminates when the ECM determines soot model loading levels are over 125% and the customer has NOT driven the vehicle in a manner that will allow an “active” regeneration to trigger and complete. The indicator stays illuminated until regeneration is complete (figure 6-5). Canadian vans use the international exhaust filter symbol instead of the message.

2007i Chevrolet Kodiak and GMC Topkick Medium Duty trucks

On the Chevrolet Kodiak and GMC TopKick 4500 and 5500 series medium duty trucks, the international exhaust filter light that was previously used for the exhaust brake is repurposed for the DPF. The amber colored light illuminates to indicate that filter regeneration is needed with 125% soot loading (figure 6-6).

Figure 6-6, Chevrolet Kodiak and GMC TopKick Amber Regeneration Required Light

6. Diesel Particulate Filter

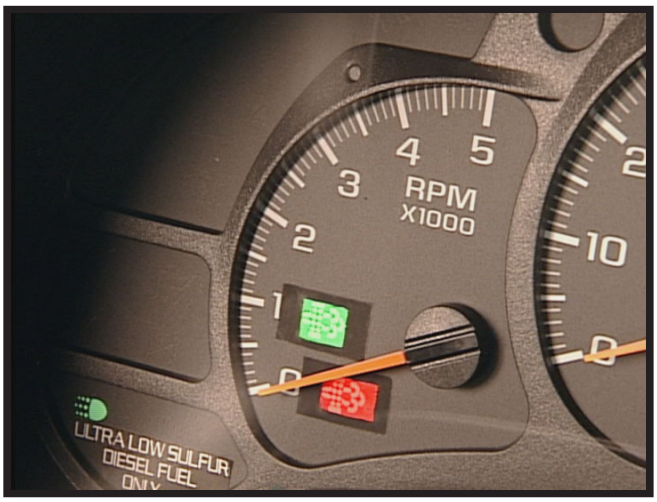


Figure 6-7, Chevrolet Kodiak and GMC TopKick Red and Green Indicator Lamps

If the vehicle operator ignores the amber DPF lamp it will turn RED at over 150% soot loading conditions. Whenever regeneration is triggered, a green lamp with the same symbol illuminates and remains illuminated until regen completes (figure 6-7).

When the regeneration required message or light is illuminated, the owner is advised by the diesel owner manual supplement to drive the vehicle under conditions that will facilitate the regeneration process.

Kodiak and Topkick Customer Requested Active Regeneration

On medium-duty Kodiak and Topkick vehicles only, a customer requested active regeneration can be performed. This is in part because these vehicles are frequently operated under conditions that do not permit the ECM to initiate the regeneration process. Such conditions might include long periods of idling or low speed driving when vehicles are used in various utility applications.

A customer requested active regeneration is initiated by depressing the Regeneration Switch on the instrument panel (figure 6-8) and applying the park brake. The regeneration process will either begin or a chime will sound indicating that a regeneration is ***not*** required. *The customer should follow all the applicable cautions in the diesel owner manual supplement.*

The system will go through two stages during active regeneration:

- The first stage warms up the DOC.
- The second stage heats the DPF to soot incineration temperature.

For warm up, airflow is reduced using the air intake valve, turbocharger boost is varied using the adjustable vanes, fuel rail pressure is adjusted, and late fuel injection pulses are added.

These actions will heat the DPF to the temperature required to incinerate the particulate matter. If a customer requested active regeneration is interrupted, the process ends and will not be activated again until the conditions are suitable for regeneration and the Regeneration Switch is pressed again.

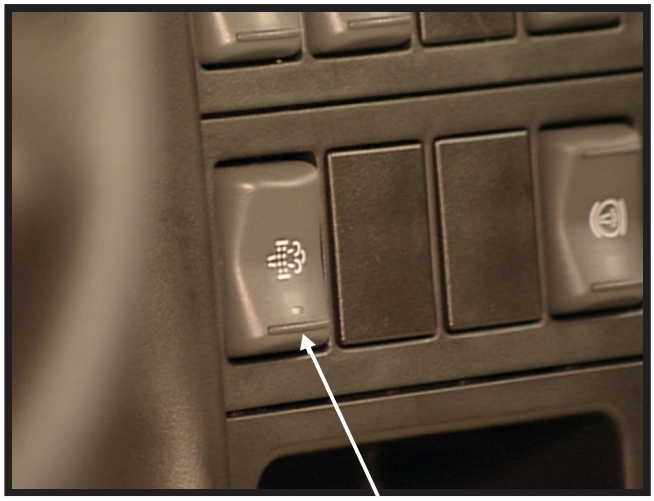


Figure 6-8, Medium Duty Truck Regeneration Switch

DPF Service Regeneration

Another active regeneration method, the “DPF Service Regeneration” is a useful tool for the dealership technician. The procedure would typically be used to clean the DPF when vehicle operating conditions did not allow the DPF to regenerate normally while the vehicle is driven.

A service regeneration procedure can also be run in order to clean the DPF when there is an unknown amount of soot present. This might result from engine, or engine control errors caused by a Charge Air Cooler leak or low compression. In these cases, a DTC P2463 would normally set, and the DPF would have 80 grams or less of accumulated soot. If over 100 grams of soot are present, P244B sets and service regeneration is not permitted.

Conditions for Running a DPF Service Regeneration

Before allowing a DPF Service Regeneration to run, the engine control module checks its data inputs to ensure that several conditions are met. A service regeneration cannot be initiated if there are active DTCs present. So, any current DTC's must be repaired before a DPF Service Regeneration can be performed, including P244B (Diesel Particulate Filter Differential Pressure Too High).

Other conditions that the ECM checks are as follows:

- The battery voltage is greater than 10 volts.
- The engine speed is between 600 and 1250 RPM.
- The brake pedal is in the released position
- The accelerator pedal is in the released position
- The transmission must be in park or neutral.
- The engine coolant temperature (ECT) is between 70°C (158°F) and 115°C (239°F).
- The vehicle's fuel tank level must be between 15 to 85 percent capacity. For safety, refueling should never be performed during the regeneration process.
- The exhaust gas temperature (EGT sensors 1 and 2) must be less than 400°C (752°F).

DPF Regeneration Cautions and Notices

– CAUTION –

Tailpipe outlet exhaust temperature will be greater than 300C/572F 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 a safe distance away from the vehicle during Service Regeneration
3. Do not leave the vehicle unattended during Service Regeneration.

– CAUTION –

To avoid extremely elevated exhaust temperatures, inspect the exhaust cooler vent located at the tailpipe and remove any debris or mud that would impede its operation.

– NOTICE –

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

Test Procedure

1. Review the DTC information with a scan tool. Repair any codes before proceeding with DPF Service Regeneration.
2. Check the coolant and oil levels before and after this procedure.

– CAUTION –

Due to the elevated exhaust temperatures at the tailpipe during service regeneration it is imperative to locate the vehicle outdoors in a designated area, away from people, combustible material, other vehicles, and buildings.

3. Park the vehicle outside the facility and away from any obstacles.
4. Place the transmission in Park and apply the Parking Brake.
5. Select DPF Service Regeneration under the Output Control menu and follow the instruction on the scan tool.
6. With the engine running, ensure the engine coolant temperature is greater than 70˚C (138˚F).
7. Command the DPF Service Regeneration with the scan tool.
8. The DPF Service Regeneration will take approximately 35 minutes, this includes:
   - 8 minutes for the exhaust system to warm up, with the engine speed slowly increasing to 1,600, then 2,200 and finally 2,500 RPM.
   - 20 minutes for the DPF to regenerate, at 2,500 RPM.
   - 3 minutes for the exhaust system to cool down, the engine speed will slowly return to 1,400 RPM, followed by 3 minutes at 800 rpm, then idle speed of 680 RPM.
9. The DPF Service Regeneration can be terminated by performing any of the following actions:
   - Applying the brake pedal
   - Applying the accelerator pedal
   - Selecting Drive or Reverse
   - Commanding DPF Service Regeneration OFF using the scan tool or disconnecting the scan tool from the vehicle.
   - The DPF Service Regeneration will be automatically terminated if certain DPF DTCs are set or if the DPF temperatures exceed a calibrated threshold.
10. After service regeneration completes, allow the vehicle to idle for an additional 5 minutes while monitoring the scan tool DTC information.

If scan tool DTC information displays P2463, P244B, or P2002 after the 5 minute idle time the DPF substrate may have melted and the filter should be replaced. Refer to SI for the latest information.

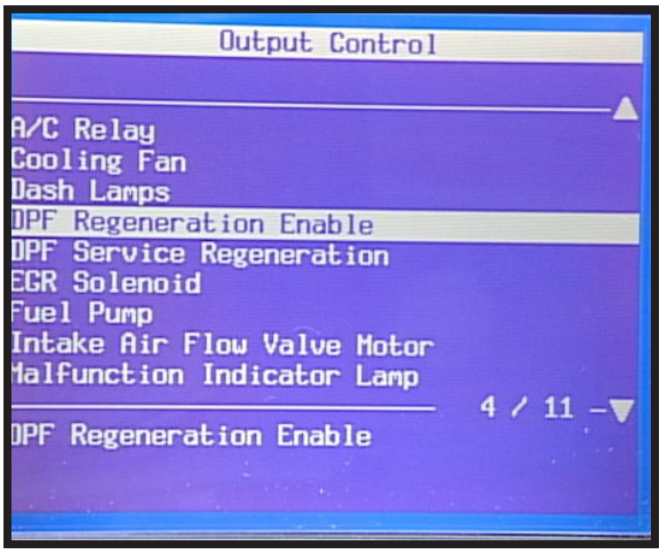


Figure 6-9, Scan Tool Regeneration Enable

Scan Tool Regeneration Enable Feature

Using the scan tool, a technician can also trigger a DPF regeneration event to occur after the customer has left the dealership; the next time conditions for an active regeneration are met (figure 6-9). This regeneration enable feature would typically be used after service procedures that require a system reset such as replacing the DPF, the ECM or the MAF sensor. It may also be required as part of some DTC diagnostics.

7. DPF System Diagnostics

DPF System Diagnostics

In this section we'll look at some diagnostic situations that relate specifically to DPF-equipped vehicles.

Limp Home Mode

Since the DPF is a very large filter, washcoated with precious catalytic metals, it is an expensive part to replace. Certain DTCs will cause the ECM to command a "fail safe" or "limp home" mode to help prevent DPF damage. The "Reduced Engine Power" lamp will illuminate (figure 7-1).

Concerns that can activate the limp home mode include:

- Leaks in the intake system.
- EGR system concerns.
- Excessive fuel delivery.
- A stuck intake valve.
- Engine management sensor concerns

Figure 7-1, "Reduced Engine Power" Lamp for Limp Home Mode

Symptoms Affected by DPF

The Symptoms document in the SI Engine Controls and Fuel section provide descriptions of conditions not covered by DTCs. The Symptoms document will be updated to reflect the possible role of the DPF in these conditions.

- Cuts Out, Misses
- Hard Start
- Hesitation, Sag, Stumble
- Lack of Power, Sluggishness, or Sponginess
- Poor Fuel Economy
- Rough, Unstable, or Incorrect Idle and Stalling
- Surges/Chuggles
- Fuel Knock/Combustion Noise
- Excessive Smoke

Figure 7-2, Charge Air Cooler Tester and Adapter

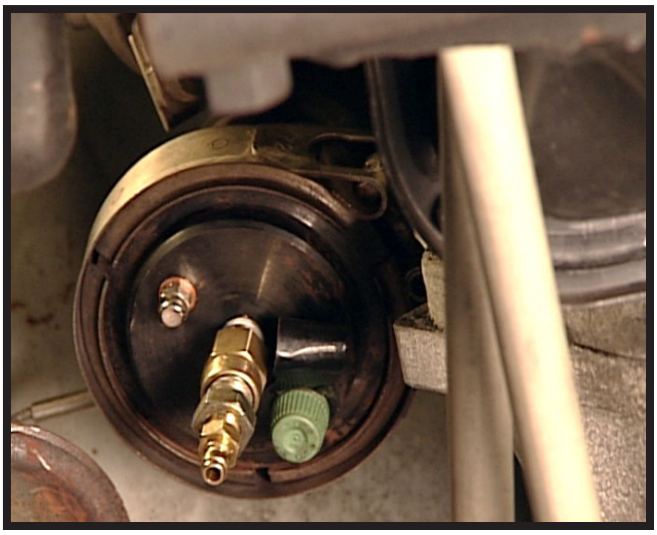


Figure 7-3, J 46091-15 Installed on Exhaust Downpipe

Charge Air Cooler Test

In order to help you deal more effectively with some of these symptoms, special tool, J 46091 Charge Air Cooler Tester, has a new J 46091-15 adapter to allow for more thorough testing of the intake, EGR and exhaust systems (figure 7-2).

The adapter clamps to the end of the exhaust downpipe using the existing band clamp. With the adapter in place you can pressurize the entire boost system to check for leaks (figure 7-3).

Restricted Exhaust Test

When testing for a restricted exhaust, you will notice that the Duramax 6600 exhaust system does not have a location for installing the J 35314-A Exhaust Back Pressure Gage. Instead, remove the suspect component and operate the vehicle to verify whether performance is improved. If performance is improved then replace the faulty component.

DPF Related Diagnostic Trouble Codes

Several new DTC's have been added that relate to the operation of the DPF and associated hardware. There are a number of new DTCs for Performance Checks of the DPF itself.

Performance Checks DTCs

P244C: Catalyst Temperature Too Low During Regeneration

P244B: Diesel Particulate Filter Differential Pressure Too High

P2002: Diesel Particulate Filter Low Efficiency

P2459: Diesel Particulate Filter Regeneration Frequency

P2463: Diesel Particulate Filter Soot Accumulation

P1448: Diesel Particulate Filter Regeneration Frequency Too Low

Exhaust Gas Temperature Sensor (EGT) DTCs

There are also codes for the two exhaust gas temperature sensors. DTCs will set if either EGT sensor's temperature is detected as high or low, or if the correlation of temperatures between the sensors is out of range.

P0545: Exhaust Gas Temperature (EGT) Sensor 1 Circuit Low Voltage

P0546: Exhaust Gas Temperature (EGT) Sensor 1 Circuit High Voltage

P2032: Exhaust Gas Temperature (EGT) Sensor 2 Circuit Low Voltage

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

P202E: Exhaust Temperature Sensor 1-2 Correlation

Differential Pressure Sensor (DPS) DTCs

DTCs that signal out of range conditions on the differential pressure sensor (DPS) circuit are:

P2454: Diesel Particulate Filter Differential Pressure Sensor Circuit Low Voltage

P2455: Diesel Particulate Filter Differential Pressure Sensor Circuit High Voltage

P2453: Diesel Particulate Filter Differential Pressure Sensor Performance

Check the *Service Information* for the most recent DTC information.

DTC Diagnostic Scenario

The following scenario is presented to give you an idea of the sort of diagnostics you might encounter with the Diesel Particulate Filter system.

Condition

A customer brings in a truck with a "Clean Exhaust Filter" message that stays on.

The scan tool shows that a DTC P2453 "Diesel Particulate Filter Differential Pressure Sensor Performance" is current. This code sets if the ECM determines that the pressure differential between the inlet and outlet of the DPF is not correct.

Inspection

- If any of the following DTCs are also present, be sure to diagnose them first. P0101, P0102, P0103, P0299, P0402, P0698 and P0699.
- Check the entire exhaust system for restrictions and damaged components. Also look for missing or broken DPF substrate material.

  Make sure that the DPS pressure lines are properly routed and that they're not restricted, kinked or leaking. During cold weather, check for possible ice build-up in the sample lines and hoses.
- With the ignition on and the engine off, check the "Particulate Filter Pressure Variance" parameter. The reading should be between minus .4 and positive .2 kilopascals.

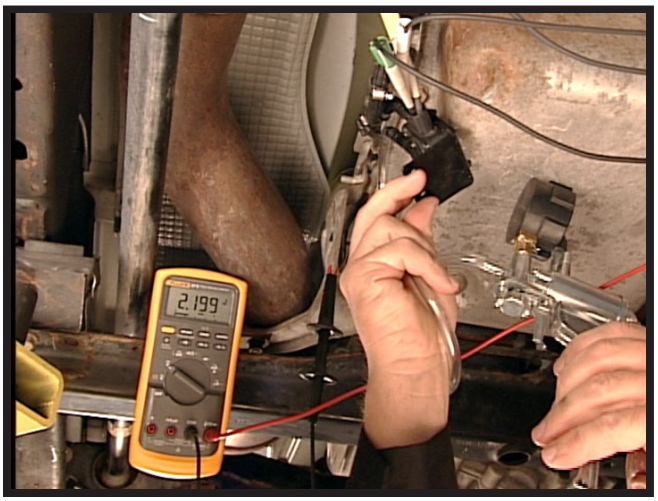


Figure 7-4, Testing DPS with Mity Vac

With the engine at idle, the reading should be between zero and 3 kilopascals.

- Observe the variance parameter as you run the engine up to the rev limiter. You should get a reading above 4 kilopascals. If the reading is too low, it could indicate broken or missing DPF substrate material, which would require the replacement of the filter.
- In order to avoid any potential misdiagnosis, it is very important to perform a thorough inspection of the DPS wiring and connector. Be sure to check for corrosion and proper harness connector terminal tension.
- Verify the integrity of the three Differential Pressure Sensor electrical circuits and the ECM.
- Confirm that engine air flow is sufficient by comparing Mass Air Flow grams per second to a known good vehicle.

Testing

If everything checks out to this point, diagnostics turn to the DPS itself. To test it, you'll need some jumpers and the J 35555 "Mity Vac" (figure 7-4).

- With the ignition OFF, remove the DPS and install a three-amp fused jumper between terminal 3 of the harness connector and the corresponding terminal of the sensor. This is the 5-volt reference circuit.
- Install a jumper wire between the DPS low reference circuit terminal 1 and ground.
- Add a third jumper wire at terminal 2 of the DPS and connect a DMM between this jumper wire and ground.
- With the ignition on, connect the Mity Vac to the Differential Pressure Sensor's larger rear port.
- Monitor the DMM voltage readout while slowly applying pressure to the port. Voltage should vary smoothly between .4 and 4.9 volts without any spikes or dropouts.

If the voltage reading is not in the specified range, or is erratic, replace the DPS.

8. Aftermarket Engine

Aftermarket Engine Performance Products and Modifications

While some aftermarket engine performance products may promise a way to increase the horsepower and torque levels of the truck's powertrain, owners should be aware that these products may have detrimental effects on the performance and life of the diesel engine's, exhaust emission systems, transmission, and drivetrain

The Duramax Diesel, Allison Automatic transmission, and drivetrain are designed and built to offer industry leading durability and performance in the most demanding applications.

Engine power enhancement products will enable the engine to operate at output (horsepower and torque) levels that may damage and reduce the life of the engine, engine emission system, transmission, and drivetrain.

Owners should be made aware that damage, failure, or reduced life caused by aftermarket engine performance enhancement products or modifications may not be covered under the vehicle warranty.

The engine control modules used in DPF-equipped vehicles are equipped with a sophisticated system of data gathering and calibrations to ensure the emissions system and all related components function as designed. Modifying the engine, intake system or exhaust system can produce operating conditions that fall outside of the scope of published service information and impede vehicle diagnosis. In other words, when a customer alters a vehicle, it can make a technician's job that much more difficult.

GM Upfitter Website

While no modifications are currently permitted to the Duramax LMM exhaust system, GM approves modifications that are performed by authorized vehicle upfitters following GM specifications. A website, www.gmupfitter.com is available that is dedicated to improving the quality of GMC and Chevrolet second stage manufactured vehicles by providing many useful services (figure 8-1). The site contains a publications page with links to Body Builder and Best Practices manuals as well as Technical Bulletins.

Figure 8-1, Upfitter Web Site

Notes

GENERAL MOTORS TRAINING MATERIALS

Additional training materials are available through the GM training materials headquarters. The training materials GM Service Technical College provides to each GM dealer service technician are available in the following formats:

- Computer Based Training (CBT) – CD-ROM
- Interactive Distance Learning (IDL)
- GM Service Know-How Videos (GM SKH) – VHS or DVD
- TechAssists – available on-line
- Supplemental Print Material

To find out more, visit www.gmstc.com or contact:

GM Training Materials

1-800-393-4831

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