COURSE NAME

Next Generation GM Diesel Engines

COURSE #

SDE0101SM

STUDENT HANDOUT

General Motors' approach to training combines a variety of training delivery methods for maximum learning benefit for the service professional.

GM GENUINE PARTS | ACDelco

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COURSE INTRODUCTION

COURSE DESCRIPTION

This course prepares technicians to diagnose and service the new generation of turbocharged diesel engines from General Motors, including the 1.6L LH7, the 2.8L LWN, and the 6.6L L5P. Topics include the description and operation, diagnosis, and service procedure overviews for each diesel engine.

COURSE OBJECTIVES

Upon successful completion of the training, the technician will be able to:

- Identify the unique features, diagnosis, and service procedures of the 1.6L LH7 diesel engine
- Identify the unique features, diagnosis, and service procedures of the 2.8L LWN diesel engine
- Identify the unique features, diagnosis, and service procedures of the 6.6L L5P diesel engine

CAUTION STATEMENT

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

The materials presented in this course are for training purposes only. The course materials are not intended to replace established service procedures or information provided by vehicle Original Equipment Manufacturers (OEMs). You are responsible for ensuring compliance with any such procedures or information.

This training program is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others. This could also damage the vehicle, or cause the vehicle to operate improperly. Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part that has not been tested or designed to the same specifications.

Some of the service procedures described in this training 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 the OEM or ACDelco, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

As a reminder, it is the responsibility of the viewer / reader to follow all appropriate safety and technical procedures as outlined throughout this training material.

MITCHELL PRODEMAND REFERENCE

Special thanks to Mitchell ProDemand for granting permission to utilize their service information as a reference source for the development of this course. Graphics, schematics, other images, as well as Mitchell ProDemand service information content have been utilized in whole or part within this course.

ACDELCO TRAINING MISSION STATEMENT

ACDelco’s mission is to provide aftermarket service professionals with the skills necessary to help safely and effectively diagnose and repair customer vehicles utilizing inviting education methods within an extensive and engaging training portfolio.

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations will be used in this course:

API — American Petroleum Institute

ATDC — After Top Dead Center

CO — Carbon Monoxide

CO2 — Carbon Dioxide

DEF — Diesel Exhaust Fluid

DOC — Diesel Oxidation Catalyst

DOHC — Dual Overhead Camshaft

DPF — Diesel Particulate Filter

DTC — Diagnostic Trouble Code

ECM — Engine Control Module

ECT — Engine Coolant Temperature sensor

EGR — Exhaust Gas Recirculation

GPCM — Glow Plug Control Module

H_2O — Water Vapor

HC — Hydrocarbon

LNT — Lean NO_x Trap

MAF — Mass Air Flow

MPa — Megapascal

N_2 — Nitrogen

NOx — Oxides of Nitrogen

PCV — Positive Crankcase Ventilation

PSI — Pounds per Square Inch

PWM — Pulse Width Modulation

SCR — Selective Catalyst Reduction

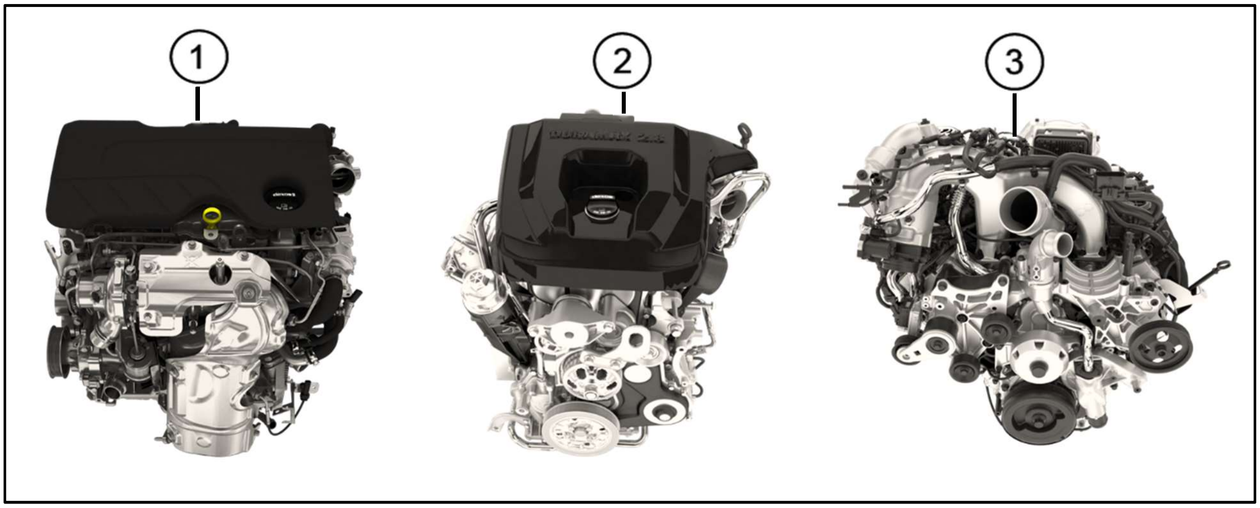
ULSD — Ultra-Low Sulfur Diesel

VGT — Variable Geometry Turbine

SHARED FEATURES AND DIAGNOSIS

OVERVIEW

Three next generation GM diesel engines are available, including the 1.6L LH7 Duramax™, the 2.8L LWN Duramax™, and the 6.6L L5P Duramax™. These engines share characteristics such as powerful, efficient performance, and quiet refinement. Next generation GM diesel engines have turbochargers with Variable Geometry Turbines (VGTs) that deliver boost that is matched to driver demand. Additional features shared by these engines include solenoid-type fuel injectors that provide precise fuel control, and ceramic glow plugs that heat up rapidly, providing starting performance similar to that of a gasoline engine.

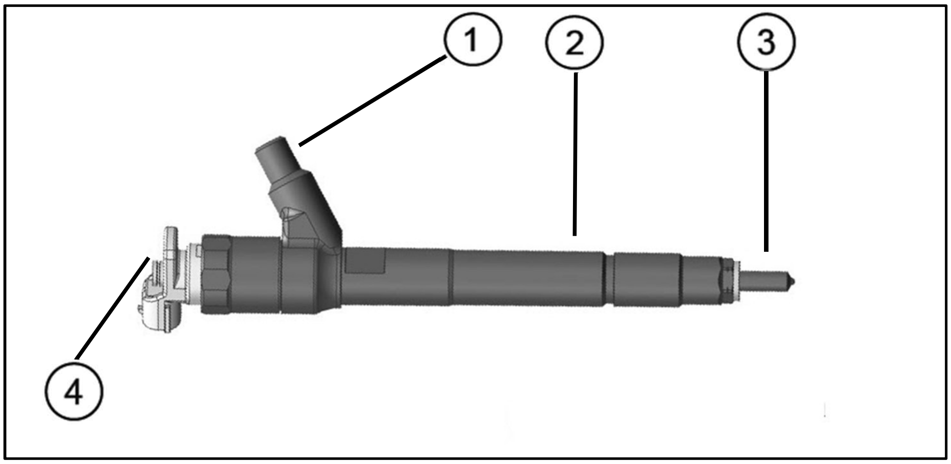


1. 1.6L LH7 Diesel Engine
2. 2.8L LWN Diesel Engine
3. 6.6L L5P Diesel Engine

Figure 2-1, Next Generation GM Diesel Engines

SOLENOID-TYPE FUEL INJECTORS

The solenoid-type fuel injectors are controlled by the Engine Control Module (ECM) and deliver fuel directly into each cylinder. Solenoid-type injectors support up to seven fuel delivery events per combustion event, contributing to lower noise, greater efficiency, and lower emissions. All injectors have a high pressure fuel pipe from the fuel rail and a low pressure return line. Fuel from the fuel injector tip is sprayed directly into the combustion chamber.



1. High Pressure Fuel Inlet
2. Injector Body
3. Injector Tip
4. Fuel Return

Figure 2-2, Solenoid-Type Injector

CERAMIC GLOW PLUGS

The 1.6L LH7, 2.8L LWN, and 6.6L L5P Duramax™ engines use ceramic glow plugs. Compared to conventional glow plugs, ceramic glow plugs enable greater efficiency through higher temperature capability and faster preheating time.

The 6.6L L5P Duramax™ 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°F (-29°C) without a block heater.

The ceramic glow plug control system is enhanced with automatic temperature compensation, a first-in-class feature providing improved robustness and capability. Automatic temperature compensation assesses and adjusts the current to each glow plug for every use, providing optimal temperature for cold start performance and durability.

When a ceramic glow plug and a conventional glow plug are compared, some differences are apparent. Ceramic glow plugs have a push-on harness connector instead of a threaded harness connector. In addition, a ceramic glow plug has a stepped shoulder between the glow plug body and the tip.

Ceramic glow plugs are much more susceptible to damage than conventional glow plugs. Damage can occur to the glow plug and not be visible, causing future engine failure. Therefore, ceramic glow plugs are considered one-time-use components. Glow plugs must be discarded whenever they are removed, and replaced with new parts. If a cylinder head is removed, the glow plugs in that head must be discarded and replaced.

Carbon accumulates in the gap between the glow plug and the glow plug bore. Carbon buildup in the glow plug bore must be removed to avoid damage to the tips of the glow plugs. When installing a ceramic glow plug in a 6.6L L5P engine, clean the glow plug bore with a glow plug bore reamer such as EN-52074 or equivalent.

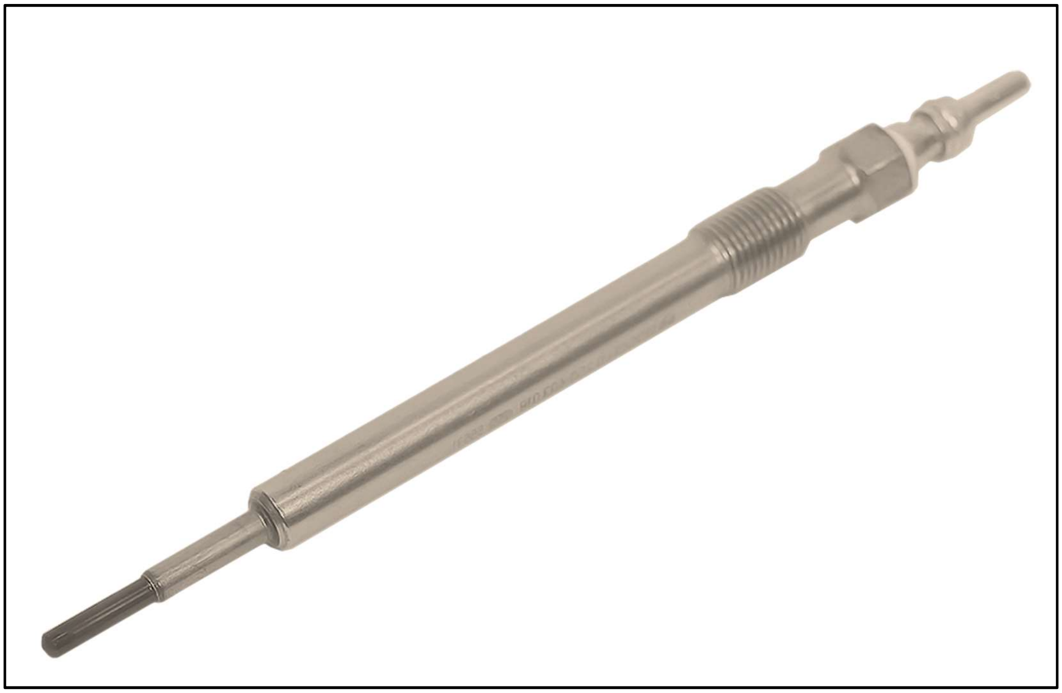
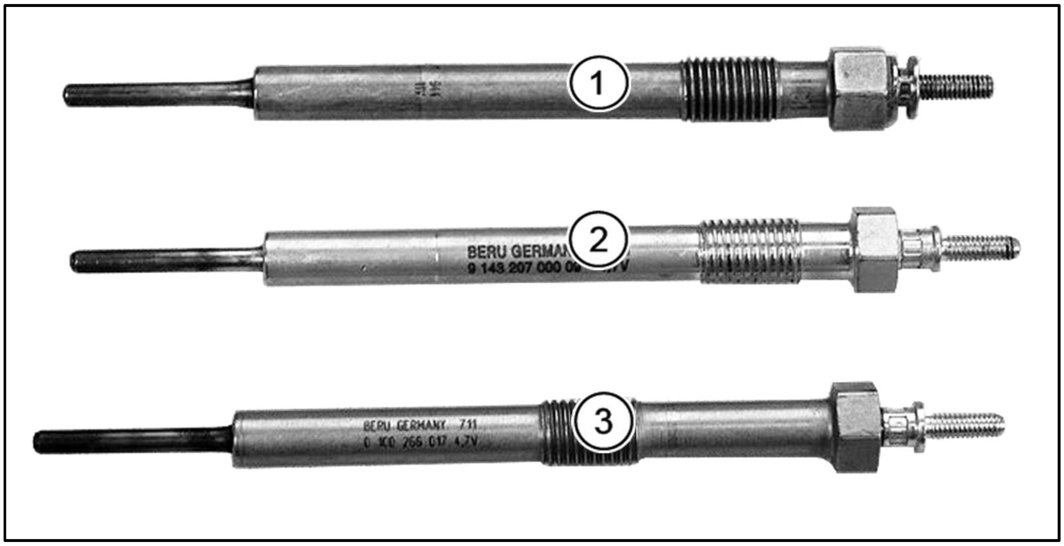


Figure 2-3, Ceramic Glow Plug, 6.6L L5P



1. LB7 6.6L Duramax™, Gold Color, 12 Volts, Not Interchangeable
2. LLY 6.6L Duramax™, Silver Color, 4.7 Volts, Not Interchangeable
3. 2006 LLY and Newer, (LBZ, LMM, LML) 6.6L Duramax™, 4.7 Volts, 1832°F (1000°C) Threads Repositioned to Prevent Interchange

Figure 2-4, Conventional 6.6L Duramax™ Engine Glow Plugs

The Glow Plug Control Module (GPCM) operates the glow plugs and is integrated in the ECM. The nominal voltage for the glow plugs is 5.4 volts. When the ignition is turned ON, the GPCM applies 7.2 volts for 2.2 seconds, and then 5.7 volts for 0.8 seconds, and then 5.4 volts until 2192°F (1200°C) is reached. The maximum voltage of the system is 10 volts. While the engine is running, the voltage varies between 4.7–10 volts when in closed loop control to maintain a glow plug temperature that ranges from 2102°–2156°F (1150°–1180°C). The temperature and the power consumption are controlled between the ECM and the GPCM within a wide range to suit the engine's pre-heating 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 short wait to crank times and maximum glow plug durability. A Diagnostic Trouble Code (DTC) will set if there is a glow plug system fault.

If the engine is cranked during or after the previous 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 operating to terminate the glow plug cycling. The glow plug initial on time varies based on the system voltage and temperature. Lower temperatures cause longer on times.

ENGINE CRANKS BUT DOES NOT RUN (1.6L LH7 AND 6.6L L5P)

Circuit / System Description

The Engine Cranks but Does Not Run diagnostic table is an organized approach to identifying a condition that causes an engine not to start. This diagnostic procedure directs the service technician to the appropriate system diagnosis.

Diagnostic Aids

If an engine cranks but does not run condition occurs only in cold ambient temperatures, fuel contamination, poor fuel quality, fuel waxing, or icing may be the cause. Fuel icing, due to water contamination, and fuel waxing, may cause fuel system restrictions significant enough to prevent the engine from starting.

The engine may start after the vehicle is brought into the service bay and the fuel is sufficiently warmed. The use of an unapproved fuel, such as fuel containing greater than 20% biodiesel, may cause severe fuel system restrictions. Unapproved fuel usage can also cause the engine to start and stall, or to start, but have no acceleration. Engine block heaters may be used to alleviate some fuel icing and waxing concerns.

Note: The following diagnostic procedure assumes that the battery is completely charged and there is adequate fuel in the fuel tank.

Check for DTCs. If any DTCs are set:

1. Refer to the Diagnostic Trouble Code List – Vehicle in service information.

If no DTCs are set:

2. Turn the ignition ON.
3. Verify the security indicator on the instrument panel cluster illuminates momentarily.
   - If the indicator stays illuminated or is flashing, refer to Diagnostic Trouble Code List – Vehicle and Immobilizer Description and Operation in service information
   - If the indicator does not stay illuminated or is not flashing, proceed to the next step
4. Verify the scan tool Engine Speed parameter is greater than 0 RPM while cranking the engine.
   - If 0 RPM, refer to DTC P0335 or P0336 in service information
   - If greater than 0 RPM, proceed to the next step
5. Verify the scan tool Engine Speed parameter, while cranking the engine, is greater than 50 RPM on a cold engine and 125 RPM on a hot engine.
   - If less than 50 RPM on a cold engine or less than 125 RPM on a hot engine, refer to Engine Cranks Slowly in service information
   - If greater than 50 RPM on a cold engine or greater than 125 RPM on a hot engine, proceed to the next step
6. Verify there are no fuel system leaks from the fuel tank to the high pressure pump.
   - If a fuel leak is present, refer to Fuel Leak Diagnosis in service information
   - If a fuel leak is not present, proceed to the next step
7. Turn the ignition ON.
8. Verify the fuel pump turns on and off when commanding the fuel pump relay on and off with a scan tool.
   - If the fuel pump does not turn on and off, refer to Fuel System Diagnosis in service information
   - If the fuel pump turns on and off, proceed to the next step
9. Verify the scan tool Fuel Rail Pressure Sensor parameter is greater than 1,450 PSI (10 MPa) while cranking the engine.
   - If not 1,450 PSI (10 MPa) or greater, refer to Fuel System Diagnosis in service information
   - If greater than 1,450 PSI, proceed to the next step

Note: If the vehicle has been run out of fuel and the engine will not start after refueling, the fuel injector return system may have become air locked.

10. Verify the customer ran the vehicle out of fuel before the Engine Cranks but Does Not Run condition occurred.
    - If the customer ran the vehicle out of fuel, refer to Fuel Return System Diagnosis in service information
    - If the customer did not run the vehicle out of fuel, proceed to the next step
11. Verify the following conditions do not exist:
    - Collapsed or restricted air intake duct to the throttle body
    - Restricted air filter element
    - A skewed Engine Coolant Temperature (ECT) sensor – refer to DTC P0117 or P0118 in service information
    - Exhaust system restricted – refer to Restricted Exhaust in service information
    - Fuel contamination – refer to Contaminants-in-Fuel Diagnosis in service information
    - Engine mechanical condition, for example, worn timing chain and gears or low compression – refer to Symptoms – Engine Mechanical or Engine Compression Test in service information
12. If a condition is found, repair as necessary.
13. If a condition is not found, all is OK.

ENGINE CRANKS BUT DOES NOT RUN (2.8L LWN ONLY)

Circuit / System Description

The Engine Cranks but Does Not Run diagnostic table is an organized approach to identifying a condition that causes an engine not to start. This diagnostic procedure directs the service technician to the appropriate system diagnosis.

Note: There are two versions of the Engine Cranks But Does Not Run procedure because the 2.8L LWN engine diagnostic procedure specifies a higher minimum cranking speed than the other two engines: 100 RPM cold and 180 RPM hot. The 1.6L LH7 and 6.6L L5P diagnostic procedures specify 50 RPM cold and 125 RPM hot. Also, the minimum rail pressure on the 2.8L LWN engine is 2900 PSI, while the 1.6L LH7 and 6.6L L5P specify 1450 PSI.

Diagnostic Aids

Inspect the vehicle for any of the following conditions:

- Insufficient fuel can cause a no start condition. Thoroughly inspect the fuel delivery system for sufficient fuel volume to the fuel injectors. Inspect the fuel supply components for partial blockage or restrictions

- Fuel injectors with partially blocked and restricted nozzles, or a malfunctioning solenoid, can cause a no start condition. Refer to Fuel System Diagnosis in service information for more information

- There may be fuel spray at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the fuel injectors and the injector circuit are okay, and fuel spray is detected, the fuel injector ON time may be inadequate. If the ECM receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known good vehicle

- Check the crankshaft position sensor engine reference signal with a scan tool. Observe the Engine Speed parameter while cranking the engine. The scan tool should indicate a steady 200–300 RPM while cranking. If erratic values are displayed, such as sudden spikes in the engine speed, the engine reference signal is not stable enough for the engine to start and run properly

- Inspect the engine for good, secure electrical grounds

Note: Slow cranking or DTCs can indicate the presence of poor grounds or a discharged battery.

- Water or foreign material in the fuel can cause a no start or engine will not stay running condition. During freezing weather, water can freeze inside the fuel system. The engine may start after 30 minutes in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting

The following diagnostic procedure assumes the verifications listed below have been performed:

- Verify the battery is completely charged – refer to Battery Inspection / Test in service information

- Verify engine cranking speed is at least 100 RPM cold and 180 RPM hot – refer to Engine Cranks Slowly in service information

- Verify there is adequate fuel in the fuel tank

1. Crank the engine for 15 seconds, and verify the DTC information with a scan tool. Verify that no DTC is set.

    - If any DTC is set, refer to the Diagnostic Trouble Code List – Vehicle in service information

    - If no DTC is set, proceed to the next step

2. Visually inspect the fuel system from the high pressure pump to the fuel tank for leaks.
   - If a fuel tank leak is present, refer to Fuel System Diagnosis in service information
   - If no fuel leaks are present, proceed to the next step
3. Crank the engine for 15 seconds, and observe the scan tool Fuel Rail Pressure Sensor parameter. The reading should be greater than 2,900 PSI (20 MPa).
   - If the fuel rail pressure sensor parameter is less than 2,900 PSI (20 MPa), refer to Fuel System Diagnosis.
   - If the fuel rail pressure sensor parameter is 2,900 PSI (20 MPa) or greater, proceed to the next step
4. Verify the following conditions do not exist:
   - Collapsed air intake duct to throttle body
   - Restricted air filter element
   - A skewed ECT sensor – verify sensor resistance against the Temperature Versus Resistance tables
   - Exhaust system restricted – refer to Restricted Exhaust
   - Fuel contamination – refer to Contaminants-in-Fuel Diagnosis
   - Engine mechanical condition; for example, worn timing belt or low compression – refer to Symptoms – Engine Controls or Engine Compression Test

   If any of the above listed conditions exist, repair as necessary.
5. If none of the above listed conditions exist, all is okay.

CONTAMINANTS IN FUEL DIAGNOSIS

Fungi and other microorganisms can survive and multiply in diesel fuel if water is present. The fungi can be present in any part of the fuel handling system. These fungi grow into long strings and will form into large globules. The growths appear slimy and are usually black, green, or brown. The fungi may grow anywhere in the fuel, but are most plentiful where diesel fuel and water meet. Service station tanks may contain fungi that could be pumped into a vehicle during refueling.

Fungi use the fuel as their main energy supply and need only trace amounts of water and minerals. As they grow and multiply, they change fuel into water, sludge, acids, and products of metabolism. The most common symptom is fuel filter plugging; however, various metal fuel system components can corrode, including the fuel sender assembly, pipes, fuel injectors, and the fuel injection pump.

WARNING: Avoid physical contact with the biocides in order to avoid personal injury.

If fungi have caused fuel system contamination, use a diesel fuel biocide to sterilize the fuel system. Do not exceed the dosage recommended on the label. Discontinue the use of a biocide when towing a trailer due to possible engine power loss. It is permissible to have biocide in the fuel when starting to tow, but do not add any biocide while towing.

Water or other contaminants in fuel will also create drivability concerns and loss of engine power. If water is present in the fuel system, the fuel cannot cool and lubricate the components, causing overheating, rust, and corrosion. This can result in component failure. Water can enter the fuel system in different ways, either through a contaminated refueling source or through long-term condensation the vehicle fuel tanks.

Like fungi and water, gasoline contamination will cause drivability concerns and a possible hard starting or a no start condition if the overall content is large enough. Gasoline raises the American Petroleum Institute (API) rating and reduces cooling and lubrication, resulting in possible component failure.

It is acceptable to use diesel fuel containing up to 20% biodiesel. Biodiesel is produced from vegetable oils or animal fat that has been chemically modified to reduce the possibility of damage to the fuel system and engine components. Concentrations greater than 20% biodiesel or the use of unmodified bio-oils blended into diesel fuel at any concentration is not recommended and may cause drivability concerns or component failure.

Because of the cleansing properties of biodiesel, switching from straight diesel to a biodiesel blend can prematurely restrict the fuel filter with normal deposits in the fuel system. A fuel filter replacement might be required sooner than the recommended interval.

Refer to service information for specific service guidelines and procedures.

CONTAMINANTS IN DIESEL EXHAUST FLUID DIAGNOSIS

Description

In order for the Selective Catalyst Reduction (SCR) system to operate at maximum efficiency and reduce the maximum amount of oxides of nitrogen (NO_x), the SCR system requires a supply of Diesel Exhaust Fluid (DEF). DEF is also called reductant or emission reduction fluid. DEF consists of a mixture of urea and deionized water. Fresh DEF should be clear in color with an ammonia smell. DEF designed for SCR systems should carry one or more of the following international certifications:

- DIN70700
- ISO 22241-1
- American Petroleum Institute (API) Certification

Inspecting for Contaminants

While contamination may result from any number of fluids, it is more likely that contamination will involve one the following common automotive fluids. Because clean DEF is clear, contamination by any of these fluids will cause the DEF to exhibit a trace of color associated with a specific contaminant.

- Windshield washer solvent (orange, purple or blue)
- Engine coolant (orange or green)
- Engine oil (brown)
- Transmission fluid (red or brown)
- Diesel fuel (clear, yellow, green, red, or brown)

Clear fluid without the presence of an ammonia odor may indicate the presence of water or DEF that is diluted with water.

Refer to service information for specific guidelines and service procedures.

1.6L LH7 DESCRIPTION AND OPERATION

SPECIFICATIONS

The 1.6L LH7 Duramax™ turbocharged diesel engine is fuel efficient, quiet, and calibrated to function optimally. The 1.6L LH7 produces low speed torque for responsive acceleration and higher RPM power to maintain cruising speed. The 1.6L LH7 is available in 2017 Chevrolet Cruze and 2018 Chevrolet Equinox models.

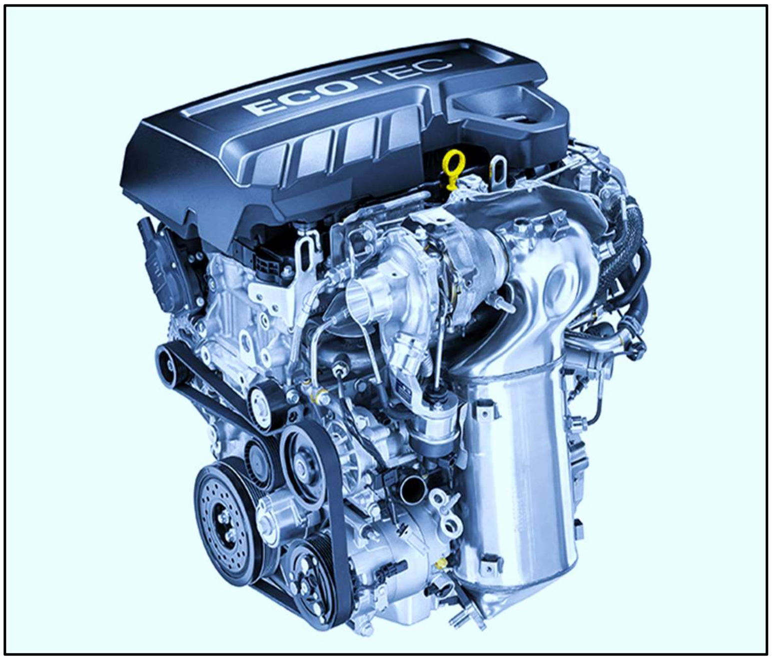


Figure 3-1, 1.6L LH7 Turbocharged Diesel Engine

Description	Specification
Displacement	97.5 cu in (1.6L)
Bore x Stroke	3.14 x 3.15 inches (79.7 x 80.1 mm)
Compression Ratio	16.0:1
Firing Order	1-3-4-2
Estimated Output at Engine Speed	134 horsepower (100 kW) / 4000 RPM
Torque at Engine Speed	236 lb ft (320 N•m) / 2000 RPM

Figure 3-2, 1.6L LH7 Engine Specifications

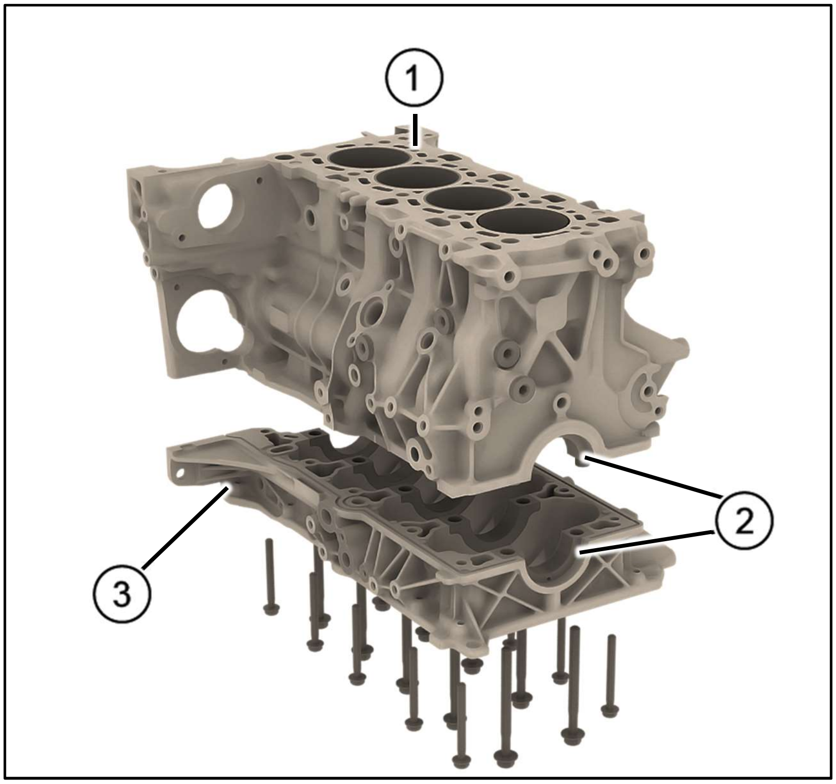
ENGINE MECHANICAL

Cylinder Block

The 1.6L LH7 cylinder block is made of aluminium with cast in place iron cylinder liners. The block has five main bearings, with the thrust bearing located on the third (center) main bearing. The third main bearing upper shell has thrust flanges on both sides. The third main bearing lower shell does not have thrust flanges.

The main bearings have nodular cast iron main bearing inserts. The lower end is supported by a die-cast aluminium bedplate formed with cast iron main bearing inserts.

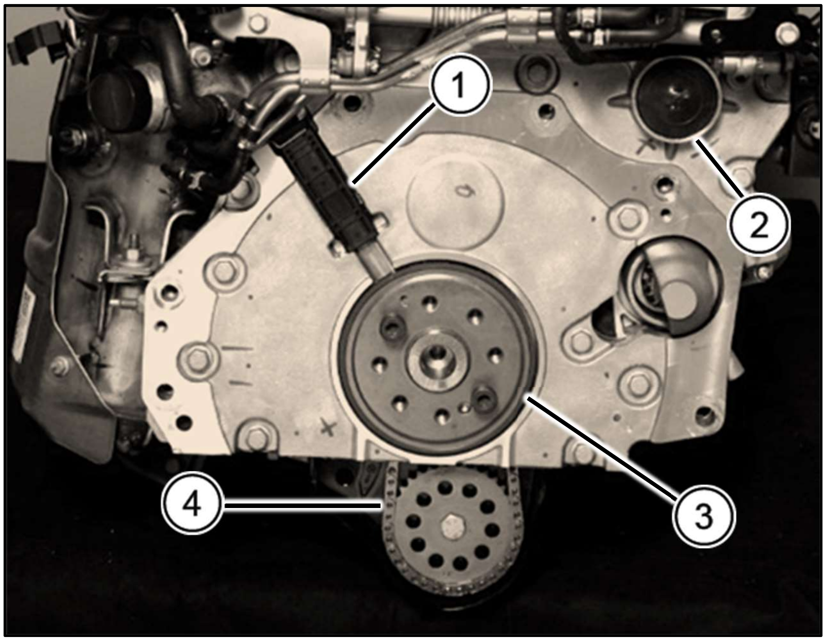
The main bearing caps, like the cylinder liners, are placed in the bedplate mold before the molten aluminum is poured. The main bearing caps are not removable from the aluminum bedplate and can only be installed in one position.



1. Cast Aluminum Cylinder Block
2. Cast Iron Main Bearing Inserts
3. Die Cast Aluminum Bedplate

Figure 3-3, 1.6L LH7 Cylinder Block and Bedplate

The rear main seal contains a crankshaft position sensor. The reluctor for the crankshaft position sensor is sandwiched between the back of the crankshaft and the flywheel. The rear of the block contains the fuel injection pump sprocket access plug.



1. Crankshaft Position Sensor
2. Fuel Injection Pump Sprocket Access Plug
3. Rear Main Seal
4. Oil / Vacuum Pump Drive Chain

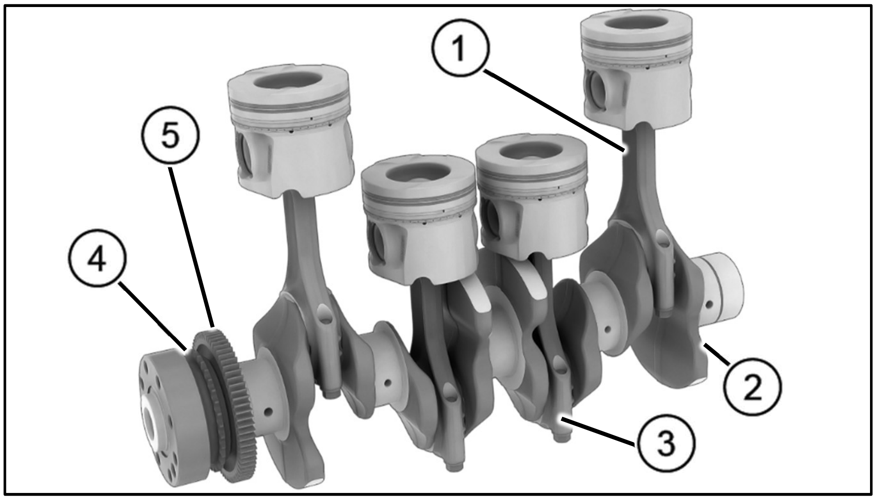
Figure 3-4, 1.6L LH7 Rear Main Seal with Crankshaft Position Sensor

Rotating Assembly

The forged steel crankshaft is supported in five main bearing journals. A crankshaft balancer controls torsional vibration.

The forged steel connecting rods have fractured split rod bearing caps.

The crowns of the aluminium alloy pistons are marked to ensure proper installation. The piston skirt is graphite-coated in two areas. The piston pins are full floating and retained by split rings.



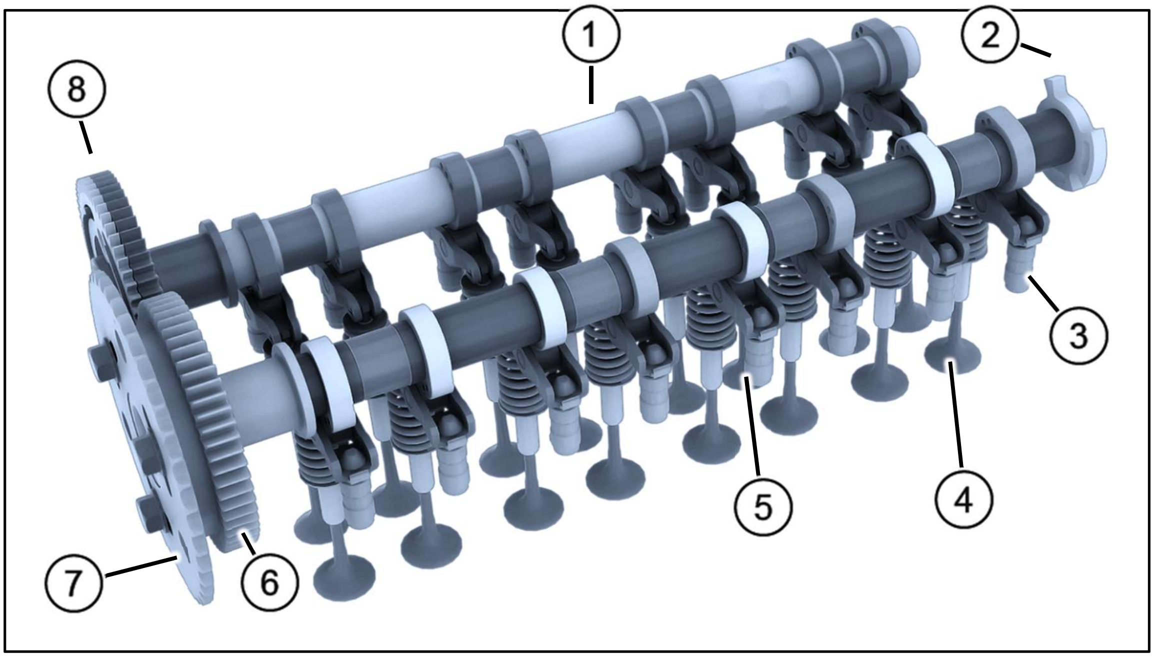
1. Forged Steel Connecting Rod
2. Forged Steel Crankshaft
3. Fractured Connecting Rod Bearing Cap
4. Flywheel Flange with Oil Pump Chain Sprocket
5. Timing System Drive Gear

Figure 3-5, 1.6L LH7 Rotating Assembly

CYLINDER HEAD AND VALVE TRAIN

The cast aluminium cylinder head is a Dual Overhead Camshaft (DOHC) design. The camshafts operate four valves per cylinder through hydraulic finger-type roller followers and valve bridges. A gear on the intake camshaft drives the exhaust camshaft. The exhaust camshaft has a split drive gear with a spring mechanism that minimizes gear backlash and noise.

To adjust for tolerance variations between cylinder blocks and components, three different head gasket grades / thicknesses are available. Diesel engine heads are flat, and do not contain combustion chambers as do gasoline engines. Due to part variation, it is possible for a piston to protrude above the cylinder bore. With a flat cylinder head, a piston that protrudes above the cylinder bore can contact the cylinder head. Therefore, the head gasket must be thick enough to provide clearance between the cylinder head and the top of the piston. Measurement of the engine block or inspection of the old gasket is required in order to select the correct grade for replacement.

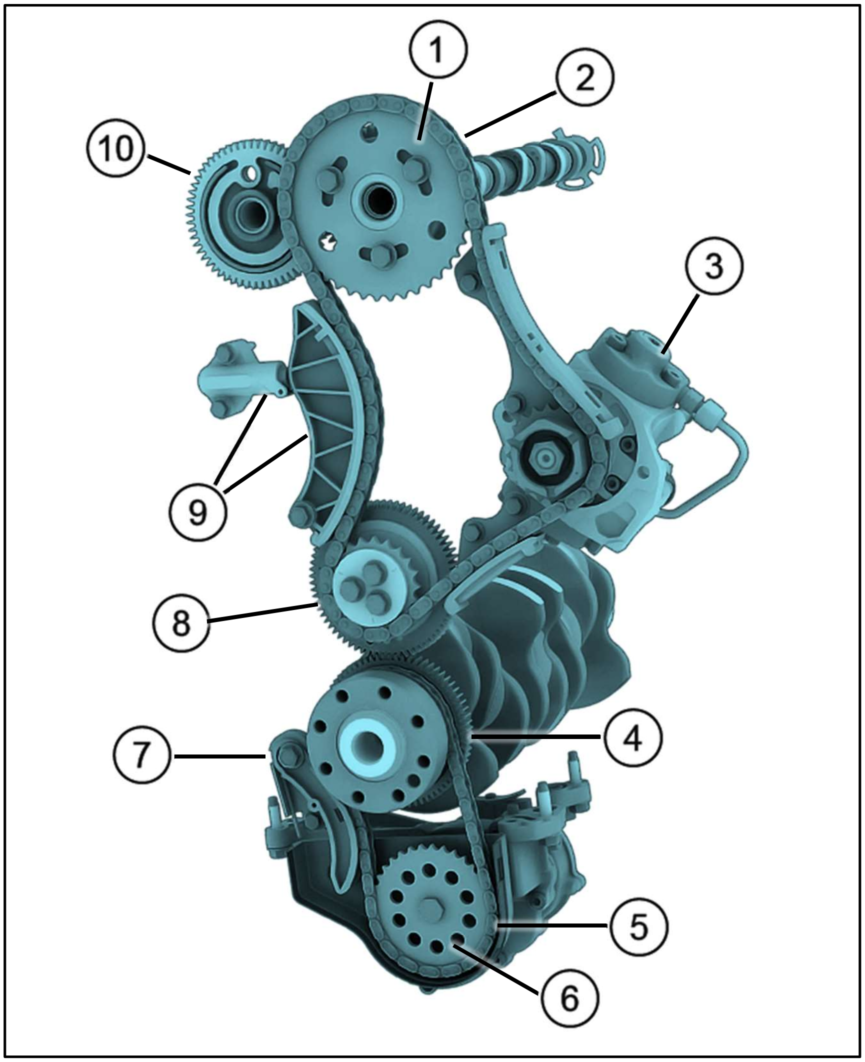


1. Exhaust Camshaft
2. Intake Camshaft Reluctor
3. Valve Bridge and Hydraulic Finger-Type Roller Follower
4. Intake Valve
5. Exhaust Valve
6. Drive Gear on Intake Camshaft
7. Sprocket on Intake Camshaft
8. Drive Gear on Exhaust Camshaft

Figure 3-6, 1.6L LH7 Valve Train

The timing chain is located at the rear of the engine on the transmission / bell housing side. A gear on the flywheel end of the crankshaft acts as the timing system drive gear. The crankshaft gear drives the timing chain idler gear, which in turn, drives the timing chain. The timing chain drives the injection pump and the intake camshaft sprocket. The lower chain on the crankshaft gear drives the oil pump.

Note: Either the engine or transmission must be removed from the vehicle in order to service the timing chain.

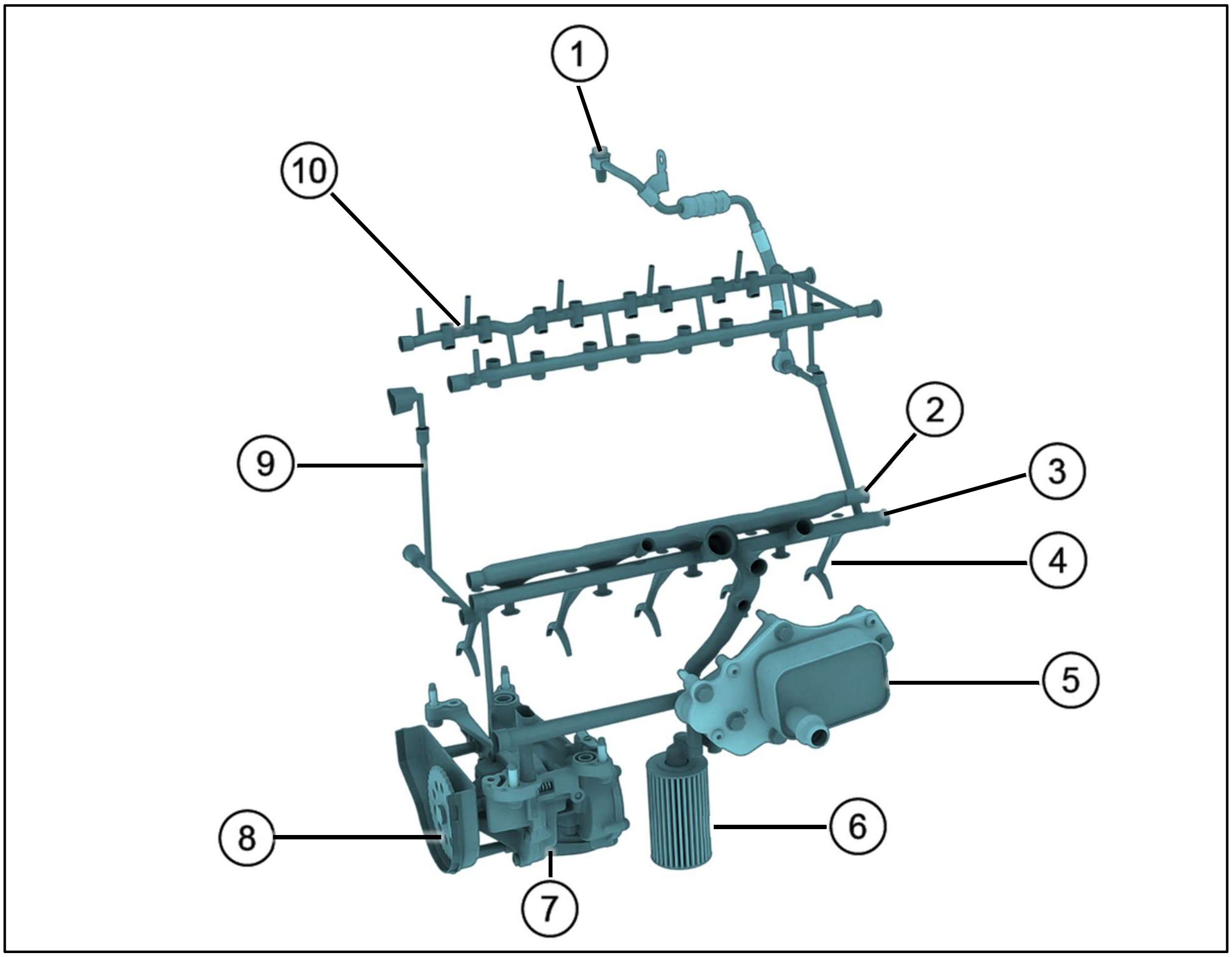


1. Intake Camshaft Sprocket
2. Timing Chain
3. Fuel Injection Pump
4. Crankshaft Gear
5. Oil / Vacuum Pump Drive Chain
6. Oil / Vacuum Pump Sprocket
7. Oil / Vacuum Pump Chain Tensioner
8. Timing Chain Idler Gear
9. Timing Chain Tensioner and Guide
10. Exhaust Camshaft Gear

Figure 3-7, 1.6L LH7 Timing Chain and Oil Pump Drive

LUBRICATION SYSTEM OVERVIEW

The lubrication system filters, cools, and delivers pressurized oil to various parts of the engine. The lubrication system includes a dedicated piston cooling jet channel with an on-off solenoid valve. Spray jets deliver oil to the underside of the pistons. A cartridge-type oil filter is integrated into the oil pan. A vacuum pump is integrated with the oil pump.



1.	Turbocharger Oil Feed Line	2.	Piston Cooling Jet Channel	3.	Main Oil Gallery
4.	Crankshaft Main Bearing Oil Passages	5.	Oil Cooler	6.	Oil Filter Cartridge
7.	Oil Pump with Integrated Vacuum Pump	8.	Oil Pump Sprocket	9.	Timing Chain Tensioner Oil Passage
10.	Oil Passages in Cylinder Head				

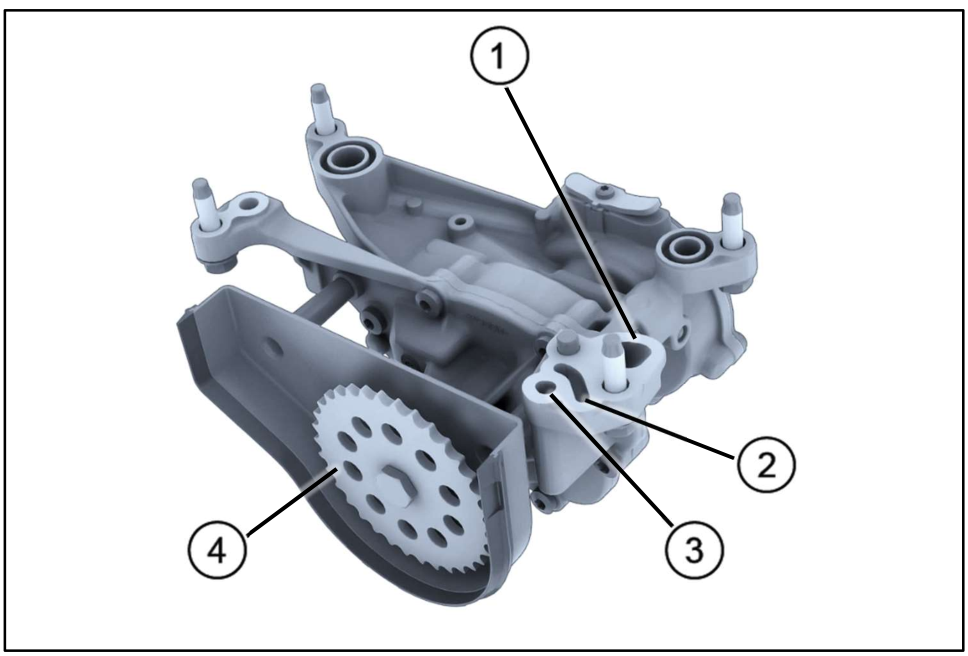
Figure 3-8, 1.6L LH7 Lubrication System Components and Oil Passages Cast in Block

1. Oil Filter Cover

Figure 3-9, 1.6L LH7 Cartridge Type Oil Filter Integrated with Oil Pan

Variable Displacement Oil Pump with Integrated Vacuum Pump

The oil pump assembly consists of a variable displacement oil pump and a vacuum pump. The oil pump assembly is chain driven by a sprocket on the crankshaft. The vacuum pump supplies vacuum to the power brake booster. The oil pump is a variable displacement design that controls pump output based on demand. Oil pump displacement control is accomplished by the ECM-controlled oil pump flow control solenoid valve, which is located on the engine block just below the starter motor. The control module commands the state of the solenoid valve based on engine speed, calculated oil temperature, engine oil pressure, and engine run time. Oil pump displacement is lower at low RPM and higher at high RPM.

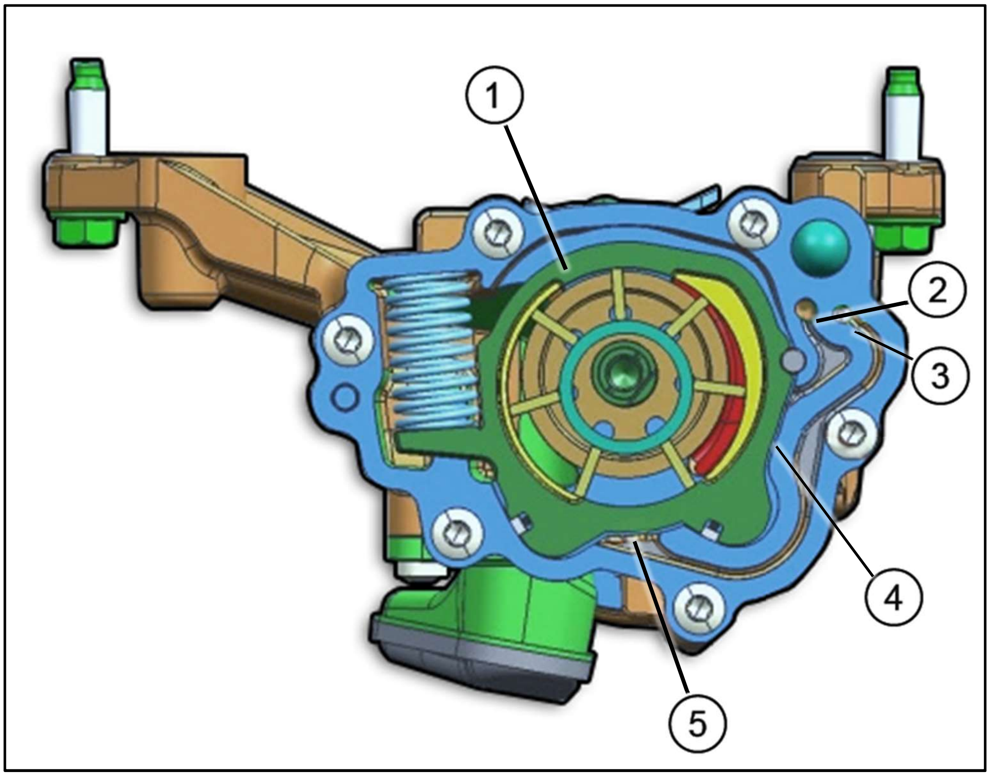


1. Oil Pump Outlet
2. Oil Pump Flow Control Solenoid Pressure
3. Main Oil Gallery Pressure Feedback
4. Oil Pump Sprocket

Figure 3-10, 1.6L LH7 Variable Displacement Oil Pump with Integrated Vacuum Pump

The variable displacement oil pump changes oil volume output by changing the position of the oil pump adjusting ring. Oil pump displacement control surface 1 is constantly supplied with pressurized oil from the main oil gallery pressure feedback passage. The spring on the oil pump adjusting ring opposes the oil pressure in the main oil gallery pressure feedback passage, and the oil pump adjusting ring remains in the high volume displacement position.

When the oil pump flow control solenoid valve is energized, pressurized oil from the main oil gallery pressure feedback passage is applied to oil pump displacement control surface 2, overcoming the force of the spring on the oil pump adjusting ring. As the spring compresses, the oil pump adjusting ring moves to the low displacement position.

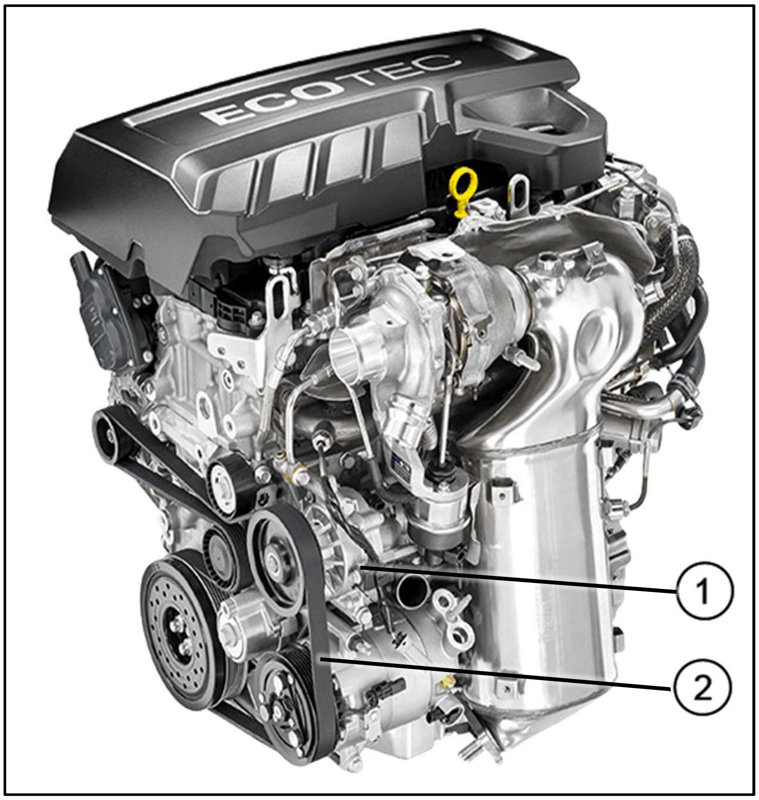


1. Oil Pump Adjusting Ring
2. Main Oil Gallery Pressure Feedback Passage
3. Oil Pump Flow Control Solenoid Pressure
4. Displacement Control Surface 1
5. Displacement Control Surface 2

Figure 3-11, 1.6L LH7 Variable Displacement Oil Pump Internal Components

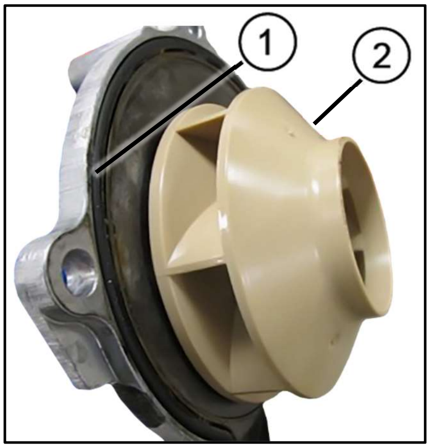
WATER PUMP

The water pump circulates coolant to the heater core and engine components. The water pump is driven by the accessory belt at the front of the engine.



1. Water Pump
2. Accessory Belt

Figure 3-12, 1.6L LH7 Water Pump and Accessory Belt



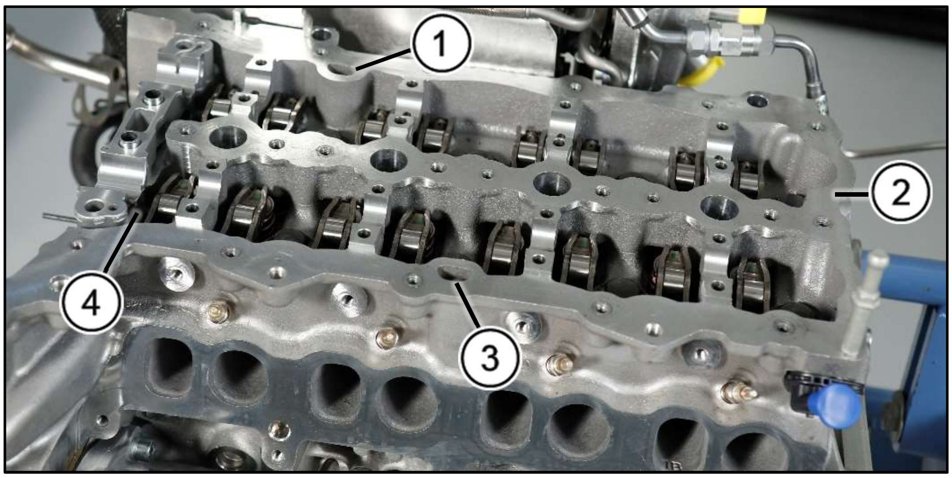
1. Bearing and Pulley Seal
2. Water Pump Impeller

Figure 3-13, 1.6L LH7 Water Pump

INDUCTION SYSTEM

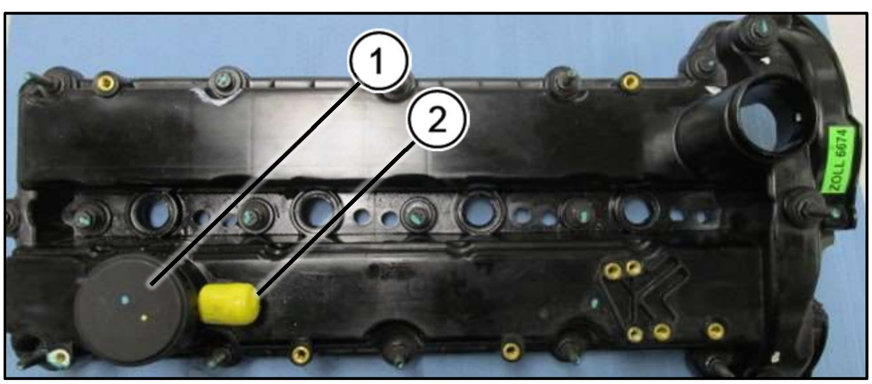
Crankcase Ventilation System

The crankcase ventilation system separates oil from the crankcase blow by gases and delivers them to the intake airstream so they can be burned in the combustion chambers. Passages cast into the cylinder block and cylinder head deliver blow by gases to the oil separator inside the cam cover. The cylinder head also provides a blow by passage from the timing chain area. Oil from the separator flows back to the oil pan. A mechanical crankcase pressure regulator valve in the camshaft cover regulates crankcase pressure. When the pressure difference between the turbocharger inlet exceeds the spring tension of the regulator valve, the valve closes to prevent oil / vapor from being siphoned into the turbocharger. A crankcase ventilation outlet near the pressure regulator valve connects to a fitting on the turbocharger air inlet.



1. Blow By Exhaust from Camshaft Cover
2. Cylinder Head
3. Blow By Inlet from Crankcase
4. Blow By Inlet from Timing Chain Area

Figure 3-14, 1.6L LH7 Crankcase Ventilation Passages in Cylinder Head

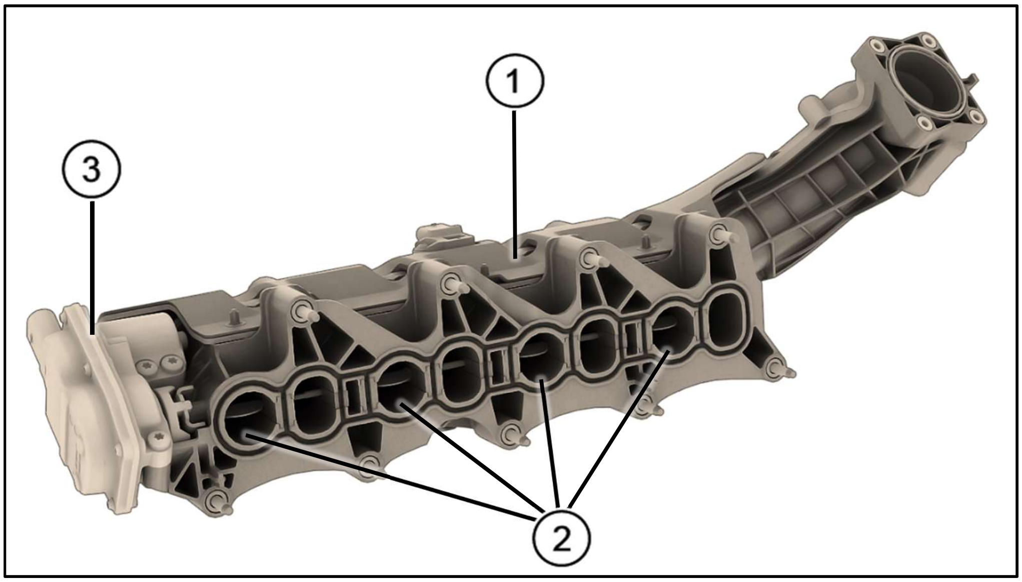


1. Crankcase Pressure Regulator Valve
2. Fitting Routes Gases to Turbocharger Air Inlet

Figure 3-15, 1.6L LH7 Crankcase Ventilation / Camshaft Cover

Intake Manifold

The intake manifold contains swirl flaps that are driven by a DC actuator. The swirl flaps are disk-shaped plates that are placed in every other intake manifold port. The swirl flaps are mounted on a shaft that extends through the intake manifold ports and provides a pivot point for opening and closing the swirl flaps. At low engine speeds, the swirl flaps create turbulence that uniformly mixes exhaust gas from the Exhaust Gas Recirculation (EGR) system into the intake air stream to promote uniform combustion. A uniform mixture of air and exhaust gas reduces the formation of NO_x during combustion.



1. Intake Manifold
2. Swirl Flaps
3. DC Actuator

Figure 3-16, 1.6L LH7 Swirl Flaps and DC Actuator

Turbocharger

A turbocharger with a VGT optimizes boost pressure in all engine operating conditions and eliminates the need for a waste gate to control boost pressure.

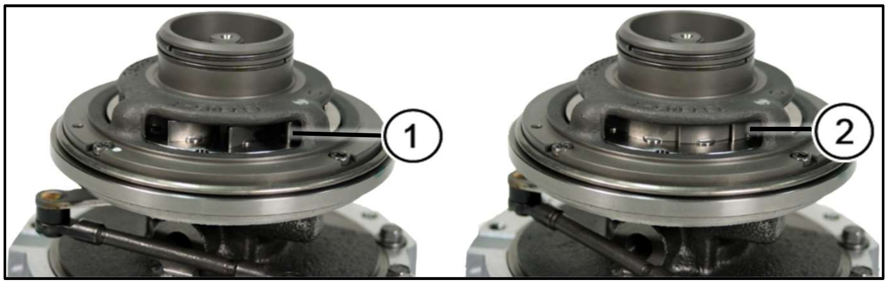
Note: A waste gate is a pressure relief valve in a turbocharger system. Engines with fixed geometry turbochargers are capable of producing more boost than the engine needs in some conditions. A waste gate controls boost pressure by releasing excess boost pressure to the atmosphere.

In a VGT, vane angles are varied to control the amount of boost pressure, depending on engine load requirements. A vacuum-operated vane position actuator with an integral vane position feedback sensor changes the vane angle. The vanes are mounted to a drive ring and connected to a linkage lever that can be rotated by the vane position actuator rod to change vane angle.

The turbocharger vanes are normally open when the engine is not under a load. The ECM commands the boost pressure actuator to close the turbocharger vanes to increase engine power by increasing boost pressure.

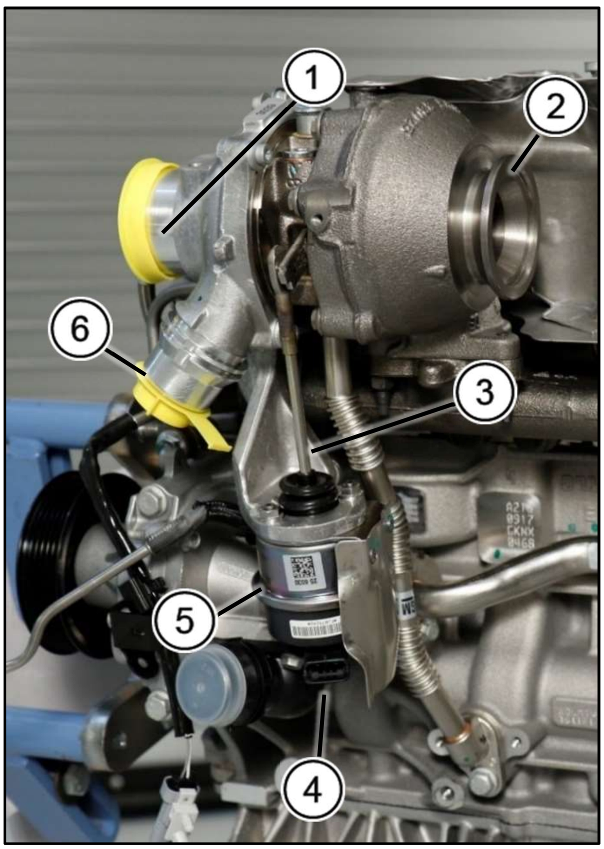
EGR flow rate is dependent on two factors: the EGR valve opening and the pressure difference between the intake manifold and the exhaust manifold. Closing the turbocharger vanes causes exhaust pressure to increase, thereby increasing EGR flow.

The ECM may close the vanes to create backpressure to drive exhaust gas through the EGR valve, as required. At extremely cold temperatures, the ECM may close the vanes at low load conditions to increase EGR flow and accelerate engine coolant heating. The ECM may also close the vanes under exhaust braking conditions. Closing the vanes increases exhaust system backpressure and exhaust manifold pressure, which acts as engine braking.



1. Turbocharger Vanes Open
2. Turbocharger Vanes Closed

Figure 3-17, Variable Geometry Turbocharger Vane Operation



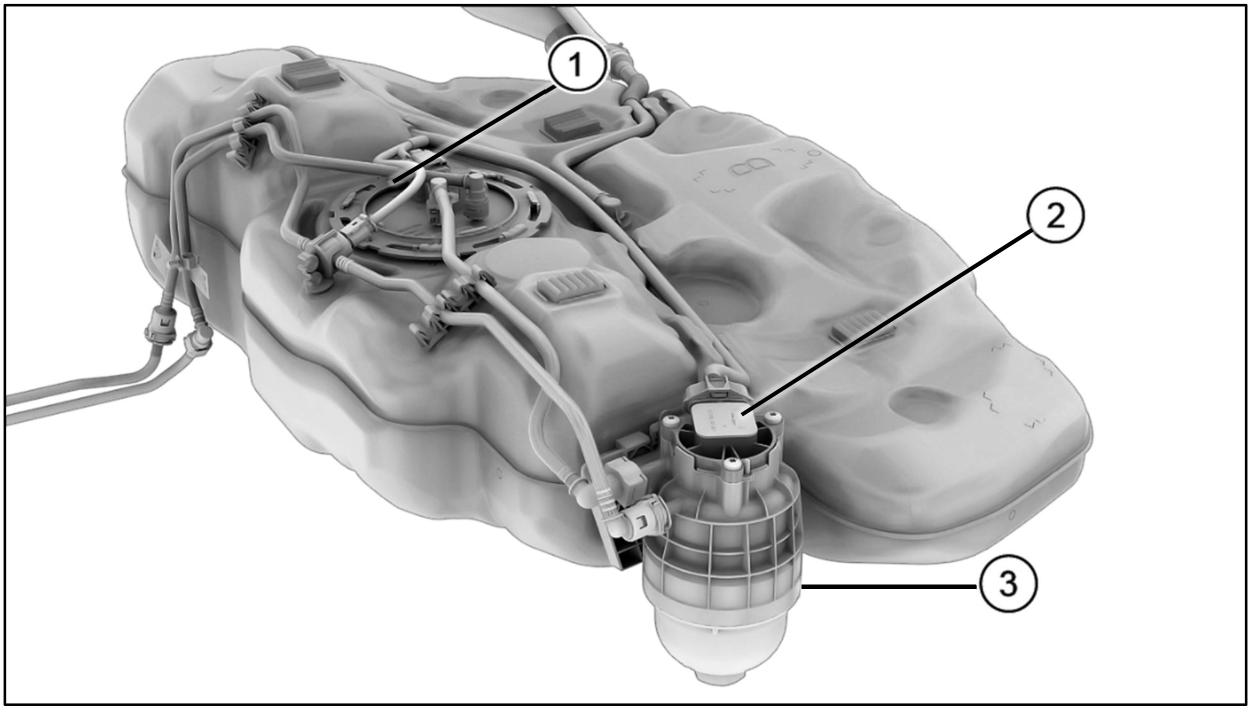
1. Air Inlet from Air Cleaner
2. Exhaust Outlet
3. Vane Position Actuator Rod
4. Vane Feedback Position Sensor
5. Vane Position Actuator
6. Compressed Air Outlet to Intake Manifold

Figure 3-18, 1.6L LH7 Turbocharger

FUEL SYSTEM

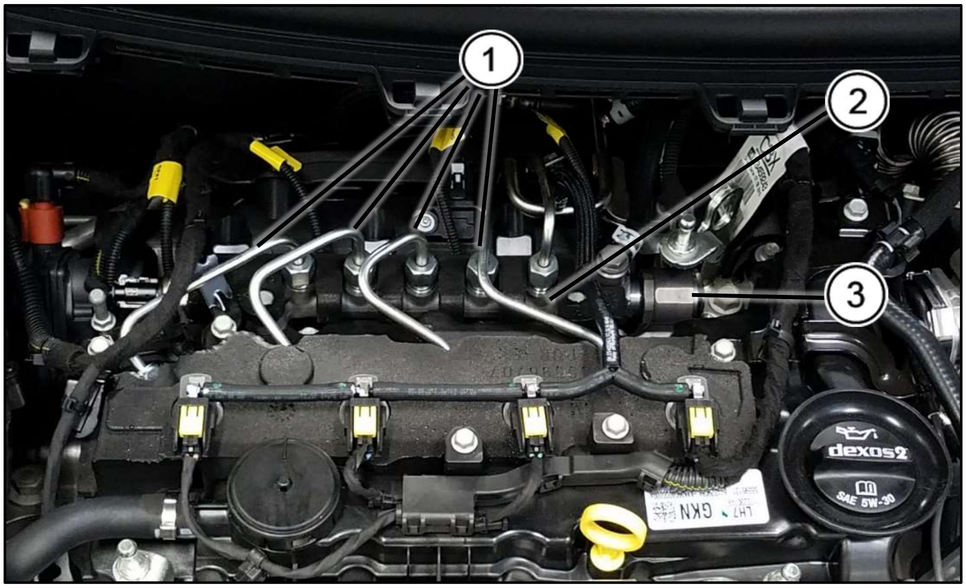
Fuel Supply System

The fuel tank stores the fuel supply and contains an electric fuel pump that is controlled by the fuel pump driver control module and the ECM. Fuel is pumped from the fuel tank through the fuel feed line to the fuel filter assembly. The fuel filter assembly consists of a fuel filter / water separator, fuel heater, fuel temperature sensor, and a water-in-fuel sensor. Fuel flows out of the fuel filter assembly through the rear fuel feed pipe to the fuel pressure sensor, and then to the high pressure fuel pump. High pressure fuel is supplied through the high pressure fuel line to the fuel rails and then through the fuel injector lines to the fuel injectors. High pressure fuel is controlled by the ECM, fuel pressure regulator 1 located on the fuel injection pump, and fuel pressure regulator 2 located on the fuel rail. Excess fuel returns to the fuel tank through the fuel return pipes.



1. Fuel Pump Module
2. Fuel Filter
3. Fuel Heater / Water in Fuel Sensor

Figure 3-19, 1.6L LH7 Fuel Tank, Fuel Pump Module, and Fuel Filter



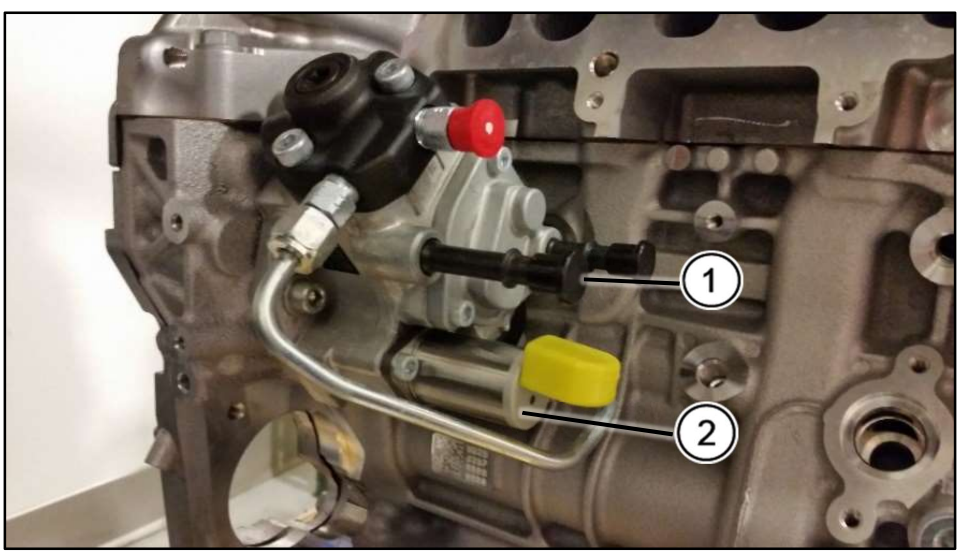
1. Fuel Injector Lines 2. Fuel Rail 3. Fuel Pressure Regulator 2

Figure 3-20, 1.6L LH7 Fuel Rail and Lines

Fuel Injection Pump

The fuel injection pump is a mechanical high pressure pump. The fuel injection pump is located on the lower left side of the engine. The fuel is pumped to the fuel rails at a specified pressure that is regulated by two fuel pressure regulators.

Note: Unlike many diesel engines, the 1.6L LH7 fuel injection pump does not need to be timed. The fuel injection pump delivers high pressure fuel to the fuel rail. The ECM and solenoid-type injectors control injection timing and quantity, not the fuel injection pump.



1. Fuel Inlet 2. Pressure Regulator 1

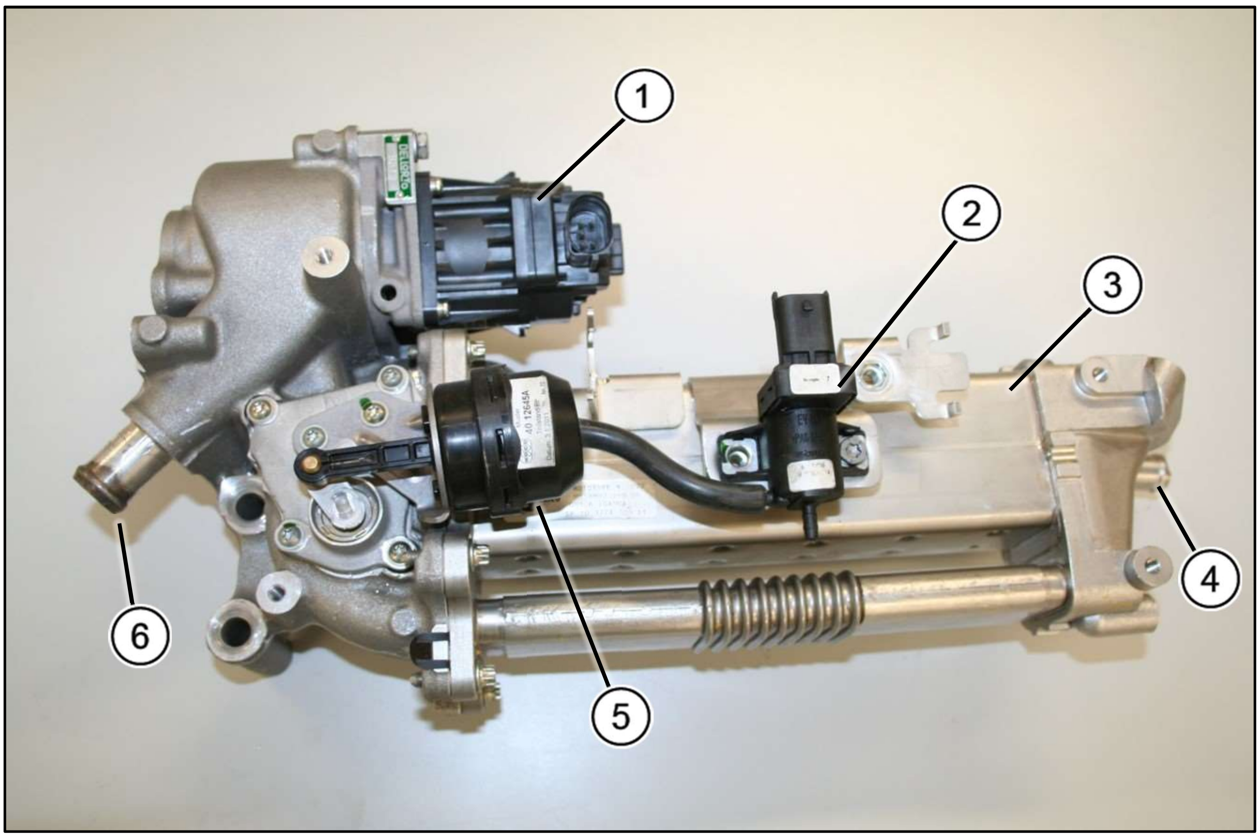
Figure 3-21, 1.6L LH7 Fuel Injection Pump

EXHAUST GAS RECIRCULATION

The EGR system reduces the amount of NO_x emission levels caused by high combustion temperatures. At temperatures above 2,500°F (1371°C), oxygen and nitrogen combine to form NO_x. Introducing small amounts of exhaust gas back into the combustion chamber displaces a small amount of oxygen entering the engine. With less oxygen in the air / fuel mixture, combustion pressures are reduced. As a result, combustion temperatures are decreased, restricting the formation of NO_x.

The EGR cooler bypass solenoid valve is controlled by the ECM. The EGR cooler bypass solenoid is an on / off device. The EGR valve is a stepper motor with a potentiometer position sensor. At engine cold start, the EGR cooler bypass allows hot exhaust gas to heat the intake air in the manifold. Once the engine operating temperature is reached, the ECM closes the EGR cooler bypass.

The Mass Air Flow (MAF) sensor signal is used by the ECM to detect the proper amount of EGR flow. The ECM closes the EGR valve, and then opens the EGR valve to 100%. The ECM then calculates the MAF difference and determines whether proper EGR flow has been detected.



1. EGR Valve
2. EGR Cooler Bypass Solenoid Valve
3. EGR Cooler
4. Coolant Inlet
5. EGR Bypass Valve Vacuum Actuator
6. Coolant Outlet

Figure 3-22, 1.6L LH7 EGR Cooler Assembly

EXHAUST AFTERTREATMENT SYSTEM

System Overview

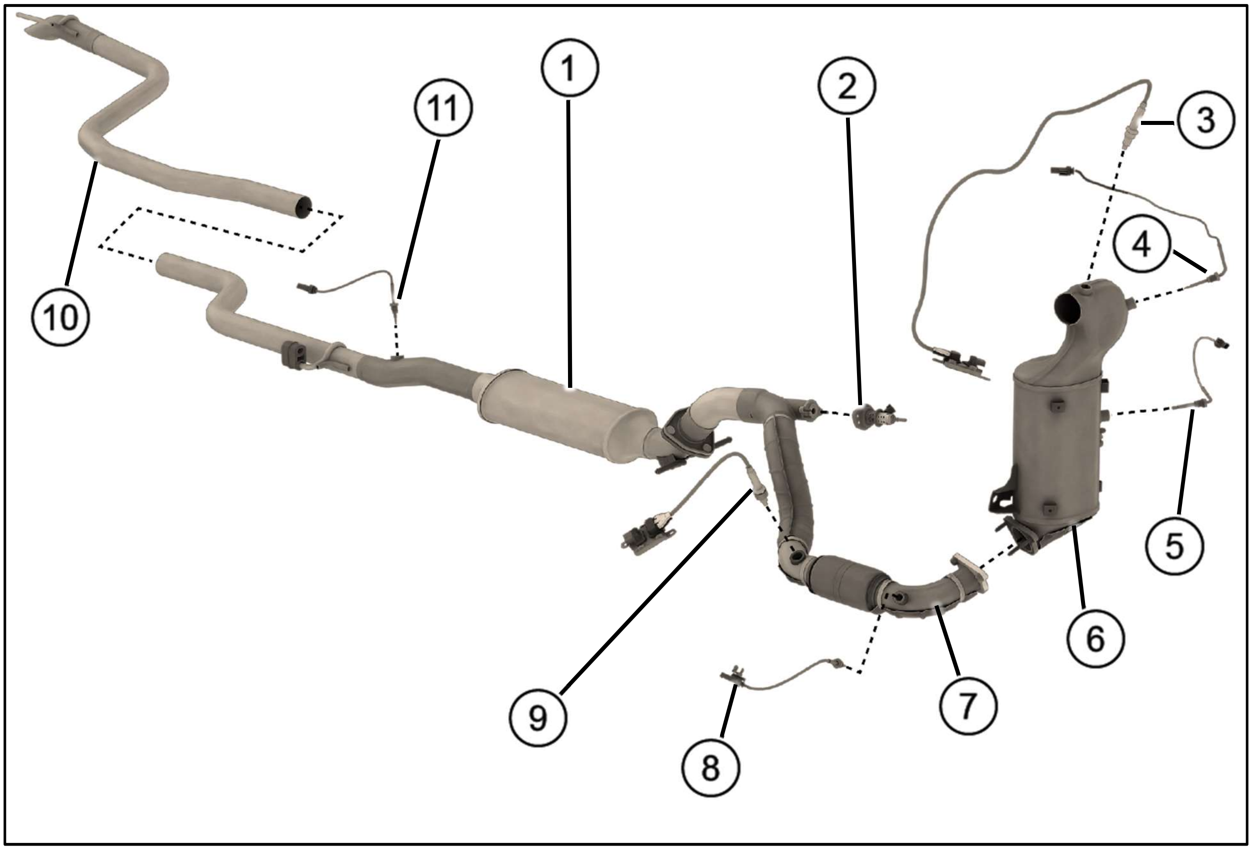
The diesel exhaust aftertreatment system is designed to reduce the levels of hydrocarbons (HC), carbon monoxide (CO), NO_x, and particulate matter remaining in the vehicle's exhaust gases. Reducing these pollutants to acceptable levels is achieved through a three-stage process:

1. Diesel Oxidation Catalyst (DOC) stage 1
2. Diesel Particulate Filter (DPF) stage 2
3. SCR stage 3

In stage 1, the DOC removes exhaust HC and CO through an oxidation process. In stage 2, particulate matter consisting of extremely small particles of carbon remaining after combustion are removed from the exhaust gas by the large surface area of the DPF. In stage 3, DEF is injected into the exhaust gases prior to entering the SCR stage. Within the SCR stage, NO_x is converted to nitrogen (N_2), carbon dioxide (CO_2), and water vapor (H_2O) through a catalytic reduction fueled by the injected DEF.

The particulate filter and Lean NO_x Trap (LNT) converter are combined in one assembly.

- NO_x sensor, position 1, is located before the DOC / LNT and DPF
- NO_x sensor, position 2, is located downstream from the SCR
- Exhaust temperature sensor, position 1, is located before the DOC / LNT and DPF
- Exhaust temperature sensor, position 2, is located near the middle of the DOC / LNT and DPF
- Exhaust temperature sensor, position 3, is located downstream of the DOC / LNT and DPF
- An exhaust particulate sensor is located upstream from the DEF injector



1. SCR	2. DEF Injector	3. NO_x Sensor, Position 1
4. Exhaust Temperature Sensor, Position 1	5. Exhaust Temperature Sensor, Position 2	6. DOC / LNT and DPF
7. Exhaust Front Pipe	8. Exhaust Temperature Sensor, Position 3	9. Exhaust Particulate Sensor
10. Exhaust Tail Pipe	11. NO_x Sensor, Position 2	

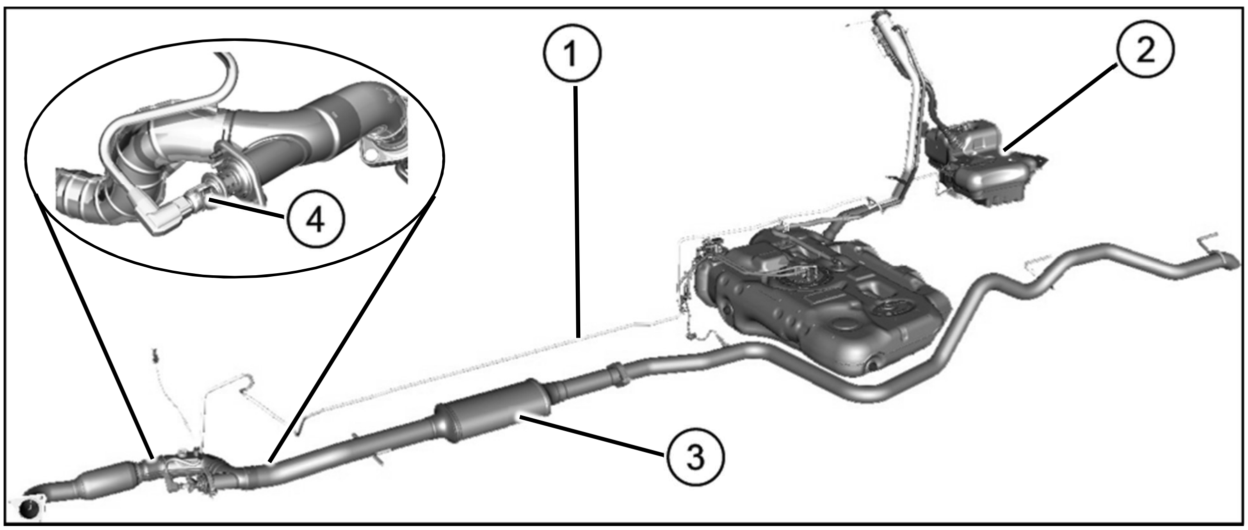
Figure 3-23, 1.6L LH7 Exhaust Aftertreatment Components

DEF SYSTEM / SCR

The DEF system stores, conditions, and delivers DEF to the DEF injector in the exhaust system upstream of the SCR. The DEF tank contains the DEF pump module and DEF quality sensor.

The main task of the DEF supply pump module is to deliver DEF from the tank to the DEF injector. The DEF supply pump may be mounted in the top or the bottom of the tank, depending on vehicle application. The components listed below are integrated into the DEF pump module:

- DEF pump
- DEF filter
- DEF tank heater
- DEF temperature sensor
- DEF pressure sensor
- DEF level sensor



1. DEF Injector Supply Pipe
2. DEF Tank
3. SCR
4. DEF Injector

Figure 3-24, 1.6L LH7 DEF System

NOTES

1.6L LH7 SERVICE

DIESEL EXHAUST FLUID TANK DRAINING AND FILLING

Before handling components that contain DEF, review the procedure for DEF handling.

WARNING: Diesel Exhaust Fluid (DEF) is corrosive. Do not allow it to come in contact with your skin, eyes, or the finished surfaces of the vehicle. If exposed, it may cause skin and eye irritation. Wear skin and eye protection when handling. Inhalation may cause irritation to the upper respiratory tract. Store in a cool and well-ventilated area. For more safety information, see the label of the DEF container. Failure to follow this procedure may result in injury and/or vehicle damage.

The DEF tank must be removed from the vehicle so that the contents of the tank can be poured out and the tank can be cleaned.

CAUTION: Previously drained DEF must not be re-used in the vehicle. Re-using DEF may result in incorrect warning messages being displayed by the on-board system.

Refill the DEF tank with the specified amount of new DEF. Perform the Reductant Fluid Tank Level Reset.

REDUCTANT FLUID TANK LEVEL RESET

This procedure resets the control module learned values for the reductant system. Refer to service information for additional information.

Note: Failure to perform this procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

Perform this procedure when the following component has been serviced:

- DEF pump and sensor assembly
- DEF reservoir assembly

Perform the following steps with a scan tool.

1. Ignition >> ON / Vehicle >> in service mode.
2. Select: Module Diagnostics.
3. Select: Engine Control Module.
4. Select: Configuration / Reset Functions.
5. Select: Reset Functions.
6. Select: Reductant Fluid Tank Reset.

Note: The scan tool does not display learn / reset status.

7. Follow the instructions on the scan tool. The procedure will complete within 10 seconds.

WATER IN FUEL DRAINING

Draining water from the fuel filter involves installing a suitable hose at the fuel filter water bleed screw, placing the hose in a suitable container, loosening the screw, and collecting the liquid.

WARNING: Fuel / gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

WARNING: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

1. Fuel Filter Water Bleed Screw

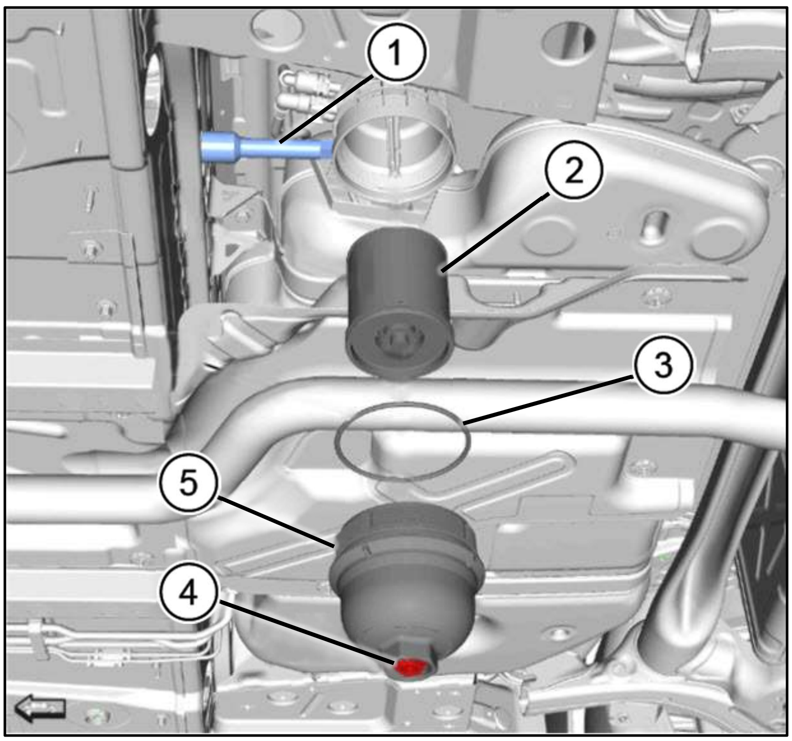
Figure 4-1, 1.6L LH7 Fuel Filter Water Bleed Screw

FUEL FILTER REPLACEMENT

Service Tips

Fuel filter replacement involves installing a hose to the fuel filter water bleed screw and draining the fuel filter. When removing or installing the fuel filter assembly cap, support the fuel filter housing by placing a 1/2-inch extension against it to prevent it from moving. Remove the fuel filter assembly cap. Use a suitable non-metallic tool to remove the fuel filter assembly cap seal and discard the seal. Replace the fuel filter and fuel filter assembly cap seal. Tighten the fuel filter assembly cap to the specified torque.

CAUTION: Do not use a screwdriver or punch to remove the sealing ring. Using a screwdriver or punch to remove the sealing ring may damage the aluminum housing sealing surface



1. 1/2-Inch Extension
2. Fuel Filter
3. Fuel Filter Sealing Ring
4. Fuel Filter Water Bleed Screw
5. Fuel Filter Assembly Cap

Figure 4-2, 1.6L LH7 Fuel Filter Disassembled View

FUEL FILTER LIFE RESET

A scan tool or the information center can be used to reset the control module learned values for the fuel filter. Perform the fuel filter life reset procedure when the fuel filter has been replaced.

Figure 4-3, 1.6L LH7 Fuel Filter Life Reset

FUEL INJECTOR REPLACEMENT

Service Tips

When the fuel injectors are removed, clean the four injector sealing surfaces in the cylinder head with the EN-47632 cleaning tool. Loosen dirt from the injector surfaces with the brush on the cleaning tool. Remove the dirt with the sponge on the cleaning tool.

CAUTION: Always rotate the EN-47632 cleaning tool in a clockwise direction. Counterclockwise rotation of the cleaning tool could loosen the lower part of the cleaning tool, which could fall into the combustion chamber. Failure to follow this caution could result in engine damage or disassembly to remove tool parts.

If the injectors will be reused, mark the injectors so that they can be installed into the same cylinder.

For additional information, refer to service information.

Figure 4-4, 1.6L LH7 Cleaning Tool EN-47632

FUEL INJECTOR FLOW RATE PROGRAMMING

The control functions for the fuel injection system are integrated in the ECM. The flow rate information for each injector, or injection quantity adjustment flow rate numbers, and cylinder position are stored in ECM memory.

The fuel injector quantity adjustment code consists of alphanumeric characters printed on the top of each injector. The fuel injector quantity adjustment code is used to perform injector flow rate programming. The fuel injector quantity adjustment code identifies the flow characteristics of each injector as measured when the injector is manufactured. The fuel injector quantity adjustment code(s) are entered into the scan tool during the fuel injector flow rate programming process.

The fuel injector quantity adjustment code characters are printed on the top of the injector in groups of four, plus the 01 at the lower right. The number on the injector is 0B14 0AFE 11FA FC02 FAF8 F8F2 01. There are 26 characters on the top of the injector, plus two more characters that are always in the scan tool as the first two digits. There are 28 digits total.

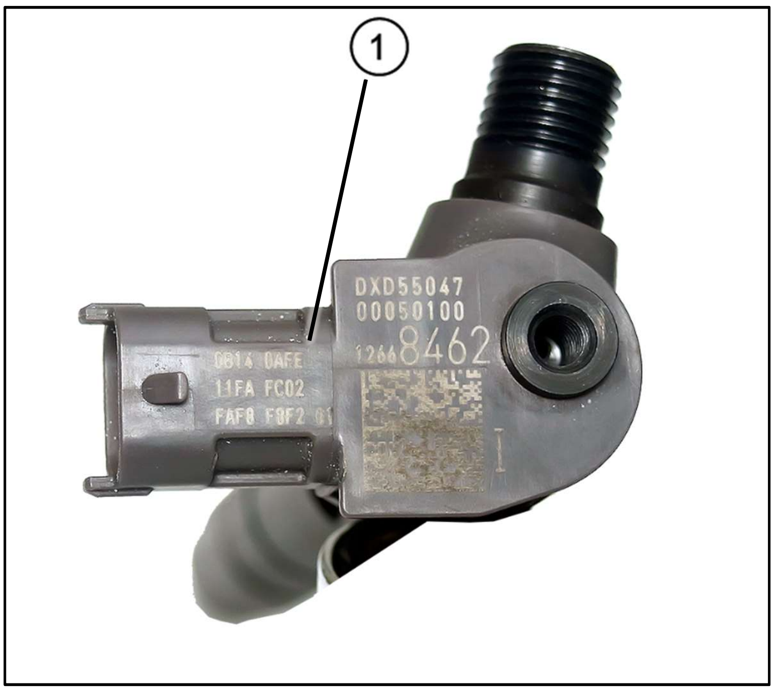
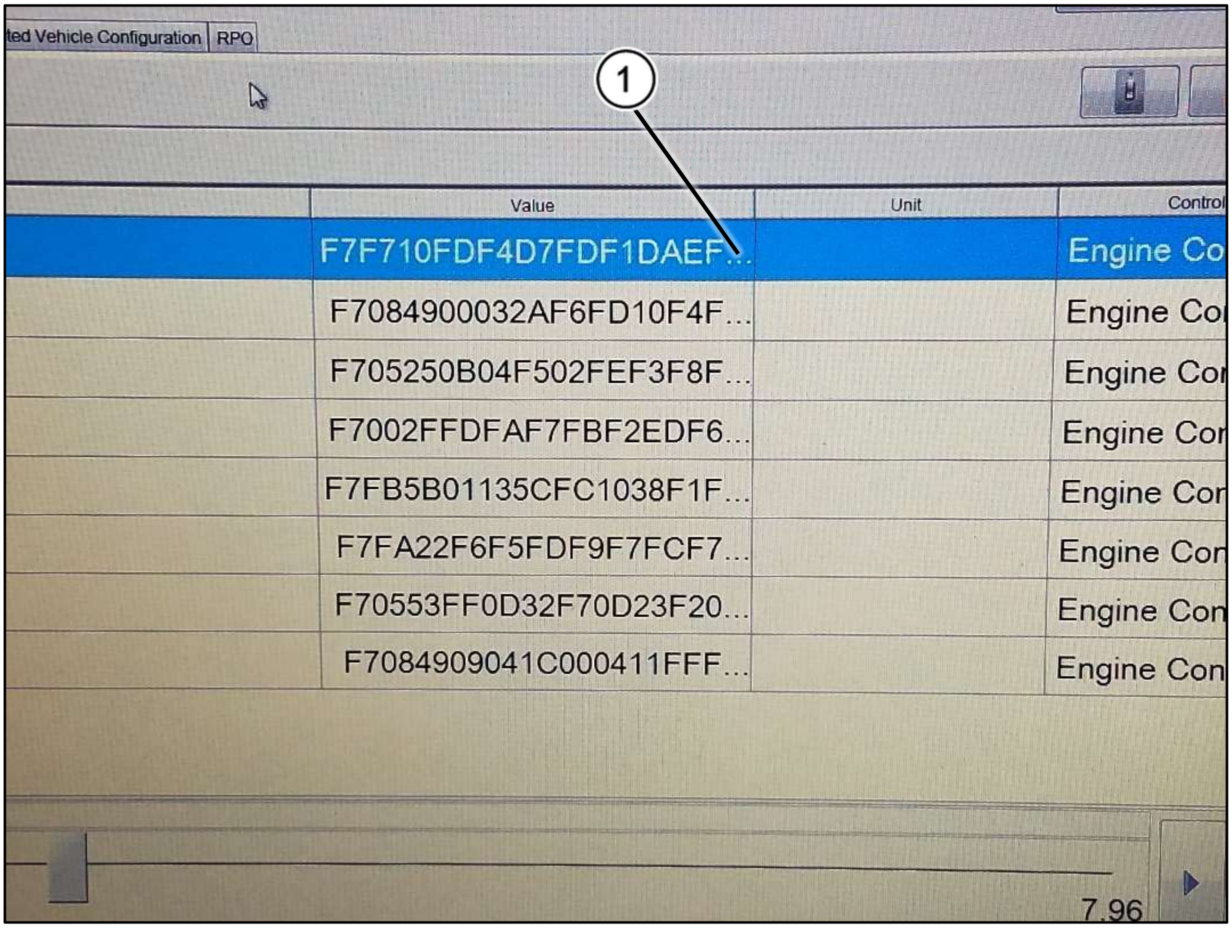


Figure 4-5, Injector Quantity Adjustment Code

Use a scan tool to perform fuel injector flow rate programming when any of the following procedures are performed:

- ECM replacement
- Fuel injector replacement

Note: If injectors are being replaced, enter the fuel injector quantity adjustment code printed on the top of the new injector(s). If the ECM is being replaced, enter the fuel injection quantity adjustment codes from the original injectors. This is a concern with some scan tools — if you take a screenshot of the fuel injector quantity adjustment codes and do not expand the field all the way open, you may only record part of the numbers. When improper programming occurs due to the missing numbers, all of the components must be removed to be able to read the numbers on the actual injector, and programming must be performed again.



1. Incomplete Part Numbers

Figure 4-6, Screen Shot Showing Incomplete Injector Quantity Adjustment Code

FUEL INJECTION SMALL QUANTITY LEARN

The fuel injection small quantity learn procedure triggers the control module to learn the values of all fuel injectors.

Use a scan tool to perform the fuel injection small quantity learn procedure when any of the following components have been replaced:

- Fuel rail pressure sensor
- ECM
- Fuel injector

Note: Failure to perform the fuel injection small quantity learn procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

Refer to service information for additional information about the conditions required for running the fuel injection small quantity learn procedure.

Note: Verify the scan tool procedure was successful.

FUEL TRIM RESET

The fuel trim reset procedure resets the control module learned values for the fuel trims back to zero after service.

Use a scan tool to perform the fuel trim reset procedure when the fuel injector has been serviced.

Refer to service information for additional information about the conditions required for running the fuel trim reset procedure.

HIGH PRESSURE FUEL CORRECTION RESET

The high pressure fuel correction reset procedure resets the control module learned values for the high pressure fuel pump.

Note: Failure to perform the high pressure fuel correction reset procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

Perform the high pressure fuel correction reset procedure when any of the following components has been replaced:

- High pressure fuel pump
- Fuel injector
- Fuel pressure regulator 1
- Fuel pressure regulator
- Fuel rail

Refer to service information for additional information about the conditions required for running the high pressure fuel correction reset procedure.

GLOW PLUG REPLACEMENT SERVICE TIPS

Use care and attention when replacing glow plugs. Avoid bending or side-loading the glow plug. The glow plug location and orientation make it possible for the push-on glow plug electrical connector to feel like it is installed to the glow plug when it is actually between the terminal and the cylinder head. If any glow plug is dropped, replace it.

2.8L LWN DESCRIPTION AND OPERATION

SPECIFICATIONS

The 2.8L LWN turbocharged diesel engine is efficient, quiet, and has excellent responsiveness. The 2.8L LWN was designed specifically for trucks, and is offered in the 2017 Chevrolet Colorado / GMC Canyon, and the Chevrolet Express / GMC Savana models.

Figure 5-1, 2017 2.8L LWN Turbocharged Diesel Engine

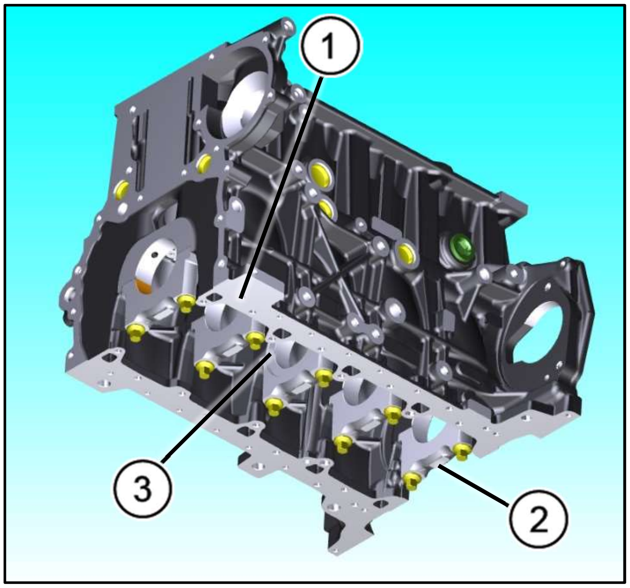
Description	Specification
Displacement	171 cu in (2.8L)
Bore x Stroke	3.7008 x 3.9390 inches (94 x 100.05 mm)
Compression Ratio	16.0:1
Firing Order	1-3-4-2
Estimated Output at Engine Speed	181 horsepower (135 kW) / 3,400 RPM
Torque at Engine Speed	369 lb ft (500 N•m) / 2,000 RPM

Figure 5-2, 2.8L LWN Engine Specifications

ENGINE MECHANICAL

Cylinder Block

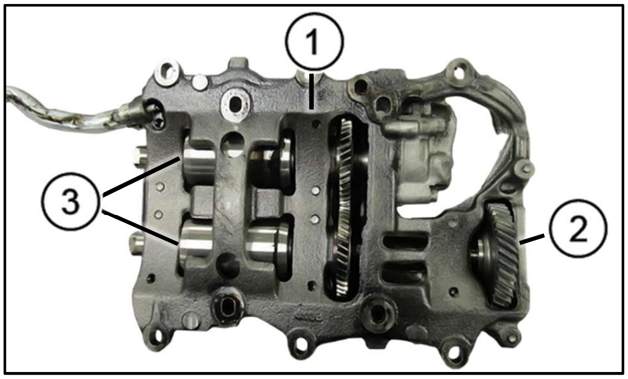
The 2.8L LWN cylinder block is made of cast grey iron. It is a deep skirt block that extends below the two-bolt main bearing caps. The block has five main bearings, with the thrust bearing located at the center (third) main bearing cap.



1. Deep Skirt
2. Two-Bolt Main Bearing Caps
3. Thrust Bearing

Figure 5-3, 2.8L LWN Engine Block

A balance shaft assembly is bolted to the bottom of the cylinder block. The balance shaft is driven from a gear at the rear of the crankshaft.

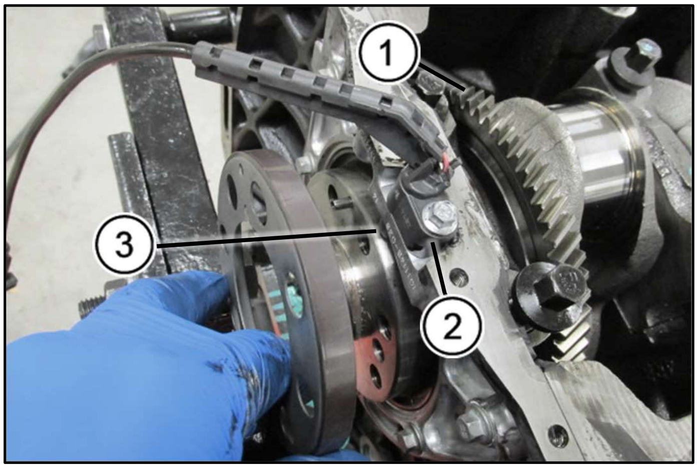


1. Balance Shaft Assembly
2. Balance Shaft Drive Gear
3. Balance Shafts

Figure 5-4, 2.8L LWN Balance Shaft Assembly

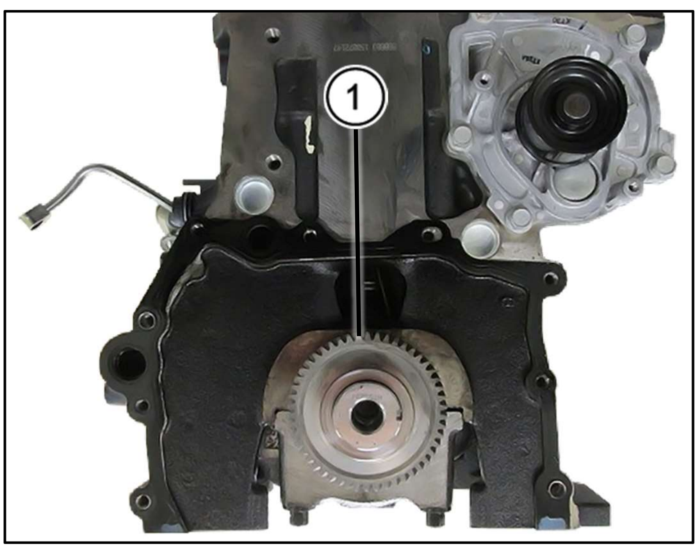
Rotating Assembly

The crankshaft is made of forged steel. The rod and main journals are induction hardened. The crankshaft position sensor is located at the flywheel end of the crankshaft. The crankshaft position sensor exciter ring is sandwiched between the crankshaft and the flexplate / flywheel. A gear on the front of the crankshaft drives the vacuum pump.



1. Balance Shaft Drive Gear
2. Crankshaft Position Sensor
3. Crankshaft Position Sensor Exciter Ring

Figure 5-5, 2.8L LWN Crankshaft Position Sensor and Exciter Ring



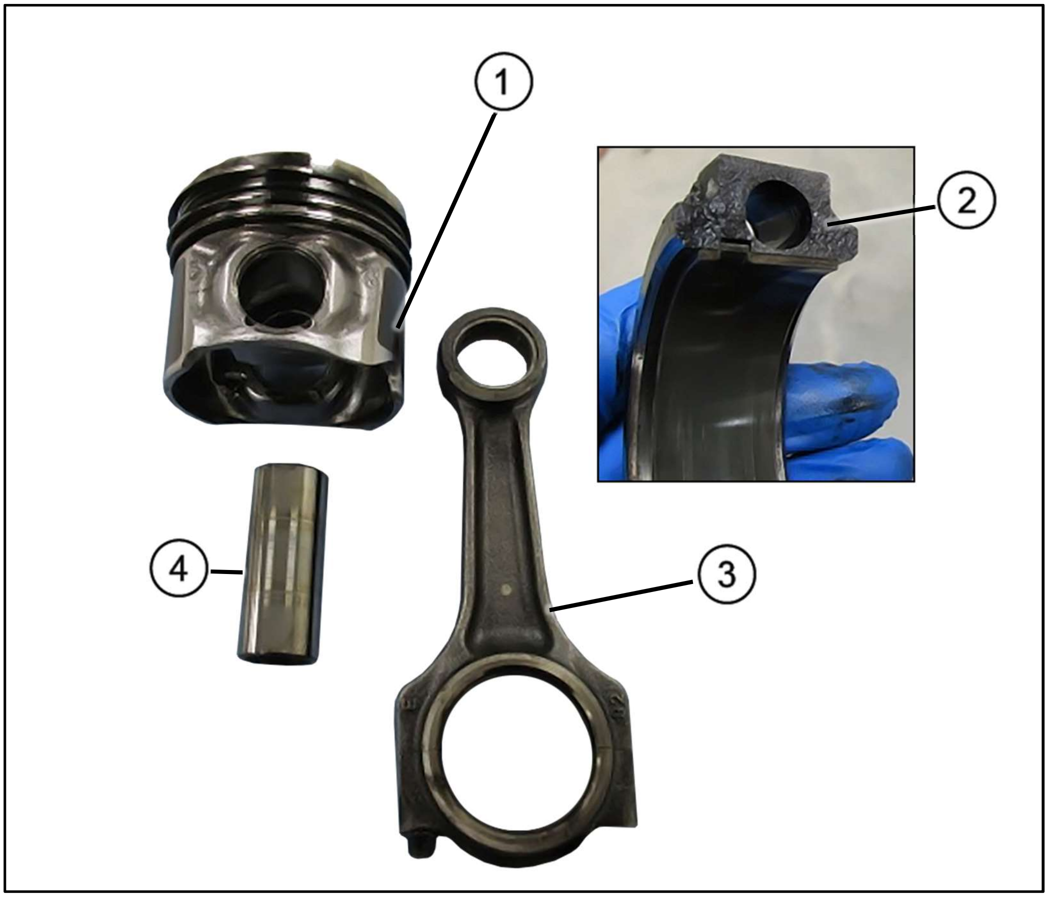
1. Vacuum Pump Drive Gear

Figure 5-6, 2.8L LWN Vacuum Pump Drive Gear on Crankshaft

The aluminum alloy pistons have graphite-coated skirts. The piston pins are full floating and retained by split rings.

Fractured / split connecting rod bearing caps are created by manufacturing the connecting rod in one piece, then breaking the cap off the connecting rod. The connecting rod and connecting rod bearing are machined to the correct size.

Note: Fractured / split connecting rod bearing caps can only be installed in one direction because the fractured / split surfaces precisely match only the area of the original fracture.



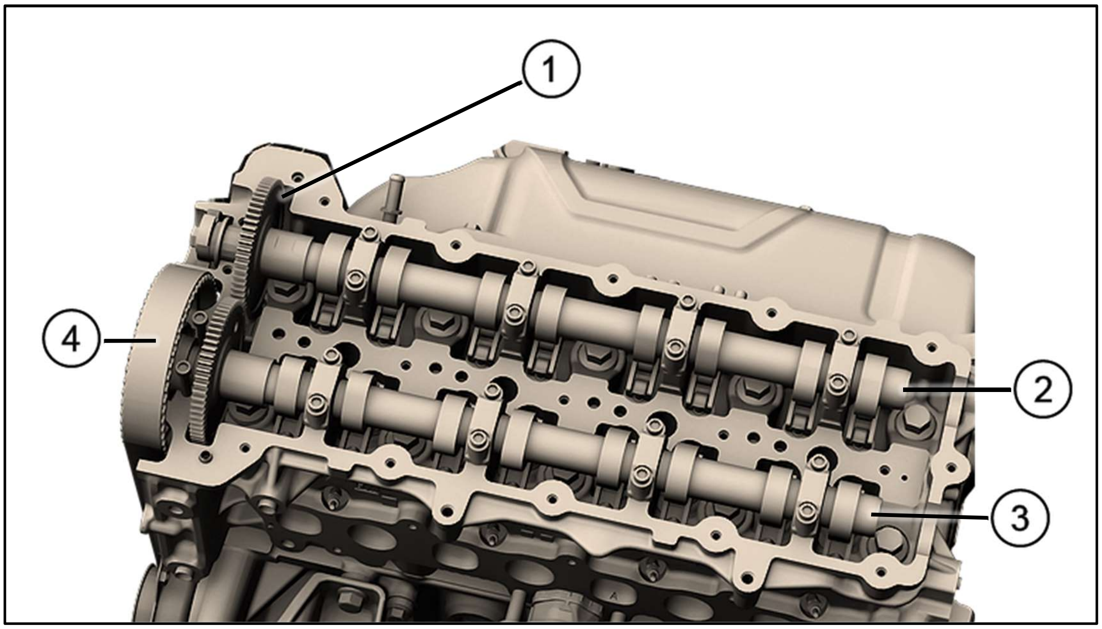
1. Graphite Coating on Piston Skirt
2. Fractured Split Connecting Rod Cap
3. Connecting Rod
4. Piston Pin

Figure 5-7, 2.8L LWN Piston and Connecting Rod

CYLINDER HEAD AND VALVE TRAIN

The cast aluminum cylinder head has sintered powdered metal valve seats and valve guides that are pressed into position. The valve train is a DOHC design. The camshafts operate four valves per cylinder. One camshaft operates all exhaust valves, and the other camshaft operates all intake valves. The timing belt drives a sprocket on the intake camshaft. The intake camshaft drives the exhaust camshaft through gears pressed onto each camshaft.

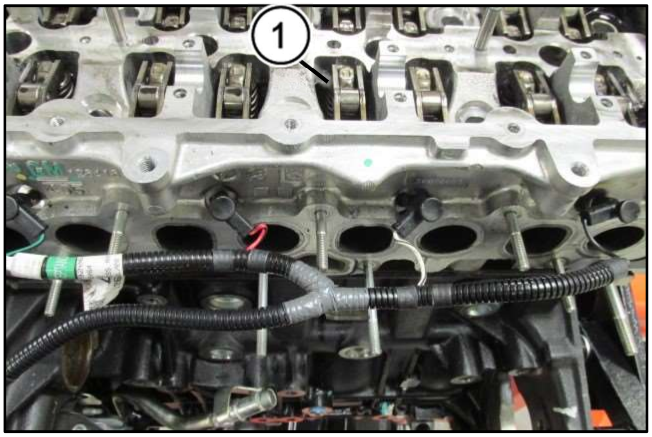
To adjust for tolerance variations between cylinder blocks and components, three different head gasket grades / thicknesses are available. Diesel engine heads are flat, and do not contain combustion chambers like gasoline engines. Due to part variation, it is possible for a piston to protrude above the cylinder bore. With a flat cylinder head, a piston that protrudes above the cylinder bore can contact the cylinder head. Therefore, the head gasket must be thick enough to provide clearance between the cylinder head and the top of the piston. Measurement of the engine block or inspection of the old gasket is required in order to select the correct grade for replacement.



1. Exhaust Camshaft Drive Gear
2. Exhaust Camshaft
3. Intake Camshaft
4. Timing Belt

Figure 5-8, 2.8L LWN Camshaft Drive

The valve train uses roller finger followers that are acted on by hydraulic lash adjusters.



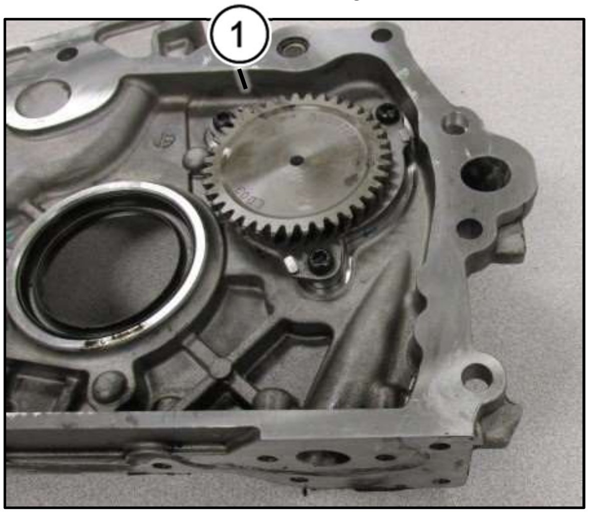
1. Roller Finger Follower

Figure 5-9, 2.8L LWN Cylinder Head with Roller Finger Followers

Figure 5-10, 2.8L LWN Roller Finger Follower

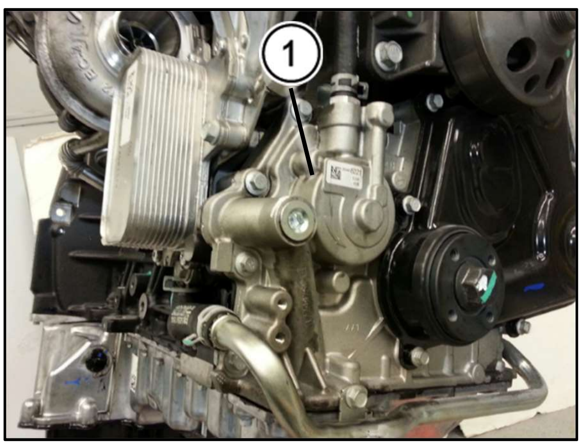
VACUUM PUMP

The vacuum pump is integrated with the front cover and driven by a gear on the front of the crankshaft. Vacuum is delivered to a fitting on the outside of the front cover and routed to other components.



1. Vacuum Pump Drive Gear

Figure 5-11, 2.8L LWN Vacuum Pump Drive Gear

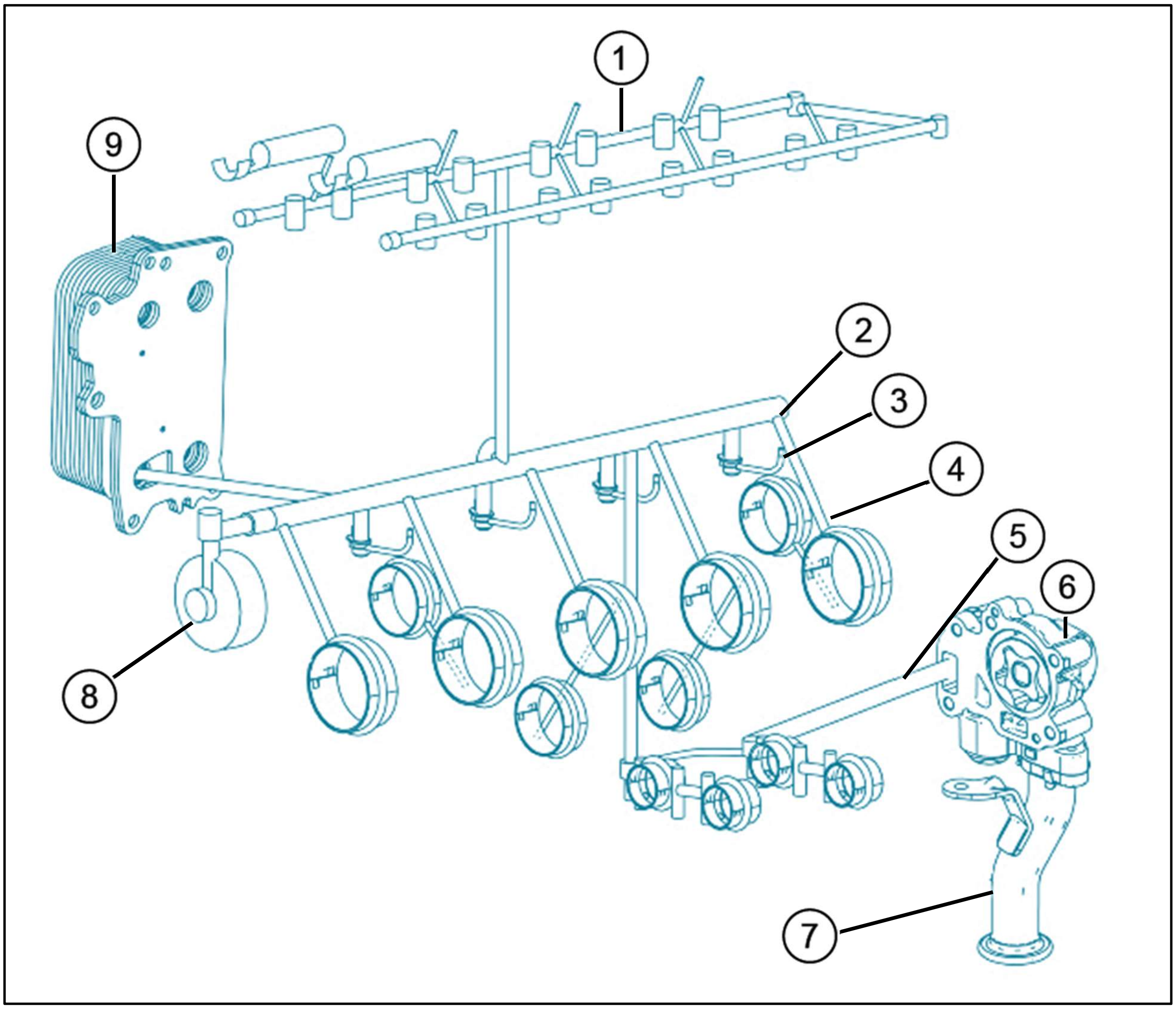


1. Vacuum Pump

Figure 5-12, 2.8L LWN Vacuum Pump

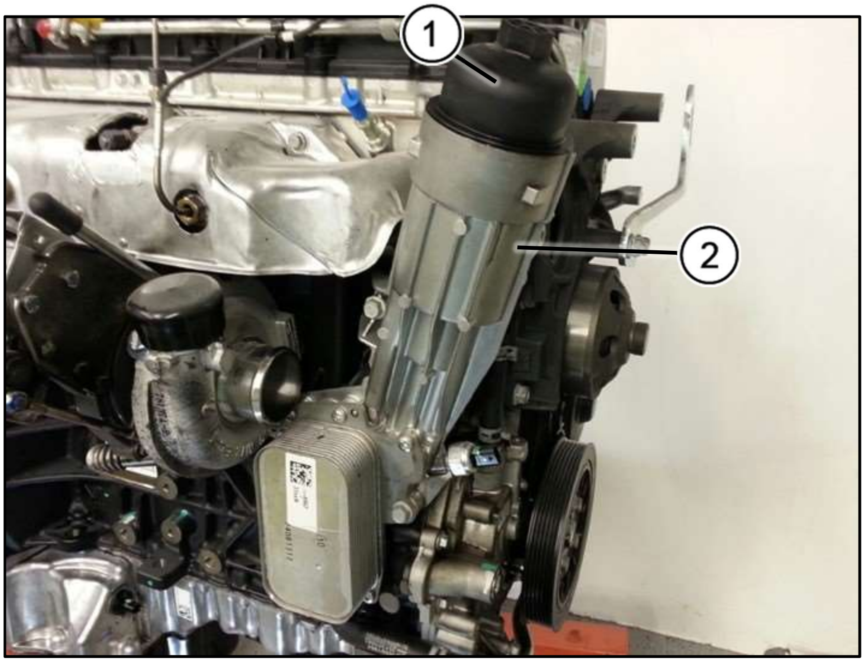
LUBRICATION SYSTEM OVERVIEW

The gerotor-style oil pump attaches to the balance shaft assembly and is gear-driven by the crankshaft. The oil pump draws oil through the suction pipe, and provides pressurized oil to the engine oil filter / cooler assembly through a passage in the cylinder block. A pressure relief valve is mounted to the front cover. An oil filter bypass valve is located under the oil filter cap and opens at 21.75 PSI (1.5 bar). An anti-drain back valve is located at the oil inlet from the cylinder block. Cooled and filtered oil exits the oil filter / cooler assembly and enters the main oil galley in the cylinder block. Branches from the main oil galley distribute oil throughout the engine. Oil drain back passages on both sides of the cylinder head and cylinder block return oil to the oil pan.



1. Camshaft Oil Galley
2. Main Oil Galley
3. Piston Oil Jets
4. Crankshaft and Connecting Rod Galley
5. Balance Shaft Oil Galley
6. Oil Pump
7. Suction Pipe
8. Vacuum Pump Oil Galley
9. Oil Cooler / Filter Assembly

Figure 5-13, 2.8L LWN Lubrication System

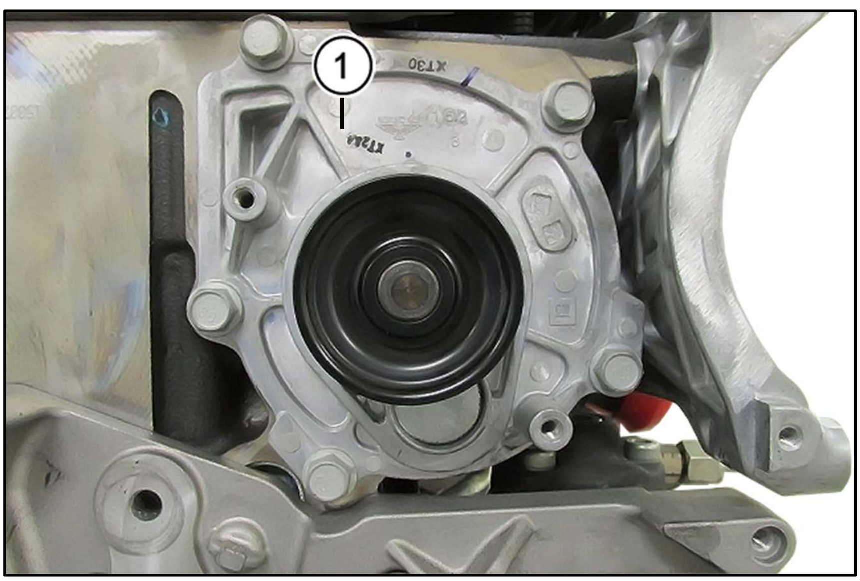


1. Oil Filter Cap
2. Oil Filter Housing and Oil Cooler Assembly

Figure 5-14, 2.8L LWN Oil Filter Housing and Oil Cooler Assembly

WATER PUMP

The water pump is located on the front of the engine and is driven off the back of the toothed timing belt.



1. Water Pump

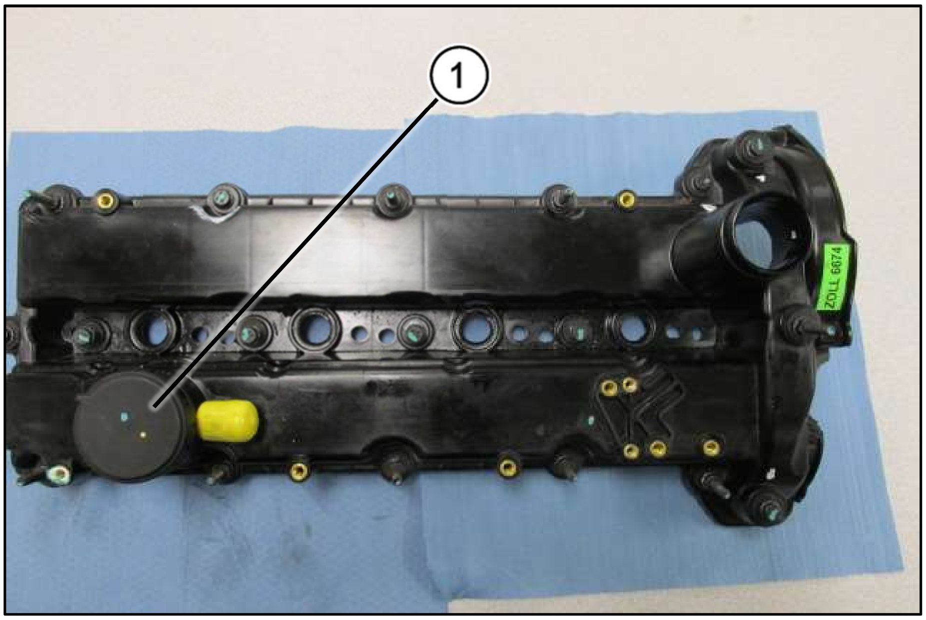
Figure 5-15, 2.8L LWN Water Pump

INDUCTION SYSTEM

Crankcase Ventilation System

A spring-loaded membrane located in the tower of the camshaft cover maintains crankcase pressure. A baffle plate in the camshaft cover separates oil from the crankcase gases. Crankcase gases are routed back to the air intake system.

Note: In a closed crankcase ventilation system, it is normal for a slight oil residue to be found in the charge air and intake system.



1. Spring-Loaded Membrane in Camshaft Cover

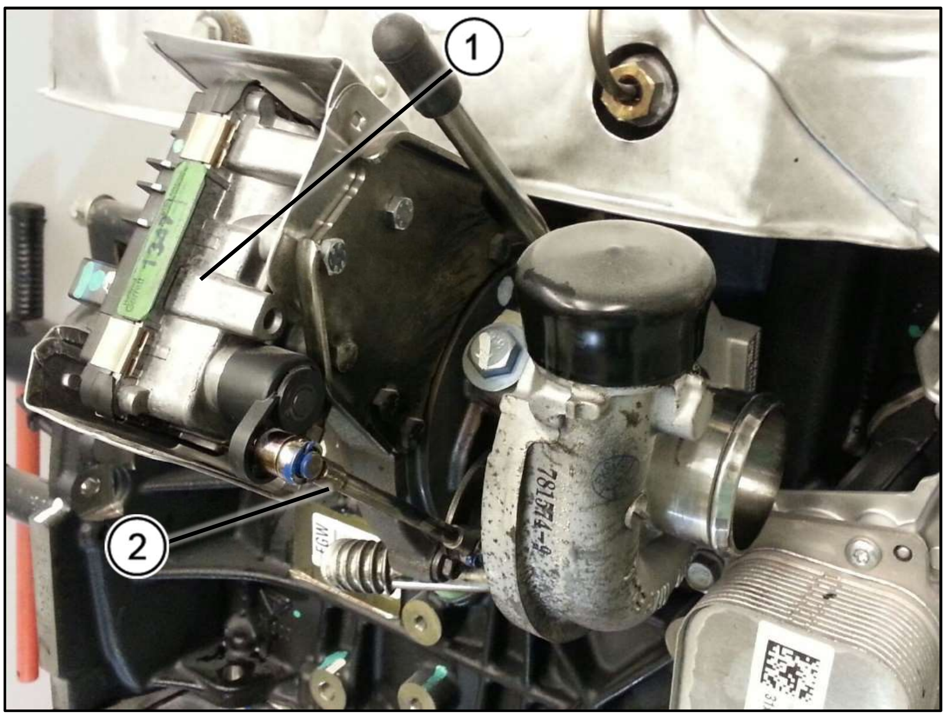
Figure 5-16, 2.8L LWN Spring-Loaded Membrane in Camshaft Cover

Turbocharger

The VGT body assembly contains a contactless VGT position sensing element that is managed by a customized integrated circuit. The VGT position sensor is mounted within the VGT body assembly and is not serviceable. The customized integrated circuit translates the voltage-based position information into serial data. The VGT position sensor information is transmitted between the VGT body and the ECM on the signal / serial data circuit.

The turbocharger vanes are normally open when the engine is not under a load. The ECM will close the turbocharger vanes to increase power and to create high pressure, using the boost pressure actuator.

The ECM will often close the turbocharger vanes to create backpressure to drive exhaust gas through the EGR valve as required. At extreme cold temperatures, the ECM may close the turbocharger vanes at low load conditions to accelerate engine coolant heating. The ECM may also close the turbocharger vanes under exhaust braking conditions.

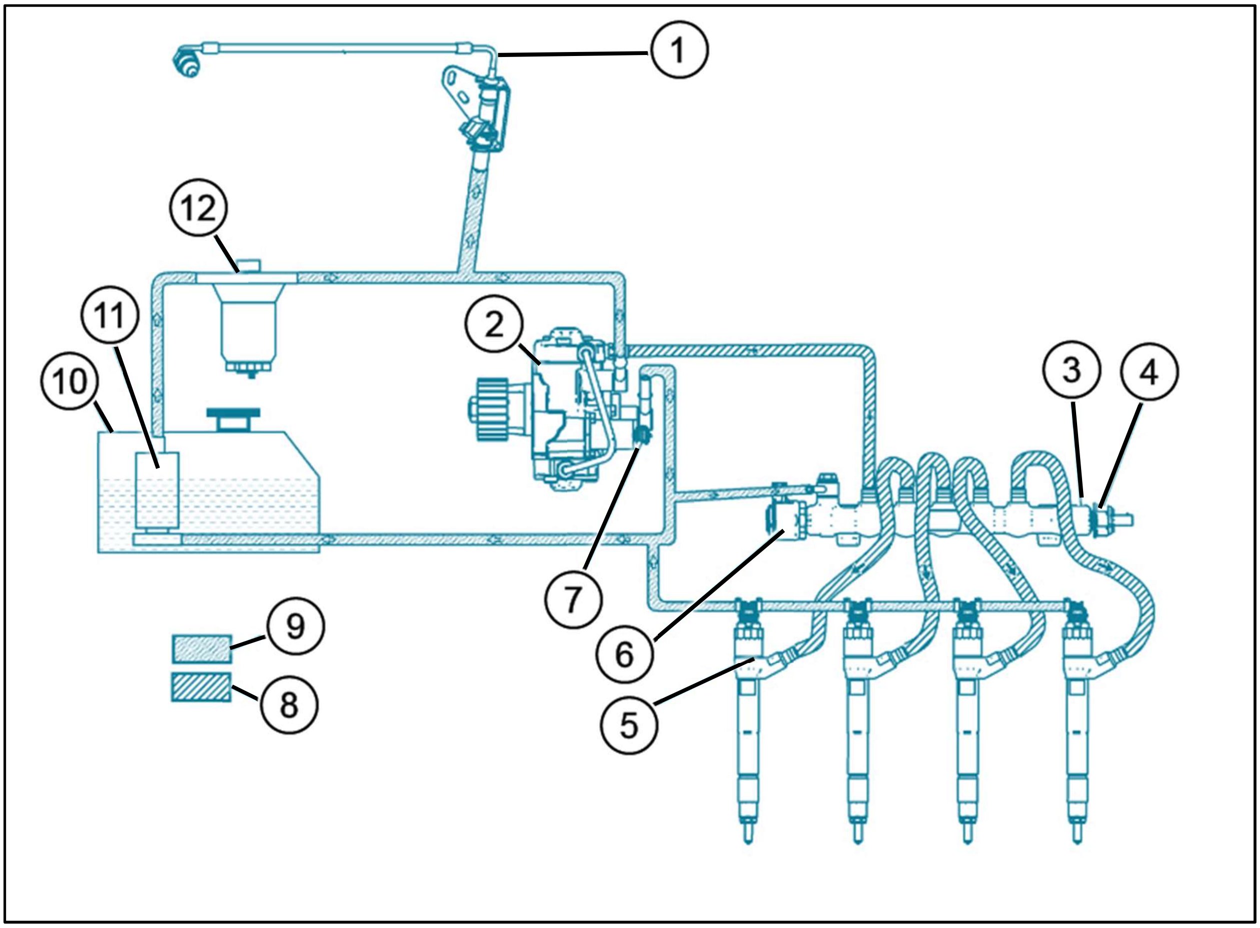


1. VGT Body Assembly
2. Turbocharger Vane Position Actuator Rod

Figure 5-17, 2.8L LWN VGT Body Assembly

FUEL SYSTEM

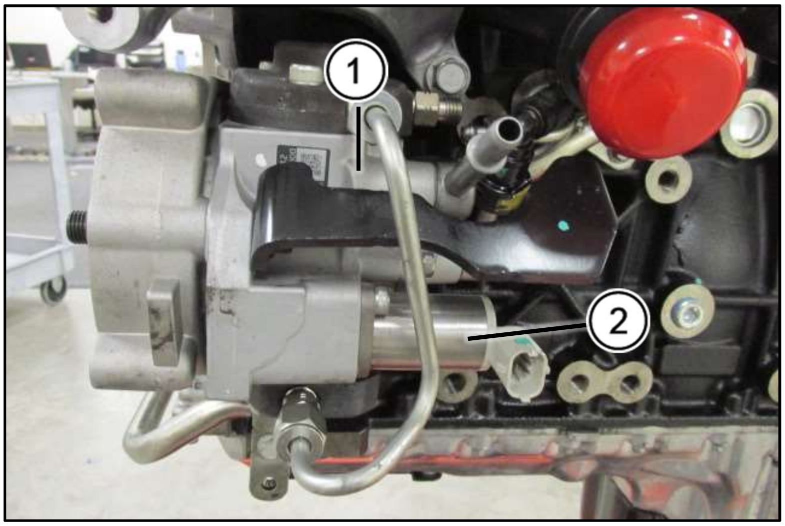
The fuel tank stores the fuel supply. An electric fuel pump module mounted in the tank provides low pressure fuel to the fuel injection pump and to the exhaust aftertreatment fuel injector. The ECM controls the fuel pump operation. Fuel is pumped through the fuel feed pipe to the fuel filter assembly. The fuel filter assembly consists of a fuel filter / water separator, fuel heater, fuel temperature sensor, and a water-in-fuel sensor. Fuel flows out of the fuel filter assembly through the rear fuel feed pipe to the exhaust aftertreatment fuel injector and to the fuel injection pump. The belt-driven fuel injection pump is mounted on the lower left corner of the engine block. High pressure fuel is supplied through the high pressure fuel line to the fuel injection fuel rail assembly, and then through the fuel injector lines to the injectors. Fuel pressure is controlled by the ECM, fuel pressure regulator 1, and fuel pressure regulator 2. Excess fuel is delivered to the fuel injection pump and injectors to lubricate and cool the components. Excess fuel then returns to the fuel tank through the fuel return pipes.



1. Exhaust Aftertreatment Fuel Injector
2. Fuel Injection Pump
3. Fuel Rail Assembly
4. Fuel Rail Pressure Sensor and Fuel Rail Pressure Sensor 2
5. Fuel Injectors
6. Fuel Rail Pressure Regulator 2
7. Fuel Rail Pressure Regulator 1
8. High Pressure Fuel
9. Low Pressure Fuel
10. Fuel Tank
11. Fuel Tank Fuel Pump Module
12. Fuel Filter Assembly

Figure 5-18, 2.8L LWN Fuel System with Exhaust Aftertreatment Injector

The fuel injection pump is located at the left front of the engine and is engine-driven by the timing belt.

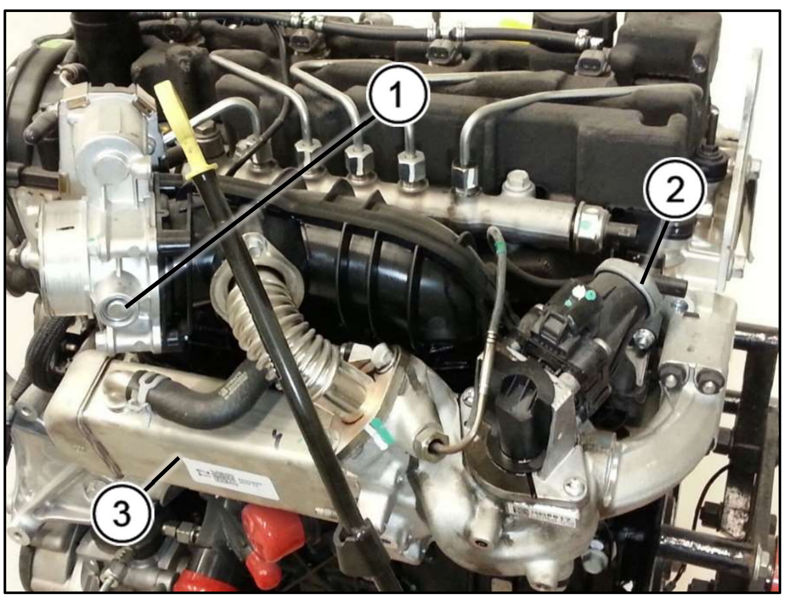


1. Fuel Injection Pump
2. Fuel Pressure Regulator 1

Figure 5-19, 2.8L LWN Fuel Injection Pump

EXHAUST GAS RECIRCULATION

The EGR system for the 2.8L LWN diesel operates similarly to the 1.6L LH7 system previously described.



1. Intake Airflow Valve
2. EGR Valve
3. EGR Cooler Assembly

Figure 5-20, 2.8L LWN EGR Components

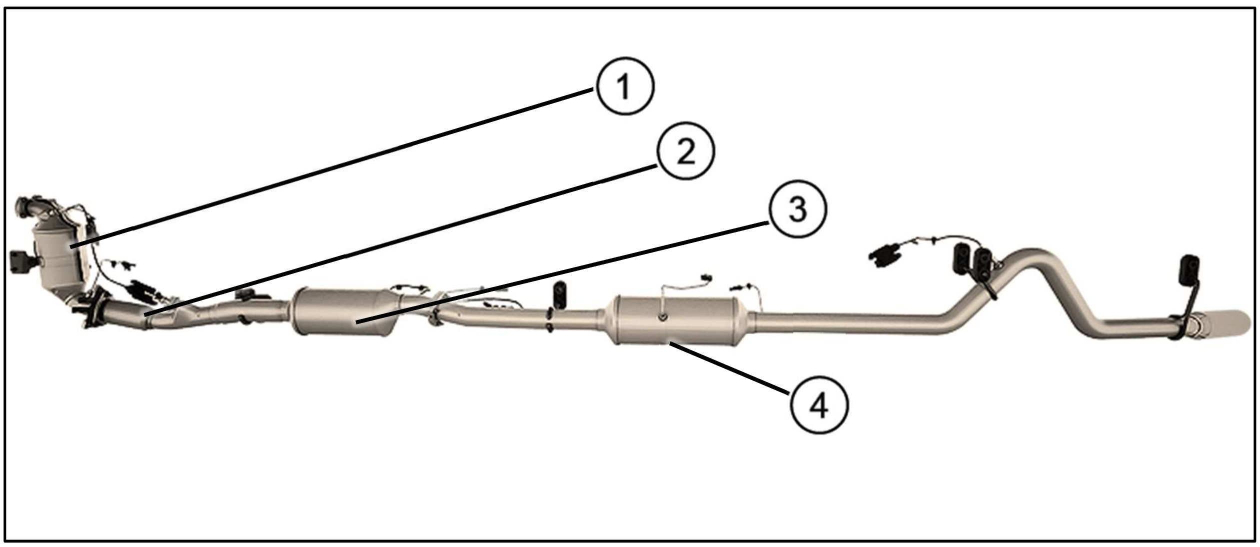
EXHAUST AFTERTREATMENT SYSTEM

The diesel exhaust aftertreatment system is designed to reduce the levels of HC, CO, NO_x, and particulate matter remaining in the vehicle's exhaust gases. Reducing these pollutants to acceptable levels is achieved through a four-stage process:

1. Close-coupled DOC stage
2. SCR stage
3. DOC stage
4. DPF stage

In stage 1, the close-coupled DOC removes exhaust HC and CO through an oxidation process. After stage 1, DEF is injected into the exhaust gases prior to entering the SCR stage. Within the SCR stage, NO_x is converted to N_2, CO_2, and H_2O through a catalytic reduction fueled by the injected DEF. The exhaust then enters a second DOC. In the final process, particulate matter consisting of extremely small particles of carbon remaining after combustion is removed from the exhaust gas by the large surface area of the DPF.

Note: The DOC portion of the DOC / DPF is upstream, while the DPF is downstream.



1. Close-Coupled DOC
2. DEF Injector
3. SCR
4. DOC / DPF

Figure 5-21, 2.8L LWN Exhaust Aftertreatment System

2.8L LWN SERVICE

DIESEL EXHAUST FLUID TANK DRAINING AND FILLING

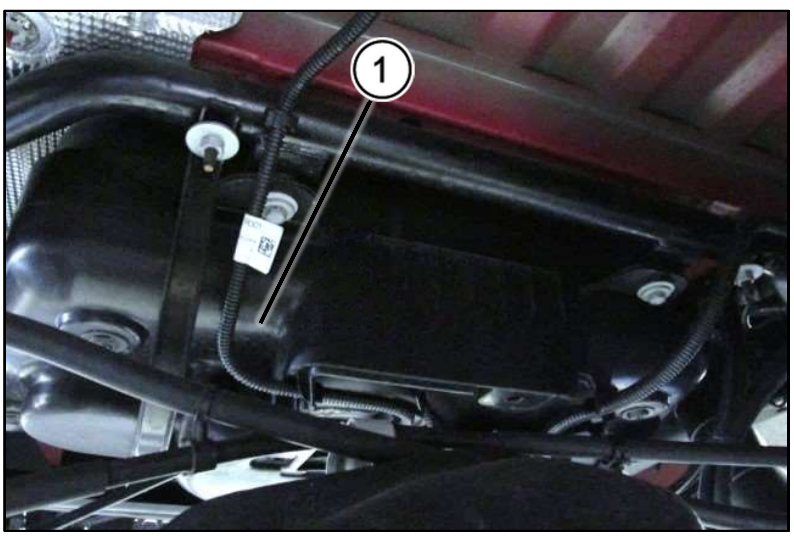
Before handling components that contain DEF, also called emission reduction fluid or reductant, review the procedure for DEF handling.

CAUTION: DEF must be drained by a clean, dedicated, siphoning pump and hose. It must NOT have any traces of gasoline, diesel fuel, or any oil-based substances. If extreme care is NOT taken to prevent contamination from fluids other than DEF, reduced performance and/or damage to the DEF system may result.

In some instances, it may be possible to disconnect the DEF line from the DEF injector and operate the DEF pump using a scan tool. This function may not be supported on all scan tools.

CAUTION: Previously drained DEF must not be reused in the vehicle. Reusing DEF may result in incorrect warning messages being displayed by the on-board system.

Refill the DEF tank with the specified amount of new emission reduction fluid.



1. DEF Tank

Figure 6-1, 2.8L LWN DEF Tank

WATER IN FUEL DRAINING

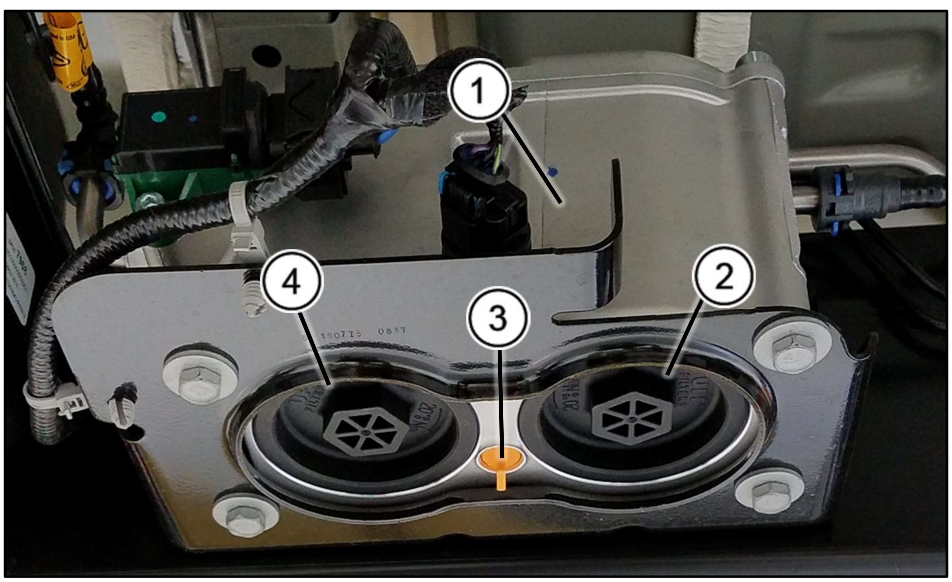
Draining water from the fuel filter involves turning the engine off for the specified amount of time to purge the fuel pressure from the complete fuel system. Water can be drained from the fuel filter assembly by opening the water-in-fuel drain screw located between the fuel filter covers. Close the drain screw by turning it clockwise until it is tight.

Note: Prime the fuel system after draining water from the fuel filter.

Fuel System Priming

The priming procedure uses the electric fuel pump in the fuel tank to prime the entire fuel system using the following procedure:

1. Turn on the ignition, with the engine off.
2. Wait 10–30 seconds for the system to prime.
3. Turn off the ignition.
4. Wait the ECM reset time.
5. Repeat steps 1 through 4.
6. Repeat steps 1 and 2, and then start the engine.



1. Fuel Filter Assembly
2. Fuel Filter Cover
3. Water-in-Fuel Drain Screw
4. Fuel Filter Cover

Figure 6-2, 2.8L LWN Fuel Filter Assembly

FUEL FILTER REPLACEMENT

The fuel filter assembly contains two fuel filters. The fuel filters can be accessed by removing the fuel filter covers located near the water-in-fuel drain screw.

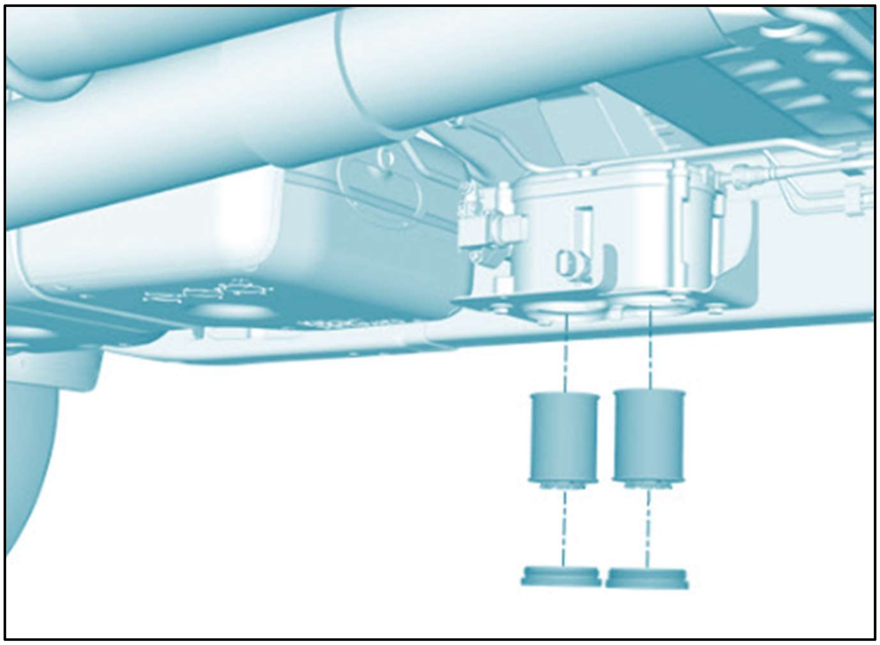


Figure 6-3, 2.8L LWN Fuel Filters and Fuel Filter Assembly

FUEL FILTER LIFE RESET

The fuel filter life reset procedure resets the control module learned values for the fuel filter. Perform the fuel filter life reset procedure with a scan tool, or follow the procedure in the owner's manual. Refer to service information for additional information about the conditions required for performing the fuel filter life reset procedure with a scan tool.

Perform this procedure when the ECM or fuel filter has been replaced.

Information Center Fuel Filter Life Remaining Reset

Reset the Fuel Filter Life Remaining display after each fuel filter change. It will not reset itself. Also, be careful not to reset the display at any time other than when the fuel filter has just been changed, because it cannot be reset accurately until the next fuel filter change. The fuel filter life will change to 100% when the system has been reset. To reset the system, press and hold the set / reset button, or the trip odometer reset stem if there are no information center buttons, for 2 seconds while Fuel Filter Life Remaining is displayed on the information center.

Figure 6-4, Display for Fuel Filter Life Remaining Reset

FUEL INJECTOR FLOW RATE PROGRAMMING

The control functions for the fuel injection system are integrated in the ECM. Each injector's flow rate information, or injection quantity adjustment flow rate numbers, and cylinder position are stored in the memory of the ECM. The fuel injector flow rate programming must be done when any of the following procedures are performed:

- ECM replacement (due to no communication)
- Fuel injector replacement

Use a scan tool to perform fuel injector flow rate programming.

Note: Enter the injection quantity adjustment code that is printed on the top of the injector(s) as is. The scan tool automatically reads the first two characters (F8) of the injection quantity adjustment code. Enter the characters from the fuel injector after these two characters.

Refer to service information for additional information about the conditions required for performing fuel injector flow rate programming.

FUEL INJECTION SMALL QUANTITY LEARN PROCEDURE

The fuel injection small quantity learn procedure triggers the control module to learn all the values of the fuel injector.

Note: Failure to perform the fuel injection small quantity learn procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

Perform the fuel injector small quantity learn procedure when any of the following components has been replaced:

- Fuel rail pressure sensor
- ECM
- Fuel injector

Refer to service information for additional information about the conditions required for performing the fuel injection small quantity learn procedure.

FUEL INJECTION PUMP REPLACEMENT

Fuel injection pump replacement involves removing the fuel injection pump drive pulley and engine front cover.

CAUTION: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Do not use paints, lubricants, or corrosion inhibitors on fasteners, or fastener joint surfaces, unless specified. These coatings affect fastener torque and joint clamping force, and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems. When using fasteners that are threaded directly into plastic, use extreme care not to strip the mating plastic part(s). Use hand tools only, and do not use any kind of impact or power tools. Fastener should be hand-tightened, fully seated, and not stripped.

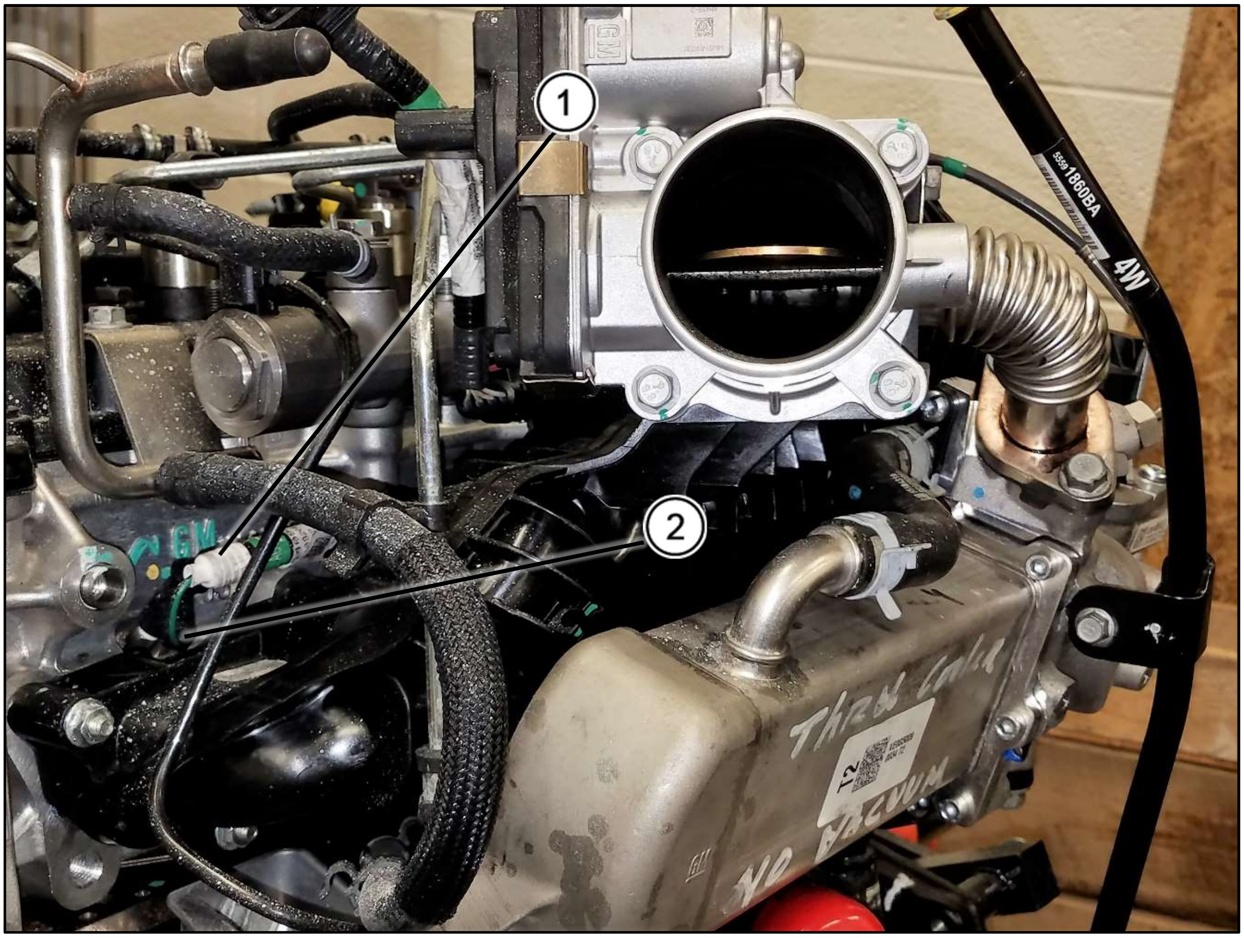
DANGER: High pressure lines deliver diesel fuel under extreme pressure from the injection pump to the fuel injectors. This may be as high as 1600 bar (23,200 PSI). Use extreme caution when inspecting for high pressure leaks. Fuel under this amount of pressure can penetrate skin, causing personal injury or death. Wear safety goggles and adequate clothing when servicing this fuel system.

GLOW PLUG REPLACEMENT

Use care and attention when replacing glow plugs. Avoid bending or side-loading the glow plug. The glow plug location and orientation make it possible for the push-on glow plug electrical connector to feel like it is installed to the glow plug when it is actually between the terminal and the cylinder head. If any glow plug is dropped, replace it.

Note: Long nose pliers may be helpful in disconnecting the glow plug wiring harness from the glow plugs.

Figure 6-5, 2.8L LWN Glow Plug



1. Glow Plug Harness
2. Glow Plug Electrical Connector

Figure 6-6, 2.8L LWN Glow Plug Location

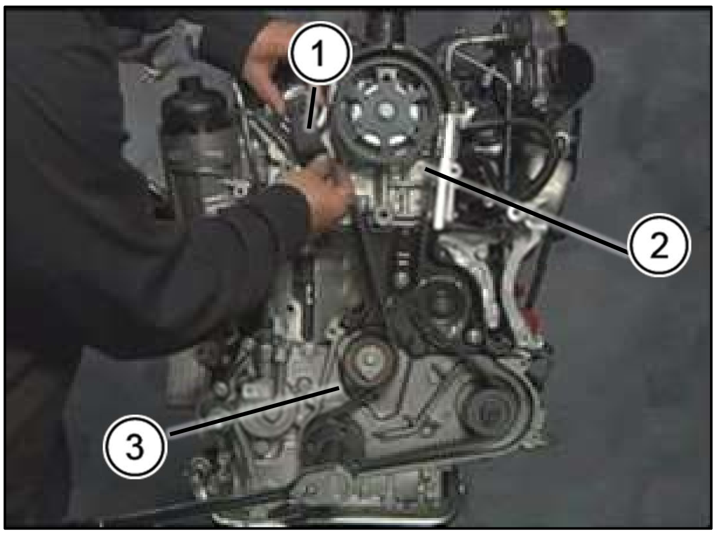
TIMING BELT REPLACEMENT

Removing the timing belt involves removing the front cover, installing an EN-51025 timing tool on the exhaust camshaft, loosening the timing belt tensioner, and removing the timing belt. The engine must be mechanically timed before installing the timing belt. The timing belt must be placed over the pulleys in a specific order.

Note: Relieve the tensioner in order to fit the belt over the pulleys.

Note: The intake camshaft pulley must be loose in order to install the timing belt; otherwise, it will not fit over the tensioner pulley.

Refer to service information for additional information related to replacing the timing belt.



1. EN-51025 Timing Tool on Exhaust Camshaft
2. Intake Camshaft Drive Pulley
3. Tensioner Pulley

Figure 6-7, 2.8L LWN Timing Belt

BALANCE SHAFT TIMING

Service Tips

Before removing the balance shaft assembly, position it as described and lock it into position using one of the methods described below:

- Rotate the crankshaft to ensure that the timing mark on the crankshaft timing pulley is aligned at 90 degrees After Top Dead Center (ATDC)
- Install the GMP/N12628143 balancer shaft gear pin to the balancer shafts before removing the assembly to maintain timing and aid installation
- If the GMP/N12628143 balancer shaft gear pin is not available, install a 4–5 mm dowel rod through the holes in both balancer shafts to maintain timing

Figure 6-8, 2.8L LWN Balance Shaft Timing with Alternative Tool

COOLING SYSTEM DRAINING AND FILLING

Coolant can be drained and filled using a static procedure or a procedure that involves using a Kent Moore GE-47716 Vac-N-Fill coolant refill tool, or equivalent. Refer to service information for additional information. A radiator drain cock is used to drain the coolant from the radiator. For complete draining of coolant from the engine block, left and right side center engine block coolant drain plugs have been provided.

WARNING: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if the radiator cap or surge tank cap is removed while the engine and radiator are still hot.

CAUTION: Improper coolant level could result in a low or high coolant level condition, causing engine damage.

Filling the cooling system using the static procedure involves the following steps:

1. Slowly fill the cooling system with a 50 / 50 coolant mixture.
2. Install the coolant pressure cap.
3. Start the engine.
4. Run the engine at 2,000 to 2,500 RPM until the engine reaches normal operating temperature. The engine should reach an operating temperature of 194°F (90°C) and the upper radiator hose should be hot.
5. Allow the engine to idle for 3 minutes.
6. Shut the engine off.
7. Allow the engine to cool.
8. Top off the coolant as necessary.

6.6L L5P DESCRIPTION AND OPERATION

SPECIFICATIONS

The 6.6L L5P Duramax® turbocharged diesel engine is completely redesigned, and shares only the bore and stroke dimensions of the previous generation engine. The 6.6L L5P engine was introduced in the 2017 Chevrolet Silverado and GMC Sierra 2500HD and 3500 HD pickup trucks.

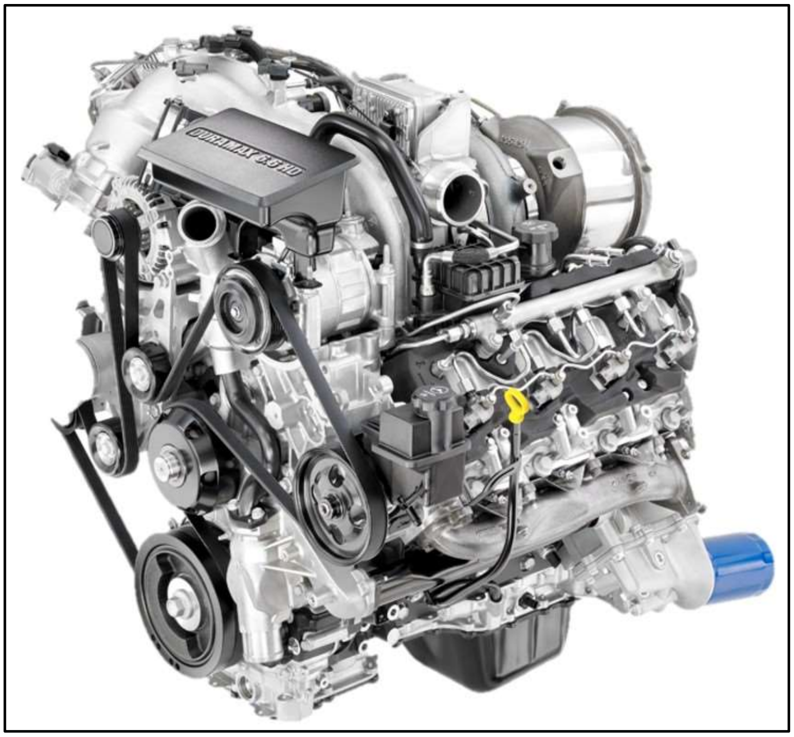


Figure 7-1, 2017 6.6L L5P Duramax® Turbocharged Diesel Engine

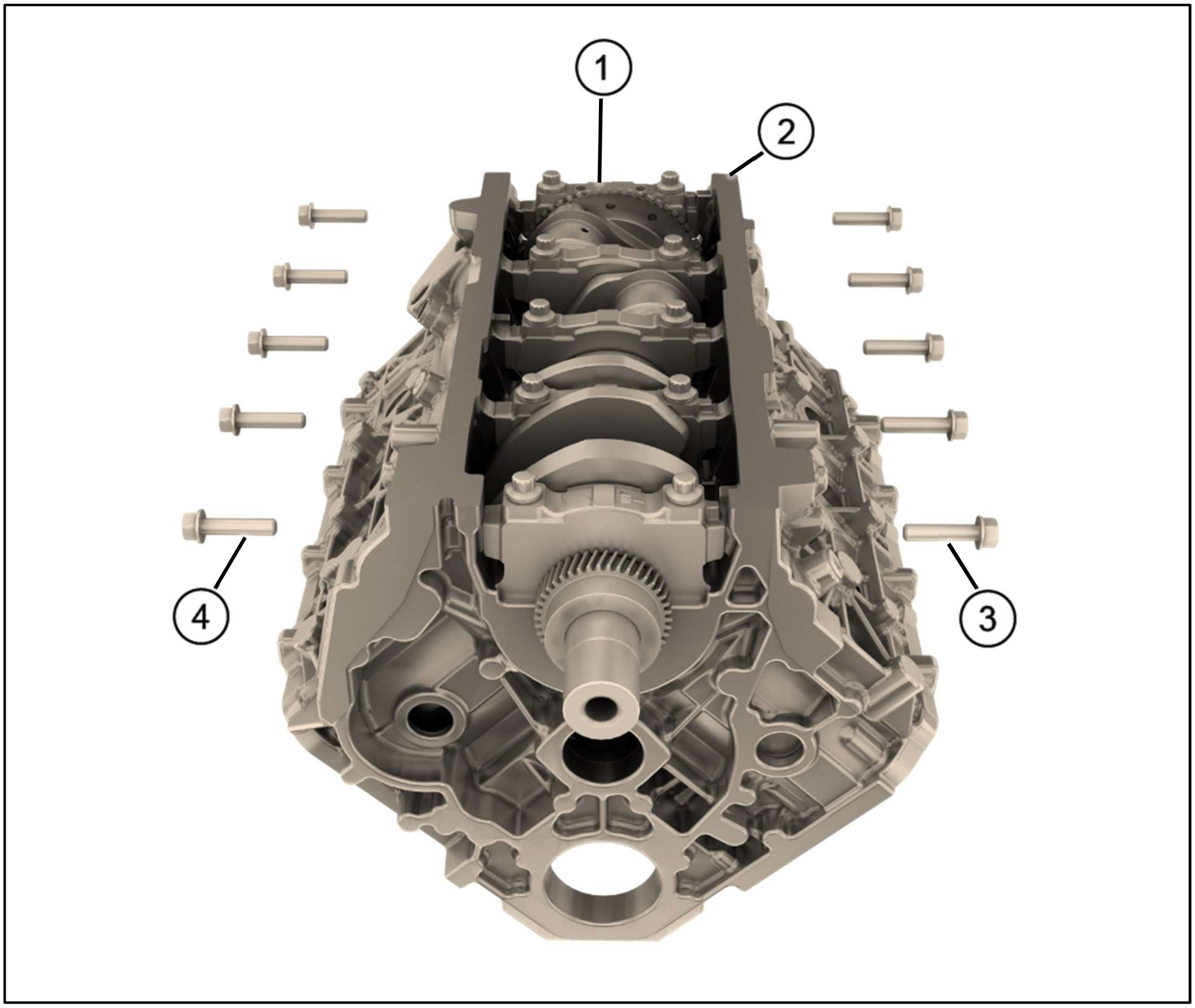
Description	Specification
Displacement	402 cu in (6.6L)
Bore x Stroke	4.0551 x 3.8976 inches (103 x 99 mm)
Compression Ratio	16.8:1
Firing Order	1-2-7-8-4-5-6-3
Estimated Output at Engine Speed	445 horsepower (332 kW) / 2,800 RPM
Torque at Engine Speed	910 lb ft (1,234 N•m) / 1,600 RPM

Figure 7-2, 2017 6.6L L5P Specifications

ENGINE MECHANICAL

Cylinder Block

The 6.6L L5P block is made of iron. It is a deep skirt block that extends below the cross-bolted four-bolt main bearing caps. The block has five main bearings, with the thrust bearing located at the number 5 main bearing cap.



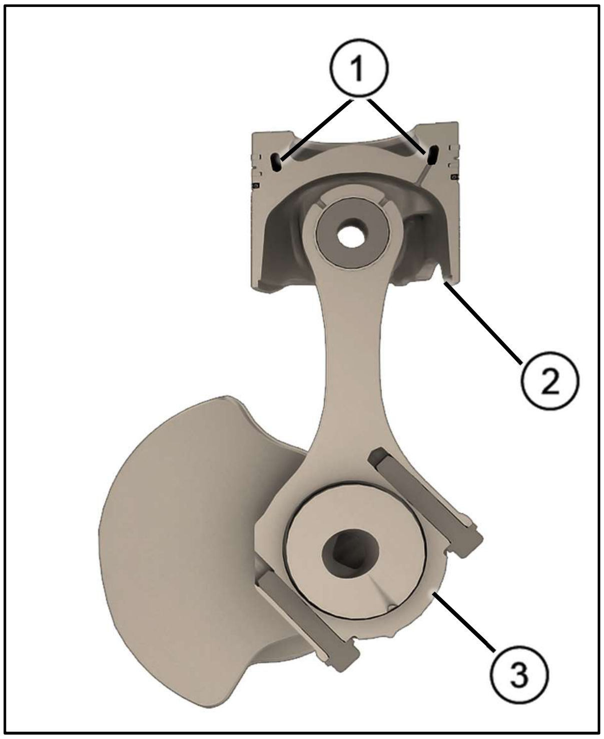
1. Number 5 Main Bearing Cap
2. Deep Skirt
3. Main Bearing Cap Cross Bolts
4. Main Bearing Cap Cross Bolts

Figure 7-3, 6.6L L5P Cylinder Block

ROTATING ASSEMBLY

The crankshaft is made of forged, nitride hardened steel. The connecting rods and caps are of a fractured split design. The connecting rod and cap are fractured split at a 45-degree angle, which allows a larger connecting rod bearing to pass through the cylinder opening.

The full-floating pistons have piston pins that are retained by round wire retainers. A cooling oil channel is cast into each piston crown. A relief notch is cut into each piston skirt to provide clearance for the piston cooling jets. The piston cooling jet nozzles spray oil up into a hole in each piston that connects to the piston cooling channel cast into the piston crown. This allows the jets of oil to fill the channels and cool the pistons.



1. Piston Cooling Oil Channels
2. Relief Notch for Piston Cooling Jet
3. 45-Degree Fractured Split Connecting Rod Cap

Figure 7-4, 6.6L L5P Rotating Assembly

CYLINDER HEADS

The aluminum cylinder heads have four valves per cylinder and high swirl combustion chambers. The cylinder head gaskets are made of laminated steel.

To adjust for tolerance variations between cylinder blocks and components, three different head gasket grades / thicknesses are available. Diesel engine heads are flat, and do not contain combustion chambers like gasoline engines. Due to part variation, it is possible for a piston to protrude above the cylinder bore. With a flat cylinder head, a piston that protrudes above the cylinder bore can contact the cylinder head. Therefore, the head gasket must be thick enough to provide clearance between the cylinder head and the top of the piston. Measurement of the engine block or inspection of the old gasket is required in order to select the correct grade for replacement.

LUBRICATION SYSTEM OVERVIEW

Engine lubrication is supplied by a crankshaft-driven gear-type oil pump mounted on the front of the engine block. Pressurized oil is directed through the sub oil gallery to a full flow oil filter. Two bypass valves in the oil cooler assembly permit oil flow in the event that the filter or oil cooler become restricted.

Oil is directed to the main oil gallery, to the left bank piston cooling channel, and to the sub oil gallery on the right cylinder bank. The sub oil gallery supplies oil to the right bank piston cooling channel.

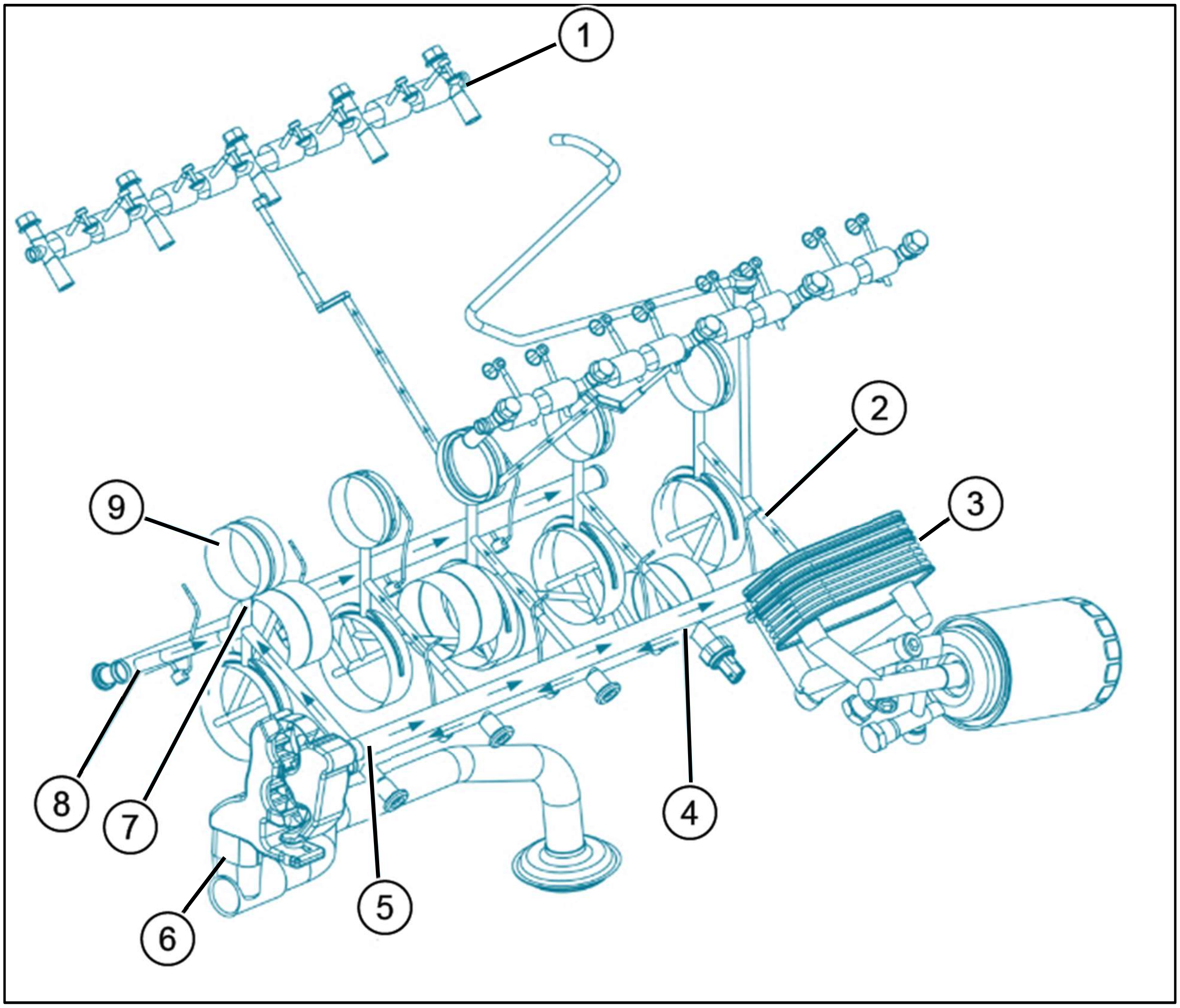
Oil flows from the main gallery to the vertical crankshaft / camshaft bearing galleries. From the crankshaft / camshaft bearing galleries, oil flows to both the camshaft bearings and the crankshaft main bearings. Oil flows from the crankshaft main bearings to the connecting rod big end.

Oil flows from the crankshaft / camshaft bearing galleries to the number 1 camshaft bearing, where it splash lubricates the fuel injection pump gear.

Oil flows from the crankshaft / camshaft bearing galleries to the numbers 2, 4, and 5 camshaft bearings.

Oil flows from the crankshaft / camshaft bearing galleries to the number 3 camshaft bearing, where it exits to both cylinder heads and enters the hollow rocker arm shafts. Oil flows through the rocker arm shafts and rocker arms, where it lubricates the upper valve train components.

Oil from the left main oil gallery is intersected in the passage that feeds the number 5 main and cam bearings, and exits at the top rear of the block to feed the turbocharger. Oil exiting the turbocharger(s) is routed through the turbocharger oil return pipe and into the flywheel housing.



1. Upper Valve Train Components	2. Sub Oil Gallery	3. Oil Cooler
4. Main Oil Gallery	5. Left Bank Piston Cooling Channel	6. Oil Pump
7. Vertical Crankshaft / Camshaft Bearing Galleries	8. Right Bank Piston Cooling Channel	9. Right Bank Sub Oil Gallery

Figure 7-5, 6.6L L5P Lubrication System

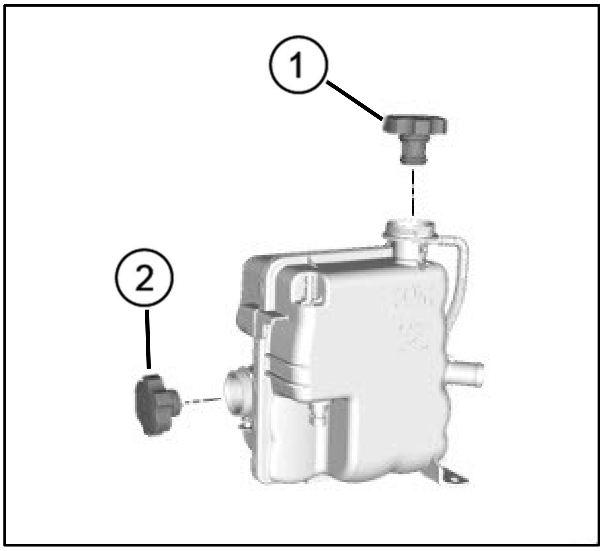
RADIATOR SURGE TANK

The L5P radiator surge tank is internally divided into two areas, with two caps that provide access to each area. The top radiator surge tank cap, which is used to fill the system, is a non-pressurized radiator surge tank cap with left-hand threads. The side radiator surge tank cap is a pressurized radiator surge tank cap with right-hand threads.

Note: The top surge tank cap turns clockwise for removal and counterclockwise to install. The presence of left-hand threads requires that a new adapter be used to perform pressure testing or the use of the GE-47716 Vac-N-Fill tool. The new adapter number is GE 52098.

During vehicle operation, the coolant heats and expands. Increased coolant volume flows into the pressurized area of the surge tank. The increased coolant volume can, in some conditions, push past the pressure cap and through a channel into the non-pressurized area of the surge tank, which acts as an overflow bottle. As the coolant circulates, the air is allowed to bubble out. This air is then transferred to the non-pressurized area of the surge tank, and travels through the top surge tank cap, where it returns to the atmosphere.

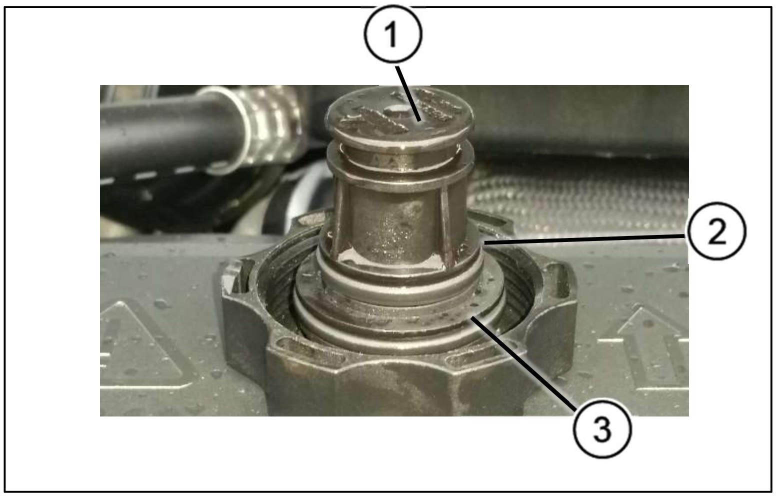
When the engine cools, the coolant, without air bubbles, is drawn back into the cooling system.



1. Top Radiator Surge Tank Cap
2. Side Radiator Surge Tank Cap

Figure 7-6, 6.6L L5P Surge Tank

The top radiator surge tank cap has three seals (instead of the two seals used in the side radiator surge tank cap). The three seals on the top radiator surge tank cap protect the customer and/or service personnel from hot fluid exiting through the top portion of the neck itself during hot engine conditions by redirecting the fluid to the lower part of the radiator surge tank.



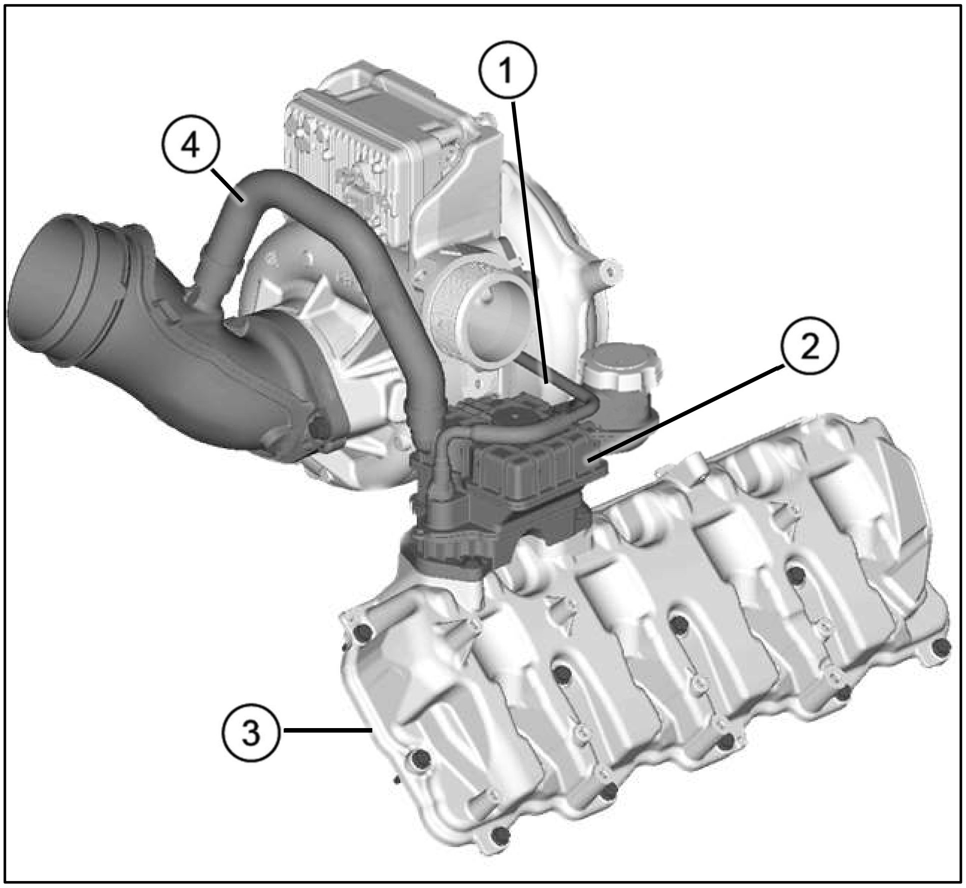
1. Seal Area
2. O-Ring Seal
3. O-Ring Seal

Figure 7-7, 6.6L L5P Top Surge Tank Cap

INDUCTION SYSTEM

Crankcase Ventilation System

An oil / air separator is located on the left valve cover. Oil removed from the crankcase gases at the separator passes through tubing down to a check valve at the bottom of the engine front cover. The oil drain check valve prevents the back-flow of crankcase pressure upwards through the drain. It allows oil to flow back to the crankcase when drain column pressures are above 2 kPa.

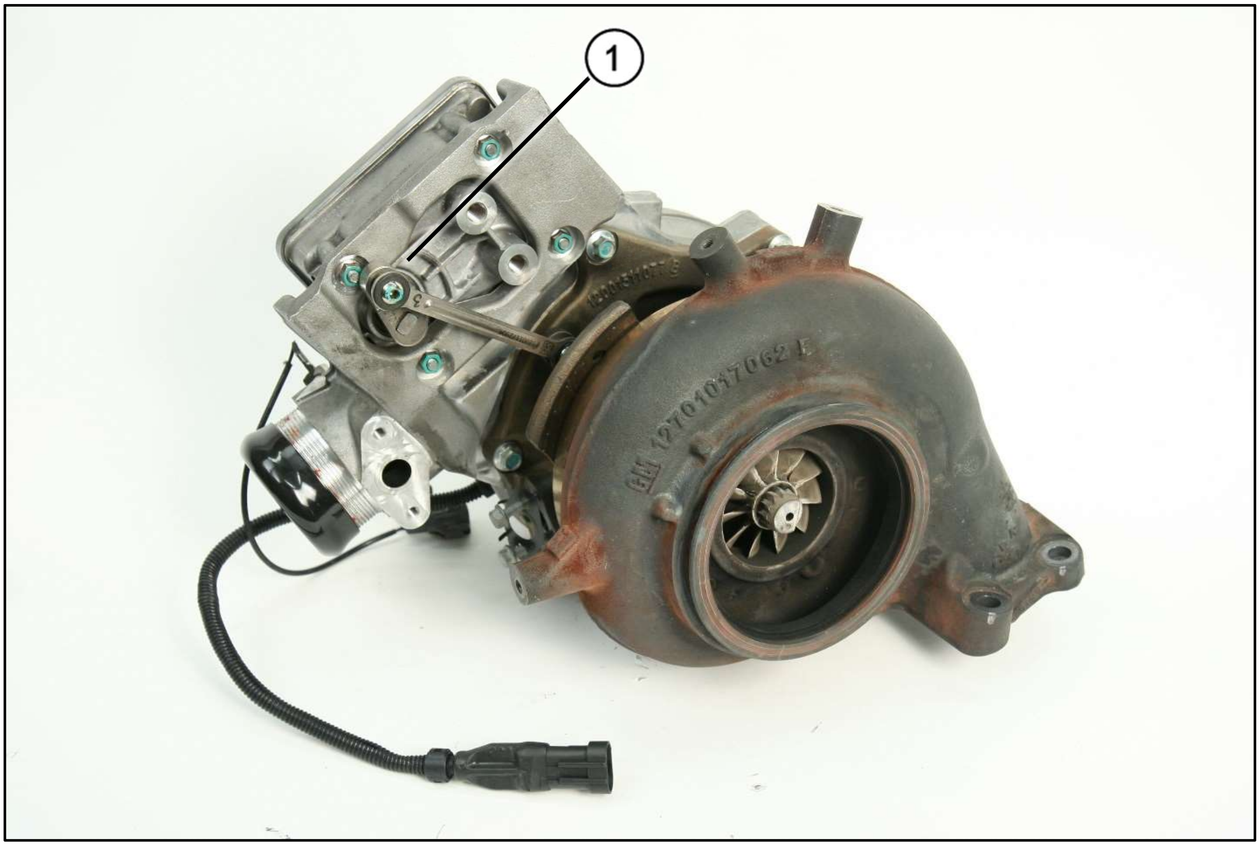


1. Compressed Air Line from Turbocharger
2. Oil / Air Separator
3. Left Valve Cover
4. Tube from Oil / Air Separator to Turbocharger Air Inlet

Figure 7-8, 6.6L L5P Crankcase Ventilation System

TURBOCHARGER

The VGT turbocharger used on the 6.6L L5P engine is single-stage and water-cooled. A turbocharger vane position actuator is mounted on top of the turbocharger and is connected to the vanes by a linkage rod. The vanes are used to vary boost pressure, and can control boost pressure independent of engine speed. The ECM communicates with the electrically operated vane position actuator to adjust vane angle and control boost, depending on engine load requirements.



1. Turbocharger Vane Position Actuator

Figure 7-9, 6.6L L5P Turbocharger Vane Position Actuator

FUEL SUPPLY SYSTEM

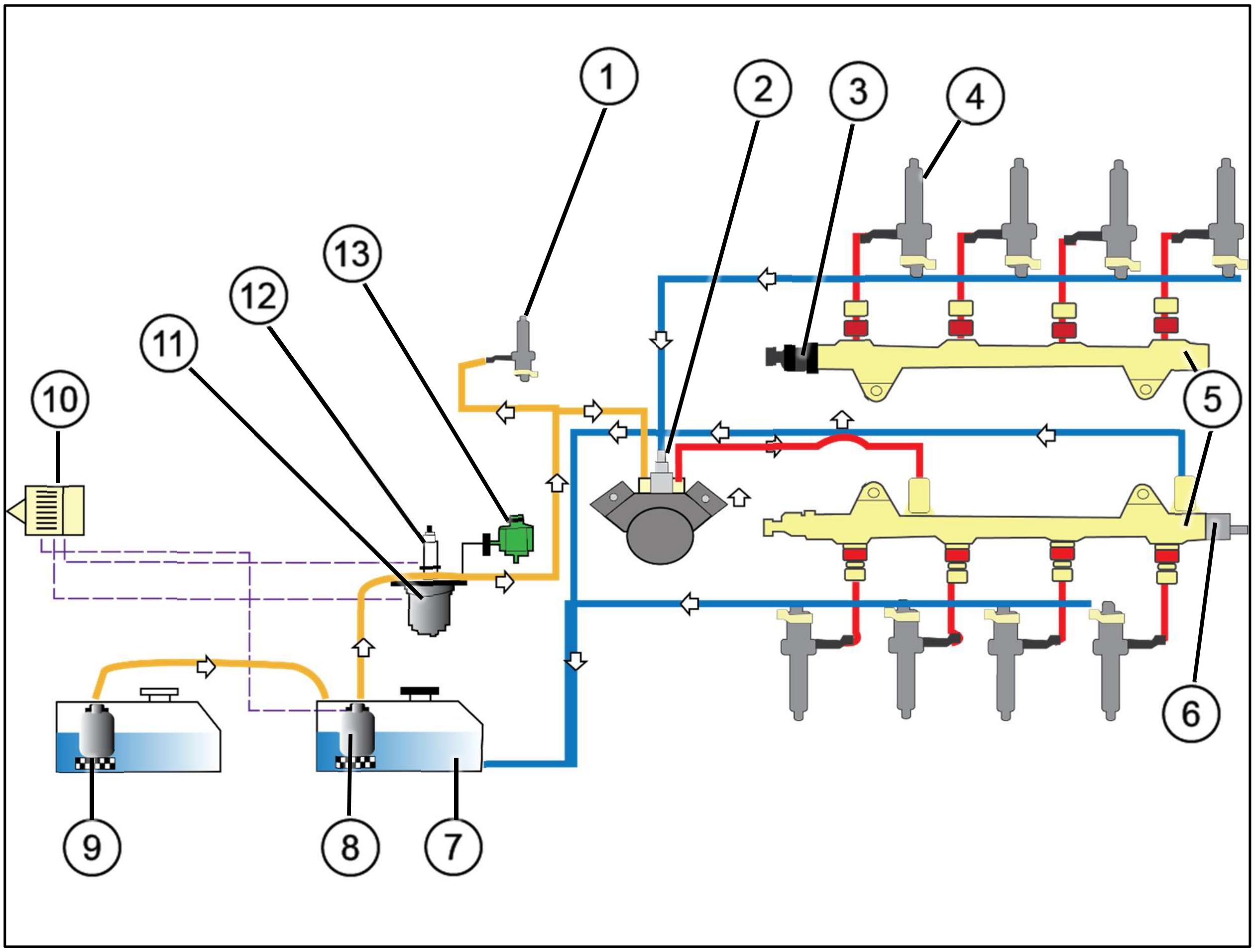
The primary fuel tank contains a three-phase electric fuel pump that is controlled by the fuel pump driver control module and ECM. Fuel is pumped from the primary fuel tank through the fuel feed line to the fuel filter assembly. The fuel filter assembly consists of a fuel filter / water separator, fuel heater, fuel temperature sensor, and a water-in-fuel sensor. Fuel flows out of the fuel filter assembly, through the rear fuel feed pipe to the exhaust aftertreatment fuel injector, and past the fuel pressure sensor to the fuel injection pump. High pressure fuel is supplied through the high pressure fuel line to the fuel rails, and then through the fuel injector lines to the fuel injectors. High pressure fuel is controlled by the ECM, fuel pressure regulator 1, and fuel pressure regulator 2. Excess fuel returns to the fuel tank through the fuel return pipes.

Fuel Pressure Regulator 1

The ECM controls fuel rail pressure using two pulse width modulated fuel rail pressure regulators. Fuel pressure regulator 1 is located in the fuel injection pump and meters the amount of fuel that enters the high pressure side of the pump. From the high pressure pump, the fuel moves to the fuel rail through a high pressure steel line. The fuel rail distributes high pressure fuel to all eight fuel injectors.

Fuel Pressure Regulator 2

Fuel pressure regulator 2 is located on the rear of the driver's side fuel rail and meters the amount of fuel being returned to the fuel tank. The ECM varies pulse width modulated voltage to the fuel pressure regulator 2 to relieve excessive fuel pressure and return fuel to the fuel tank. When the ignition is off, fuel pressure regulator 2 opens to bleed off the pressure in the fuel rail.

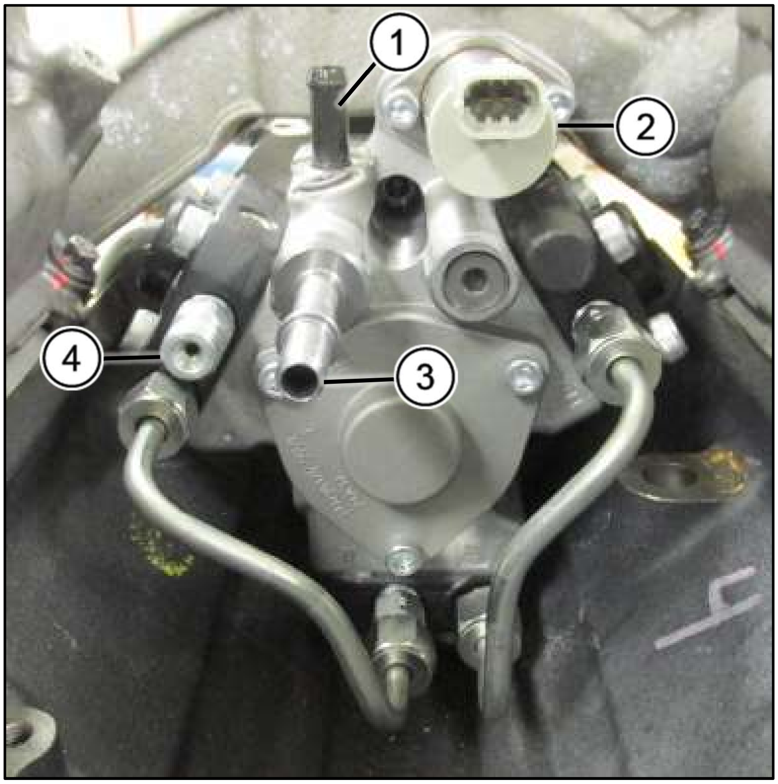


1. Aftertreatment Fuel Injector
2. Injection Pump
3. Pressure Sensor (Dual)
4. Injectors (8)
5. Fuel Rails (2)
6. Regulator 2
7. Primary Fuel Tank
8. 3-Phase Electric Fuel Pump
9. Transfer Pump (If Equipped)
10. Fuel Pump Driver Control Module
11. Fuel Filter Assembly
12. Temperature Sensor
13. Pressure Sensor

Figure 7-10, 6.6L L5P Fuel System

FUEL INJECTION PUMP

The fuel injection pump is a mechanical, two-cylinder, piston-type, high pressure pump supplied by Denso. 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.



1. Fuel Return
2. Regulator 1
3. Fuel Inlet
4. High Pressure Fuel to Left Common Rail

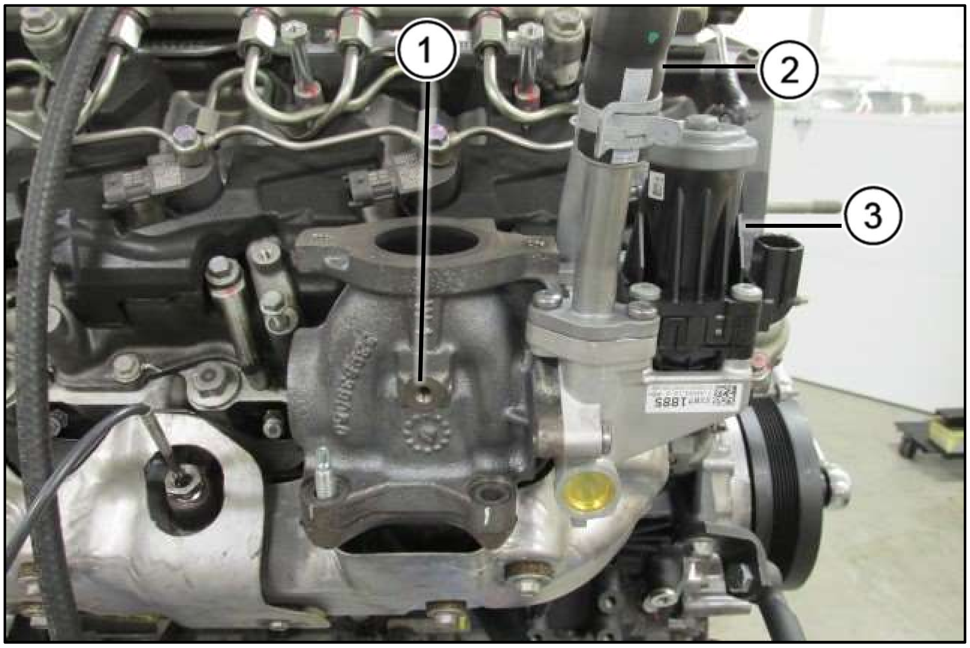
Figure 7-11, 6.6L L5P Fuel Injection Pump

EXHAUST GAS RECIRCULATION

The EGR system reduces the amount of NO_x emission levels caused by high combustion temperatures. At temperatures above 2,500°F (1371°C), oxygen and nitrogen combine to form NO_x. Introducing small amounts of exhaust gas back into the combustion chamber displaces a small amount of oxygen entering the engine. With less oxygen in the air / fuel mixture, combustion pressures are reduced, and as a result, temperatures are decreased, restricting the formation of NO_x.

The EGR cooler bypass solenoid is an on-off device, not Pulse Width Modulation (PWM) controlled by the ECM. At engine cold start, the EGR cooler bypass allows hot exhaust gas to heat the intake air in the manifold. Once the engine operating temperature is reached, the ECM closes the EGR cooler bypass.

The MAF sensor signal is used by the ECM to detect the proper amount of EGR flow. The ECM closes the EGR valve, and then opens the EGR valve to 100%. The ECM then calculates the MAF difference and determines whether proper EGR flow has been detected.



1. EGR Valve
2. Coolant Hose
3. EGR Motor

Figure 7-12, 6.6L L5P EGR Valve

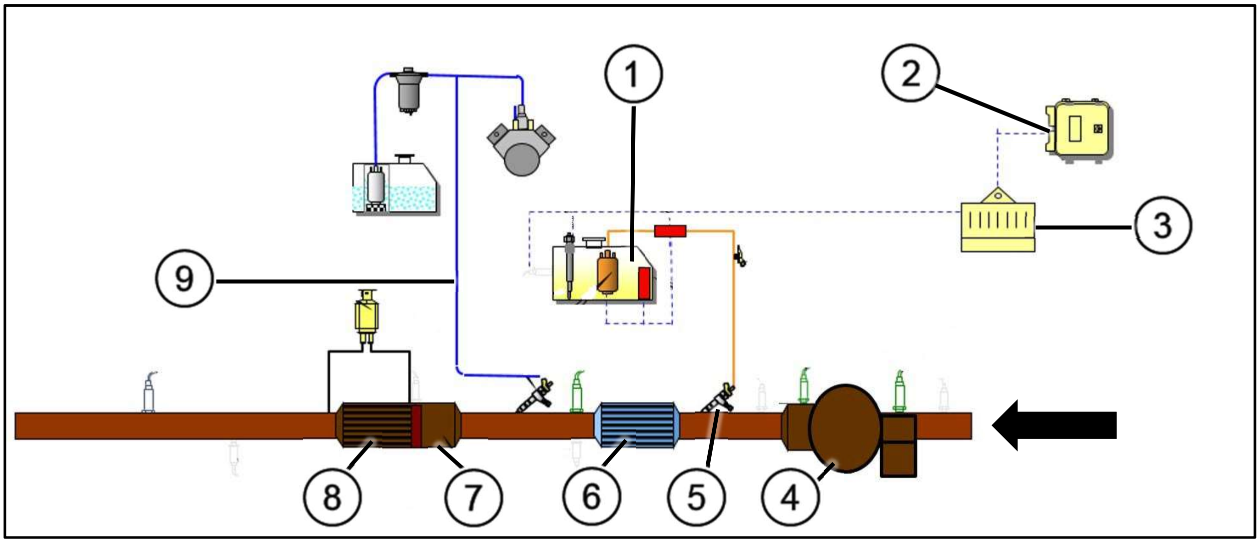
EXHAUST AFTERTREATMENT SYSTEM

System Overview

The diesel exhaust aftertreatment system is designed to reduce the levels of HC, CO, NO_x, and particulate matter remaining in the vehicle’s exhaust gases. Reducing these pollutants to acceptable levels is achieved through a four-stage process:

1. Close-coupled DOC stage
2. SCR stage
3. DOC stage
4. DPF stage

In stage 1, the close-coupled DOC removes exhaust HC and CO through an oxidation process. After stage 1, DEF is injected into the exhaust gases prior to entering the SCR stage. Within the SCR stage, NO_x is converted to N_2, CO_2, and H_2O through a catalytic reduction fueled by the injected DEF. The exhaust then enters a second DOC. In the final process, particulate matter consisting of extremely small particles of carbon remaining after combustion are removed from the exhaust gas by the large surface area of the DPF.



1.	DEF Tank and Components	2.	ECM	3.	SCR Control Module (DEF)
4.	Close Coupled DOC at Turbo	5.	DEF Injector	6.	SCR
7.	DOC	8.	DPF	9.	Fuel Line to HC Injector

Figure 7-13, 6.6L L5P Exhaust Aftertreatment System

Close-Coupled Diesel Oxidation Catalyst

The DOC functions much like the catalytic converter used with gasoline-fueled engines. As with all catalytic converters, the DOC must be hot in order to effectively convert the exhaust HC and CO into CO_2 and H_2O. On cold starts, the exhaust gases are not hot enough to create temperatures within the DOC high enough to support full HC and CO conversion. The temperature at which full 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 drivability and one or more DTCs being set.

Note: ULSD was mandated to reduce sulfur dioxide emissions from road-going diesel-powered vehicles.

Selective Catalyst Reduction

While diesel engines are more fuel efficient and produce less HC and CO than gasoline engines, as a rule they generate much higher levels of NO_x. In order to meet today's tighter NO_x limits, an SCR catalyst, along with DEF, is used to convert NO_x into N_2, CO_2, and H_2O.

NO_x Sensor

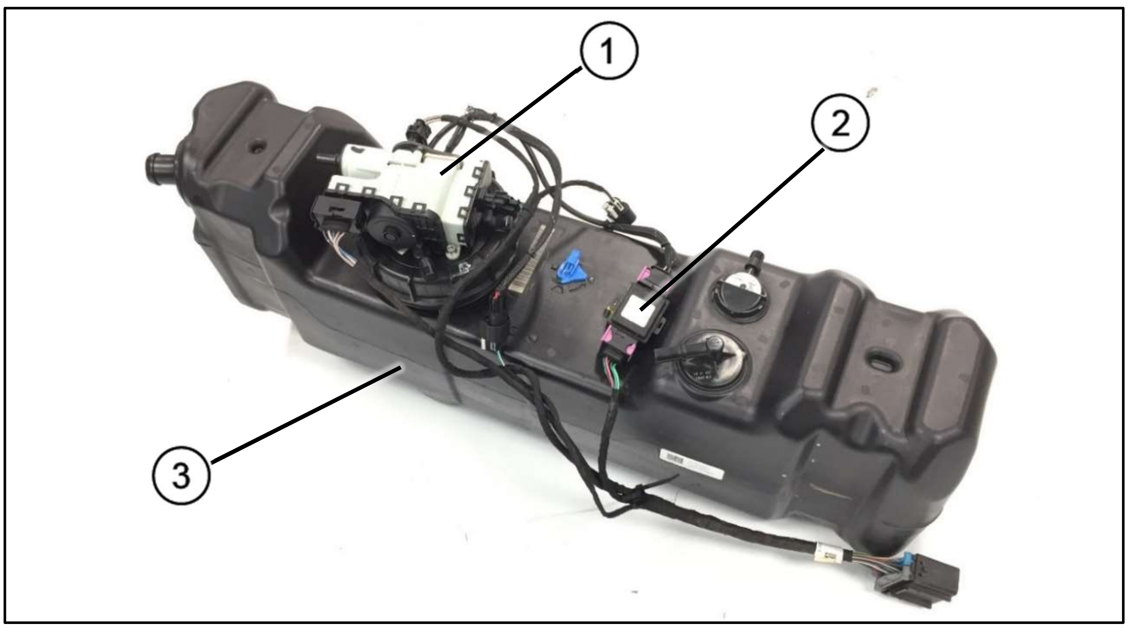
The ECM uses two smart NO_x sensors to control exhaust NO_x levels. The first NO_x sensor is located at the turbocharger outlet and monitors the engine out NO_x. The second NO_x sensor is located in the exhaust pipe downstream of the SCR and monitors NO_x levels exiting the aftertreatment system. The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

The NO_x sensors incorporate an electric heater that is controlled by the NO_x module to quickly bring the sensors to operating temperature. As moisture remaining in the exhaust pipe could interfere with sensor operation, there is a delay turning on the heaters until the exhaust temperature exceeds a calibrated value. This allows any moisture remaining in the exhaust pipe to boil off before it can affect NO_x sensor operation. Depending on engine temperature at start up, the delay can be less than 1 minute or as long as 2 minutes. NO_x sensor 1 can reach operating temperature faster than NO_x sensor 2, as it is closer to the engine's hot exhaust. At idle or low engine speeds, NO_x sensor 2 may require up to 5 minutes to reach operating temperature. The sensors must be hot before accurate exhaust NO_x readings are available to the ECM.

Diesel Exhaust Fluid System

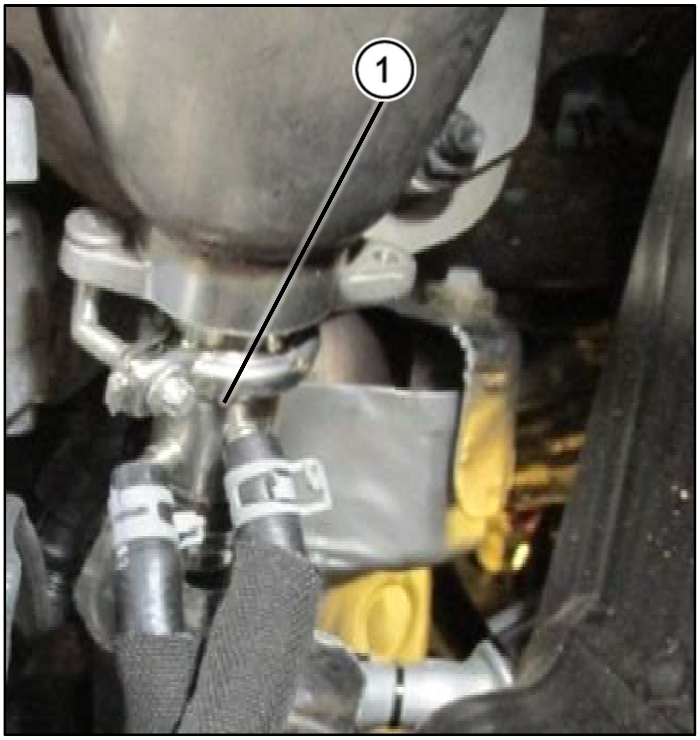
The DEF system consists of the following components located at the DEF reservoir:

- Electrically-operated DEF pump
- Integrated DEF level sensor and DEF temperature sensor
- DEF control module
- DEF quality sensor
- DEF system heaters



1. DEF Control Module and Pump
2. DEF Quality Sensor
3. DEF Reservoir

Figure 7-14, 6.6L L5P DEF Pump and Control Module



1. DEF Injector

Figure 7-15, 6.6L L5P DEF Injector (Liquid-Cooled)

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

The on-board reservoir holds DEF. A pump within the reservoir supplies pressurized DEF to the DEF injector located upstream of the SCR. A DEF level sensor within the DEF reservoir provides the DEF control module a signal indicating DEF level. The DEF pressure sensor provides the DEF control module with a voltage signal proportional to the pressure generated by the DEF pump. The DEF control module varies the duty-cycle of the pump voltage to maintain DEF pressure within a calibrated range.

When the ignition is turned OFF, the DEF pump runs in reverse for about 45 seconds in order to purge the supply line of DEF. There is a 1-minute delay between ignition OFF and the start of purge to allow the exhaust system to cool in order to prevent hot exhaust gas from being drawn into the DEF line. The ECM also commands the DEF injector open during the purge process. Purging prevents the DEF from freezing in the pump or supply line to the DEF injector.

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

Note: Lower quality or aged DEF causes more DEF to be injected to achieve the proper aftertreatment; for example, a vehicle that is used just to tow a camper or a boat a few times a year.

Cold Weather Operation

As DEF will freeze at 12°F (-11°C), there are two DEF heaters. DEF heater 1 is in the DEF reservoir and DEF heater 2 is in the supply line to the DEF injector. The DEF control module monitors the DEF temperature sensor located within the reservoir in order to determine if DEF temperature is below its freeze point. If the module determines that the DEF may be frozen, it energizes the DEF heaters.

DEF pump operation is disabled for a calibrated amount of time to allow the heaters time to thaw the frozen DEF. Once the thaw period expires, the module energizes the DEF pump to circulate warm DEF back to the reservoir to speed thawing. The ECM looks for an increase in the DEF temperature to verify that the DEF reservoir heater is working.

6.6L L5P SERVICE

DIESEL EXHAUST FLUID SYSTEM DRAINING AND FILLING

Draining the DEF system involves the following activities:

- Using a low pressure, clean water hose to spray dirt and debris from the DEF tank and components
- Drying the components with a low pressure air hose
- Hand-drying the connections and joints

Refer to service information for additional information.

CAUTION: The DEF system is part of the emission system for this vehicle, and must be serviced while observing extreme care to prevent foreign contamination of any kind from entering this system. If extreme care is NOT taken to prevent contamination from dirt, debris, fluids other than DEF, etc., reduced performance and/or damage to the DEF system may result.
Cleanliness of the DEF system is crucial to ensure proper operation. Before opening any part of the DEF system, ensure connections and joints are thoroughly clean and dry of any dirt, debris, or other contaminants. Use only low pressure water and low pressure air, as directed.
DEF will have a tendency over time to develop areas of dried crystallization residue. Crystallization residue is a normal process for this fluid. Dried DEF crystallization residue can be wiped away, or flushed away with clean water, depending on the location of the crystallization.

CAUTION: The DEF must be drained by a clean, dedicated, siphoning pump and hose. It must NOT have any traces of gasoline, diesel fuel, or any oil-based substances. If extreme care is NOT taken to prevent contamination from fluids other than DEF, reduced performance and/or damage to the DEF system may result.

REDUCTANT FLUID TANK LEVEL RESET

The following procedure resets the control module learned values for the reductant system. Refer to service information for additional information.

Note: Failure to perform this procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

Perform this procedure when the following components have been serviced:

- DEF pump and sensor assembly
- DEF reservoir assembly

Perform the following steps with a scan tool:

1. Ignition >> ON / Vehicle >> in service mode.
2. Select: Module Diagnostics.
3. Select: Engine Control Module.
4. Select: Configuration / Reset Functions.
5. Select: Reset Functions.
6. Select: Reductant Fluid Tank Reset.

Note: The scan tool does not display learn / reset status.

7. Follow the instructions on the scan tool. The procedure will complete within 10 seconds.

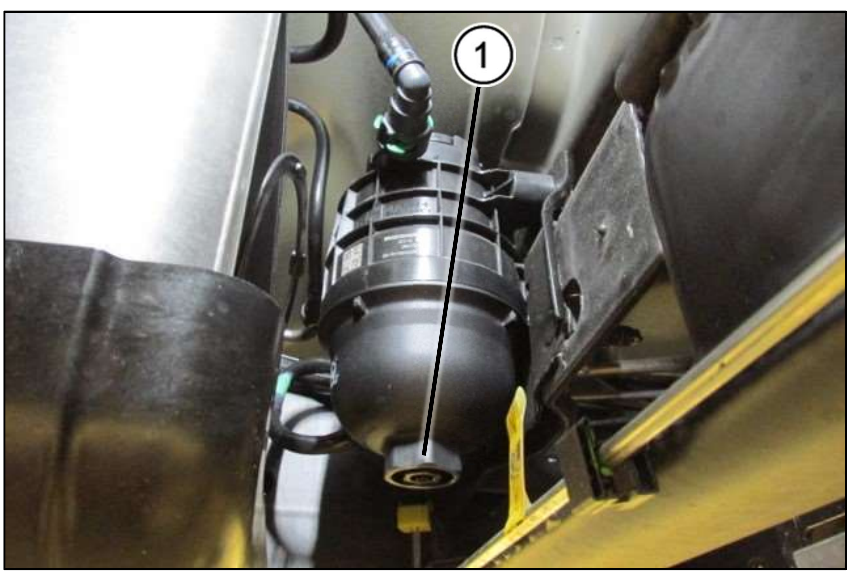
WATER IN FUEL DRAINING

Draining water from the fuel filter involves the following activities:

- Installing a suitable hose at the fuel filter water bleed screw
- Placing the hose in a suitable container
- Loosening the fuel filter drain plug, and collecting the liquid
- After draining the water-contaminated fuel from the fuel filter, prime the fuel system until only diesel fuel is visible
- Tighten the drain plug and remove the container and hose

WARNING: Diesel fuel / gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

WARNING: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

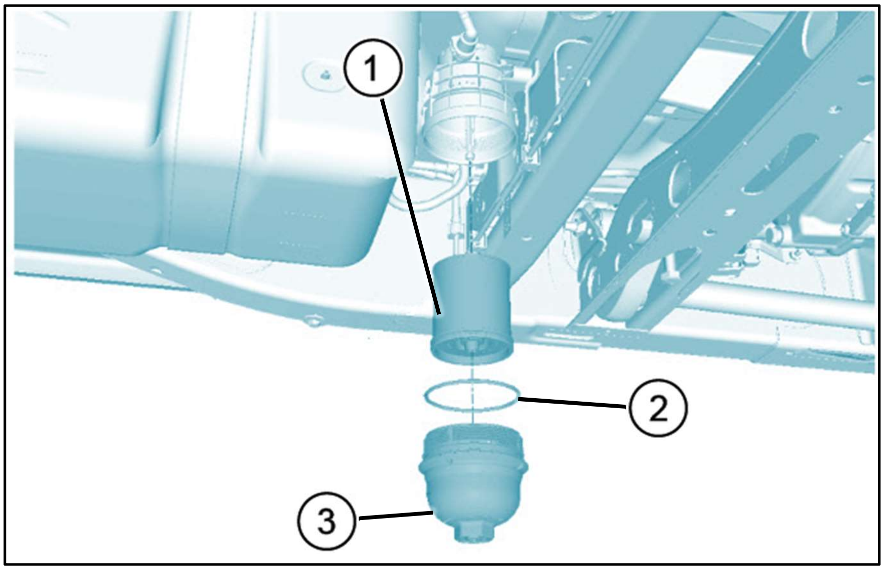


1. Fuel Filter Drain Plug

Figure 8-1, 6.6L L5P Fuel Filter Drain Plug

FUEL FILTER REPLACEMENT

Fuel filter replacement involves supporting the fuel filter housing, draining the fuel from the filter, and removing the fuel / water separator reservoir. Install the replacement fuel filter with a new seal, and prime the system.



1. Fuel Filter 2. Fuel Filter Seal 3. Fuel / Water Separator Reservoir

Figure 8-2, 6.6L L5P Fuel Filter Replacement

FUEL FILTER LIFE RESET

A scan tool or the driver information center can be used to reset the control module learned values for the fuel filter. Refer to the Owner’s Manual for the reset procedure. Perform the fuel filter life reset procedure when the fuel filter has been replaced.

FUEL INJECTOR FLOW RATE PROGRAMMING

The control functions for the fuel injection system are integrated in the ECM. The flow rate information for each injector, or injection quantity adjustment flow rate numbers, and cylinder position are stored in ECM memory.

Use a scan tool to perform fuel injector flow rate programming when any of the following procedures are completed:

- ECM replacement
- Fuel injector replacement

Note: If injectors are being replaced, enter the injection quantity adjustment code from the new injector(s). If the ECM is being replaced, enter the injection quantity adjustment code from the original injectors.

FUEL INJECTION PUMP REPLACEMENT

Replacing the fuel injection pump involves the removal and installation of the following components:

- Upper intake manifold
- Engine coolant thermostat housing
- EGR manifold cooling pipe
- Fuel feed and return pipe
- Fuel injection fuel return pipe
- Fuel high pressure pipe – rail to rail

If the fuel injection pump will be reused, clean and inspect it.

GLOW PLUG REPLACEMENT

Observe the following precautions when servicing glow plugs:

- Glow plugs must be discarded whenever removed, and replaced with new parts
- If a cylinder head is removed, the accompanying glow plugs must be discarded and replaced with new parts
- Handle glow plugs with extreme care; do not allow glow plugs to touch each other
- Do not use power tools to install glow plugs
- Before installation of a new glow plug, EN-52074 Glow Plug Bore Reamer must be used to clean the glow plug bore

CAUTION: The glow plug bore MUST be cleaned prior to glow plug installation. If the glow plug bore is not cleaned of carbon buildup prior to glow plug installation, it may cause severe damage to the glow plug. If the glow plug is damaged, the glow plug bore and combustion chamber must be cleaned of all debris, and the glow plug must be replaced.

Whenever a glow plug has been repaired, replaced, removed, or serviced, perform the glow plug learn procedure with a scan tool.

Note: Failure to perform the glow plug learn procedure may result in poor system performance, DTCs being set, or customer dissatisfaction.

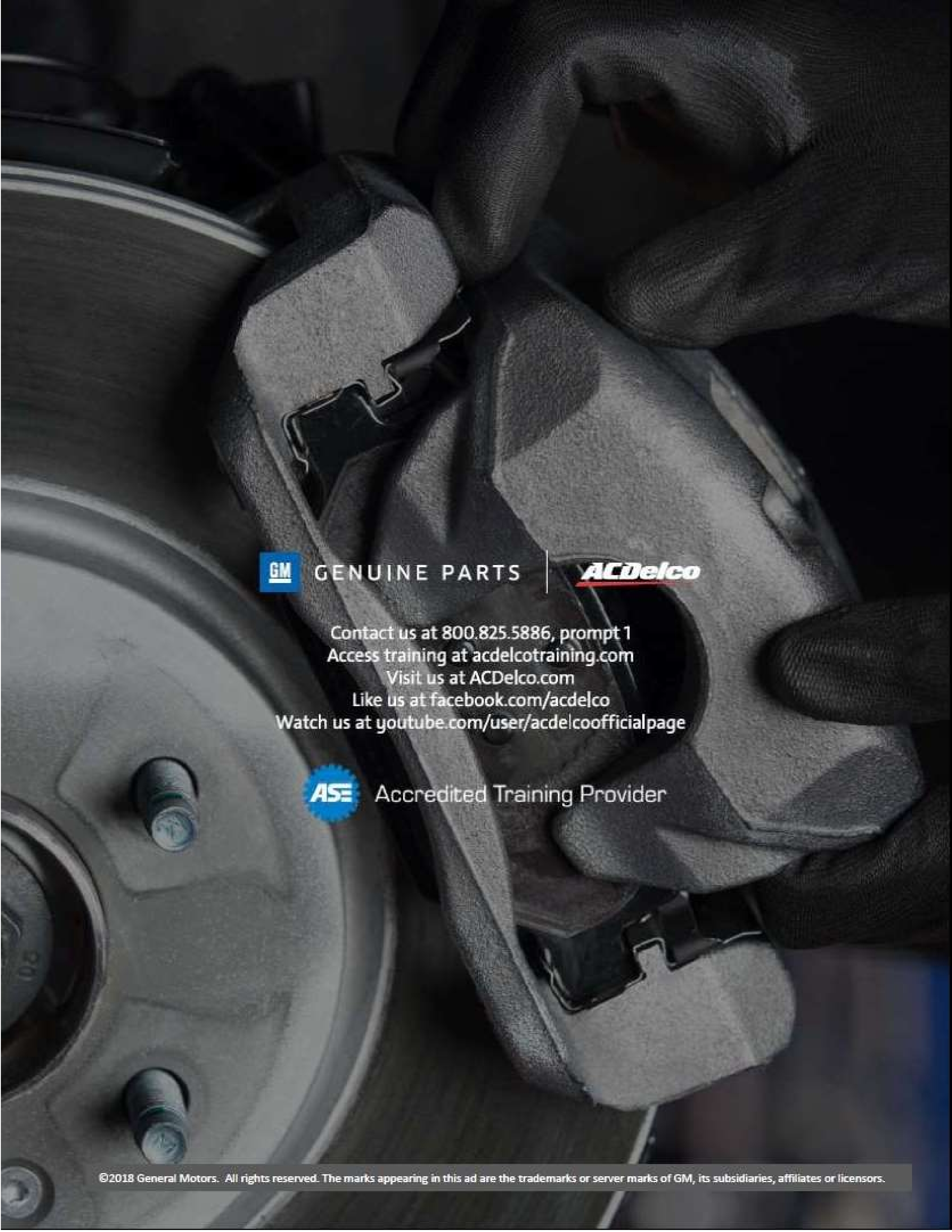
ADDITONAL RESOURCES

COMMUNICATION

ACDelco distributes the following communication channels to provide timely information to ACDelco technicians.

- Intune is a newsletter delivers helpful maintenance reminders, automotive tips, and feature stories
- ACDelco Insider provides product information, promotional opportunities, and highlights from ACDelco advertising and marketing highlights. The ACDelco Insider also provides information on the latest trends in automotive service and complex vehicle systems
- ACDelco Press Releases announce the latest ACDelco news and important updates

NOTES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