Diesel combustion occurs when fuel is injected into the hot, highly compressed air in the cylinder.

![Image: Diesel engine operation diagram with labels for exhaust valve, air intake valve, injector, and fuel injection system]

A typical injector pump type of automotive diesel fuel-injection system.
Figure 19-3: A Cummins diesel engine as found in a Dodge pickup truck. A high-pressure pump feeding high-pressure fuel at 30,000 PSI is used to supply fuel to the common rail, which has tubes running to each injector. Note the thick cylinder walls and heavy-duty construction.

Chart 19-1: Comparison between a typical gasoline and a diesel engine.

<table>
<thead>
<tr>
<th>SYSTEM OR COMPONENT</th>
<th>DIESEL ENGINE</th>
<th>GASOLINE ENGINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>Cast iron and aluminum (FIGURE 19-3)</td>
<td>Cast iron or aluminum and as light as possible</td>
</tr>
<tr>
<td>Cylinder head</td>
<td>Cast iron or aluminum</td>
<td>Cast iron or aluminum</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>17:1 to 22:1</td>
<td>9:1 to 13:1</td>
</tr>
<tr>
<td>Peak engine speed</td>
<td>2000 to 2500 RPM</td>
<td>5000 to 6000 RPM</td>
</tr>
<tr>
<td>Pistons</td>
<td>Aluminum with combustion pockets and heavy-duty connector rods (FIGURE 19-4)</td>
<td>Iron, usually forged or cast with valve relief but no combustion pockets</td>
</tr>
</tbody>
</table>

Figure 19-4: A rod/piston assembly from a 5.9-liter Cummins diesel engine used in a Dodge pickup truck.
Figure 19-5  An indirect injection diesel engine uses a prechamber and a glow plug.

Figure 19-6  A direct injection diesel engine injects the fuel directly into the combustion chamber. Many designs do not use a glow plug.

Figure 19-7  A fuel temperature sensor is being tested using an ice bath.
Figure 19-8  A typical distributor-type diesel injection pump showing the pump, lines, and fuel filter.

Figure 19-9  A schematic of Standardy diesel fuel-injection pump assembly showing all of the related components.

Figure 19-10  Overview of a computer-controlled high-pressure common rail V-8 diesel engine.
TECH TIP: Change Oil Regularly in a Ford Diesel Engine

Ford 7.3 and 6.0 liter diesel engines pump unfiltered oil from the sump to the high-pressure oil pump and then to the injectors. This means that not changing oil regularly can contribute to accumulation of dirt in the engine and will subject the fuel injectors to wear and potential damage as particles suspended in the oil get forced into the injectors.

Figure 19-11: A HEUI injector from a Ford PowerStroke diesel engine. The O-ring grooves indicate the location of the O-rings that seal the fuel section of the injector from coolant and from the engine oil.

TECH TIP: Never Allow a Diesel Engine to Run Out of Fuel

If a gasoline-powered vehicle runs out of gasoline, it is an inconvenience and a possible additional expense to get some gasoline. However, if a vehicle equipped with a diesel engine runs out of fuel, it can be a major concern. Besides getting coolant in the tank, the other problem is getting all of the air out of the pump, lines, and injectors so the engine will operate correctly.

The procedure usually involves starting the engine long enough to recirculate the oil in the lines, turning the starter on long enough to get liquid fuel back into the injectors, then starting the engine again using the correct fuel. Consult service information for the exact service procedure if the diesel engine is run out of fuel.

NOTE: Some diesel engines, such as the General Motors Duramax V-8, are equipped with a priming pump located under the hood on top of the fuel filter. Pushing down and releasing the priming pump with a vent valve open will purge any trapped air from the system. Always follow the vehicle manufacturer's instructions.
Figure 19-12 Typical computer-controlled diesel engine fuel injectors.

Figure 19-13 A Duramax injector showing all the internal parts.

Figure 19-14 A glow plug assortment showing the various types and sizes of glow plugs used. Always use the specified glow plug.
Figure 19-15 A schematic of a typical glow plug circuit. Notice that the glow plug relay and intake air heater relay are both computer controlled.

Figure 19-16 A wire-wound electric heater is used to warm the intake air on some diesel engines.

FREQUENTLY ASKED QUESTION: How Can You Tell If Gasoline Has Been Added to the Diesel Fuel by Mistake?

If gasoline has been accidentally added to diesel fuel and is burned in a diesel engine, the result can be very damaging to the engine. The gasoline can ignite faster than diesel fuel, which would tend to increase the temperature of combustion. This high temperature can harm injectors and glow plugs, as well as pistons, head gaskets, and other major diesel engine components. If contaminated fuel is suspected, first smell the fuel at the filler neck. If the fuel smells like gasoline, then the tank should be drained and refilled with diesel fuel. If the smell test does not indicate a gasoline or any rancid smell, then test a sample for proper specific gravity.

NOTE: Diesel fuel designed for on-road use should be green. Red diesel fuel (high sulfur) should only be used in off-road or farm equipment.
Figure 19-17 A typical accelerator pedal position (APP) sensor uses three different sensors in one package with each creating a different voltage as the accelerator is moved.

Figure 19-18 A Cummins diesel turbocharger is used to increase the power and torque of the engine.

Figure 19-19 An air charge cooler is used to cool the compressed air.
Figure 19-20 A variable vane turbocharger allows the boost to be controlled without the need of a wastegate.

Figure 19-21 A cutaway showing the exhaust cooler. The cooler the exhaust is, the more effective it is in controlling NOx emissions.

Figure 19-22 Relative size of particulate matter to a human hair.
**FREQUENTLY ASKED QUESTION**

What Is the Big Deal for the Need to Control Very Small Soot Particles?

For many years soot or particulate matter (PM) was thought to be less of a health concern than exhaust emissions from gasoline engines. It was felt that the soot could simply fall to the ground without causing any noticeable harm to people or the environment. However, it was discovered that the small soot particulates when breathed in are not expelled from the lungs like larger particles but instead get trapped in the deep areas of the lungs where they accumulate.

**Figure 19-23** Chemical reaction within the DOC.

**Figure 19-24** Aftertreatment of diesel exhaust is handled by the DOC and DPF.
Figure 19-25  The soot is trapped in the passages of the DPF. The exhaust has to flow through the sides of the trap and exit.

Figure 19-26  EGT 1 and EGT 2 are used by the PCM to help control after treatment.

Figure 19-27  Regeneration burns the soot and renew the DPF.
WARNING

Tailpipe outlet exhaust temperature will be greater than 572°F (300°C) during service regeneration. To help prevent personal injury or property damage from fire or burns, keep vehicle exhaust away from any object and people.

Figure 19-28 The post injection pulse occur to create the heat needed for regeneration.

FREQUENTLY ASKED QUESTION

Will the Postinjection Pulses Reduce Fuel Economy?
Maybe. Due to the added fuel-injection pulses and late fuel-injection timing, an increase in fuel consumption may be noticed on the driver information center (DIC) during the regeneration time period. A drop in overall fuel economy should not be noticeable. SEE FIGURE 19-28.
FREQUENTLY ASKED QUESTION

What Is an Exhaust Air Cooler?
An exhaust air cooler is simply a section of tailpipe that has slits for air to enter. As hot exhaust rushes past the gap, outside air is drawn into the area which reduces the exhaust discharge temperature. The cooler significantly lowers exhaust temperature at the tailpipe from about 800°F (430°C) to approximately 500°F (270°C). ▶ SEE FIGURE 19-29.

Figure 19-29
The exhaust is split into two outlets and has slits to help draw outside air in as the exhaust leaves the tailpipe. The end result is cooler exhaust gases exiting the tailpipe.

Figure 19-30
Diesel exhaust fluid costs $3 to $4 a gallon and is housed in a separate container that holds from 5 to 10 gallons, or enough to last until the next scheduled oil change in most diesel vehicles that use it.
Urea (diesel exhaust fluid) injection is used to reduce NOx exhaust emissions. It is injected after the diesel oxidation catalyst (DOC) and before the diesel particulate filter (DPF) on this 6.7 liter Ford diesel engine.

The values can be obtained by using a scan tool and basic test equipment. Always follow the vehicle manufacturer’s recommended procedures.

Chart 19-2 (continued) The values can be obtained by using a scan tool and basic test equipment. Always follow the vehicle manufacturer’s recommended procedures.
Figure 19-32  A pressure gauge checking the fuel pressure from the lift pump on a Cummins 6.7 liter diesel.

Figure 19-33  A compression gauge that is designed for the higher compression ratio of a diesel engine should be used when checking the compression.

Figure 19-34  A typical pop tester used to check the spray pattern of a diesel engine injector.
An opacity test is sometimes used during a state emission test on diesel engines.

**TECH TIP:** Always Use Cardboard to Check for High-Pressure Leaks

If diesel fuel is found on the engine, a high-pressure leak could be present. When checking for such a leak, wear protective clothing including safety glasses, a face shield, gloves, and a long-sleeved shirt. Then use a piece of cardboard to locate the high-pressure leak. When a Duramax diesel is running, the pressure in the common rail and injector tubes can reach over 20,000 PSI. At these pressures, the diesel fuel is atomized and cannot be seen but can penetrate the skin and cause personal injury. A leak will be shown as a dark area on the cardboard. When a leak is found, shut off the engine and find the exact location of the leak without the engine running.

**CAUTION:** Sometimes a leak can actually cut through the cardboard, so use extreme care.

The letters on the side of this injector on a Cummins 6.7 liter diesel indicate the calibration number for the injector.
Do Not Switch Injectors

In the past, it was common practice to switch diesel fuel injectors from one cylinder to another when diagnosing a dead cylinder problem. However, most high-pressure common rail systems used in new diesels utilize precisely calibrated injectors that should not be mixed up during service. Each injector has its own calibration number.

SEE FIGURE 19–35.