

Automotive Engines Theory and Servicing

Ninth Edition

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Chapter 11

Diesel Engine
Operation and
Diagnosis

ALWAYS LEARNING

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OBJECTIVES (1 OF 3)

- 11.1** State the characteristics of diesel engines.
- 11.2** Describe the fuel tank and lift pump, injection pump, and engine-driven vacuum pump.
- 11.3** Explain the HEUI system.
- 11.4** Discuss the purpose of glow plugs, diesel fuel heaters, diesel injector nozzles, and accelerator pedal position sensors.

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OBJECTIVES (2 OF 3)

- 11.5** Explain the purpose of diesel engine turbochargers.
- 11.6** Discuss the purpose of the exhaust gas recirculation system, selective catalytic reduction, and diesel oxidation catalysts.
- 11.7** Explain diesel particulate matter, and discuss the function of diesel exhaust particulate filters.

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OBJECTIVES (3 OF 3)

11.8 Discuss diesel exhaust smoke diagnosis.

11.9 Discuss compression testing, glow plug resistance balance test, injector pop testing, and diesel emission testing.

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DIESEL ENGINES (1 OF 3)

- The diesel engine uses heat created by compression to ignite the fuel, so it requires no spark ignition system.
 - The diesel engine requires compression ratios of 16:1 and higher.
 - Incoming air is compressed until its temperature reaches about 1,000°F (540°C).
 - This is called heat of compression.

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DIESEL ENGINES (2 OF 3)

- As the piston reaches the top of its compression stroke, fuel is injected into the cylinder, where it is ignited by the hot air.
- As the fuel burns, it expands and produces power.
 - It is made heavier and stronger than the same size gasoline-powered engine.

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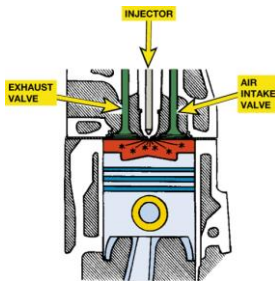
DIESEL ENGINES (3 OF 3)

- A diesel engine uses a fuel system with a precision injection pump and individual fuel injectors.
 - The pump delivers fuel to the injectors at a high pressure and at timed intervals.
 - Each injector sprays fuel into the combustion chamber at the precise moment required for efficient combustion.

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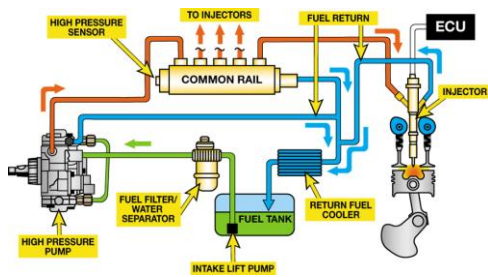
FIGURE 11-1 Diesel combustion occurs when fuel is injected into the hot, highly compressed air in the cylinder.



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FIGURE 11-2 A Typical high-pressure common rail (HPCR) type diesel fuel system.



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THREE PHASES OF COMBUSTION

- What are the three phases to the combustion in a diesel engine?

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FUEL TANK AND LIFT PUMP PARTS INVOLVED

- A fuel tank used on a vehicle equipped with a diesel engine differs from the one used with a gasoline engine.
 - The filler neck is larger for diesel fuel.
 - There are no evaporative emission control devices or a charcoal (carbon) canister.

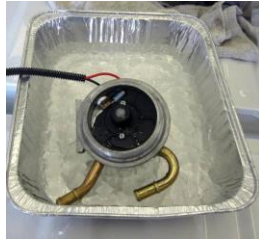


FIGURE 11-7 A fuel temperature sensor is being tested using an ice bath.

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INJECTION PUMP

- Need For High-pressure Fuel Pump
- Distributor Injection Pump
- High-pressure Common Rail



FIGURE 11-8 A typical distributor-type diesel injection pump showing the pump, lines, and fuel filter.

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HEUI SYSTEM (1 OF 2)

- The components used include:
 - High-pressure engine oil pump and reservoir
 - Pressure regulator for the engine oil
 - Passages in the cylinder head for flow of fuel to the injectors

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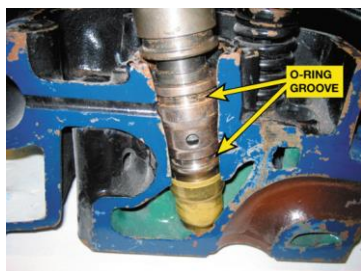
HEUI SYSTEM (2 OF 2)

- The engine oil is pressurized to provide an opening pressure strong enough to overcome the fuel pressure when the solenoid is commanded to open by the PCM.

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FIGURE 11–11 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.



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DIESEL INJECTOR NOZZLES (1 OF 2)

- The tip of the injector nozzle has many holes to deliver an atomized spray of diesel fuel into the cylinder.
- The electric solenoid attached to the injector nozzle is computer controlled and opens to allow fuel to flow into the injector pressure chamber.

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DIESEL INJECTOR NOZZLES (2 OF 2)

- Parts of a diesel injector nozzle include:
 - Heat shield
 - Injector body
 - Diesel injector needle valve
 - Injector pressure chamber

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FIGURE 11-12 Typical computer-controlled diesel engine fuel injectors.



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GLOW PLUGS

- Purpose and Function
- Operation
- Heated Inlet Air



FIGURE 11–14 A glow plug assortment showing the various types and sizes of glow plugs used. Always use the specified glow plugs.

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ENGINE-DRIVEN VACUUM PUMP (1 OF 2)

- Because a diesel engine is unthrottled, it creates very little vacuum in the intake manifold.
 - Several engine and vehicle components operate using vacuum, such as the exhaust gas recirculation (EGR) valve and the heating and ventilation blend and air doors.

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ENGINE-DRIVEN VACUUM PUMP (2 OF 2)

- Most diesels used in cars and light trucks are equipped with an engine-driven vacuum pump to supply the vacuum for these components.

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DIESEL FUEL HEATERS

- Diesel fuel heaters help prevent power loss and stalling in cold weather.
 - The heater is placed in the fuel line between the tank and the primary filter.
 - Some coolant heaters are thermostatically controlled, which allows fuel to bypass the heater once it has reached operating temperature.

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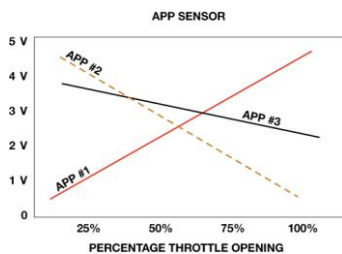
ACCELERATOR PEDAL POSITION SENSOR

- Some light-truck diesel engines are equipped with an electronic throttle to control the amount of fuel injected into the engine.
- A throttle-by-wire system uses an accelerator pedal position (APP) sensor.

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FIGURE 11-17 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.



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DIESEL ENGINE TURBOCHARGERS

- Turbocharged Diesels
- Air Charge Cooler
- Variable Turbocharger



FIGURE 11-18 A Cummins diesel turbocharger is used to increase the power and torque of the engine.

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EXHAUST GAS RECIRCULATION (1 OF 2)

- The EGR system recycles some exhaust gas back into the intake stream to cool combustion, which reduces oxides of nitrogen (NO_x) emissions.
- The EGR system includes:
 - Plumbing that carries some exhaust gas from the turbocharger exhaust inlet to the intake ports

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EXHAUST GAS RECIRCULATION (2 OF 2)

- EGR control valve
- Stainless steel cooling element used to cool the exhaust gases

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FIGURE 11-21 A cutaway showing the exhaust cooler. The cooler the exhaust is, the more effective it is in controlling NOx emissions.



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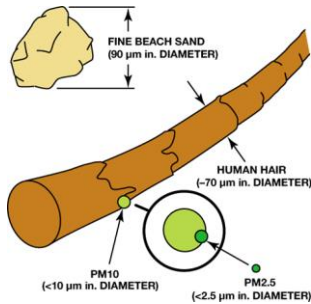
DIESEL PARTICULATE MATTER

- Particulate Matter Standards
 - Total suspended particulate (TSP)
 - PM10
 - PM2.5
- Soot Categories
 - Fine
 - Ultrafine

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FIGURE 11-22 Relative size of particulate matter to a human hair.



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DIESEL OXIDATION CATALYST (1 OF 2)

- Catalysts chemically react with exhaust gas to convert harmful nitrogen oxide into nitrogen dioxide, and to oxidize absorbed hydrocarbons.
- The chemical reaction acts as a combustor for the unburned fuel that is characteristic of diesel compression ignition.

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DIESEL OXIDATION CATALYST (2 OF 2)

- The DOC reduces: Carbon monoxide (CO), Hydrocarbons (HC), Odor-causing compounds such as aldehydes and sulfur.

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DIESEL EXHAUST PARTICULATE FILTER (1 OF 2)

- Purpose and Function
- Operation
- Exhaust Gas Temperature Sensors
- DPF Differential Pressure Sensor
- Diesel Particulate Filter Regeneration

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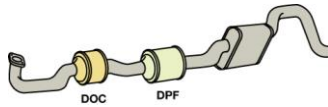
DIESEL EXHAUST PARTICULATE FILTER (2 OF 2)

- DPF Regeneration Process
- Types of DPF Regeneration
- Ash Loading

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FIGURE 11-24 Aftertreatment of diesel exhaust is handled by the DOC and DPF.



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SELECTIVE CATALYTIC REDUCTION

- Purpose and Function
 - Selective catalytic reduction (SCR) is a method used to reduce NOx emissions by injecting urea into the exhaust stream.
 - Instead of using large amounts of exhaust gas recirculation (EGR), the SCR system uses a urea.
- Advantages of SCR
- Disadvantages of SCR

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FIGURE 11–30 Diesel exhaust fluid 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 SCR.



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DIESEL EXHAUST SMOKE DIAGNOSIS (1 OF 2)

- Some exhaust smoke is considered normal operation for many diesel engines, especially older units.

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DIESEL EXHAUST SMOKE DIAGNOSIS (2 OF 2)

- The cause of excessive exhaust smoke should be diagnosed and repaired.
 - Black Smoke
 - White Smoke
 - Gray or Blue Smoke

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DISEL PERFORMANCE DIAGNOSIS

- Common faults include:
 - Hard starting
 - No start
 - Extended cranking before starting
 - Low power

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FIGURE 11-32 A pressure gauge checking the fuel pressure from the lift pump on a Cummins 6.7 liter diesel.



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COMPRESSION TESTING (1 OF 2)

- A compression test is fundamental for determining the mechanical condition of a diesel engine.
- Worn piston rings can cause low power and excessive exhaust smoke.

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COMPRESSION TESTING (2 OF 2)

- To test the compression on a diesel engine, the following will have to be done.
 - Remove the glow plug (if equipped) or the injector.
 - Use a diesel compression gauge, as the compression is too high to use a gasoline engine compression gauge.

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FIGURE 11-33 A compression gauge that is designed for the higher compression ratio of a diesel engine should be used when checking the compression.



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GLOW PLUG RESISTANCE BALANCE TEST

- Glow plugs increase in resistance as their temperature increases.
- All glow plugs should have about the same resistance when checked with an ohmmeter.
- A similar test of the resistance of the glow plugs can be used to detect a weak cylinder.
- This test is particularly helpful on a diesel engine that is not computer controlled.

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INJECTOR POP TESTING

- A pop tester is a device used for checking a diesel injector nozzle for proper spray pattern.
- The handle is depressed and popoff pressure is displayed on the gauge.



FIGURE 11-34 A typical pop tester used to check the spray pattern of a diesel engine injector.

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DIESEL EMISSION TESTING

- Opacity Test
- Snap Acceleration Test
- Rolling Acceleration Test
- Stall Acceleration Test

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SUMMARY (1 OF 3)

- A diesel engine uses heat of compression to ignite the diesel fuel when it is injected into the compressed air in the combustion chamber.
- The typical diesel engine fuel system consists of the fuel tank, lift pump, water-fuel separator, and fuel filter.

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SUMMARY (2 OF 3)

- The engine-driven injection pump supplies high-pressure diesel fuel to the injectors.
- Injector nozzles are either opened by the high-pressure pulse from the distributor pump or electrically by the computer on a common rail design.

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SUMMARY (3 OF 3)

- Glow plugs are used to help start a cold diesel engine and help prevent excessive white smoke during warm-up.
- Emissions are controlled on newer diesel engines
- Diesel engine testing

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