

Automotive Technology 6th Edition

Chapter 19 Diesel Engine Operation & Diagnosis

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASE Education (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASE Education (NATEF) Task Sheets.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	<p>Explain the chapter learning objectives to the students as listed:</p> <ol style="list-style-type: none"> 1. State the characteristics of diesel engines. 2. Describe the fuel tank and lift pump, and the injection pump. 3. Explain the HEUI system. 4. Discuss the purpose and function of glow plugs, diesel fuel heaters, engine-driven vacuum pumps, diesel injector nozzles, and accelerator pedal position sensors. 5. Explain the purpose and function of diesel engine turbochargers. 6. Discuss the purpose and function of the exhaust gas recirculation system and diesel oxidation catalysts. 7. Explain diesel particulate matter, and discuss the function of diesel exhaust particulate filters. 8. Discuss selective catalytic reduction and diesel exhaust fluid (DEF). 9. Discuss compression testing, glow plug resistance balance test, injector pop testing, and diesel emission testing including diesel exhaust smoke diagnosis. 10. Discuss selective catalytic reduction and diesel exhaust fluid (DEF). 11. Discuss compression testing, glow plug resistance balance test, injector pop testing, and diesel emission testing including diesel exhaust smoke diagnosis.
Establish the Mood or Climate	Provide a WELCOME , Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on the 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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1. SLIDE 1 Ch19 DIESEL ENGINE OPERATION & DIAGNOSIS



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DIESEL Engine

Videos



DISCUSSION: Ask the students to discuss the advantages & disadvantages of diesel engines as opposed to gasoline engines. Ask the students why a diesel block has to be constructed much heavier than a gasoline engine block.



SAFETY Always be very careful when working on a Diesel engine that is running with air intake removed. Because most diesel **ENGINES DO NOT USE** a throttle plate, objects can very easily be sucked into engine, causing serious engine damage. **MOST OEMs** offer intake covers.



2. **SLIDE 2 EXPLAIN** Figure 19-1 Diesel combustion occurs when fuel is injected into the hot, highly compressed air in the cylinder.

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DEMONSTRATION: Ask the students why diesel engine does not have spark plugs. (ANS:Diesel relies on the heat of compression to ignite fuel instead of spark)

3. **SLIDE 3 EXPLAIN** Figure 19-2 A typical injector pump type of automotive diesel fuel–injection system.

DISCUSS CHART 19-1

SAFETY Diesel engine fuel systems operate under **extremely high pressure.** Severe injury can result if caution is not observed when opening fuel system. The high-pressure fuel can actually penetrate skin.

4. **SLIDE 4 EXPLAIN** Figure 19-3 Cummins diesel engine as found in a Dodge pickup truck. A high-pressure pump (up to 30,000 PSI) is used to supply diesel fuel to this common rail, which has tubes running to each injector. Note the thick cylinder walls and heavy-duty construction.
5. **SLIDE 5 EXPLAIN** Figure 19-4 Rod/piston assembly from a 5.9 liter Cummins diesel engine used in a Dodge pickup truck.

Show ANIMATION:
Diesel 4-Stroke Cycle (View) (Download)

6. **SLIDE 6 EXPLAIN** Figure 19-5 indirect injection diesel engine uses a prechamber and a glow plug.

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DISCUSSION: Ask the students why diesel fuel does not evaporate as easily as gasoline

Show ANIMATION Diesel High Pressure Common Rail (View) (Download)

7. **SLIDE 7 EXPLAIN** Figure 19-6 direct injection diesel engine injects the fuel directly into the combustion chamber. Many designs do not use a glow plug.
8. **SLIDE 8 EXPLAIN** Figure 19-7 fuel temperature sensor is being tested using an ice bath.

DISCUSS 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 and the price includes a road use tax. Red diesel fuel should only be found in off-road or farm equipment and is not taxed.

ICONS

C19 Diesel Operation & Diagnosis



9. **SLIDE 9 EXPLAIN** Figure 19-8 A typical distributor-type diesel injection pump showing the pump, lines, and fuel filter.

10. **SLIDE 10 EXPLAIN** Figure 19-9 A schematic of Stanadyne diesel fuel-injection pump assembly showing all of the related components.



DEMONSTRATION: Show typical fuel flow through a distributor type of fuel system. FIGURE 19-9



DISCUSSION: Ask the students why each fuel line of a distributor-type injection system must be the same length. (Answer: To ensure that the injector timing is correct)



11. **SLIDE 11 EXPLAIN** Figure 19-10 Overview of a computer-controlled high-pressure common rail V-8 diesel engine



12. **SLIDE 12 EXPLAIN** Figure 19-11 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 engine oil.



HANDS-ON TASK: Have the students search service information for bulletins relating to oil change intervals on Ford 7.7, 6.0, and 6.4 liter diesel engines







13. **SLIDE 13 EXPLAIN** Figure 19-12 Typical computer-controlled diesel engine fuel injectors.

14. **SLIDE 14 EXPLAIN** Figure 19-13 Duramax injector showing all the internal parts.



DEMONSTRATION: Show the students some examples of various diesel injector nozzles. FIGURE 19-13

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	<p>Show ANIMATION Fuel Injector, Electronic-Control (View) (Download) Piezo Electronic Fuel Injector (View) (Download)</p>
	<p>EXPLAIN TECH TIP: Change Oil Regularly in a Ford Diesel Engine: Ford 7.3, 6.0, and 6.4 liter diesel engines pump unfiltered oil from the sump to the high-pressure oil pump and then to the injectors. This means 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.</p>
	<p>EXPLAIN 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 adding diesel fuel to the tank, other problem is getting all of air out of pump, lines, and injectors so the engine will operate correctly. The procedure usually involves cranking engine long enough to get liquid diesel fuel back into system, but at the same time keeping cranking time short enough to avoid overheating the starter. Consult service information for the exact service procedure if the diesel engine is run out of fuel. NOTE: Some diesel engines, such as the GM Duramax V-8, use a priming pump located on top of fuel filter. Pushing down and releasing priming pump with a vent valve open will purge any trapped air from the system. Follow OEM instructions.</p>
	<p>HANDS-ON TASK: Using service information, have the students research correct procedure for purging air from specific vehicle equipped with a diesel engine.</p>

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C19 Diesel Operation & Diagnosis



15. SLIDE 15 **EXPLAIN** Figure 19-14 A glow plug assortment showing the various types and sizes of glow plugs used. Always use the specified glow plugs.



DEMONSTRATION: Show examples of glow plugs and show them how to test them with an ohmmeter. **FIGURE 19-14, 15**



HANDS-ON TASK: Grade the students on their ability to test glow plugs and determine if they are functional **FIGURE 19-14, 15**



DISCUSSION: Ask students why diesel engine doesn't generate enough vacuum to operate a vacuum-controlled device. (ANS: to generate vacuum in an engine, you need a restriction to incoming air such as a throttle plate. Since MOST diesels do not have throttle plate, there is no restriction to incoming air and very little vacuum is created OR is there a way to retain vacuum)



16. SLIDE 16 **EXPLAIN** FIGURE 19-15 schematic of a typical glow plug circuit.

17. SLIDE 17 **EXPLAIN** FIGURE 19-16 The intake heater grid is used to warm the intake air and increase pre-ignition temperatures. The heater may continue to be cycled to decrease the amount of time needed to warm the engine.

18. SLIDE 18 **EXPLAIN** 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.



DEMONSTRATION: Show the students an example of an **Accelerator Pedal Position (APP) IN Figure 19-17** sensor and how to test it using either a scan tool or a DMM

ICONS

C19 Diesel Operation & Diagnosis



19. **SLIDE 19 EXPLAIN** Figure 19-18 A Cummins diesel turbocharger is used to increase the power and torque of the engine.
20. **SLIDE 20 EXPLAIN** Figure 19-19 An air charge cooler is used to cool the compressed air.
21. **SLIDE 21 EXPLAIN** Figure 19-20 A variable vane turbocharger allows the boost to be controlled without the need of a wastegate.



Variable Vane Turbocharger (View) (Download)
Diesel Turbocharger & Intercooler (View) (Download)



22. **SLIDE 22 EXPLAIN** Figure 19-21 A cutaway showing the exhaust cooler. The cooler the exhaust is, the more effective it is in controlling NOx emissions.



DEMONSTRATION: Given a diesel engine equipped with an EGR system, point out the various components that make up the EGR system.



DISCUSSION: Ask the students how recirculating hot exhaust gases helps cool the combustion.



23. **SLIDE 23 EXPLAIN** Figure 19-22 Relative size of particulate matter to a human hair.
24. **SLIDE 24 EXPLAIN** Figure 19-23 Chemical reaction within the DOC.



DEMONSTRATION: On a newer vehicle equipped with a DOC and a DPF, point out the components on the vehicle. FIGURES 19-23 to 19-26

ICONS

C19 Diesel Operation & Diagnosis



25. **SLIDE 25 EXPLAIN FIGURE 19-24** After treatment of diesel exhaust is handled by the DOC and DPF.
26. **SLIDE 26 EXPLAIN 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.
27. **SLIDE 27 EXPLAIN Figure 19-26** EGT 1 and EGT 2 are used by the PCM to help control after treatment



DISCUSS 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. 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.



**[Diesel Particulate Filter \(View\)](#) ([Download](#))
[Diesel Exhaust Fluid \(View\)](#) ([Download](#))**



SAFETY Usually regeneration of particulate filter occurs when vehicle is driven. At times a vehicle may require regeneration in the shop. Make sure that the vehicle is parked outside away from any other vehicles before starting regeneration process.



HANDS-ON TASK: Using service information, have the students look up what symptoms would result from excessive exhaust back pressure.

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DISCUSS FREQUENTLY ASKED QUESTION: Will the Post injection 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 regeneration time period. A drop in overall fuel economy should not be noticeable.

• **SEE FIGURE 19-28**



28. SLIDE 28 **EXPLAIN** Figure 19-27 Regeneration burns the soot and renews the DPF.

29. SLIDE 29 **EXPLAIN** Figure 19-28 post injection pulse occurs to create the heat needed for regeneration



DISCUSS 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.**



30. SLIDE 30 **EXPLAIN** FIGURE 19-29 The exhaust is split into two outlets and has slits to help draw outside air in as exhaust leaves the tailpipe.



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.

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C19 Diesel Operation & Diagnosis



31. **SLIDE 31 EXPLAIN FIGURE 19-30** 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.

DEMONSTRATION: Using a scan tool on vehicle equipped with a particulate filter, show students scan tool data that relates to particulate filter regeneration

DEMONSTRATION: If you have access to a vehicle with urea injection, show students the components that comprise the urea injection system. (System introduced in the 2010 model year ON GM DURAMAX ENGINE) FIGURE 19-31










HANDS-ON TASK: Have the students search for sources and prices of diesel urea: FIGURE 19-31

Some states do random smoke tests on heavy duty diesels as part of their clean air program. If the vehicles fail this smoke test there can be heavy fines, or vehicle may be required to be parked until repaired.

32. **SLIDE 32 EXPLAIN Figure 19-31** 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

33. **SLIDE 33 EXPLAIN Figure 19-32** pressure gauge checking the fuel pressure from the lift pump on a Cummins 6.7 liter diesel.

34. **SLIDE 34 EXPLAIN Figure 19-33** compression gauge that is designed for the higher compression rate of a diesel engine should be used when checking the compression.

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	<p><u>DISCUSS CHART 19-2</u></p>
	<p><u>DEMONSTRATION:</u> Show the students how to perform diesel engine compression test</p>
	<p><u>HANDS-ON TASK:</u> Have the students perform a compression test on a diesel engine.</p>
	<p><u>DEMONSTRATION:</u> Show the students how to perform a cylinder balance test on a vehicle that is equipped with glow plugs.</p>
	<p><u>HANDS-ON TASK:</u> Have the students perform a glow plug resistance test</p>
  <p>QUESTION</p>	<p><u>DISCUSSION:</u> Ask the students why a diesel engine requires such a high fuel pressure.</p>
	<p>35. SLIDE 35 <u>EXPLAIN</u> Figure 19-34 typical pop tester used to check the spray pattern of a diesel engine injector.</p>
	<p><u>DISCUSS CHART 19-3 OPACITY TESTING</u></p>

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C19 Diesel Operation & Diagnosis



EXPLAIN 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 exact location of the leak without the engine running.



EXPLAIN TECH TIP: 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 diesel engines utilize precisely calibrated injectors that should not be mixed up during service. Each injector has its own calibration number. • **SEE FIGURE 19-35.**



36. **SLIDE 36 EXPLAIN** Figure 19-35 The letters on the side of this injector on a Cummins 6.7 liter diesel indicate the calibration number for the injector.



ON-VEHICLE ASE EDUCATION TASK

Flexible Fuel Vehicle Identification

Alternative Fuel Power and Economy Specifications

Diesel Engine Identification



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