# Automotive Engines

# Chapter 11 Diesel Engine Operation

## Opening Your Class

| KEY ELEMENT | EXAMPLES |
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| **Introduce Content** | This engine systems course or class provides complete coverage of the components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Real World Fixes, Videos, Animations, and NATEF Task Sheet references. |
| **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, which translates into more money. |
| **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.** | Explain the chapter learning objectives to the students.<br>1. Describe how the proper grade of gasoline affects engine performance.<br>2. List gasoline purchasing considerations.<br>3. Discuss how volatility affects driveability.<br>4. Explain how oxygenated fuels can reduce CO exhaust emissions.<br>5. Discuss safety precautions when working with gasoline.. |
| **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. |

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|  | **1. SLIDE 1 Ch11 DIESEL ENGINE OPERATION**<br>**2. SLIDES 2-3 EXPLAIN** OBJECTIVES & KEY TERMS |
|  | **DISCUSSION: Ask students to discuss advantages & disadvantages of diesel engines as opposed to gasoline engines. Ask students why a diesel block has to be constructed much heavier than a gasoline engine block.** |
|  | **Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/**<br>**WEB SITE REGULARLY UPDATED**<br>**VIDEOS**<br>**Engine Operation (17 Links)** |
|  | **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.** |
|  | **4. SLIDE 4 EXPLAIN** Diesel Engines<br>**5. SLIDE 5 EXPLAIN FIGURE 11-1** Diesel combustion occurs when fuel is injected into the hot, highly compressed air in the cylinder.<br>**6. SLIDE 6 EXPLAIN** Diesel Engines |
|  | **DISCUSSION: Ask the students why diesel engine does not have spark plugs. (ANS: Diesel relies on heat of compression to ignite fuel instead of spark)** |

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|  | 7. **SLIDE 7 EXPLAIN FIGURE 11-2** typical injector pump type of automotive diesel fuel–injection system<br>8. **SLIDE 8 EXPLAIN DIESEL ENGINES**<br>9. **SLIDE 9 EXPLAIN CHART 11-1** |
|  | 10. **SLIDE 10 EXPLAIN FIGURE 11-3** 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. |
|  | **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.** |
|  | 11. **SLIDE 11 EXPLAIN FIGURE 11-4** Rod/piston assembly from a 5.9 liter Cummins diesel engine used in a Dodge pickup truck. |
|  | **Show ANIMATION: DIESEL ENG OPERATION www.myautomotivelab.com**<br>http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter11_Fig_11_5/index.htm |
|  | **Show ANIMATION: Diesel 4-Stroke Cycle**<br>http://www.jameshalderman.com/animations.html#a1 |
|  | 12. **SLIDE 12 EXPLAIN FIGURE 11-5** indirect injection diesel engine uses a prechamber and a glow plug. |
|  | **DISCUSSION: Ask the students why diesel fuel does not evaporate as easily as gasoline** |
|  | **Show ANIMATION: IDI DIESEL OPERATION HPCR www.myautomotivelab.com**<br>http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A1_Animation/Chapter11_Fig_11_10/index.htm |

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|  | **13. SLIDE 13 EXPLAIN FIGURE 11-6** direct injection diesel engine injects the fuel directly into the combustion chamber. Many designs do not use a glow plug. |
|  | **Show ANIMATION: DI DIESEL OPERATION**<br>**www.myautomotivelab.com**<br>**http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A0_Animation/Chapter19_Fig_19_4/index.htm** |
|  | **14. SLIDE 14 EXPLAIN THREE PHASES OF COMBUSTION** |
|  | **15. SLIDE 15 EXPLAIN** Fuel Tank and Lift Pump & **EXPLAIN FIGURE 11-7** A fuel temperature sensor is being tested using an ice bath. |
| | **16. SLIDE 16 EXPLAIN** Injection Pump & **EXPLAIN FIGURE 11-8** A typical distributor-type diesel injection pump showing the pump, lines, and fuel filter. |
| | **17. SLIDE 17 EXPLAIN FIGURE 11-9** 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 15-9** |
|  | **DISCUSSION: Ask the students why each fuel line of a distributor-type injection system must be the same length. (Answer: To ensure that injector timing is correct)** |
|  | **18. SLIDE 18 EXPLAIN FIGURE 11-10** Overview of a computer-controlled high-pressure common rail V-8 diesel engine |
| | **19. SLIDES 19-20 EXPLAIN** Heui System |
| | **21. SLIDE 21 EXPLAIN FIGURE 11-11** 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 injector from coolant and from engine oil. |
|  | **22. SLIDE 22 EXPLAIN TECH TIP** |

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|  | **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** |
|  | **23. SLIDE 23 EXPLAIN** Diesel Injector Nozzles |
| | **24. SLIDE 24 EXPLAIN electric solenoid attached to the injector nozzle is computer controlled and opens to allow fuel to flow into the injector pressure chamber EXPLAIN FIGURE 11-12** Typical computer-controlled diesel engine fuel injectors. |
|  | **25. SLIDE 25 EXPLAIN TECH TIP** |
|  | **26. SLIDE 26 EXPLAIN FIGURE 11-13** A Duramax injector showing all the internal parts. |
|  | **DEMONSTRATION: Show the students some examples of various diesel injector nozzles. FIGURE 11-13** |
|  | **HANDS-ON TASK: Using service information, have the students research correct procedure for purging air from specific vehicle equipped with a diesel engine.** |
|  | **27. SLIDE 27 EXPLAIN** Glow Plugs **EXPLAIN FIGURE 11-14** A glow plug assortment showing the various types and sizes of glow plugs used. Always use the specified glow plugs |
| | **28. SLIDE 28 EXPLAIN FIGURE 11–15** A schematic of a typical glow plug circuit. Notice that the glow plug relay and intake air heater relay are both computer controlled |
|  | **DEMONSTRATION: Show the students some examples of glow plugs and show them how to test them with an ohmmeter. FIGURE 11-14** |
|  | **HANDS-ON TASK: Grade the students on their ability to test glow plugs and determine if they are functional FIGURE 11-14 & 15** |
|  | **29. SLIDE 29 EXPLAIN** Diesel Fuel Heaters **FIGURE 11–16** A wire-wound electric heater is used to warm the intake air on some diesel engines |

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|   | 30. **SLIDE 30** EXPLAIN Engine Driven Vacuum Pump<br>**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)** |
|  | 31. **SLIDE 31 EXPLAIN FREQUENTLY ASKED QUESTION** |
|  | 32. **SLIDE 32** EXPLAIN Diesel Fuel Heaters<br>33. **SLIDES 33** EXPLAIN **Accelerator Pedal Position Sensor &** EXPLAIN **Figure 11-17** typical accelerator pedal position (APP) sensor uses three different sensors in one package with each creating a different voltage as the accelerator is moved. |
|  | 34. **SLIDE 34** EXPLAIN Diesel Engine Turbochargers & EXPLAIN **FIGURE 11-18** Cummins diesel turbocharger is used to increase power & torque<br>35. **SLIDE 35** EXPLAIN **FIGURE 11-19** An air charge cooler is used to cool the compressed air.<br>36. **SLIDE 36** EXPLAIN **Figure 11-20** variable vane turbocharger allows the boost to be controlled without the need of a wastegate |
|  | **ANIMATION: Turbocharger Operation**<br>**http://www.jameshalderman.com/animations.html#a1** |
|  | **ANIMATION: Turbocharger Blow-Off Valve**<br>**http://www.jameshalderman.com/animations.html#a1** |
|  | **ANIMATION: Turbocharger Wastegate**<br>**http://www.jameshalderman.com/animations.html#a1** |
|   | **DEMONSTRATION: Given a diesel engine equipped with an EGR system, point out the various components that make up the EGR system.** |

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|  | **37. SLIDE 37 EXPLAIN Exhaust Gas Recirculation & EXPLAIN Figure 11-21** cutaway showing the exhaust cooler. The cooler the exhaust is, the more effective it is in controlling NOx emissions |
|   | **DISCUSSION: Ask the students how recirculating hot exhaust gases helps cool the combustion.** |
|  | **38. SLIDE 38 EXPLAIN** Diesel Particulate Matter |
|  | **39. SLIDE 39 EXPLAIN FREQUENTLY ASKED QUESTION** |
|  | **40. SLIDE 40 EXPLAIN** Diesel Oxidation Catalyst<br>**41. SLIDE 41 EXPLAIN Figure 11-22** Relative size of particulate matter to a human hair<br>**42. SLIDE 42 EXPLAIN Figure 11-23** Chemical reaction within the DOC |
|   | **DEMONSTRATION: On a newer vehicle equipped with a DOC and a DPF, point out the components on the vehicle** |
|  | **43. SLIDE 43 EXPLAIN** Diesel Exhaust Particulate Filter<br>**44. SLIDE 44 EXPLAIN FIGURE 11-24** Aftertreatment of diesel exhaust is handled by the DOC and DPF<br>**45. SLIDE 45 EXPLAIN FIGURE 11-25** The soot is trapped in the passages of the DPF. The exhaust has to flow through the sides of the trap and exit<br>**46. SLIDE 46 EXPLAIN FIGURE 11–26** EGT 1 and EGT 2 are used by the PCM to help control after treatment<br>**47. SLIDE 47 EXPLAIN FIGURE 11–27** Regeneration burns the soot and renews the DPF |
|  | **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.** |
|  | **48. SLIDE 48 EXPLAIN FREQUENTLY ASKED QUESTION** |

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|  | **49. SLIDE 49 EXPLAIN FIGURE 11–28** The post injection pulse occurs to create the heat needed for regeneration. |
|  | **50. SLIDE 50 EXPLAIN WARNING** |
|  | **51. SLIDE 51 EXPLAIN FREQUENTLY ASKED QUESTION** |
|  | **HANDS-ON TASK: Using service information, have the students look up what symptoms would result from excessive exhaust back pressure.** |
|  | **52. SLIDE 52 EXPLAIN FIGURE 11–29** 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 |
| | **53. SLIDE 53 EXPLAIN SELECTIVE CATALYTIC REDUCTION** |
| | **54. SLIDE 54 EXPLAIN FIGURE 11-30** 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 SCR (Selective catalytic reduction) |
| | **55. SLIDE 55 EXPLAIN FIGURE 11–31** 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 |
|   | **DEMONSTRATION: On a newer vehicle equipped with a DOC and a DPF, point out the components on the vehicle.** |
|  | **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.** |

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|  | **HANDS-ON TASK:** Using service information, have the students look up what symptoms would result from excessive exhaust back pressure. |
|  | **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. (This system has just been introduced in the 2010 model year ON GM DURAMAX ENGINE) |
|  | **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. (Introduced in 2010 model year GM DURAMAX ENGINE) |
|  | **HANDS-ON TASK:** Have the students search for sources and prices of diesel urea |
|  | **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.** |
|  | 56. **SLIDE 56** EXPLAIN Diesel Exhaust Smoke Diagnosis Diesel Emission Control Systems<br>57. **SLIDE** 57 EXPLAIN CHART 11-2 |
|  | **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.** |

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|  | **58. SLIDE 58 EXPLAIN FIGURE 11–32** pressure gauge checking the fuel pressure from the lift pump on a Cummins 6.7 liter diesel |
|  | **59. SLIDE 59 EXPLAIN Compression Testing**<br>**60. SLIDE 60 EXPLAIN FIGURE 11-33** compression gauge that is designed for the higher compression rate of a diesel engine should be used when checking the compression. |
|  | **DEMONSTRATION: Show the students how to perform diesel engine compression test** |
|  | **HANDS-ON TASK: Have the students perform a compression test on a diesel engine.** |
|  | **61. SLIDE 61 EXPLAIN** Glow Plug Resistance Balance Test |
|  | **DEMONSTRATION: Show the students how to perform a cylinder balance test on a vehicle that is equipped with glow plugs.** |
|  | **HANDS-ON TASK: Have the students perform a glow plug resistance test** |
|  | **DISCUSSION: Ask the students why a diesel engine requires such a high fuel pressure.** |
|  | **62. SLIDE 62 EXPLAIN FIGURE 11-34** typical pop tester used to check the spray pattern of a diesel engine injector |
|  | **63. SLIDE 63 EXPLAIN TECH TIP** |
|  | **64. SLIDE 64 EXPLAIN Diesel Emissions Testing**<br>**65. SLIDE 65 EXPLAIN Chart 19-3** An opacity test is sometimes used during a state emission test on diesel engines |

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|     | **66. SLIDE 66** EXPLAIN TECH TIP<br><br>**67. SLIDE 67** EXPLAIN **FIGURE 11–35** The letters on the side of this injector on a Cummins 6.7 liter diesel indicate the calibration number for the injector<br><br>**Talk through SUMMARY and questions**<br><br>**HOMEWORK: complete Ch11 crossword puzzle:** http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_11.pdf |