Automotive Engines
Chapter 19 Emission Control Devices
Opening Your Class

KEY ELEMENT	EXAMPLES
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 learning objectives to students. 1. Prepare for the ASE Engine Performance (A8) certification test content area "D" (Emission Control Systems). 2. Prepare for the ASE Engine Performance (A8) certification test content area "D" (Emission Control Systems). 3. Describe the purpose and function of the exhaust gas recirculation (EGR) system. 4. Explain methods for diagnosing and testing for faults in the exhaust gas recirculation system. 5. Describe the purpose and function of the positive crankcase ventilation (PCV) and the secondary air-injection (SAI) reaction systems. 6. Explain methods for diagnosing and testing faults in the PCV and SAI systems. 7. Describe the purpose and function of the catalytic converter. 8. Explain the method for diagnosing and testing the catalytic converter. 9. Describe the purpose and function of the evaporative emission control system. 10. Discuss how the evaporative emission control system is tested under OBD-II regulations. 11. Explain methods for diagnosing and testing faults in the evaporative emission control system.
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 CH19 EMISSION CONTROL DEVICES**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS UPDATED REGULARLY**
	**DEMONSTRATION: Show students basic emissions system components. Make sure students can identify components & their functions**
	**2. SLIDES 2-3 EXPLAIN OBJECTIVES & KEY TERMS** **4. SLIDE 4 EXPLAIN** INTRODUCTION **5. SLIDE 5 EXPLAIN SMOG** **6. SLIDE 6 EXPLAIN FIGURE 19-1** Notice the red-brown haze which is often over many major cities. This haze is the result of oxides or nitrogen in the atmosphere
	**DISCUSSION: Have the students discuss 3 main pollutants for which vehicles are tested. How are the main pollutants produced?**
	**DISCUSSION: Have the students discuss hydrocarbons, carbon monoxide, & oxides of Nitrogen. What are acceptable levels of each pollutant? What are units of measurement for properly tuned and running engine? What is meant by air pollution score (BIN)?**
	**Exhaust Gas Recirculation, EGR** **Show ANIMATION** **http://www.jameshalderman.com/**
	**7. SLIDES 7-8 EXPLAIN EGR** **9. SLIDE 9 EXPLAIN FIGURE 19-2** When the EGR valve opens, the exhaust gases flow through the valve and into passages in the intake manifold. **10. SLIDE 10 EXPLAIN FIGURE 19–3** A vacuum-operated EGR valve. The vacuum to the EGR valve is

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	computer controlled by the EGR valve control solenoid 11. **SLIDE 11 EXPLAIN FIGURE 19–4** An EGR valve position sensor on top of an EGR valve
	**DISCUSSION: Have the students talk about how EGR systems are designed to recirculate exhaust into the combustion chamber. What conditions must be present to allow proper engine operation while exhaust is recirculated?**
	**DEMONSTRATION: While applying vacuum using a hand-held pump, open & close a standard EGR valve so students can see diaphragm & valve operation.**
	**DEMONSTRATION: Pass around various EGR valves to the students. Point out positive and negative backpressure styles and how they vary.**
	**DEMONSTRATION: Pass around both digital and linear EGR valves for the students to see.**
	12. **SLIDE 12 EXPLAIN FIGURE 19–5** Digital EGR valve 13. **SLIDE 13 EXPLAIN FIGURE 19–6** General Motors linear EGR valve 14. **SLIDE 14 EXPLAIN FIGURE 19–7** The EGR valve pintle is pulse-width modulated and a three-wire potentiometer provides pintle-position information back to the PCM
	15. **SLIDE 15 EXPLAIN TECH TIP**
	16. **SLIDE 16 EXPLAIN OBD-II EGR MONITORING STRATEGIES** 17. **SLIDE 17 EXPLAIN FIGURE 19–8** A DPFE sensor and related components 18. **SLIDE 18 EXPLAIN FIGURE 19–9** OBD-II active test. The PCM opens the EGR valve and then monitors the MAP sensor and/or engine speed (RPM) to verify that it meets acceptable values

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	**DISCUSSION:** Have students talk about purpose of onboard diagnostic systems. How did computer control systems function prior to OBD-I? Have the students discuss OBD-I. What were some of shortcomings/problems of OBD-I?
	**HANDS-ON TASK:** Have the students locate the diagnostic link connector (DLC) on several OBD-I vehicles using component locators. Ask students to compare various locations to standardized locations on an OBD-II vehicle
	**19. SLIDE 19** EXPLAIN DIAGNOSING A DEFECTIVE EGR SYSTEM
	**20. SLIDE 20** EXPLAIN TECH TIP
	**21. SLIDE 21** EXPLAIN REAL WORLD FIX
	**22. SLIDE 22** EXPLAIN DIAGNOSING A DEFECTIVE EGR SYSTEM
	**23. SLIDE 23** EXPLAIN TECH TIP
	**24. SLIDE 24** EXPLAIN TECH TIP **FIGURE 19–10** Removing the EGR passage plugs from the intake manifold on a Honda
	25. SLIDE 25 EXPLAIN EGR DIAGNOSTIC CODES
	**26. SLIDE 26** EXPLAIN Crankcase Ventilation
	27. SLIDE 27 EXPLAIN **FIGURE 19–11** PCV valve in a cutaway valve cover, showing the baffles that prevent liquid oil from being drawn into the intake manifold**.**
	28. SLIDE 28 EXPLAIN Crankcase Ventilation & **FIGURE 19-12** Spring force, crankcase pressure, and intake manifold vacuum work together to regulate the flow rate through the PCV valve
	29. SLIDE 29 EXPLAIN **FIGURE 19–13** Air flows through the PCV valve during idle, cruising, and light-load conditions

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	30. **SLIDE 30** EXPLAIN **FIGURE 19–14** Air flows through the PCV valve during acceleration and when the engine is under a heavy load 31. **SLIDE 31** EXPLAIN **FIGURE 19–15** PCV valve operation in the event of a backfire 32. **SLIDE 32** EXPLAIN REAL WORLD FIX
	33. **SLIDE 33** EXPLAIN TECH TIP
	**Positive Crankcase Ventilation (PCV)** **Show ANIMATION** **http://www.jameshalderman.com/**
	**DEMONSTRATION: Pass around various PCV valves for the students to see. Students should understand where the PCV valve can be located on an engine**
	**DEMONSTRATION: Show the students how to check valve operation by shaking the valve**
	34. **SLIDE 34** EXPLAIN PCV SYSTEM DIAGNOSIS 35. **SLIDE 35** EXPLAIN PCV SYSTEM DIAGNOSIS & **FIGURE 19–16** Using a gauge that measures vacuum in units of inches of water to test the vacuum at the dipstick tube, being sure that the PCV system is capable of drawing a vacuum on the crankcase. Note that 28 in. of water equals 1 PSI, or about 2 in. of mercury (in. Hg) of vacuum. **FIGURE 19–17** Most PCV valves used on newer vehicles are secured with fasteners, which makes it more difficult to disconnect and therefore less likely to increase emissions
	**HANDS-ON TASK: Have the students locate PCV system components on their own vehicles. Ask them to explain how air flows through the system.**
	36. **SLIDE 36** EXPLAIN REAL WORLD FIX

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	**37. SLIDE 37 EXPLAIN FREQUENTLY ASKED QUESTION**
	**38. SLIDE 38 EXPLAIN PCV-RELATED DIAGNOSTIC TROUBLE CODE**
	**39. SLIDE 39 EXPLAIN Secondary Air Injection** **40. SLIDE 40 EXPLAIN FIGURE 19-18** typical belt-driven AIR pump. Air enters through the revolving fins behind the drive pulley. The fins act as an air filter because dirt is heavier than air, and therefore the dirt is deflected off of the fins at same time air is being drawn into the pump. **41. SLIDE 41 EXPLAIN FIGURE 19-19** external air manifold and exhaust check valve on a restored muscle car engine **42. SLIDE 42 EXPLAIN FIGURE 19–20** (a) When the engine is cold and before the oxygen sensor is hot enough to achieve closed loop, the airflow from the air pump is directed to the exhaust manifold(s) through the one-way check valves which keep the exhaust gases from entering the switching solenoids and the pump itself. (b) When the engine achieves closed loop, the air is directed to the catalytic converter. **43. SLIDE 43 EXPLAIN FIGURE 19-21** typical electric motor–driven SAI pump. This unit is on a Chevrolet Corvette and only works when the engine is cold **44. SLIDE 44 EXPLAIN CHART 19-1** **45. SLIDE 45 EXPLAIN SAI DIAGNOSTIC CHART**
	**DEMONSTRATION: Show the students various types of air injection pumps. Most belt-driven pumps can be easily disassembled to show their internal components.**
	**HANDS-ON TASK: Have the students use electronic service information COMPONENT LOCATOR to locate the secondary air-injection components on their own cars. Students should be able to identify components and explain their operation and purposes.**

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	**46. SLIDE 46 EXPLAIN Catalytic Converters** **47. SLIDE 47 EXPLAIN FIGURE 19-22** Most catalytic converters are located as close to the exhaust manifold as possible, as seen in this display of a Chevrolet Corvette. **48. SLIDE 48 EXPLAIN Catalytic Converters** **49. SLIDE 49 EXPLAIN FIGURE 19–23** typical catalytic converter with a monolithic substrate **50. SLIDE 50 EXPLAIN FIGURE 19-24** three-way catalytic converter first separates the NOx into nitrogen and oxygen and then converts HC and CO into harmless water (H2O) and carbon dioxide (CO2). The nitrogen (N) passes through the converter, exits the tailpipe, and enters the atmosphere, which is about 78% nitrogen
	**Show ANIMATION: CATALYTIC CONVERTER OPERATION: www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A16_Animation/Chapter62_Fig_62_22/index.htm
	**Catalytic Converter (2004+)** **Show ANIMATION** **http://www.jameshalderman.com/**
	**DEMONSTRATION: With vehicle on lift, show installed catalytic converters & their locations. Point out the reduction catalyst & oxidizing catalyst**
	**Because prices of precious metals used in catalytic converters have risen steeply in the past few years, these components have become popular among thieves. Owners of trucks & 4WD vehicles have returned to their parked vehicles to find that thieves have stolen their catalytic converters with battery-powered reciprocating saw. Replacements can run as high as $2,500.**

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	**51. SLIDE 51 EXPLAIN FIGURE 19–25** OBD-II catalytic converter monitor compares the signals of the upstream and downstream HO2S to determine converter efficiency
	**52. SLIDE 52 EXPLAIN FREQUENTLY ASKED QUESTION**
	**53. SLIDE 53 EXPLAIN DIAGNOSING CATALYTIC CONVERTERS**
	54. SLIDE 54 EXPLAIN FIGURE 19–26 A back pressure tool can be made by using an oxygen sensor housing and epoxy or braze to hold the tube to the housing
	55. SLIDE 55 EXPLAIN FIGURE 19–27 The temperature of the outlet should be at least 10% hotter than the temperature of the inlet. If a converter is not working, the inlet temperature will be hotter than the outlet temperature
	**DISCUSSION: Have the students discuss how often a PCM tests a catalytic converter. How is catalytic converter monitor classified? When will the monitor check the efficiency of converter? What will happen if the test fails?**
	**56. SLIDE 56 EXPLAIN TECH TIP**
	**DEMONSTRATION: Have the students talk about diagnosing catalytic converters. How are catalytic converters tested?**
	**DEMONSTRATION: Connect a digital storage oscilloscope (DSO) to an Upstream Oxygen Sensor & operate engine at normal operating temperature. Show waveform of an upstream oxygen sensor in operation**
	**Evaporative Emission Control System Show ANIMATION http://www.jameshalderman.com/**

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	**57. SLIDE 57 EXPLAIN FIGURE 19–28** Whenever replacing a catalytic converter with a universal unit, first measure the distance between the rear brick and the center of the rear oxygen sensor. Be sure that the replacement unit is installed to the same dimension
	**58. SLIDE 58 EXPLAIN TECH TIP**
	**59. SLIDE 59 EXPLAIN CATALYTIC CONVERTER REPLACEMENT GUIDELINES**
	60. SLIDE 60 EXPLAIN CATALYTIC CONVERTER DISGNOSIS GUIDE
	**61. SLIDE 61 EXPLAIN** Evaporative Emission Control System
	62. SLIDE 62 EXPLAIN FIGURE 19–29 Capless system from a Ford Flex does not use a replaceable cap; instead, it has a spring-loaded closure
	**DISCUSSION: Have the students list and describe main functions of the evaporative system & potential problems. What is the system designed to do with fuel vapors (hydrocarbons)? What are potential problems with the system?**
	**63. SLIDE 63 EXPLAIN FREQUENTLY ASKED QUESTION**
	**64. SLIDE 64 EXPLAIN Figure 32-11** charcoal canister can be located under the hood or underneath the vehicle. EVAP system includes all of the lines, hoses, and valves, plus the charcoal canister.
	**HANDS-ON TASK: STUDENTS Cut open a used evaporative canister to show the students what activated charcoal granules look like.**
	**65. SLIDE 65 EXPLAIN FIGURE 19–31** evaporative emission control system includes all of the lines, hoses, and valves, plus the charcoal canister.
	66. SLIDE 66 EXPLAIN FIGURE 19–32 typical evaporative emission control system. Note that when computer turns on canister purge solenoid valve, manifold vacuum draws any stored vapors from canister into engine. Manifold vacuum also is applied to pressure control valve. When this valve opens,

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fumes from the fuel tank are drawn into charcoal canister and eventually into engine. When solenoid valve is turned off (or engine stops and there is no manifold vacuum), pressure control valve is spring-loaded shut to keep vapors inside fuel tank from escaping to atmosphere.

DEMONSTRATION: Pass around examples of evaporative purge & vent solenoids. Show how to locate purge and vent solenoids on a vehicle using electrical component locator.

SAFETY Remind the students of extreme fire hazard of working around & servicing evaporative emission system on a vehicle. Fuel vapors are extremely explosive.

67. **SLIDE 67** EXPLAIN EVAPORATIVE EMISSION CONTROL SYSTEM CHART 19-2
68. **SLIDE 68** EXPLAIN EVAPORATIVE EMISSION CONTROL SYSTEM
69. **SLIDE 69** EXPLAIN TECH TIP

DISCUSSION: Have the students talk about fuel evaporation rates. What factors (e.g., alcohol content, temperature, atmospheric pressure, etc.) influence fuel evaporation rates?

DEMONSTRATION: Show how to use an alcohol test kit to obtain a sample of fuel from a vehicle & test for alcohol content.

70. **SLIDE 70** EXPLAIN **LEAK DETECTION PUMP SYSTEM & FIGURE 19–33** A leak detection pump (LDP) used on some Chrysler vehicles to pressurize (slightly) the fuel system to check for leaks
71. **SLIDE 71** EXPLAIN **ONBOARD REFUELING VAPOR RECOVERY FIGURE 19–34** A restricted fuel fill pipe shown on a vehicle with the interior removed
72. **SLIDE 72** EXPLAIN **STATE INSPECTION EVAP TESTS**
73. **SLIDE 73** EXPLAIN **DIAGNOSING EVAP**

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	SYSTEM FIGURE 19–35 Some vehicles will display a message if an evaporative control system leak is detected that could be the result of a loose gas cap
	**74. SLIDE 74 EXPLAIN DIAGNOSING EVAP SYSTEM & FIGURE 19–36** To test for a leak, this tester was set to the 0.02 in. hole and turned on. The ball rose in the scale on the left and the red arrow was moved to that location. When testing the system for leaks, if the ball rises higher than the arrow, then the leak is larger than 0.02 in. If the ball does not rise to the level of the arrow, the leak is smaller than 0.02 in
	75. SLIDE 75 EXPLAIN DIAGNOSING EVAP SYSTEM FIGURE 19–37 This unit is applying smoke to the fuel tank through an adapter and the leak was easily found to be the gas cap seal. **FIGURE 19–38** An emission tester that uses nitrogen to pressurize the fuel system
	76. SLIDE 76 EXPLAIN EVAPORATIVE SYSTEM MONITOR FIGURE 19–39 fuel tank pressure sensor (black unit with three wires) looks like a MAP sensor and is usually located on top of the fuel pump module (white unit)
	**77. SLIDE 77 EXPLAIN TECH TIP**
	**78. SLIDE 78 EXPLAIN TECH TIP & FIGURE 19–40** This Toyota cap has a warning. The check engine light will come on if not tightened until one click.
	79. SLIDES 79-80 EXPLAIN TYPICAL EVAP MONITOR
	**81. SLIDE 81 EXPLAIN TECH TIP**
	**82. SLIDE 82 EXPLAIN TECH TIP & FIGURE 19–41** fuel level must be between 15% and 85% before the EVAP monitor will run on most vehicles.
	83. SLIDE 83 EXPLAIN EVAP SYSTEM-RELATED DIAGNOSTIC TROUBLE CODES
	**DEMONSTRATION: Show the students how to use a vehicle underhood ECS label & wiring diagram and/or vacuum diagram to determine whether the vehicle has an enhanced or non-enhanced system.**

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	**HANDS-ON TASK:** Ask the students to identify and locate purge solenoid & evaporative canisters on their own cars using OEM service information.
	**Students can easily remember rest position of both purge & vent solenoids (normally closed & normally open, respectively) by using analogy of a home's front & back doors. Front door is usually closed, whereas back door is frequently left open.**
	**DEMONSTRATION:** Show how to leak-check an evaporative system using a smoke machine. Create a small leak by disconnecting a vacuum or vapor hose to show smoke diagnosis. FIGURES
	**ON-VEHICLE NATEF TASK** Inspect and test components and hoses of evaporative emissions control system; perform necessary action.
	**Talk through SUMMARY and questions**
	**HOMEWORK:** variables are names given to specific values.