# Advanced Engine Performance Diagnosis 6/E

## Chapter 13 Ignition System Operation

## Opening Your Class

| KEY ELEMENT | EXAMPLES |
|---|---|
| **Introduce Content** | This 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. Prepare for ASE Engine Performance (A8) certification test content area "B" (Ignition System Diagnosis and Repair).<br>2. Explain how ignition coils create 40,000 volts.<br>3. Discuss crankshaft position sensor and pickup coil operation.<br>4. Describe the operation of waste-spark and coil-on-plug ignition systems |
| **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 Advanced Engine Performance Diagnosis 6/E Chapter Images found on Jim's web site @ www.jameshalderman.com**

**LINK CHP 13: Chapter Images**

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|  | **1. SLIDE 1 CH13 Ignition System Operation** |
|  | **Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/**<br>**WEB SITE REGULARLY UPDATED** |
|  | **Videos** |
|  | **At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them**<br>**Crossword Puzzle (Microsoft Word) (PDF)**<br>**Word Search Puzzle (Microsoft Word) (PDF)** |
|  | |
|  | 2. **SLIDE 2 EXPLAIN Figure 13-1** point-type distributor from a hot rod being tested on a distributor machine. |
|  | **DEMONSTRATION: SHOW A POINT-TYPE DISTRIBUTOR. REVIEW ITS MAJOR COMPONENTS & SHOW HOW TO SET AIR GAP. SHOW MAJOR COMPONENTS OF A DISTRIBUTOR IGNITION SYSTEM.**<br>**HANDS-ON TASK: PASS AROUND POINT-TYPE DISTRIBUTOR & HAVE STUDENTS SET AIR GAP** |
|  | |
|  | 3. **SLIDE 3 EXPLAIN Figure 13-2** primary ignition system is used to trigger and therefore create the secondary (high-voltage) spark from ignition coil. Some ignition coils are electrically connected, called married (top figure) whereas others use separated primary and secondary windings, called divorced (lower figure). |
|  | **DISCUSSION: DISCUSS THE PRIMARY & SECONDARY IGNITION CIRCUITS. HOW DO 2 CIRCUITS FUNCTION INDEPENDENTLY & HOW DO** |

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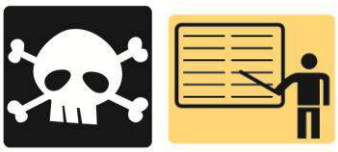
|  | **THEY INTERACT? FIGURE 13-2**<br>4. **SLIDE 4 EXPLAIN Figure 13-3** steel laminations used in an E coil helps increase the magnetic field strength, which helps the coil produce higher energy output for a more complete combustion in the cylinders.<br>5. **SLIDE 5 EXPLAIN Figure 13-4** primary windings are inside secondary windings on this General Motors coil.<br>6. **SLIDE 6 EXPLAIN Figure 13-5** primary ignition system is used to trigger and therefore create the secondary (high-voltage) spark from the ignition coil. |
|  | **DISCUSSION: HAVE THE STUDENTS TALK ABOUT IGNITION COIL OPERATION. WHAT PROCESS DOES AN IGNITION USE TO PRODUCE A HIGH-VOLTAGE SPARK FROM AN IGNITION COIL?** |
|  | **DISCUSSION: HAVE THE STUDENTS DISCUSS THE CONSTRUCTION OF AN IGNITION COIL. WHAT IS AT THE CORE OF AN IGNITION COIL? WHAT IS THE PURPOSE OF CORE? FIG 13-3. 4, & 5** |
|  | **HANDS-ON TASK: HAVE STUDENTS DISASSEMBLE OLD COILS. HAVE THEM IDENTIFY INTERNAL COMPONENTS AND POINT OUT ELECTRICAL CONNECTIONS. OPTION: STUDENTS DRAW OR DESCRIBE THE PRIMARY AND SECONDARY CIRCUITS. REFER TO FIGURES 13–3, 13–4, & 13–5 AS NEEDED.** |
|  | **EXPLAIN WARNING** |
|  | **DEMONSTRATION: REVIEW WITH STUDENTS HOW TO USE A HAND-HELD OSCILLOSCOPE (GMM), INCLUDING SETUP AND INTERPRETING WAVEFORM PATTERNS. THEN SHOW THEM HOW TO CHECK PICKUP ON AN ELECTRONIC IGNITION SYSTEM USING AN OSCILLOSCOPE** |
|  | **DISCUSSION: USING AN IGNITION SYSTEM WIRING DIAGRAM, HAVE THE STUDENTS LOCATE TRIGGERING DEVICE. HOW DOES THIS TRIGGERING DEVICE WORK?** |

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| | **HALL EFFECT SENSOR** |
| | 7. **SLIDE 7 EXPLAIN Figure 13-6** Operation of a typical pulse generator (pickup coil). At the bottom is a line drawing of a typical scope pattern of the output voltage of a pickup coil. The ICM receives this voltage from pickup coil and opens the ground circuit to the ignition coil when the voltage starts down from its peak (just as the reluctor teeth start moving away from pickup coil). |
| DEMO | **DEMONSTRATION: USING OSCILLOSCOPE, SHOW WAVEFORM PATTERN OF PULSE GENERATOR. COMPARE PATTERN WITH FIG 13–6** |
| | 8. **SLIDE 8 EXPLAIN Figure 13-7** A magnetic sensor uses a permanent magnet surrounded by a coil of wire. The notches of the crankshaft (or camshaft) create a variable magnetic field strength around the coil. When a metallic section is close to the sensor, the magnetic field is stronger because metal is a better conductor of magnetic lines of force than air. |
| | 9. **SLIDE 9 EXPLAIN Figure 13-8** A Hall-effect sensor produces an on-off voltage signal whether it is used with a blade or a notched wheel. |
| | 10. **SLIDE 10 EXPLAIN Figure 13-9** Some Hall-effect sensors look like magnetic sensors. This Hall-effect camshaft reference sensor and crankshaft position sensor have an electronic circuit built in that creates a 0 to 5 volt signal as shown at bottom. These Hall-effect sensors have 3 wires: a power supply (8 volts) from the computer (controller), a signal (0 to 5 volts), and a signal ground. |
| DEMO | **DEMONSTRATION: USING AN OSCILLOSCOPE SHOW WAVEFORM PATTERNS OF MAGNETIC SENSOR & HALL-EFFECT SENSOR. COMPARE THESE SCOPE PATTERNS WITH FIGURES 13–7 & 8** |
| QUESTION | **DISCUSSION: DISCUSS HALL EFFECT. HOW IS HALL-EFFECT SWITCH DIFFERENT FROM MAGNETIC PULSE GENERATOR? FIG 13-7 & 8** |
| | 11. **SLIDE 11 EXPLAIN Figure 13-10 (a)** Typical optical distributor. |
| | 12. **SLIDE 12 EXPLAIN Figure 13-10 (b)** Cylinder I slit |

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| | signals computer piston position for cylinder I. The 1-degree slits provide accurate engine speed information to PCM. |
|  | **EXPLAIN TECH-TIP ON PAGE 181** |
|  | **HANDS-ON TASK: HAVE STUDENTS REMOVE A DISTRIBUTOR FROM A VEHICLE WITH OPTICAL SENSOR, REVIEW SVC INFO. HAVE THEM ID DISTRIBUTOR COMPONENTS & TEST CRANK ANGLE SENSOR. HAVE THEM DISASSEMBLE DISTRIBUTOR, REMOVING SHAFT & NOTING BUSHING/BEARING & SEAL AREAS: FIGURES 13-9 & 10** |
|  | **DEMONSTRATION: SHOW HOW TO INSPECT A TORQUE CONVERTER DRIVE PLATE. HIGHLIGHT IMPORTANCE OF A THOROUGH INSPECTION TO AVOID A DRIVEABILITY CONDITION. FIGURE 13-9** |
|  | **DEMONSTRATION: SHOW HOW TO REPLACE CRANKSHAFT (CKP)/CAMSHAFT POSITION SENSORS (CMP) & MAKE ADJUSTMENTS USING A GAUGING TOOL. SHOW HOW TO MONITOR CRANKSHAFT/CAMSHAFT POSITION SENSORS USING SCAN TOOL** |
|  | **DEMONSTRATION: REVIEW CAMSHAFT & CRANKSHAFT TIMING. USE OPENED TIMING COVER TO EMPHASIZE TIMING MARKINGS AND WHAT IS HAPPENING TO PISTON & VALVE POSITIONS** |
|  | 13. **SLIDE 13 EXPLAIN Figure 13-11 light shield being installed before the rotor is attached.**<br>14. **SLIDE 14 EXPLAIN Figure 8-12** firing order is cast or stamped on the intake manifold on most engines that have a distributor ignition |
|  | **EXPLAIN TECH-TIP ON PAGE 182** |
|  | **HANDS-ON TASK: HAVE STUDENTS IDENTIFY PROPER FIRING ORDER FOR A SELECTED VEHICLE IN THE SHOP. THEN HAVE THEM VERIFY THE SPARK PLUG WIRE ROUTING. GRADE THEM** |

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| | **ON THEIR UNDERSTANDING OF WHERE TO FIND THE FIRING ORDER AND LOCATION OF THE SPARK PLUG WIRES. FIGURE 13-12** |
|  | **Waste Spark Ignition System 1**<br>**Waste Spark Ignition System 2** |
|  | **15. SLIDE 15 EXPLAIN Figure 13-13** waste-spark system fires one cylinder while its piston is on the compression stroke and into paired or companion cylinders while it is on the exhaust stroke. In a typical engine, it requires only about 2 to 3 kV to fire the cylinder on the exhaust stroke. The remaining coil energy is available to fire the spark plug under compression (typically about 8 to 12 kV). |
|  | **DEMONSTRATION: DEMO WASTE-SPARK IGNITION SYSTEM OPERATION: FIGURE 13-13** |
| | **16. SLIDE 16 EXPLAIN Figure 13-14** Typical wiring diagram of V-6 waste-spark ignition system. PCM is in control of ignition timing based on information from various engine sensors including RPM, MAP & engine coolant temperature (ECT). Timing signal is sent to module through electronic spark timing (EST) wire |
|  | **DISCUSS FREQUENTLY ASKED QUESTION** |
|  | **17. SLIDE 17 EXPLAIN Figure 13-15** The slight (5 microsecond) difference in the firing of the companion cylinders is enough time to allow the PCM to determine which cylinder is firing on the compression stroke. The compression sensing ignition (CSI) signal is then processed by the PCM which then determines which cylinder is on the compression stroke. |
|  | **EXPLAIN TECH-TIP ON PAGE 184** |
|  | **DISCUSSION: DISCUSS WASTE-SPARK IGNITION SYSTEMS. REVIEW REVERSE POLARITY THAT IS OCCURRING IN A DIS. WHAT IS PATH OF CURRENT? FIGURE 13-13, 14, 15** |

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|  | **DISCUSSION: HAVE THE STUDENTS REVIEW THE PURPOSE OF A CRANKSHAFT SENSOR (CKP). WHY IS THERE ADJUSTMENT ON SOME ENGINES?** |
|  | **DEMONSTRATION: USING IGNITION OSCILLOSCOPE, SHOW STUDENTS TYPICAL CONNECTING PROCEDURE FOR OBTAINING IGNITION PATTERNS.** |
|  | **DEMONSTRATION: SHOW LAB VEHICLE WITH AN IGNITION MODULE UNDER COIL PACK. REMOVE IGNITION MODULE & DEMO TESTING PIN LOCATIONS.** |
|  | **YOU SHOULD NOT CHECK FOR SPARK BY PULLING PLUG WIRE ON RUNNING ENGINE. IN ADDITION TO RISKING PERSONAL INJURY, YOU COULD DAMAGE OR SHORTEN ELECTRONIC IGNITION COMPONENTS LIFE. METHOD OF CHECKING FOR CYLINDER FIRING WAS USED ON OLDER SYSTEMS.** |
|  | **SHOW ANIMATION: COIL-ON-PLUG OP COIL-ON-PLUG IGNITION SYSTEM** |
|  | **18. SLIDE 18 EXPLAIN Figure 13-16** PCM uses input data from all of the engine sensors including the crankshaft position (CKP) senor and determines the optimum ignition timing, then triggers the primary ignition circuit to fire the spark plugs. |
|  | **19. SLIDE 19 EXPLAIN Figure 13-17** An overhead camshaft engine equipped with variable valve timing on both the intake and exhaust camshafts and the coil-on-plug ignition. |
| | **20. SLIDE 20 EXPLAIN Figure 13-18** Chrysler Hemi V-8 that has two spark plugs per cylinder. The coil on top of one spark plug fires that plug and, through a spark plug wire, fires a plug in the companion cylinder. |
|  | **EXPLAIN SAFETY-TIP** |
|  | **DISCUSSION: HAVE STUDENTS STUDY AND DISCUSS FIGURE 13–16. WHAT COP IGNITION SYSTEM ELIMINATE?** |

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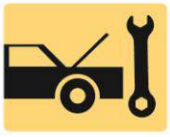
|   | **DEMONSTRATION: SHOW THE STUDENTS COP IGNITION SYSTEMS WITH 2 & 3 PRIMARY WIRES AND EXPLAIN THE DIFFERENCES.** |
|   | **DISCUSSION: HAVE STUDENTS STUDY AND DISCUSS FIGURE 13–16. WHAT DOES THE COIL-ON-PLUG (COP) IGNITION SYSTEM ELIMINATE?** |
|   | **DEMONSTRATION: SHOW THE STUDENTS COP IGNITION SYSTEMS WITH 2 & 3 PRIMARY WIRES AND EXPLAIN THE DIFFERENCES.** |
|  | 21. **SLIDE 21 EXPLAIN Figure 13-19** DC voltage is applied across the spark plug gap after the plug fires and the circuit can determine if the correct air-fuel ratio was present in the cylinder and if knock occurred. The applied voltage for **ION** sensing does not jump spark plug gap but rather determines the conductivity of the ionized gases left over from the combustion process. |
|  | **HANDS-ON TASK: HAVE STUDENTS DRAW WIRING DIAGRAMS OF 2 & 3 WIRE COP PRIMARY IGNITION SYSTEMS. GRADE THEM ON ACCURACY** |
|   | **DISCUSSION: HAVE STUDENTS STUDY FIGURE 13–19 AND DISCUSS ION-SENSING IGNITION SYSTEMS. WHAT IS PURPOSE OF MEASURING ELECTRICITY CONDUCTED BY IONIZED COMBUSTION FLAME?** |
|  | 22. **SLIDE 22 EXPLAIN Figure 13-20** typical knock sensor on side of block. Some are located in "V" of a V-type engine and are not noticeable until the intake manifold has been removed. |
|   | **DEMONSTRATION: SHOW LOCATION OF KNOCK SENSOR AND DEMONSTRATE TESTING PROCEDURE. DISCUSS KNOCK SENSOR'S PURPOSE. FIGURE 13–20** |
|  | **HANDS-ON TASK: HAVE THE STUDENTS TEST KNOCK SENSORS ON SHOP VEHICLES USING GMM & SCAN TOOL. HAVE THEM DRAW WAVEFORMS THEY DETECT TO START BUILDING A LIBRARY OF KNOWN-GOOD KNOCK SENSOR WAVEFORMS.** |

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|  | **FIGURE 13–20**<br>23. **SLIDE 23 EXPLAIN Figure 13-21** typical waveform from a knock sensor during a spark knock event. This signal is sent to the computer which in turn retards the ignition timing. This timing retard is accomplished by an output command from the computer to either a spark advance control unit or directly to the ignition module |
|  | **DISCUSSION: HAVE THE STUDENTS TALK ABOUT WHAT HAPPENS WITH SOME ENGINE COMPUTERS WHEN THEY DETECT KNOCK SENSOR SIGNALS AT IDLE SPEED. WHY SHOULD KNOCK SENSORS BE CHECKED AT OFF IDLE IN ORDER TO ISOLATE A TRUE ENGINE KNOCK CONDITION?** |
|  | **DISCUSS REAL WORLD FIX** |
|  | 24. **SLIDE 24 EXPLAIN Figure 13-22** SPOUT connector on a Ford that is equipped with a distributor ignition. This connector has to be disconnected to separate the PCM in order to set base ignition timing |
|  | **DISCUSSION: HAVE STUDENTS DISCUSS BYPASS IGNITION CONTROL. WHAT CONTROLS TIMING?** |
|  | **DISCUSSION: DISCUSS UP-INTEGRATED IGNITION CONTROL. WHAT IS DIFFERENCE BETWEEN A BYPASS IGNITION CONTROL CIRCUIT AND UPINTEGRATED IGNITION?** |
|  | **ON-VEHICLE NATEF TASK RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, SUCH AS IGNITION SYSTEM IDENTIFICATION** |