Advanced Engine Performance Diagnosis 6/E

Chapter 14 Ignition System Diagnosis

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. 1. Prepare for ASE Engine Performance (A8) certification test content area “B” (Ignition System Diagnosis and Repair). 2. Describe the procedure used to check for spark. 3. Discuss what to inspect and look for during a visual inspection of the ignition system. 4. Explain how to test pickup coils, ignition coils, and spark plug wires. 5. Discuss how to current ramp ignition coils using a low ampere current clamp and a scope. 6. Describe how to test the ignition system using an oscilloscope.
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 14: Chapter Images

ICONS	Ch14 Ignition System Diagnosis

1. **SLIDE 1 CH14 Ignition System Diagnosis**

Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/

WEB SITE REGULARLY UPDATED

Engine Controls (284 Links)

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

Crossword Puzzle (Microsoft Word) (PDF)

Word Search Puzzle (Microsoft Word) (PDF)

2. **SLIDE 2 EXPLAIN Figure 14-1** A spark tester looks like a regular spark plug with an alligator clip attached to the shell. This tester has a specified gap that requires at least 25,000 volts (25 kV) to fire.
3. **SLIDE 3 EXPLAIN Figure 14-2** A close-up showing the recessed center electrode on a spark tester. It is recessed 3/8 in. into the shell and the spark must then jump another 3/8 in. to the shell for a total gap of 3/4 in.

DEMONSTRATION: SHOW HOW TO PROPERLY USE A SPARK TESTER FIGURE 14-1 & 2 TO CHECK FOR SPARK

DISCUSSION: DISCUSS SPARK COLOR. HOW CAN SPARK COLOR BE USED TO DETERMINE SPARK QUALITY?

ON-VEHICLE NATEF TASK

MEETS NATEF TASK: SPARK PLUG SPECIFICATIONS: RESEARCH APPLICABLE VEHICLE AND SERVICE INFORMATION, SUCH AS ENGINE MANAGEMENT SYSTEM OPERATION, VEHICLE SERVICE HISTORY, SERVICE

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	PRECAUTIONS, AND TSBS **EXPLAIN TECH-TIPS** 4. **SLIDE 4 EXPLAIN Figure 14-3** Checking an ignition coil using a multimeter set to read ohms
	HANDS-ON TASK: HAVE THE STUDENTS TEST IGNITION COILS, USING OHMMETER TO DETERMINE COIL CONDITION. FIGURE 14-3
	PERFORM CAREFUL VISUAL INSPECTION OF COIL HOUSING. INSPECTION WILL HELP TO LOCATE BURN MARKS OR CRACKS THAT INDICATE A FAULTY COIL.
	ON-VEHICLE NATEF TASK: IGNITION COIL TESTING INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING AND SOLID STATE COMPONENTS; TEST IGNITION COIL (S); PERFORM NECESSARY ACTION.
	EXPLAIN TECH-TIP 5. **SLIDE 5 EXPLAIN FIGURE 14–4** If the coil is working, the end of the magnetic pickup tool will move with the changes in the magnetic field around the coil
	SAFETY HAVE STUDENTS REVIEW HAZARDS OF WORKING WITH ELECTRICAL COMPONENTS. EXPLAIN TO REDUCE CHANCES OF BEING SHOCKED, THEY SHOULD NOT HOLD/TOUCH A SPARK TESTER WHILE CHECKING FOR SPARK. FIGURE 14-4
QUESTION	**DISCUSSION: HAVE THE STUDENTS DISCUSS WHAT RESULTS FROM LOW/NO VOLTAGE TO PRIMARY SIDE OF COIL. HOW DOES LOWER-THAN-NORMAL VOLTAGE IN THE PRIMARY CIRCUIT AFFECT SECONDARY CIRCUIT?**
	6. **SLIDE 6 EXPLAIN Figure 14-5** A waveform showing the primary current flow through the primary windings of an ignition coil

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	DISCUSSION: DISCUSS WAVEFORM THAT SHOWS PRIMARY CURRENT FLOW IN **FIG 14–5**. HOW WILL **DSO**, TIME, VOLTAGE, AND CURRENT SETTINGS DIFFER WHEN CHECKING SECONDARY IGNITION CIRCUITS?
	7. **SLIDE 7 EXPLAIN Figure 14-6** Schematic of a typical waste-spark ignition system showing the location for the power feed and grounds: **EXPLAIN CHART 14-1** ignition coil ramp times vary according to the type of ignition system 8. **SLIDE 8 EXPLAIN Figure 14-7** example of a good coil current flow waveform pattern. Note the regular shape of the rise time and slope. Duration of the waveform may change as the module adjusts the dwell. The dwell is usually increased as the engine speed is increased 9. **SLIDE 9 EXPLAIN Figure 14-8 (a)** waveform pattern showing an open in the coil primary. 10. **SLIDE 10 EXPLAIN Figure 14-8 (b)** shorted coil pattern waveform
	DEMONSTRATION: SHOW HOW TO PREPARE A **DSO (DIGITAL STORAGE OSCILLOSCOPE)** TO OBTAIN PRIMARY CIRCUIT PATTERNS.
	ON-VEHICLE NATEF TASK SCOPE TESTING: INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING AND SOLID STATE COMPONENTS; TEST IGNITION COIL (S); PERFORM NECESSARY ACTION
	DISCUSSION: HAVE THE STUDENTS TALK ABOUT ANALYSIS OF WAVEFORMS. WHAT SHOULD YOU LOOK FOR WHEN ANALYZING WAVEFORMS TO DETERMINE IGNITION COIL CONDITION? **FIGURES 14-6, 7, & 8**
	DISCUSSION: DISCUSS THE DIFFERENCE BETWEEN THE TERMS **SHORTED AND OPEN**. HOW DO THESE TERMS RELATE TO COILS?
	DEMONSTRATION: SHOW STUDENTS HOW TO USE A SCAN TOOL ON A **LAB VEHICLE** TO OBTAIN ENGINE RPM.

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DISCUSSION: HAVE STUDENTS TALK ABOUT RELATIONSHIP BETWEEN **TEMPERATURE & RESISTANCE**. HOW DOES TEMPERATURE AFFECT RESISTANCE OF SENSORS AND COILS?

HANDS-ON TASK: PROVIDE THE STUDENTS WITH IGNITION COIL PRIMARY WAVEFORMS. HAVE THE STUDENTS **IDENTIFY KEY PARTS OF WAVEFORM** THAT CAN BE ANALYZED TO DETERMINE COIL CONDITION.

11. **SLIDE 11 EXPLAIN FIGURE 14–9** Measuring the resistance of an HEI pickup coil using a digital multimeter set to the ohms position. The reading on the face of the meter is 0.796 kΩ or 796 ohms in the middle of the 500- to 1,500-ohm specifications

HANDS-ON TASK: HAVE THE STUDENTS TEST A MAGNETIC SENSOR (PICKUP COIL) USING AN OHMMETER TO DETERMINE ELECTRICAL INTEGRITY OF SENSOR.

FIGURE 14-9

12. **SLIDE 12 EXPLAIN Figure 14-10** typical pickup coil showing how the waveform is created as the timer core rotates inside the pole piece.

DEMONSTRATION: SHOW HOW TO **TEST A MAGNETIC SENSOR (PICKUP COIL)** USING AN AC VOLTMETER TO DETERMINE SENSOR CONDITION **FIGURE 14-10**

13. **SLIDE 13 EXPLAIN Figure 14-11** (a) A voltage waveform of a pickup coil at low engine speed. (b) A current waveform of the current through the primary windings of the ignition coil at low engine speed. (c) A voltage waveform of a pickup coil at high speed. (d) A current waveform through the primary winding of the ignition coil at high engine speed
14. **SLIDE 14 EXPLAIN FIGURE 14–12** A diagnostic trouble code P0336 was displayed on a Tech 2 scan tool as the only code.

DISCUSSION: HAVE STUDENTS TALK ABOUT CHANGES IN **FREQUENCY**. HOW DOES **AMPLITUDE** OF AN AC SIGNAL CHANGE WITH CHANGES IN FREQUENCY? **FIGURE 14-11**

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HANDS-ON TASK: HAVE STUDENTS LOCATE AND INSPECT CKP & CMP IGNITION SENSORS TO DETERMINE TYPES OF SENSORS. CHECK THEM USING A SCAN TOOL FIGURE 14-12, 13, 14

15. **SLIDE 15 EXPLAIN FIGURE 14–13** engine started and was running, but the Tech 2 displayed zero RPM.
16. **SLIDE 16 EXPLAIN FIGURE 14–14** old crankshaft showing the reluctor notches. The damage was not visible, but the engine started each time after the crankshaft was replaced
17. **SLIDE 17 EXPLAIN Figure 14-15** The connection required to test a Hall-effect sensor. A typical waveform from a Hall-effect sensor is a digital square wave. Check service information for the signal wire location.

DISCUSSION: HAVE STUDENTS TALK ABOUT DIFFERENCE BETWEEN ANALOG & DIGITAL SIGNALS. DOES SCOPE TESTING USE AN ANALOG OR A DIGITAL SIGNAL? FIGURE 14-15

18. **SLIDE 18 EXPLAIN Figure 14-16 (a)** low-resolution signal has same # of pulses as engine has cylinders. **(b)** dual trace pattern showing both low-resolution & high-resolution signals that usually represent 1 degree of rotation

DEMONSTRATION: USE A DSO TO SHOW DIFFERENT WAVEFORMS GENERATED BY PICKUP COIL, HALL-EFFECT, AND OPTICAL SENSORS: FIGURES 14-15 & 16

EXPLAIN TECH-TIPS

19. **SLIDE 19 EXPLAIN FIGURE 14–17** track inside an ignition coil is not a short, but a low-resistance path or hole that has been burned through from the secondary wiring to the steel core.

DISCUSSION: HAVE STUDENTS DISCUSS TERM TRACKING. WHAT IS TRACKING? WHAT TYPES OF PROBLEMS DOES IT CAUSE? HOW CAN IT BE FOUND FIGURE 14-17

EXPLAIN TECH-TIP

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	DISCUSSION: **HAVE THE STUDENTS DISCUSS THE PURPOSE OF "SUPPRESSION" WIRES. HOW DO THEY WORK?**
	20. **SLIDE 20 EXPLAIN Figure 14-18** Corroded terminals on a waste-spark coil can cause misfire diagnostic trouble codes to be set. 21. **SLIDE 21 EXPLAIN Figure 14-19** This spark plug boot on an overhead camshaft engine has been arcing to the valve cover causing a misfire to occur
	HANDS-ON TASK: **HAVE THE STUDENTS REMOVE SPARK PLUG WIRES TO INSPECT FOR EVIDENCE OF SPARK LEAKAGE. MAKE SURE WIRES ARE REINSTALLED CORRECTLY, FOLLOWING PROPER ROUTING & USE OF WIRE SEPARATORS. CHECK FOR CORROSION FIGURE 14-18**
	22. **SLIDE 22 EXPLAIN Figure 14-20** Measuring the resistance of a spark plug wire with a multimeter set to the ohms position. The reading of 16.03 kΩ (16.03 ohms) is okay because the wire is about 2 ft long. Maximum allowable resistance for a spark plug wire this long would be 20 kΩ (20,000 ohms). 23. **SLIDE 23 EXPLAIN Figure 14-21** Spark plug wire boot pliers are a handy addition to any tool box
	HANDS-ON TASK: **HAVE STUDENTS USE OHMMETER TO TEST SPARK PLUG WIRES FOR CONTINUITY AND COMPARE COLLECTED VALUES TO SPECIFICATIONS TO DETERMINE CONDITION. FIGURE 149-19/20/21/22**
	EXPLAIN TECH-TIP 24. **SLIDE 24 EXPLAIN FIGURE 14–22** A water spray bottle is an excellent diagnostic tool to help find an intermittent engine misfire caused by a break in a secondary ignition circuit component
	25. **SLIDE 25 EXPLAIN Figure 14-23** Parts of spark plug. 26. **SLIDE 26 EXPLAIN Figure 14-24** The heat range of a spark plug is determined by the distance the heat flows from the tip to the cylinder head

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DISCUSSION: HAVE STUDENTS DISCUSS SPARK PLUG HEAT RANGE & HOW IT AFFECTS ENGINE OPERATION AND EMISSIONS. IS IT EVER ACCEPTABLE OR BENEFICIAL TO VARY FROM OEM RECOMMENDATIONS?

FIGURES 14-23 & 24

BE SURE TO CHECK THE REACH OF ANY NEW SPARK PLUGS BEING INSTALLED. INSTALLING SPARK PLUGS WITH THE WRONG REACH INTO AN ENGINE MAY CAUSE SEVERE ENGINE DAMAGE.

27. **SLIDE 27 EXPLAIN Figure 14-25** When removing spark plugs, it is wise to arrange them so that they can be compared and any problem can be identified with a particular cylinder.

DISCUSSION: DISCUSS IMPORTANCE OF KEEPING SPARK PLUGS IN CORRECT ORDER DURING REMOVAL. HOW CAN THE SPARK PLUGS HELP TO DIAGNOSE ENGINE OPERATING CONDITION? FIGURE 9-25

28. **SLIDE 28 EXPLAIN Figure 14-26** A spark plug thread chaser is a low-cost tool that hopefully will not be used often, but is necessary in order to clean the threads before installing new spark plugs

DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE STEPS FOR REPLACING SPARK PLUGS. WHY SHOULD THE ENGINE BE ALLOWED TO COOL BEFORE REMOVING SPARK PLUGS? FIG 14-26

HANDS-ON TASK: HAVE THE STUDENTS GAP A SET OF SPARK PLUGS USING PROPER TOOLS.

DISCUSSION: DISUCSS OIL-FOULED SPARK PLUGS AND FUEL- OR CARBON-FOULED SPARK PLUGS. WILL CHANGING FOULED SPARK PLUGS PROVIDE A LONG-TERM CURE FOR DRIVABILITY COMPLAINTS? FIGURES 14-27 TO 14-30

29. **SLIDE 29 EXPLAIN Figure 14-27** normally worn spark plug uses tapered platinum-tipped center electrode.
30. **SLIDE 30 EXPLAIN Figure 14-28** Spark plug removed from an engine after 500-mile race. Note clipped side (ground) electrode. Electrode design and

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narrow (0.025 in.) gap are used to ensure that a spark occurs during extremely high engine speed operation.

31. **SLIDE 31 EXPLAIN Figure 14-29** Typical worn spark plug. Notice the rounded center electrode. The deposits indicate a possible coolant usage problem.
32. **SLIDE 32 EXPLAIN Figure 14-30** New spark plug **that** was fouled by an overly rich air-fuel mixture. The engine from which this spark plug came had a defective (stuck partially open) injector on this one cylinder only & **EXPLAIN CHART 14–2** Typical spark plug installation torque.

<u>DISCUSSION:</u> DISCUSS WHY SOME SPARK PLUGS USE MULTIPLE GROUND ELECTRODES. HOW DO MULTIPLE GROUND ELECTRODES AFFECT OPERATION AND SERVICE LIFE?

<u>DISCUSSION:</u> HAVE THE STUDENTS DISCUSS THE DIFFERENCE BETWEEN BTDC & ATDC. HOW WOULD CHANGES IN IGNITION TIMING AFFECT ENGINE OPERATION?

EXPLAIN TECH-TIP

33. **SLIDE 33 EXPLAIN Figure 14-31** Ignition timing marks are found on the harmonic balancers on engines equipped with distributors that can be adjusted for timing.
34. **SLIDE 34 EXPLAIN Figure 14-32** initial (base) timing is where spark plug fires at idle speed. The PCM then advances timing based primarily on engine speed

<u>DEMONSTRATION:</u> SHOW HOW TO USE A <u>TIMING LIGHT TO CHECK AND/OR ADJUST IGNITION TIMING</u>. DEMONSTRATE FOR STUDENTS HOW TO DETERMINE WHETHER TIMING IS ADJUSTABLE. <u>FIGURE 14-31</u>

<u>HANDS-ON TASK:</u> HAVE STUDENTS RETRIEVE TIMING SPECIFICATIONS FROM VECI OR SERVICE INFORMATION. HAVE THEM FOLLOW PROCEDURE TO CORRECTLY CHECK AND <u>ADJUST IGNITION TIMING</u> <u>FIGURE 14-31</u>

35. **SLIDE 35 EXPLAIN Figure 14-33** firing order is cast or stamped on the intake manifold of most engines that have a distributor ignition.

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	DISCUSSION: HAVE THE STUDENTS DISCUSS HOW INITIAL TIMING CHANGES WITH ENGINE WEAR. CAN CHANGES BE MADE TO COMPENSATE FOR WEAR? HOW?
	DISCUSSION: HAVE THE STUDENTS DISCUSS HOW FIRING ORDER CAN BE USED TO FIND COMPANION CYLINDERS. WHERE CAN FIRING ORDER BE FOUND? **FIGURE 14-33**
	HANDS-ON TASK: PROVIDE THE STUDENTS WITH A VEHICLE THAT HAS **INCORRECT FIRING ORDER**. HAVE THEM USE SPECIFICATIONS TO INSPECT AND CORRECT FIRING ORDER. **FIGURE 14-34**
	EXPLAIN TECH-TIP 36. **SLIDE 36 EXPLAIN FIGURE 14–34** Always take the time to install spark plug wires back into the original holding brackets (wiring combs) 37. **SLIDE 37 EXPLAIN Figure 14-35** The relationship between the crankshaft position (CKP) sensor and the camshaft position (CMP) sensor is affected by wear in the timing gear and/or chain.
	DISCUSSION: DISCUSS DISTRIBUTOR INDEXING. HOW DOES INCORRECT DISTRIBUTOR INDEXING AFFECT OPERATION? **FIGURE 14-35**
	38. **SLIDE 38 EXPLAIN Figure 14-36** scan tool displays excessive cam retard on a Chevrolet pickup truck V-6. The cam retard value should be ± 2 degrees & 39. **SLIDE 39 EXPLAIN Figure 14-37** worn distributor drive gear can be the cause of an out-of-specification camshaft position (CMP) signal.
	HANDS-ON TASK: HAVE STUDENTS HOOK UP A **SCAN TOOL** TO SEE HOW IGNITION TIMING CHANGES AS ENGINE SPEED & LOAD CHANGE. **FIGURE 14-36**
	DISCUSSION: HAVE THE STUDENTS DISCUSS WHAT CAN CAUSE **NO-START CONDITION**. HOW DO YOU SYSTEMATICALLY TEST IGNITION SYSTEM COMPONENTS & CIRCUITRY TO DETERMINE CAUSE OF NO-SPARK CONDITION?

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	40. **SLIDE 40 EXPLAIN Figure 14-38** Typical engine analyzer hookup that includes a scope display. (1) Coil wire on top of distributor cap if integral type of coil; (2) number 1 spark plug connection; (3) negative side of ignition coil; (4) ground (negative) connection of battery.
	41. **SLIDE 41 EXPLAIN Figure 14-39** Clip-on adapters are used with an ignition system that uses an integral ignition coil.
	DEMONSTRATION: SHOW HOW TO PROPERLY HOOK UP AN IGNITION OSCILLOSCOPE TO CHECK SECONDARY IGNITION PATTERNS. BE SURE TO DISCUSS HOW VOLTAGE AND TIME DIVISIONS CAN BE CHANGED ON MANY SCOPES. FIGURES 149-38 & 39
	SECONDARY IGNITION SCOPE PATTERN
	DISCUSSION: HAVE THE STUDENTS DISCUSS HOW SCOPE CONNECTION POINTS DIFFER BETWEEN DISTRIBUTOR, WASTE-SPARK, AND COIL ON-PLUG SYSTEMS. ARE ANY SPECIAL ADAPTERS NEEDED? ARE THERE ANY DIFFICULTIES YOU MAY FACE WHEN TESTING DIFFERENT TYPES OF SYSTEMS? FIGURES 14-38 & 39
	42. **SLIDE 42 EXPLAIN Figure 14-40** Typical secondary ignition oscilloscope pattern.
	43. **SLIDE 43 EXPLAIN Figure 14-41** A single cylinder is shown at the top and a 4-cylinder engine at the bottom
	44. **SLIDE 44 EXPLAIN Figure 14-42** Drawing shows what is occurring electrically at each part of the scope pattern
	DISCUSSION: HAVE THE STUDENTS DISCUSS THE DIFFERENT PARTS OF A TYPICAL SECONDARY IGNITION PATTERN. WHAT DOES EACH SECTION REPRESENT? FIGURES 14-40, 41 & 42
	45. **SLIDE 45 EXPLAIN Figure 14-43** Typical secondary ignition pattern. Note the lack of firing lines on the superimposed pattern.

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	46. **SLIDE 46 EXPLAIN Figure 14-44** Raster is the best scope position to view the spark lines of all the cylinders to check for differences. Most scopes display cylinder 1 at the bottom. The other cylinders are positioned by firing order above cylinder 1.
QUESTION	**DISCUSSION: HAVE THE STUDENTS DISCUSS HOW FIRING LINE ANALYSIS CAN BE USED TO DETERMINE SECONDARY IGNITION SYSTEM COMPONENT CONDITION. WHAT ARE COMMON CAUSES OF ABNORMALLY HIGH OR LOW FIRING LINE VOLTAGE? FIGURES 14-43 & 44**
DEMO	**DEMONSTRATION: SHOW DIFFERENT IGNITION SYSTEM PATTERNS (PARADE, RASTER, SUPERIMPOSED) AND HOW THEY CAN BE USED TO DIAGNOSE SECONDARY SYSTEM CONDITION. FIGURES 14-42, 43, & 44**
	47. **SLIDE 47 EXPLAIN Figure 14-45** Display is the only position to view the firing lines of all cylinders. Cylinder 1 is displayed on the left (except for its firing line, which is shown on the right). The cylinders are displayed from left to right by firing order.
QUESTION	**DISCUSSION: DISCUSS HOW THE DISPLAY OR PARADE PATTERN CAN BE USED TO DIAGNOSE SECONDARY IGNITION SYSTEM ABNORMALITIES. HOW DOES A LEAN MIXTURE COMPARE TO RICH MIXTURE? FIGURES 14-45**
We Support ASE NATEF	**ON-VEHICLE NATEF TASK POSITION SENSOR WAVEFORM TESTING INSPECT AND TEST CRANKSHAFT (CKP) & CAMSHAFT (CMP) POSITION SENSOR (S); PERFORM NECESSARY ACTION**
	EXPLAIN CHART 14–3
	48. **SLIDE 48 EXPLAIN Figure 14-46** downward-sloping spark line usually indicates high secondary ignition system resistance or an excessively rich air-fuel mixture.
	HANDS-ON TASK: HAVE THE STUDENTS HOOK UP A SECONDARY IGNITION SCOPE AND USE DIFFERENT PATTERNS TO DETERMINE SECONDARY IGNITION SYSTEM CONDITION. FIGURE 14-46

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	DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE IMPORTANCE OF **DWELL** & FACTORS THAT AFFECT IT. HOW DOES DWELL DIFFER BETWEEN DISTRIBUTOR IGNITION, WASTE-SPARK, AND COIL-ON-PLUG SYSTEMS?
	49. **SLIDE 49 EXPLAIN Figure 14-47** An upward-sloping spark line usually indicates a mechanical engine problem or a lean air-fuel mixture.
	DISCUSSION: HAVE THE STUDENTS DISCUSS HOW FIRING VOLTAGE AFFECTS SPARK DURATION. HOW IS REQUIRED VOLTAGE AFFECTED BY A LEAN CYLINDER? **FIGURE 14-47**
	50. **SLIDE 50 EXPLAIN Figure 14-48** relationship between height of firing line and length of spark line can be illustrated using a rope. Because energy cannot be destroyed, stored energy in an ignition coil must dissipate totally, regardless of engine operating conditions
	HANDS-ON TASK: HAVE THE STUDENTS USE OSCILLOSCOPE TO PERFORM AN ACCELERATION CHECK TO DETERMINE SECONDARY IGNITION SYSTEM CONDITION.
	ON-VEHICLE NATEF TASK DIAGNOSE ELECTRONIC IGNITION-RELATED PROBLEMS; DETERMINE NECESSARY ACTION
	ON-VEHICLE NATEF TASK USING SCAN TOOL DIAGNOSE ELECTRONIC IGNITION-RELATED PROBLEMS; DETERMINE ACTION
	ON-VEHICLE NATEF TASK: IGNITION INSPECTION & TESTING: INSPECT AND TEST IGNITION PRIMARY AND SECONDARY CIRCUIT WIRING; PERFORM NECESSARY ACTION.
	ON-VEHICLE NATEF TASK: SPARK PLUG INSPECTION: INSPECT & TEST **SPARK PLUGS**
	51. **SLIDE 51 EXPLAIN Figure 14-49** A dual trace scope pattern showing both the power and the waste spark from the same coil (cylinders 1 and 6). Note that the firing line is higher on the cylinder that is under compression (power); otherwise, both patterns are almost identical

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	52. SLIDE 52 EXPLAIN Figure 14-50 A secondary waveform of a Ford 4.6 liter V-8, showing three sparks occurring at idle speed
	DISCUSSION: HAVE THE STUDENTS TALK ABOUT SCOPE-TESTING A WASTE-SPARK SYSTEM. WHY IS THE FIRING VOLTAGE MEASURED ACROSS THE WASTE CYLINDER LOWER THAN THE VOLTAGE MEASURED ACROSS POWER CYLINDER? FIGURES 14-49 & 50
	DEMONSTRATION: SHOW THE STUDENTS HOW TO PERFORM A ROTOR AIR GAP TEST TO CHECK DISTRIBUTOR CAP AND ROTOR CONDITION.
	ON-VEHICLE NATEF TASK INSPECT, TEST, AND/OR REPLACE IGNITION CONTROL MODULE, POWERTRAIN/ENGINE CONTROL MODULE; REPROGRAM AS NECESSARY
	ON-VEHICLE NATEF TASK INSPECT AND TEST CRANKSHAFT AND CAMSHAFT POSITION SENSOR(S); PERFORM NECESSARY ACTION