

Automotive Electrical & Engine Performance 8/E

Chapter 8 Automotive Wiring and Wire Repair

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Electrical & Engine Performance 8th edition provides complete coverage of automotive areas pertaining vehicle electrical systems and engine performance. 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, and Animations that are listed in this Lesson Plan. This Lesson Plan also references ASE Education (NATEF) Task Sheets available from Jim's web site.
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.	<p>Explain the chapter learning objectives to the students.</p> <ol style="list-style-type: none"> 1. Explain the purpose of ground wires, battery cables, and jumper cables. 2. Explain automotive wiring and the wire gauge systems. 3. Describe how fusible links and fuses protect circuits and wiring. 4. Discuss circuit breakers and PTC electronic circuit protection devices. 5. List the steps for performing a proper wire repair. 6. Perform solder repair of electrical wiring. 7. Explain the types of electrical conduit. <p>This chapter will help you prepare for the ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic System Diagnosis).</p>
Establish the Mood or Climate	Provide a <i>WELCOME</i> , 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 **Automotive Electrical & Engine Performance** 8th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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1. SLIDE 1 CH6 Automotive Wiring and Wire Repair



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WEB SITE IS CONSTANTLY UPDATED



Videos



At the beginning of this class, you can download the crossword puzzle & Word Search from Jim's web site to familiarize your class with terms in this chapter & then discuss them, see below:



HTTP://WWW.JAMESHALDERMAN.COM/BOOKS_A8.HTML#ANCHOR2

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CROSSWORD PUZZLE (MICROSOFT WORD) (PDF)

WORD SEARCH PUZZLE (MICROSOFT WORD) (PDF)

DISCUSS CHART 8-1 list of relative conductivity of metals, showing silver to be the best.

DISCUSS CHART 8-2 American wire gauge (AWG) number and the actual conductor diameter in inches.

DISCUSS CHART 8-3 Metric wire size in squared millimeters (mm²) conversion chart to American wire gauge (AWG).

DISCUSS CHART 8-4 Recommended AWG wire size increases as length increases because all wire has internal resistance. Longer wire is, greater resistance. The larger diameter is, lower resistance.

DISCUSS FREQUENTLY ASKED QUESTION:

WHY IS THERE A GROUND STRAP ON MY EXHAUST SYSTEM? The ground strap is only there to dissipate static electricity. Static electricity is created when the flow of the exhaust gases travels through the system. Using a ground strap connected to the exhaust system helps prevent static charge from building up,



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which could cause a spark to jump to the body or frame of the vehicle. If a vehicle is equipped with a ground strap, be sure that it is connected at both ends to help ensure long exhaust system life. If static electricity is allowed to discharge from the exhaust system to the body or frame of the vehicle, the resulting arcing points can cause rust or corrosion, shortening the life of the exhaust system. If a new exhaust system is installed, be sure to reattach the ground strap. Most vehicles also use a ground strap connected to the fuel filler tube for the same reason.

SOME WIRE GAUGES HAVE BOTH AWG & METRIC SCALES



DEMONSTRATION: SHOW STUDENTS HOW TO USE A STANDARD WIRE GAUGE

DEMONSTRATION: DISCUSS RECOMMENDATIONS SHOWN IN CHARTS 8-4, 5, & 6. WHAT IS RELATIONSHIP BETWEEN LENGTH AND RESISTANCE? WHAT IS THE RELATIONSHIP BETWEEN DIAMETER & RESISTANCE?

2. **SLIDE 2 EXPLAIN** Figure 8-1 All lights and accessories ground to body of vehicle. Body ground wires such as this one are needed to conduct all of current from these components back to negative terminal of battery. Body ground wire connects body to engine. Most battery negative cables attach to engine.
3. **SLIDE 3 EXPLAIN** Figure 8-2 Battery cables are designed to carry heavy starter current & usually 4 gauge or larger wire. This battery has a thermal blanket covering to help protect battery from high temperatures. Wiring covered with plastic conduit called split-loom tubing

DEMONSTRATION: DEMONSTRATE PROPER WAY TO ATTACH JUMPER CABLES AND DISCUSS NEED TO CHECK THE WIRE GAUGE OF JUMPER CABLES & NOT RELY ON OUTSIDE DIAMETER OF THE WIRE.

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DISCUSS FREQUENTLY ASKED QUESTION:

WHAT IS A TWISTED PAIR? A twisted pair is used to transmit low-voltage signals, using two wires that are twisted together. Electromagnetic interference can create a voltage in a wire and twisting the two signal wires cancels out the induced voltage. A twisted pair means that the two wires have at least nine turns per foot (turns per meter). A rule of thumb is a twisted pair should have one twist per inch of length.



4. SLIDE 4 **EXPLAIN** Figure 8-3 fuse panel

5. SLIDE 5 **EXPLAIN** Figure 8-4 Blade-type fuses can be tested through openings in plastic at top of fuse

6. SLIDE 6 **EXPLAIN** Figure 8-5 Three sizes of blade-type fuses: mini on the left, standard or ATO type in the center, and maxi on the right

7. SLIDE 7 **EXPLAIN** Figure 8-6 comparison of the various types of protective devices used in most vehicles.

8. SLIDE 8 **EXPLAIN** Figure 8-7 To test a fuse, use a test light to check for power at the power side of the fuse. The ignition switch and lights may have to be on before some fuses receive power. If the fuse is good, the test light should light on both sides (power side and load side) of the fuse

DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE DIFFERENT COLORS FOR AMPERAGE RATINGS. WHY ARE COLORS A GOOD IDEA?



9. SLIDE 9 **EXPLAIN** Figure 8-8 Typical blade circuit breaker fits into the same space as a blade fuse. If excessive current flows through the bimetallic strip, the strip bends and opens the contacts and stops current flow. When the circuit breaker cools, the contacts close again, completing the electrical circuit.

10. SLIDE 10 **EXPLAIN** Figure 8-9 Electrical symbols used to represent circuit breakers.

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11. **SLIDE 11 EXPLAIN Figure 8-10** (a) normal operation of a PTC circuit protector such as in a power window motor circuit showing the many conducting paths. With normal current flow, the temperature of the PTC circuit protector remains normal. (b) When current exceeds the amperage rating of the PTC circuit protector, the polymer material that makes up the electronic circuit protector increases in resistance. As shown, a high-resistance electrical path still exists even though the motor will stop operating as a result of the very low current flow through the very high resistance. The circuit protector will not reset or cool down until voltage is removed from circuit.
12. **SLIDE 12 EXPLAIN Figure 8-11** PTC circuit protectors are used extensively in the power distribution center of this Chrysler vehicle.
13. **SLIDE 13 EXPLAIN Figure 8-12** Fusible links are usually located close to battery and are usually attached to a junction block. Notice that they are only 6 to 9 in. long and feed more than one fuse from each fusible link.
14. **SLIDE 14 EXPLAIN Figure 8-13** 125 ampere rated mega fuse used to control the current from alternator



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ASE EDUCATION TASK SHEET A9: INSPECT AND TEST FUSIBLE LINKS, CIRCUIT BREAKERS, AND FUSES; DETERMINE NEEDED ACTION.

OPTIONAL HOMEWORK: USE INFORMATION IN CHART 8-4 TO CREATE A TABLE IN WHICH YOU ASSIGN RANDOM CIRCUIT LENGTHS AND AMPERAGE LOADS. HAVE STUDENTS SELECT PROPER WIRE SIZE TO SAFELY CARRY CIRCUIT LOAD. GRADE THEM ON THEIR UNDERSTANDING OF RELATIONSHIP BETWEEN WIRE SIZE AND LOAD AND THEIR SELECTION OF SIZE TO USE.

SEARCH INTERNET: HAVE STUDENTS USE INTERNET TO RESEARCH LOCATIONS OF FUSE PANELS. WHERE PANELS ARE TYPICALLY LOCATED? HAVE STUDENTS WRITE GUIDELINES FOR LOCATING FUSE PANELS
EXPLAIN TECH TIP: *Find the Root Cause*

If a mega fuse or fusible link fails, find the root cause before replacing it. A mega fuse can fail due to vibration or physical damage as a result of a collision or corrosion. Check to see if the fuse itself is loose

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and can be moved by hand. If loose, simply replace the mega fuse. If a fusible link or mega fuse has failed due to excessive current, check for evidence of a collision or any other reason that could cause an excessive amount of current to flow. This inspection should include each electrical component being supplied current from fusible link. After being sure that the root cause has been found and corrected, replace the fusible link or mega fuse.

15. SLIDE 15 **EXPLAIN** Terminals and Connectors & **EXPLAIN** Figure 8-14 Some terminals have seals attached to help seal the electrical connections.
16. SLIDE 16 **EXPLAIN** Figure 8-15 Separate a connector by opening the lock and pulling the two apart
17. SLIDE 17 **EXPLAIN** Figure 8-16 secondary locks help retain the terminals in the connector.
18. SLIDE 18 **EXPLAIN** Figure 8-17 Use small removal tool, sometimes called a pick, to release terminals from the connector.

EXPLAIN TECH TIP: *Look for "Green Crud."*

Corroded connections are major cause of intermittent electrical problems and open circuits.

Usual sequence of conditions is as follows:

1. **Heat causes expansion. This heat can be from external sources, such as connectors being too close to the exhaust system. Another possible source of heat is a poor connection at the terminal, causing a voltage drop and heat due to the electrical resistance.**
2. **Condensation occurs when a connector cools. Moisture from condensation causes rust and corrosion.**
1. **3. Water gets into connector. If corroded connectors are noticed, terminal should be cleaned and condition of electrical connection to wire terminal end(s) confirmed. Many OEMS recommend using a dielectric silicone or lithium-based grease inside connectors to prevent moisture from getting into and attacking the connector.**

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19. **SLIDE 19 EXPLAIN** Figure 8-18 Always use rosin-core solder for electrical or electronic soldering. Also, use small-diameter solder for small soldering irons. Use large-diameter solder only for large-diameter (large-gauge) wire and higher-wattage soldering irons (guns)

20. **SLIDE 20 EXPLAIN** Figure 8-19 butane-powered soldering tool. Cap has a built-in striker to light a converter in the tip of the tool. This handy soldering tool produces the equivalent of 60 watts of heat. It operates for about 1/2 hour on one charge from commonly available butane refill dispenser.



DEMONSTRATION: DEMO SEVERAL DIFFERENT TYPES OF CONNECTORS, INCLUDING THOSE WITH CONNECTOR POSITION ASSURANCE CLIPS. EXPLAIN THAT IT'S NECESSARY TO GUARANTEE THAT CONNECTORS WILL STAY TOGETHER IN SUPPLEMENTAL RESTRAINT SYSTEMS.



DEMONSTRATE REMOVAL OF TERMINALS FROM SEVERAL DIFFERENT TYPES OF CONNECTORS. MAKE SURE TO HAVE PROPER TERMINAL REMOVAL TOOLS AVAILABLE FOR TEACHING STUDENTS ABOUT DIFFERENT CONNECTORS.



21. **SLIDE 21 EXPLAIN** Figure 8-20 Notice that to create a good crimp the open part of the terminal is placed in the jaws of the crimping tool toward the anvil or the W-shape part.

22. **SLIDE 22 EXPLAIN** Figure 8-21 All hand-crimped splices or terminals should be soldered to be assured of a good electrical connection.



DISCUSSION: DISCUSS PROCESS OF SOLDERING WIRES AND THE TYPE OF SOLDER USED. WHAT DO THE PERCENTAGES OF EACH ALLOY IN A SOLDER DETERMINE?



DEMONSTRATION: DEMONSTRATE USE OF A SOLDERING IRON TO CONNECT WIRING. POINT OUT TO THE STUDENTS THAT THEY SHOULD MAKE SURE THAT THE SOLDER JOINT IS SMOOTH; OTHERWISE, A SHARP POINT COULD PUNCTURE SHRINK WRAP AND CAUSE A SHORT CIRCUIT

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23. **SLIDE 23 EXPLAIN FIGURE 8-22** A butane torch especially designed for use on heat shrink applies heat without an open flame, which could cause damage

24. **SLIDE 24 EXPLAIN Figure 8-23** typical crimp-and-seal connector. This type of connector is first lightly crimped to retain the ends of the wires and then it is heated. The tubing shrinks around the wire splice, and thermoplastic glue melts on the inside to provide an effective weather-resistant seal.

25. **SLIDE 25 EXPLAIN Figure 8-24** Heating crimp-and-seal connector melts the glue and forms an effective seal against moisture.



DISCUSS FREQUENTLY ASKED QUESTION: WHAT METHOD OF WIRE REPAIR SHOULD I USE?

OEMS recommend all wire repairs performed under hood, or where repair could be exposed to elements, be weatherproof. Most commonly recommended methods include:

- **Crimp-and-seal connector. These connectors are special and are not like low cost insulated-type crimp connectors. This type of connector is recommended by gm and others and is sealed using heat after mechanical crimp has secured the wire ends together.**
- **Solder and adhesive-lined heat shrink tubing. This method is recommended by Chrysler and it uses special heat shrink that has glue inside that melts when heated to form a sealed connection. Regular heat shrink tubing can be used inside a vehicle, but should not be used where it can be exposed to elements.**

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- **Solder and electrical tape. This is acceptable to use inside vehicle where splice is not exposed to outside elements. It is best to use a crimp and seal, even on inside of vehicle, for best results.**

26. **SLIDE 26 EXPLAIN Figure 8-25** Conduit that has a paint strip is constructed of plastic that can withstand high underhood temperatures.
27. **SLIDE 27 EXPLAIN Figure 8-26 (a)** Blue conduit is used to cover circuits that carry up to 42 volts.
28. **SLIDE 28 EXPLAIN Figure 8-26 (b)** Yellow conduit can also be used to cover 42 volt wiring.
29. **SLIDE 29 EXPLAIN Figure 8-27** Always follow OEM instructions which include use of linesman's (high-voltage) gloves if working on circuits in orange conduit.

ASE EDUCATION TASK A10. INSPECT, TEST, REPAIR, AND/OR REPLACE COMPONENTS, CONNECTORS, TERMINALS, HARNESSSES, AND WIRING IN ELECTRICAL/ELECTRONIC SYSTEMS (INCLUDING SOLDER REPAIRS); DETERMINE NEEDED ACTION.