

Automotive Electrical & Engine Performance 7/E














Chapter 38 Fuel Injection System Diagnosis & Service










Opening Your Class








KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers Automotive Electrical & Engine Performance . It correlates material to task lists specified by ASE and NATEF.
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. <ol style="list-style-type: none">1. Explain the diagnosis of electronic fuel-injection systems.2. Describe how to test for an injector pulse.3. Understand the process of checking fuel injector resistance.4. Explain how to scope-test fuel injectors and conduct pressure-drop balance and injector voltage-drop tests
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 7/E Chapter Images found on Jim's web site @ www.jameshalderman.com









LINK CHP 38: [Chapter Images](#)














ICONS	Ch38 Fuel Injection System Diagnosis &SVC
       	<p>1. SLIDE 1 CH38 Fuel Injection System Diagnosis & Service</p> <p>Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE REGULARLY UPDATED</p> <p><u>Videos</u></p> <p>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</p> <p><u>Crossword Puzzle (Microsoft Word) (PDF)</u> <u>Word Search Puzzle (Microsoft Word) (PDF)</u></p> <p>2. SLIDE 2 EXPLAIN Figure 38-1 If the vacuum hose is removed from the fuel-pressure regulator when the engine is running, the fuel pressure should increase. If it does not increase, then the fuel pump is not capable of supplying adequate pressure or the fuel-pressure regulator is defective. If gasoline is visible in the vacuum hose, the regulator is leaking and should be replaced</p>
 	<p><u>DEMONSTRATION: SHOW THE STUDENTS LOCATION OF FUEL RAIL AND PRESSURE REGULATOR ON A VEHICLE. POINT OUT VACUUM CONNECTIONS AT REGULATOR AND INTAKE MANIFOLDS. SHOW THEM FUEL INLET AND RETURN LINES AT FUEL RAIL. FIGURE 38-1</u></p>
	<p>EXPLAIN TECH-TIP</p> <p>3. SLIDE 3 EXPLAIN FIGURE 38-2 (a) A fuel-pressure graph after key on, engine off (KOEO) on a TBI system.</p>
	<p>4. SLIDE 4 EXPLAIN FIGURE 38-2 (b) Pressure drop after 10 minutes on a normal port fuel-injection system</p>
  <p>QUESTION</p>	<p><u>DISCUSSION: HAVE THE STUDENTS TALK ABOUT PORT FUEL-INJECTED ENGINES. WHY IS A FUEL PRESSURE REGULATOR NEEDED? WHY MUST PRESSURE DIFFERENTIAL BETWEEN FUEL RAIL AND INTAKE MANIFOLD REMAIN CONSTANT?</u></p>

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	<p>DISCUSSION: HAVE THE STUDENTS TALK ABOUT POSITIVE CRANKCASE VENTILATION SYSTEMS. WHAT PROBLEMS OR ISSUES CAN BE CAUSED BY A CLOGGED PCV SYSTEM? <u>FIGURE 37-2 & 3</u></p>
	<p>5. SLIDE 5 EXPLAIN Figure 37-3 clogged PCV system caused engine oil fumes to be drawn into the air cleaner assembly. This is what the technician discovered during a visual inspection on this TBI system</p>
	<p><u>DEMONSTRATION: SHOW GOOD & DEFECTIVE (OIL CONTAMINATED, BRITTLE, SOFT, OR DETERIORATED) VACUUM HOSES. SHOW HOW TO CHECK FOR INJECTOR OPERATION BY LISTENING FOR INJECTOR CLICKING WITH A</u></p>
	<p><u>STETHOSCOPE. DISCONNECT ONE INJECTOR TO SIMULATE A NONOPERATIVE CONDITION. FIGURE 37-4</u></p>
	<p><u>DISCUSSION: DISCUSS VACUUM LEAKS. WHAT EFFECT WILL A RUPTURED OR LEAKING PRESSURE REGULATOR HAVE ON ENGINE OPERATION? EXPLAIN THAT EXCESS FUEL CAN BE DRAWN INTO INTAKE MANIFOLD, RESULTING IN AN EXTREMELY RICH CONDITION THAT CAN DAMAGE CATALYTIC CONVERTER.</u></p>
	<p>EXPLAIN TECH-TIP</p>
	<p>6. SLIDE 6 EXPLAIN FIGURE 37-4 All fuel injectors should make the same sound with the engine running at idle speed. A lack of sound indicates a possible electrically open injector or a break in the wiring. A defective computer could also be the cause of a lack of clicking (pulsing) of the injectors.</p>
	<p>7. SLIDE 7 EXPLAIN FIGURE 37-5 Fuel should be heard returning to the fuel tank at the fuel return line if the fuel-pump and fuel-pressure regulator are functioning correctly.</p> <p>EXPLAIN TECH-TIP</p>
	<p>8. SLIDE 8 EXPLAIN Figure 37-6 Using scan tool to check for IAC counts or percentage as part of a diagnostic routine</p>

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	<p>DISCUSSION:HAVE THE STUDENTS DISCUSS <u>NORMAL IAC COUNTS</u>. WHAT DOES A VERY HIGH OR VERY LOW IAC COUNT (45 OR 5) INDICATE? FIGURE 37-6</p>
	<p>EXPLAIN TECH-TIP</p>
	<p>HANDS-ON TASK: HAVE STUDENTS USE <u>ON-LINE SERVICE INFORMATION</u> TO LOOK UP <u>FUEL PRESSURE SPECIFICATIONS</u> FOR THEIR OWN CARS.</p>
	<p>ON-VEHICLE NATEF TASK:DIAGNOSE HOT OR COLD <u>NO-STARTING, HARD STARTING, POOR DRIVEABILITY, INCORRECT IDLE SPEED, POOR IDLE, FLOODING, HESITATION, SURGING</u></p>
	<p>9. SLIDE 9EXPLAINFigure 37-7 Checking the fuel pressure using a fuel-pressure gauge connected to the Schrader valve.</p>
	<p>10. SLIDE 10EXPLAINFigure 37-8 Shutoff valves must be used on vehicles equipped with plastic fuel lines to isolate the cause of a pressure drop in the fuel system</p>
	<p>DEMONSTRATION:DEMONSTRATE A FUEL PRESSURE TEST WITH A PRESSURE GAUGE CONNECTED TO FUEL RAIL AND A VACUUM GAUGE CONNECTED TO INTAKE VACUUM SOURCE. HOLD THROTTLE WIDE OPEN TO DEMONSTRATE LOW VACUUM AND ITS EFFECT ON FUEL PRESSURE. REMOVE VACUUM HOSE CONNECTED TO THE PRESSURE REGULATOR TO SHOW INCREASE IN FUEL PRESSURE. FIGURES 37-7 & 8</p>
	<p>11. SLIDE 11EXPLAINFigure 37-9 (a) Noid lights are usually purchased as an assortment so that one is available for any type/size of injector wiring connector.</p>
	<p>12. SLIDE 12EXPLAIN(b)Connector is unplugged from injector and a Noid light is plugged into harness side of connector. Noid light should flash when engine is being cranked if power circuit and the pulsing to ground by the computer are functioning normally.</p>

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	<p><u>DEMONSTRATION:</u> INSTALL A <u>NOID LIGHT</u> IN INJECTOR HARNESS AND CRANK OR OPERATE ENGINE TO DEMONSTRATE LIGHT OPERATION FOR DIAGNOSIS. WHAT CAN CAUSE A NOID LIGHT NOT TO FLASH OR TO FLASH DIMLY: <u>FIGURE 37-9</u></p>
	<p><u>DISCUSSION:</u>DISCUSS FUEL-INJECTOR RESISTANCE. WHY IS INJECTOR RESISTANCE CRITICAL? <u>ASK STUDENTS TO LOOK UP INJECTOR RESISTANCE SPECIFICATIONS FOR THEIR OWN CARS.</u></p>
	<p>13. SLIDE 13 EXPLAIN Figure 37-10 Use DMM set to read DC volts to check the voltage drop of the positive circuit to the fuel injector. A reading of 0.5 volt or less is generally considered to be acceptable</p> <p>14. SLIDE 14 EXPLAIN Figure 37-11 An ohmmeter is connected to the injector electrical terminals to read injector coil resistance.</p>
 	<p><u>DEMONSTRATION:</u>SHOW HOW TO CHECK INJECTOR RESISTANCE WITH OHMMETER. HEAT INJECTOR WITH A HEAT GUN & THEN RECHECK RESISTANCE TO DEMONSTRATE HEAT RELATED CHANGE. <u>FIGURE 37-11</u>ALSO SHOW <u>VOLTAGE DROP METHOD IN FIGURE 37-10</u></p>
	<p>SOME VEHICLES ARE DESIGNED TO SHUT DOWN INJECTORS INDIVIDUALLY, OR IN GROUPS THAT CAN CAUSE A NO-START CONDITION, TO PROTECT PCM CIRCUITRY IF CURRENT IS TOO HIGH.</p>
	<p><u>DISCUSSION:</u>DISCUSS <u>RELATIONSHIP BETWEEN RESISTANCE AND AMPERAGE (OHM'S LAW).</u> HOW DOES A CHANGE IN RESISTANCE AFFECT INJECTOR OPERATION? HOW CAN A DECREASE IN RESISTANCE CAUSE DAMAGE TO INJECTOR DRIVE CIRCUITRY?</p>
 	<p><u>DEMONSTRATION:</u> SHOW HOW TO DISCONNECT INJECTORS & CHECK FOR RESISTANCE. REMIND STUDENTS THAT RESISTANCE WILL CHANGE AS INJECTOR TEMPERATURE CHANGES. AN <u>INFRARED THERMOMETER</u> CAN BE USED TO CHECK INJECTOR TEMPERATURE AND COMPARE</p>

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	<p>RESISTANCE SPECS FIGURES 37-11, 12, & 13</p> <p>15. SLIDE 15 EXPLAIN Figure 37-12 To measure fuel-injector resistance, a technician constructed a short wiring harness with a double banana plug that fits into the V and COM terminals of the meter and an injector connector at the other end. This setup makes checking resistance of fuel injectors quick and easy</p>
	<p>HANDS-ON TASK: HAVE THE STUDENTS CHECK INJECTOR RESISTANCE ON THEIR OWN CARS, STARTING WITH A COMPARISON MEASUREMENT TO SPECIFICATIONS. FIGURES 37-11, 12, & 13</p>
 <p>QUESTION</p>	<p>DISCUSSION: TALK ABOUT A PRESSURE-DROP BALANCE TEST. WHAT HAPPENS TO FUEL DELIVERY IF AN INJECTOR IS RESTRICTED? HOW WILL CHANGE IN AIR/FUEL MIXTURE IN 1 CYLINDER AFFECT ENGINE OPERATION?</p>
	<p>16. SLIDE 16 EXPLAIN Figure 37-13 (a) meter is connected to read one group of “3” 12-ohm injectors. Result should be 4 ohms & this reading is little low indicating that at least 1 injector is shorted (low resistance).</p> <p>17. SLIDE 17 EXPLAIN Figure 37-13(b) meter is connected to other group of 3 injectors and indicates that most, if not all 3, injectors are shorted. Replaced all 6 injectors and engine ran great.</p>
	<p>EXPLAIN TECH-TIP</p>
	<p>18. SLIDE 18 EXPLAIN Measuring Resistance of Individual Injectors & EXPLAIN Figure 37-14 If an injector has specified resistance, this does not mean that it is okay. This injector had specified resistance yet it did not deliver correct amount of fuel because it was clogged</p>
 <p>DEMO</p>	<p>DEMONSTRATION: SHOW EXAMPLES OF GOOD AND BAD INJECTORS. REMIND THEM THAT INJECTOR SPRAY PATTERNS CANNOT BE DETERMINED BY A VISUAL INSPECTION OF INJECTOR ALONE. FIGURE 37-14</p>
	<p>19. SLIDE 19 EXPLAIN Figure 37-15 After connecting a pressure gauge, unplug the electrical connector from an injector and attach test lead from the pulse unit to injector</p>

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 	<p><u>DEMONSTRATION: PERFORM AN INJECTOR PRESSURE BALANCE TEST. INSERT A CHECK BALL FROM A CARBURETOR OR AUTOMATIC TRANSMISSION INTO AN INJECTOR INLET PRIOR TO PERFORMING A BALANCE TEST WITH A SIMULATED PLUGGED OR RESTRICTED INJECTOR. FIGURE 37-15</u></p>
	<p>20. SLIDE 20 EXPLAIN Injector Voltage-Drop Tests & EXPLAIN Figure 37-16 An injector tester being used to check the voltage drop through the injector while the tester is sending current through the injectors. This test is used to check the coil inside the injector. This same tester can be used to check for equal pressure drop of each injector by pulsing the injector on for 500 ms</p>
 	<p><u>DEMONSTRATION: PERFORM A VOLTAGE-DROP TEST ACROSS INJECTORS. FIGURE 37-16</u></p>
 	<p><u>DISCUSSION: HAVE THE STUDENTS TALK ABOUT VOLTAGE-DROP TESTS. WHY IS THE VOLTAGE DROP ACROSS THE INJECTORS IMPORTANT? WHAT PROBLEMS OR SYMPTOMS WOULD BE PRESENT IF VOLTAGE DROP WAS HIGHER ACROSS ONE INJECTOR? FIGURE 37-16</u></p>
	<p>21. SLIDE 21 EXPLAIN Scope-Testing Fuel Injectors & EXPLAIN Figure 37-17 A digital storage oscilloscope can be easily connected to an injector by carefully back probing the electrical connector.</p> <p>22. SLIDE 22 EXPLAIN Figure 37-18 injector on-time is called the pulse width</p>
 	<p><u>DEMONSTRATION: DISPLAY INJECTOR DRIVE CIRCUIT WAVEFORM USING AN OSCILLOSCOPE. AFTER DISPLAYING WAVEFORM, MEASURE INJECTOR RESISTANCE. FIGURES 37-17 & 18</u></p>
	<p>23. SLIDE 23 EXPLAIN Figure 37-19 A typical peak-and-hold fuel-injector waveform. Most fuel injectors that measure less than 6 ohms will usually display a similar waveform</p>
 	<p><u>DEMONSTRATION: WITH A SCOPE CONNECTED TO AN INJECTOR DRIVE CIRCUIT, SHOW HOW PCM CONTROLS FUEL MIXTURE BY CHANGING INJECTOR ON-TIME WITH THE COOLANT TEMPERATURE</u></p>

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SENSOR SIGNAL WIRE OPEN AND GROUNDING. THIS PROCESS ALLOWS PCM TO THINK THE ENGINE IS OPERATING AT TEMPERATURE EXTREMES, SO IT CHANGES FUEL MIXTURE ACCORDINGLY. FIGURE 37-19

DISCUSS FREQUENTLY ASKED QUESTION

24. SLIDE 24 EXPLAIN FIGURE 37-20 set of 6 reconditioned injectors. The sixth injector is barely visible at the far right

ON-VEHICLE NATEF TASK INSPECT AND TEST FUEL INJECTORS.

ON-VEHICLE NATEF TASK FUEL INJECTOR BALANCE TEST

ON-VEHICLE NATEF TASK INJECTOR VOLTAGE WAVEFORM TEST

DISCUSSION: HAVE THE STUDENTS TALK ABOUT IDLE AIR SPEED CONTROL. WHAT IS CONTROLLED BY INCREASING OR DECREASING AMOUNT OF AIR BYPASSING THROTTLE PLATE?

25. SLIDE 25 EXPLAIN Figure 37-21 IAC controls idle speed by controlling amount of air that passes around throttle plate. More airflow results in higher idle speed.












26. SLIDE 26 EXPLAIN Figure 37-22 A typical IAC.

27. SLIDE 27 EXPLAIN Figure 37-23 Some IAC units are purchased with the housing as shown. Carbon buildup in these passages can cause a rough or unstable idling or stalling.

DEMONSTRATION: SHOW EXAMPLES OF IDLE AIR CONTROL VALVES. CONNECT IDLE AIR CONTROL VALVE TO 12 VOLT SOURCE TO DEMONSTRATE OPERATION FIG 37-21, 22, & 23

DISCUSS REAL-WORLD FIX

28. SLIDE 28 EXPLAIN FIGURE 37-24 (a) Nothing looks unusual when the hood is first opened. (b) When the cover is removed from the top of the engine, a mouse or some other animal nest is visible. The animal had already

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 	<p>eaten through a couple of injector wires. At least the cause of the intermittent misfire was discovered</p> <p><u>DEMONSTRATION: CONNECT SCAN TOOL TO A VEHICLE & OPERATE IDLE AIR CONTROL VALVE TO DEMONSTRATE ITS OPERATION. SHOW STUDENTS IDLE AIR COUNTS AS DISPLAYED ON SCAN TOOL.</u></p>
	<p><u>HANDS-ON TASK: HAVE STUDENTS REMOVE THROTTLE BODY FROM THEIR OWN CARS AND INSPECT THE IDLE AIR CONTROL VALVE PASSAGES FOR DEPOSITS, CLEANING AS NECESSARY.</u></p>
	<p><u>THROTTLE BODIES SHOULD BE REMOVED & CLEANED PERIODICALLY TO ENSURE PROPER ENGINE IDLE SPEEDS.</u></p>
	<p>29. <u>SLIDE 29 EXPLAIN</u> Figure 37-25 Checking fuel-pump volume using a hose from the outlet of the fuel-pressure regulator into a calibrated container.</p> <p>30. <u>SLIDE 30 EXPLAIN</u> Figure 37-26 Testing fuel-pump volume using a fuel-pressure gauge with a bleed hose inserted into a suitable container. The engine is running during this test</p>
 	<p><u>DEMONSTRATION: DEMONSTRATE TESTING OF FUEL PUMP VOLUME WITH A PRESSURE GAUGE CONNECTED TO A RUNNING ENGINE. FIG 37-25 & 26</u></p>
 	<p><u>SAFETY FUEL LEAKS FROM IMPROPERLY INSTALLED TEST EQUIPMENT CAN BE CATASTROPHIC. EMPHASIZE SAFETY BY DEMONSTRATING CHECKS FOR FUEL LEAKS WITH A TESTER INSTALLED, THE KEY ON, & ENGINE OFF. REMIND STUDENTS TO HAVE A FIRE EXTINGUISHER AVAILABLE BEFORE STARTING A TEST.</u></p>
  <p>QUESTION</p>	<p><u>DISCUSSION: HAVE THE STUDENTS DISCUSS FUEL PUMP VOLUME DEMANDS. WHY IS CHECKING FUEL PUMP VOLUME IMPORTANT? FIGURES 37-25 & 26</u></p>

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31. **SLIDE 31 EXPLAIN** Figure 37-27 A typical two-line cleaning machine hookup, showing an extension hose that can be used to squirt a cleaning solution into the throttle body while the engine is running on the cleaning solution and gasoline mixture. Typical two-line cleaning machines include Carbon Clean, Auto Care, Injector Test, DeCarbon, or Motor-Vac.
32. **SLIDE 32 EXPLAIN** Figure 37-28 To thoroughly clean a throttle body, it is sometimes best to remove it from the vehicle
33. **SLIDE 33 EXPLAIN** Figure 38.29 To thoroughly clean a throttle body, it is sometimes best to remove it from the vehicle.
34. **SLIDE 34 EXPLAIN** Figure 38.30 The amount each injector is able to flow is displayed in glass cylinders are each injector for a quick visual check.
35. **SLIDE 35 EXPLAIN** Figure 38.31 The line that has the yellow tag is a high-pressure line and this line must be replaced with a new part if removed even for a few minutes to gain access to another part.



DEMONSTRATION: REMOVE THROTTLE BODY TO INSPECT IT FOR CARBON DEPOSITS. CLEAN AND REINSTALL IT WITHOUT RELEARNING COMPUTER IDLE AIR CONTROL COUNTS TO DEMONSTRATE IMPROPER IDLE SPEED. PERFORM COMPUTER RELEARN ACCORDING TO SPECIFICATIONS. FIGURES 37-27 & 28








DISCUSSION: DISCUSS FUEL TRIM VALUES. WHAT HAPPENS TO LONG TERM FUEL TRIM WHEN SHORT-TERM FUEL TRIM REACHES ITS REDUCTION LIMIT? WHAT HAPPENS WHEN SHORT-TERM FUEL TRIM REACHES ENRICHMENT LIMIT? WHAT HAPPENS WHEN LONG-TERM FUEL TRIM REACHES ITS CORRECTION LIMITS?



EXPLAIN TECH-TIP



36. **SLIDES 36-53 EXPLAIN** Diagnostics Show
54. **SLIDES 54-65 EXPLAIN** FUEL INJECTOR CLEANING Show

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 		<p><u>DEMONSTRATION:</u> CONNECT A SCAN TOOL TO A RUNNING ENGINE SO STUDENTS CAN <u>VIEW LONG & SHORT-TERM FUEL TRIM VALUES.</u> CREATE RICH & LEAN CONDITIONS BY USING PROPANE ENRICHMENT & CREATING VACUUM OR AIR LEAKS. SHOW STUDENTS FUEL TRIM CORRECTIONS AS THE MIXTURE CHANGES.</p>
 		<p><u>DEMONSTRATION:</u> SHOW THE STUDENTS HOW TO <u>FIND THE FUEL PUMP RELAY</u> USING A COMPONENT LOCATOR.</p>
		<p>WHEN OEM DOES NOT PROVIDE IDENTIFICATION INFORMATION ON COVER OF RELAY BOX, RELAYS MUST BE LOCATED AND IDENTIFIED USING AN ELECTRICAL COMPONENT LOCATOR.</p>