Automotive Electrical & Engine Performance 8/E
Chapter 40 Fuel-Injection System Diagnosis & Service
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 ASEEducation (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 ASEEducation (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.	Explain learning objectives to students as listed below: 1. Explain how to check a fuel-pressure regulator. 2. Describe how to test fuel injectors. 3. Explain how to diagnose electronic fuel-injection problems. 4. Describe how to service the fuel-injection system. **This chapter will help you prepare for Engine Repair (A8) ASE certification test content area "C" (Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair).**
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 Automotive Electrical & Engine Performance 8th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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http://www.jameshalderman.com/books_a8.html#anchor2

ICONS	Ch40 Fuel-Injection System Diag & Service
	1. SLIDE 1 CH40 FUEL-INJECTION SYSTEM DIAGNOSIS & SERVICE **Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **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** **DOWNLOAD** **CROSSWORD PUZZLE (MICROSOFT WORD) (PDF)** **WORD SEARCH PUZZLE (MICROSOFT WORD) (PDF** Quick Check Injector Pulse (View) (Download) Quick Check Injector Volts (View) (Download) Test Injector Resistance (View) (Download) **2. SLIDE 2 EXPLAIN Figure 40-1** 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 **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 40-1** **DISCUSSION: DISCUSS PORT FUEL-INJECTED ENGINES. WHY IS A FUEL PRESSURE REGULATOR NEEDED? WHY MUST PRESSURE DIFFERENTIAL BETWEEN FUEL RAIL AND INTAKE MANIFOLD REMAIN CONSTANT?**

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	DISCUSSION: HAVE THE STUDENTS TALK ABOUT POSITIVE CRANKCASE VENTILATION SYSTEMS. WHAT PROBLEMS OR ISSUES CAN BE CAUSED BY A CLOGGED PCV SYSTEM? **FIGURE 40-2 & 3**
	EXPLAIN TECH TIP*: Pressure Transducer Fuel Pressure Test*: Using a pressure transducer and a graphing multimeter (GMM) or digital storage oscilloscope (DSO) allows service technician to view the fuel pressure over time. • SEE FIGURE 40–2(a). Note that the fuel pressure dropped from 15 PSI down to 6 PSI on a TBI equipped vehicle after just one minute. A normal pressure holding capability is shown in • FIGURE 40–2(b). when pressure dropped only about 10% after 10 minutes on a port–fuel–injection system.
	3. SLIDE 3 EXPLAIN **FIGURE 40–2** **(a)** fuel-pressure graph after key on, engine off (KOEO) on a TBI system. (b) Pressure drop after 10 minutes on a normal port fuel-injection system. 4. SLIDE 4 EXPLAIN **Figure 40-3** 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
	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 **STETHOSCOPE**. DISCONNECT ONE INJECTOR TO SIMULATE A NONOPERATIVE CONDITION.
	DISCUSSION: HAVE THE STUDENTS TALK ABOUT **VACUUM LEAKS.** WHAT EFFECT WILL A RUPTURED OR LEAKING PRESSURE REGULATOR HAVE ON ENGINE OPERATION? EXPLAIN THAT EXCESS FUEL CAN BE DRAWN INTO THE INTAKE MANIFOLD, RESULTING IN AN EXTREMELY RICH CONDITION THAT CAN DAMAGE CATALYTIC CONVERTER.
	EXPLAIN TECH TIP: ***Stethoscope Fuel-Injection Test:*** A commonly used test for injector operation

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	is to listen to the injector using a stethoscope with the engine operating at idle speed. • SEE FIGURE 83–4. All injectors should produce the same clicking sound. If any injector makes a clunking or rattling sound, it should be tested further or replaced. With the engine still running, place the end of the stethoscope probe to the return line from the fuel pressure regulator. • SEE FIGURE 40–5. Fuel should be heard flowing back to the fuel tank if the fuel-pump pressure is higher than the fuel-regulator pressure. If no sound of fuel is heard, then either the fuel pump or fuel-pressure regulator is at fault.
	5. **SLIDE 5** EXPLAIN **FIGURE 40-4** All fuel injectors should make the same sound with the engine running at idle speed. 6. **SLIDE 6 EXPLAIN FIGURE 40-5** Fuel should be heard returning to fuel tank at fuel return line if fuel-pump and fuel-pressure regulator are functioning correctly. 7. **SLIDE 7** EXPLAIN **FIGURE 40–6** Checking fuel pressure using a fuel-pressure gauge connected to Schrader valve.
	EXPLAIN TECH TIP *Quick and Easy Leaking Injector Test* Leaking injectors may be found by disabling the ignition, unhooking all injectors, and checking exhaust for hydrocarbons (HC), using a gas analyzer, while cranking engine (maximum HC 5 300 PPM).
	EXPLAIN TECH TIP *No Spark, No Squirt* **Most electronic fuel-injection computer systems use ignition primary (pickup coil or crank sensor) pulse as trigger for when to inject (squirt) fuel from the injectors (nozzles). If this signal is not present, no fuel is injected. Because this pulse is also necessary to trigger the module to create a spark from the coil, it can be said that "no spark" could also mean "no squirt." Therefore, if cause of a no-start condition is observed to be a lack of fuel injection, do not start testing or replacing fuel-**

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	system components until the ignition system is checked for proper operation.
QUESTION	**DISCUSSION: HAVE THE STUDENTS DISCUSS NORMAL IAC COUNTS. WHAT DOES A VERY HIGH OR VERY LOW IAC COUNT (_45 OR _5) INDICATE?**
	HANDS-ON TASK: HAVE STUDENTS USE ON-LINE SERVICE INFORMATION TO LOOK UP FUEL PRESSURE SPECIFICATIONS FOR THEIR OWN CARS.
Education Foundation	**ASEEDUCATION TASK D1 DIAGNOSE (TROUBLESHOOT) HOT OR COLD NO-STARTING, HARD STARTING, POOR DRIVEABLILITY, INCORRECT IDLE SPEED, POOR IDLE, FLOODING, HESITATION, SURGING, ENGINE MISFIRE, POWER LOSS, STALLING, POOR MILEAGE, DIESELING, AND EMISSIONS PROBLEMS; DETERMINE NEEDED ACTION.**
	8. **SLIDE 8 EXPLAIN FIGURE 40–7** Shutoff valves must be used on vehicles equipped with plastic fuel lines to isolate the cause of a pressure drop in the fuel system**.** 9. **SLIDE 9 EXPLAIN FIGURE 40–8** (a) Noid lights are usually purchased as an assortment so that one is available for any type or size of injector wiring connector. (b) The connector is unplugged from the injector and a Noid light is plugged into the injector connector. The Noid light should flash when engine is being cranked if power circuit and pulsing to ground by computer are functioning okay**.**
DEMO	**DEMONSTRATION: INSTALL A NOID LIGHT 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**
DEMO	**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.**

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	10. **SLIDE 10 EXPLAIN FIGURE 40–9** Use a DMM set to read DC volts to check voltage drop of positive circuit to the fuel injector. A reading of 0.5 volt or less is generally considered to be acceptable..
	11. **SLIDE 11 EXPLAIN FIGURE 40–10** Connections and settings necessary to measure fuel-injector resistance. **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 40-9**
	DEMONSTRATION: PERFORM A VOLTAGE-DROP TEST ACROSS INJECTORS. FIGURE 40-9
	DISCUSSION: HAVE THE STUDENTS DISCUSS FUEL-INJECTOR RESISTANCE. WHY IS INJECTOR RESISTANCE CRITICAL? ASK STUDENTS TO LOOK UP INJECTOR RESISTANCE SPECIFICATIONS FOR THEIR OWN CARS.
	12. **SLIDE 12 EXPLAIN FIGURE 40–11** 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.
	DISCUSS FREQUENTLY ASKED QUESTION: *HOW DOES THE FIAT CHRYSLER MULTIAIR SYSTEM WORK?* Some Chrysler and FIAT brand vehicles use a type of system that includes following unique features: • **ENGINE HAS ONE OVERHEAD CAMSHAFT, BUT ONLY EXHAUST CAM LOBES ACTUALLY OPEN EXHAUST VALVES.** • **INTAKE CAMSHAFT LOBES ARE USED TO PRESSURIZE ENGINE OIL, WHICH IS DIRECTED TO A SOLENOID THAT IS PWM.**

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	• OIL FROM SOLENOID IS SENT TO PISTON ON TOP OF INTAKE VALVES, WHICH ARE OPENED BY PISTON. • TIMING AND VALVE LIFT ARE DETERMINED BY PCM THAT PULSES CONTROL SOLENOID TO ALLOW OIL TO OPEN VALVE. • SEE FIGURE 40–12. Because the intake valves are opened using pressured engine oil, it is critical that the specified oil be used and changed at specified interval. Some customers complain of a "clatter" from the engine, especially at idle, which is normal for this engine and is due to operation of control solenoids.
	13. SLIDE 13 EXPLAIN FIGURE 40–12 In a multiair engine design, the exhaust valves are opened by the exhaust camshaft lobes. Intake valves are opened by the high-pressure engine oil, high pressure being produced by a lobe-actuated piston and controlled by a PCM-controlled solenoids.
	DEMONSTRATION: SHOW HOW TO CHECK INJECTOR RESISTANCE WITH OHMMETER. HEAT INJECTOR WITH A HEAT GUN & THEN RECHECK RESISTANCE TO DEMONSTRATE HEAT RELATED CHANGE.
	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.
	DISCUSSION: DISCUSS RELATIONSHIP BETWEEN RESISTANCE AND AMPERAGE (OHM'S LAW). HOW DOES A CHANGE IN RESISTANCE AFFECT INJECTOR OPERATION? HOW CAN A DECREASE IN RESISTANCE CAUSE DAMAGE TO INJECTOR DRIVE CIRCUITRY?

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	DEMONSTRATION: SHOW HOW TO DISCONNECT INJECTORS & CHECK FOR RESISTANCE. REMIND STUDENTS THAT RESISTANCE WILL CHANGE AS INJECTOR TEMPERATURE CHANGES. AN **INFRARED THERMOMETER** CAN BE USED TO CHECK INJECTOR TEMPERATURE AND COMPARE RESISTANCE SPECS
	EXPLAIN TECH TIP ***Equal Resistance Test*** All fuel injectors should measure the specified resistance. However, specification often indicates the temperature of injectors be at room temperature and, of course, varies according to temperature. Rather than waiting for all of injectors to achieve room temperature, measure resistance and check that they are all within 0.4 ohm of each other. To determine the difference, record resistance of each injector and then subtract lowest resistance reading from highest resistance reading to get difference. If more than 0.4 ohm, then further testing is needed to verify defective injector(s). • **SEE FIGURE 40–13**
	14. **SLIDE 14** EXPLAIN **FIGURE 40–13** 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.
	HANDS-ON TASK: HAVE THE STUDENTS CHECK INJECTOR RESISTANCE ON THEIR OWN CARS, STARTING WITH A COMPARISON MEASUREMENT TO SPECIFICATIONS.
	DISCUSSION: HAVE STUDENTS 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?
	15. **SLIDE 15** EXPLAIN **FIGURE 40–14** Connect a fuel-pressure gauge to the fuel rail at the Schrader valve. 16. **SLIDE 16** EXPLAIN **FIGURE 40–15** injector tester being used to check voltage drop through injector while tester is sending current through injectors. This test is used to check coil inside injector. This same tester can be

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	used to check for equal pressure drop of each injector by pulsing the injector on for 500 ms
	17. **SLIDE 17 EXPLAIN FIGURE 40–16** digital storage oscilloscope can be easily connected to an injector by carefully back-probing the electrical connector**.**
DEMO	**DEMONSTRATION: SHOW EXAMPLES OF GOOD AND BAD INJECTORS. REMIND THEM THAT INJECTOR SPRAY PATTERNS CANNOT BE DETERMINED BY A VISUAL INSPECTION OF INJECTOR ALONE.**
DEMO	**DEMONSTRATION: DISPLAY AN INJECTOR DRIVE CIRCUIT WAVEFORM USING AN OSCILLOSCOPE. AFTER DISPLAYING WAVEFORM, MEASURE INJECTOR RESISTANCE.**
	18. **SLIDE 18 EXPLAIN FIGURE 40–17** The injector on-time is called the pulse width.
DEMO	**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.**
	19. **SLIDE 19 EXPLAIN FIGURE 40–18** A typical peak-and-hold fuel-injector waveform. Most fuel injectors that measure <6 ohms usually display a similar waveform.
	20. **SLIDE 20 EXPLAIN FIGURE 40–19** A waveform of a pulse-width modulated fuel injector. At the end, when the voltage is removed, there is an inductive spike created similar to the spike created but other types of injectors.
	DISCUSS FREQUENTLY ASKED QUESTION: ***IF THREE OF SIX INJECTORS ARE DEFECTIVE, SHOULD I ALSO REPLACE THE OTHER THREE?*** **THIS IS A GOOD QUESTION. MANY SERVICE TECHNICIANS RECOMMEND" THAT THE THREE GOOD INJECTORS BE REPLACED ALONG WITH OTHER THREE THAT TESTED AS BEING DEFECTIVE. THE REASONS GIVEN BY THESE TECHNICIANS INCLUDE:**

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	• **All six injectors have been operating under same fuel, engine, and weather conditions.** • **The labor required to replace all six is just about same as replacing only 3 defective injectors.** • **Replacing all 6 at 6 same time helps ensure that all of injectors are flowing same amount of fuel so that engine is operating most efficiently. With these ideas in mind, 6 customer should be informed and offered choice. Complete sets of injectors, such as those in • FIGURE 40–20, can be purchased at a reasonable cost.**
	20. SLIDE 20 EXPLAIN **FIGURE 40–20** A set of six reconditioned injectors. The sixth injector is barely visible at the far right.
DEMO	**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 SENSOR SIGNAL WIRE OPEN AND GROUNDED. THIS PROCESS ALLOWS PCM TO THINK THE ENGINE IS OPERATING AT TEMPERATURE EXTREMES, SO IT CHANGES FUEL MIXTURE ACCORDINGLY.**
Education Foundation	**ASEEDUCATION TASK A1: IDENTIFY AND INTERPRET ENGINE PERFORMANCE CONCERNS; DETERMINE NEEDED ACTION.**
Education Foundation	**ASEEDUCATION TASK A6: PERFORM CYLINDER POWER BALANCE TEST; DETERMINE NEEDED ACTION.**

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Education Foundation	**ASEEDUCATION TASK D7: INSPECT, TEST, AND/OR REPLACE FUEL INJECTORS..**
Education Foundation	**ASEEDUCATION TASK D8. VERIFY IDLE CONTROL OPERATION.**
Education Foundation	**ASEEDUCATION TASK B2. ACCESS AND USE SERVICE INFORMATION TO PERFORM STEP-BY-STEP (TROUBLESHOOTING) DIAGNOSIS.**
Education Foundation	**ASEEDUCATION TASK B3. PERFORM ACTIVE TESTS OF ACTUATORS USING A SCAN TOOL; DETERMINE NEEDED ACTION.**
QUESTION	**DISCUSSION: TALK ABOUT IDLE AIR SPEED CONTROL. WHAT IS CONTROLLED BY INCREASING OR DECREASING AMOUNT OF AIR BYPASSING THROTTLE PLATE?**
	22. **SLIDE 22 EXPLAIN FIGURE 40–21** An IAC controls idle speed by controlling amount of air that passes around throttle plate. More airflow results in higher idle 23. **SLIDE 23 EXPLAIN FIGURE 40–22** A typical IAC. 24. **SLIDE 24 EXPLAIN FIGURE 40–23** Some IAC units are purchased with the housing, as shown. Carbon buildup in these passages can cause a rough or unstable idling or stalling.
	DISCUSS CASE STUDY: *THERE IS NO SUBSTITUTE FOR A THOROUGH VISUAL INSPECTION* **An intermittent "check engine" light and a random-misfire DTC P0300 was being diagnosed. A scan tool did not provide any help because all systems seemed to be functioning normally. Finally, technician removed engine**

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	cover and discovered nest. • SEE FIGURE 40–24. **SUMMARY:** • **Complaint—customer stated that the "check engine" light was on.** • **Cause—stored P0300 DTC was stored, indicating a random misfire had been detected, caused by an animal that had partially eaten some fuel injector wires.** • **Correction—mouse nest was removed and the wiring was repaired.**
	25. SLIDE 25 EXPLAIN FIGURE 40–24 When the cover is removed from the top of the engine, a mouse or some other animal nest is visible. The animal had already eaten through a couple of injector wires. At least cause of the intermittent misfire was discovered**.** **26. SLIDE 26 EXPLAIN FIGURE 40–25** Checking fuel-pump volume using a hose from outlet of the fuel-pressure regulator into a calibrated container**.** **27. SLIDE 27 EXPLAIN FIGURE 40–26** 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.
	DEMONSTRATION: SHOW EXAMPLES OF IDLE AIR CONTROL VALVES. CONNECT IDLE AIR CONTROL VALVE TO 12 VOLT SOURCE TO DEMONSTRATE OPERATION.
	DEMONSTRATION: CONNECT SCAN TOOL TO A VEHICLE & OPERATE IDLE AIR CONTROL VALVE TO DEMONSTRATE ITS OPERATION.
	HANDS-ON TASK: REMOVE THROTTLE BODY FROM THEIR OWN CARS AND INSPECT THE IDLE AIR CONTROL VALVE PASSAGES FOR DEPOSITS, CLEANING AS NECESSARY.
	THROTTLE BODIES SHOULD BE REMOVED AND CLEANED PERIODICALLY FOR GOOD OPERATION

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	ON-VEHICLE ASEEDUCATION TASK D6. **INSPECT THROTTLE BODY, AIR INDUCTION SYSTEM, INTAKE MANIFOLD AND GASKETS FOR VACUUM LEAKS AND/OR UNMETERED AIR.**
Education Foundation	
	28. SLIDE 28 EXPLAIN FIGURE 40–27 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. **29. SLIDE 29 EXPLAIN FIGURE 40–28** To thoroughly clean a throttle body, it is sometimes best to remove it from the vehicle check.
	EXPLAIN TECH *TIP Check the Injectors at "Bends and Ends."* Injectors that are most likely to become restricted due to clogging of filter basket screen are injectors at ends of rail, especially on returnless systems where dirt can accumulate. Also, injectors that are located at bends of fuel rail are also subject to possible clogging due dirt being deposited where fuel makes a turn in the rail. This partial clogging of injectors are often seen in returnless type fuel injection systems where fuel does not flow but instead dead-ends in the fuel rail.
	EXPLAIN TECH TIP *Use an Injector Tester* **The best way to check injectors is to remove them all from the engine and test them using an injector tester. A typical injector tester uses a special nonflammable test fluid that has the same viscosity as gasoline. The tester pulses the injectors, and the amount of fuel delivered, as well as the spray pattern, can be seen. Many testers are capable of varying the frequency of the pulse, as well as the duration, that helps find intermittent injector faults.** **• SEE FIGURE 40–29.**
	30. SLIDE 30 EXPLAIN FIGURE 40–29 The amount each injector is able to flow is displayed in glass cylinders for each injector for a quick visual check.

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DEMO	**DEMONSTRATION:** DEMONSTRATE TESTING OF FUEL PUMP VOLUME WITH A PRESSURE GAUGE CONNECTED TO A RUNNING ENGINE.
QUESTION	**DISCUSSION:** DISCUSS FUEL PUMP VOLUME DEMANDS. WHY IS CHECKING FUEL PUMP VOLUME IMPORTANT?
	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. HAVE **FIRE EXTINGUISHER AVAILABLE** BEFORE STARTING A TEST.
WARNING	BEFORE OPENING ANY PART OF HIGH-PRESSURE SECTION OF GASOLINE DIRECT INJECTION (GDI) SYSTEM, PRESSURE MUST BE BLED OFF. HIGH PRESSURES OF THIS FUEL SYSTEM CAN CAUSE INJURY OR DEATH. IF ANY OF HIGH-PRESSURE LINES ARE REMOVED, EVEN TEMPORARILY, THEY MUST BE REPLACED BECAUSE ENDS USE A BALL-FITTING THAT DEFORMS TO CREATE HIGH-PRESSURE SEAL. ONCE THIS SEAL HAS BEEN OPENED, A NEW BALL END MUST BE USED TO INSURE A PROPER SEAL. • SEE FIGURE 40–30. ALWAYS CHECK SERVICE INFORMATION FOR EXACT PROCEDURES TO FOLLOW FOR VEHICLE BEING SERVICED.
	31. **SLIDE 31** EXPLAIN **FIGURE 40–30** 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.
DEMO	**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.

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QUESTION	**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?
	32. SLIDES 32-44 OPTIONAL EXPLAIN FUEL INJECTOR CLEANING
DEMO	**DEMONSTRATION:** CONNECT SCAN TOOL TO A RUNNING ENGINE SO STUDENTS CAN **VIEW LONG & SHORT-TERM FUEL TRIM VALUES.** CREATE RICH & LEAN CONDITIONS BY USING PROPANE ENRICHMENT & CREATING VACUUM OR AIR LEAKS. SHOW STUDENTS FUEL TRIM CORRECTIONS AS THE MIXTURE CHANGES.
DEMO	**DEMONSTRATION:** SHOW THE STUDENTS HOW TO **FIND THE FUEL PUMP RELAY** USING A COMPONENT LOCATOR.
	WHEN OEM DOES NOT PROVIDE IDENTIFICATION INFORMATION ON COVER OF RELAY BOX, RELAYS MUST BE LOCATED AND IDENTIFIED USING AN ELECTRICAL COMPONENT LOCATOR.