Automotive Fuel and Emissions Control Systems 4/E

Chapter 20 Fuel Injection Components & Operation

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of **Automotive Fuel and Emissions Control Systems.** 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. 1. Describe the operation of electronic fuel-injection systems and compare speed-density and mass airflow fuel-injection-type systems. 2. Explain the operation of throttle-body injection and port fuel-injection systems. 3. Understand the purpose and function of a fuel-pressure regulator. 4. Differentiate between electronic and mechanical returnless fuel systems and discuss demand delivery systems. 5. List the types of fuel-injection systems and explain their modes of operation. 6. Understand the use of idle control and stepper motors in fuel-injection 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 Fuel & Emission Control 4th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 20: Chapter Images

ICONS	Ch20 Fuel Injection Components/Operation
	1. SLIDE 1 CH20 Fuel Injection Components/Operation
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ 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 Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF)
	2. SLIDE 2 EXPLAIN Figure 20-1 Typical port fuel-injection system, indicating the location of various components. Notice that the fuel-pressure regulator is located on the fuel return side of the system. The computer does not control fuel pressure. But does control the operation of the electric fuel pump (on most systems) and the pulsing on and off of injectors
	
	DISCUSSION: DISCUSS HOW PCM CONTROLS FUEL INJECTION SYSTEM. WHAT ARE SOME COMMON COMPONENTS OF AN ELECTRONIC FUEL-INJECTION SYSTEM? FIGURE 20-1
	DISCUSSION: DISCUSS 2 TYPES OF ELECTRONIC FUEL-INJECTION SYSTEMS. WHICH TYPE IS MORE EFFICIENT? DISCUSS DIAGRAM SHOWN IN FIG 20–1. WHY IS THE PRESSURE REGULATOR POSITIONED AFTER THE INJECTORS?
	Electronic Fuel Injection, EFI 1 Electronic Fuel Injection, EFI 2

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	**EXPLAIN TECH-TIP**
	3. **SLIDE 3 EXPLAIN Figure 20-2** dual-nozzle TBI unit on GM 4.3-L V-6 engine. Fuel is squirted above throttle plate where fuel mixes with air before entering intake manifold. 4. **SLIDE 4 EXPLAIN Figure 20-3** typical port fuel-injection system squirts fuel into low pressure (vacuum) of intake manifold, 2-3 in. (70-100 mm) from intake valve
	**DEMONSTRATION: SHOW FUEL INJECTORS. SHOW INJECTORS FOR PFI & TBI DISCUSS SIMILARITY OF INJECTORS. FIGURES 20-1 TO 20-7**
	**DISCUSSION: DISCUSS SPEED-DENSITY FUEL-INJECTION SYSTEMS. ASK THEM TO DISCUSS THE IMPORTANCE OF COOLANT TEMPERATURE & AMBIENT AIR TEMPERATURE ON THESE SYSTEMS.**
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE MASS AIRFLOW FUEL-INJECTION SYSTEM & HOW IT WORKS. HOW IS IT DIFFERENT FROM SPEED-DENSITY SYSTEM?**
	5. **SLIDE 5 EXPLAIN Figure 20-4** tension of spring in the fuel-pressure regulator determines the operating pressure on a throttle-body fuel-injection unit
	**DISCUSS FREQUENTLY ASKED QUESTION**
	6. **SLIDE 6 EXPLAIN Figure 20-5** injectors receive fuel & supported by fuel rail 7. **SLIDE 7 EXPLAIN Figure 20-6** Cross-section of a typical port fuel-injection nozzle assembly. These injectors are serviced as an assembly only; no part replacement or service is possible except for replacement of external O-ring seals
	**DEMONSTRATION: SHOW 2 VEHICLES, ONE WITH PORT FUEL INJECTION & OTHER WITH THROTTLE-BODY FUEL INJECTION. ASK STUDENTS TO EXPLAIN DIFFERENCES BETWEEN 2 SYSTEMS.**

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	8. **SLIDE 8 EXPLAIN Figure 20-7** Port fuel injectors spray atomized fuel into the intake manifold about 3 inches (75 mm) from the intake valve 9. **SLIDE 9 EXPLAIN Figure 20-8** port fuel-injected engine that is equipped with long, tuned intake manifold runners **DISCUSS FREQUENTLY ASKED QUESTION**
 	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE FIRING ORDER OF A SEQUENTIAL FUEL INJECTION SYSTEM. CAN FUEL INJECTOR FIRING TIME BE ADJUSTED LIKE IGNITION TIMING?**
	**DEMONSTRATION: SHOW INTAKE MANIFOLDS ON PORT FUEL-INJECTED VEHICLES. ALLOW THEM TO SEE LENGTHS OF THE RUNNERS. POINT OUT THAT ALL RUNNERS CAN BE THE SAME LENGTH AND CAN BE TUNED FOR OPTIMUM PERFORMANCE. FIGURE 20-8**
	**4-CYLINDER ENGINES ARE GOOD EXAMPLES FOR AN INTAKE MANIFOLD DEMONSTRATION. THESE VEHICLES USUALLY HAVE MANIFOLD RUNNERS THAT ARE EASIER TO VIEW.**
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE SENSORS THAT AFFECT FUEL PULSE WIDTH. WHAT CAN HAPPEN IF A SENSOR GIVES A FALSE READING?**
	**DEMONSTRATION: SHOW CAR WITH SEQUENTIAL FUEL INJECTION. POINT OUT DIFFERENCE IN COLOR OF WIRES TO INJECTORS.**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS THE GROUPED DOUBLE-FIRE, SIMULTANEOUS DOUBLE-FIRE, & SEQUENTIAL INJECTION FIRING CHARACTERISTICS. WHICH ONE IS THE MOST EFFICIENT?**

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	10. **SLIDE 10 EXPLAIN Figure 20-9** A typical port fuel-injected system showing a vacuum-controlled fuel-pressure regulator. 11. **SLIDE 11 EXPLAIN Figure 20-10** typical fuel-pressure regulator that has a spring that exerts 46 pounds of force against fuel. If 20 inches of vacuum are applied above the spring, the vacuum reduces the force exerted by the spring on the fuel, allowing the fuel to return to the tank at a lower pressure.
	**DEMONSTRATION: SHOW EXAMPLES OF FUEL PRESSURE REGULATORS FOR THROTTLE-BODY AND PORT FUEL INJECTION. POINT OUT VACUUM HOSE FITTING ON THE PORT FUEL INJECTION REGULATOR. FIGURES 20-9 &10**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS THE DIFFERENCES BETWEEN FUEL-PRESSURE REGULATORS AND VACUUM BIASED FUEL-PRESSURE REGULATORS. WHY IS A SECONDARY CONTROL SOURCE (VACUUM) USED WITH PORT INJECTION? FIGURES 20-9 & 10**
	**EXPLAIN TECH-TIP**
	12. **SLIDE 12 EXPLAIN FIGURE 20–11** A lack of fuel flow could be due to a restricted fuel-pressure regulator. Notice the fine screen filter. If this filter were to become clogged, higher than normal fuel pressure would occur.
	**DEMONSTRATION: EXPLAIN HOW LEAKING DIAPHRAGM CAN ALLOW FUEL TO ENTER ENGINE & CAUSE RICH CONDITION. SHOW HOW TO REMOVE VACUUM LID TO CHECK FOR PRESENCE OF FUEL. FIGURE 20-11**
	13. **SLIDE 13 EXPLAIN Figure 20-12** The fuel-pressure sensor and fuel-temperature sensor are often constructed together in one assembly to help give the PCM the needed data to control the fuel-pump speed 14. **SLIDE 14 EXPLAIN Figure 20-13** mechanical returnless fuel system. The bypass regulator in the fuel filter controls fuel line pressure.

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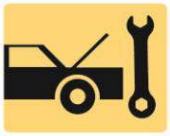
	**DISCUSSION: TALK ABOUT MECHANICAL RETURNLESS FUEL SYSTEMS FIGURE 20-13. HOW ARE THESE SYSTEMS DIFFERENT FROM ELECTRONIC RETURNLESS SYSTEMS? WHAT ARE THEIR LIMITATIONS? DISCUSS WHY THERE IS NO PRESSURE REGULATOR IN AN ELECTRONIC RETURNLESS FUEL SYSTEM. WHAT TAKES ITS PLACE?**
	15. **SLIDE 15 EXPLAIN Figure 20-14** demand delivery system uses a fuel pressure regulator attached to the fuel pump assembly
	**DISCUSSION: HAVE THE STUDENTS DISCUSS DEMAND DELIVERY SYSTEM OF FUEL DELIVERY. HOW DOES IT DIFFER FROM OTHER SYSTEMS OF FUEL DELIVERY? FIGURE 20-14**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	16. **SLIDE 16 EXPLAIN FIGURE 20–15** rectangular-shaped fuel rail is used to help dampen fuel system pulsations and noise caused by injectors opening and closing.
	**DEMONSTRATION: SHOW EXAMPLES OF ROUND & RECTANGULAR CROSS-SECTION FUEL RAILS. EXPLAIN HOW RECTANGULAR-SHAPED FUEL RAIL CAN HELP CONTROL PULSATIONS AND NOISE: FIGURE 20-15**
	**DEMONSTRATION: SHOW THE STUDENTS HOW TO USE A STETHOSCOPE TO LISTEN FOR NOISES.**
	**HANDS-ON TASK: HAVE THEM USE STETHOSCOPE TO LISTEN TO FUEL INJECTORS ON RUNNING ENGINE.**
	17. **SLIDE 17 EXPLAIN Fuel Injectors & EXPLAIN Figure 19-16** multiport fuel injector. Notice that the fuel flows straight through and does not come in contact with the coil windings.
	18. **SLIDE 18 EXPLAIN Figure 20-17** Each of 8 injectors shown are producing a correct spray pattern for the applications. While all throttle-body injectors spray a conical pattern, most port fuel injections do not.

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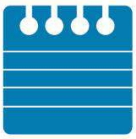
	**DEMONSTRATION: SHOW EXAMPLES OF FUEL INJECTORS, NOTE STRAINER SCREEN, SEALS, & FUEL DISCHARGE NOZZLE. SHOW CENTRAL PORT-INJECTION ASSEMBLY FROM A GM VEHICLE & POINT OUT CENTRAL INJECTOR, FUEL DISTRIBUTION TUBES, & POPPET VALVES IN EACH TUBE NOZZLE. FIG 20-16, 17 & 18**
	**DISCUSSION: HAVE STUDENTS DISCUSS FUEL INJECTORS DESIGN. DO INJECTORS THAT HAVE DISTINCTIVE SPRAY PATTERNS HAVE TO BE INSTALLED IN A SPECIFIC WAY? WHY ARE DEPOSIT-RESISTANT FUEL INJECTORS USED IN SOME APPLICATIONS? FIG 20-16, 17 & 18**
	**DISCUSS FREQUENTLY ASKED QUESTION**
	19. **SLIDE 19 EXPLAIN Central Port Injection & EXPLAIN Figure 20-18** central port fuel-injection system.
	**DEMONSTRATION: SHOW HOW TO CALCULATE INJECTOR SIZE REQUIRED FOR AN ENGINE. WORK THROUGH CALCULATIONS WITH THEM**
	20. **SLIDE 20 EXPLAIN Figure 20-19** factory replacement unit for a CSFI unit that has individual injectors at ends that go into the intake manifold instead of poppet valves
	**EGR & CRANKCASE VENTILATION VAPORS ARE USUALLY INTRODUCED NEAR THROTTLE BLADE TO BE DISTRIBUTED EQUALLY AMONG ALL CYLINDERS. THIS COMBINATION OF HOT EXHAUST & OILY VAPOR CAN CREATE DEPOSITS ON FUEL INJECTORS, ALTERING OR RESTRICTING FUEL FLOW.**
	**DISCUSSION: HAVE THE STUDENTS DISCUSS FUEL INJECTOR MODES OF OPERATION. WHAT ACTUALLY CONTROLS THESE MODES OF OPERATION?**
	**DEMONSTRATION: DEMONSTRATE CLEAR FLOOD MODE OPERATION TO THE STUDENTS. TRY THIS BEFORE CLASS TO MAKE SURE THE VEHICLE WILL COMPLY.**

ICONS	Ch20 Fuel Injection Components/Operation
	**ANIMATION:**
	IDLE AIR CONTROL, IAC
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**21. SLIDE 21 EXPLAIN Figure 20-20** The small arrows indicate the air bypassing the throttle plate in the closed throttle position. This air is called minimum air. The air flowing through the IAC (blue arrows) is the airflow that determines the idle speed
	**DISCUSSION: DISCUSS NEED FOR AN IDLE CONTROL SYSTEM ON FUEL-INJECTED ENGINE. WHAT OTHER FUNCTION CAN THIS CONTROL PERFORM? DISCUSS STEPPER MOTORS & SOLENOIDS USED FOR IDLE AIR CONTROL. WHICH OF THESE IS MORE ACCURATE? FIG 20-20**
	**22. SLIDE 22 EXPLAIN Figure 20-21** Most stepper motors use four wires, which are pulsed by the computer to rotate the armature in steps
	**DISCUSS FREQUENTLY ASKED QUESTION**
	**DEMONSTRATION: WHILE MONITORING DATA ON SCAN TOOL, START ENGINE & ALLOW STUDENTS TO SEE STEPS OR % OF IDLE AIR CONTROL PERFORMED BY PCM. SHOW EXAMPLES OF IDLE AIR CONTROL VALVES OR STEPPER MOTORS USED ON FUEL-INJECTED ENGINES.**