Light Vehicle Diesel Engines

Chapter 1 Diesel Engine Operation

Opening Your Class

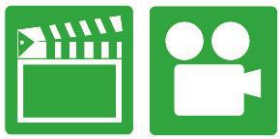
KEY ELEMENT	EXAMPLES
Introduce Content	This Light Vehicle Diesel Engines 1st text provides complete coverage of light duty diesel engine components, operation, and diagnosis. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, and Real World Fixes..www.jameshalderman.com contains Videos, Animations, and NATEF Task Sheets for use in the lab and classroom.
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.
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 as listed: 1. Prepare for the light Vehicle Diesel engine (A9) ASE certification test content area "**A**" (general Diagnosis). 2. Explain how a four-stroke cycle engine operates. 3. List the various characteristics by which vehicle engines are classified. 4. Discuss how a compression ratio is calculated. 5. Explain how engine size is determined. 6. Describe how displacement is affected by the bore and stroke of the engine
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 the 1st Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

LINK CHP 01: Diesel Engine Operation

http://www.jameshalderman.com/books_a9.html

NOTE: You can use Chapter Images or Power Point files: Though out Power Point Presentations, you will find questions and answers on slides that can be used for discussion.

ICONS	Chp01 Diesel Engine Operation
	1. SLIDE 1 Ch1 DIESEL ENGINE OPERATION
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS CONSTANTLY UPDATED **Light Diesel (111 Links)**
	http://www.jameshalderman.com/books_a9.html Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF
	**DISCUSSION:** Ask the students to discuss the advantages & disadvantages of diesel engines as opposed to gasoline engines. Ask the students why a diesel block has to be constructed much heavier than a gasoline engine block.
	Show ANIMATION: Diesel 4-Stroke Cycle (View) (Download)
	**SAFETY** Always be very careful when working on a Diesel engine that is running with air intake removed. Because most diesel ENGINES DO NOT USE a throttle plate, objects can very easily be sucked into engine, causing serious engine damage. MOST OEMs offer intake covers.

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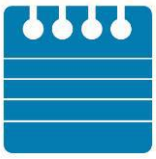
	**2. SLIDE 2 EXPLAIN FIGURE 1-1** In diesel engine downward movement of the piston draws air into cylinder through the intake valve on the intake stroke. On compression stroke, the air is compressed by the upward movement of the piston with both valves closed. Fuel is injected and ignition occurs at the beginning of the power stroke, and combustion drives the piston downward to produce power. On the exhaust stroke, the upward-moving piston forces the burned gases out the open exhaust valve.
 **INTAKE STROKE**	**INTAKE STROKE: starts with piston at top dead center (TDC). Lobe on camshaft opens intake valve Piston moves down in bore due to crankshaft rotation. As piston moves down, it pulls outside air through air cleaner and into the intake manifold past open intake valve and into cylinder. Downward movement of piston creates a low-pressure area above piston (volume increases, pressure decreases). Air rushes in to fill space left by PISTON downward movement, because atmospheric pressure is greater than pressure in cylinder. Piston tries to inhale a volume equal to its own displacement. During intake stroke, air-is inducted. Energy needed to move piston from TDC downward comes from either flywheel or overlapping power strokes. As piston nears BDC it slows down nearly to a stop. When piston reaches BDC, intake valve closes sealing cylinder & compression stroke begins.**
 **COMPRESSION**	**COMPRESSION STROKE: Turning crankshaft now forces piston upward. Both valves are closed; there is no way (except past rings) for air to get out. Volume is decreasing as piston rises, so air-is compressed. Pressure is inversely proportional to volume according to Boyle's law. In**

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STROKE Internal energy of gas is increased as heat is added to gas. Near end of compression stroke, spontaneous combustion will ignite the air/fuel after they the air mixes with the fuel after injection **VOLUME BDC** **VOLUME TDC**  **POWER STROKE** **Point where air and fuel meet is called the diffusion flame.**	**compression of a gas, volume decreases & pressure and temperature rise as external work is done on gas. Compression ratio is ratio of volume at BDC to volume at TDC (clearance volume). Higher compression ratio means higher thermal efficiency or that portion of heat supplied to engine that is turned into work. As compression ratio increases, expansion ratio also increases; thus, thermal efficiency increases.** **COMPRESSION RATIO** **POWER STROKE (COMBUSTION): The power stroke begins after diesel fuel is directly sprayed into the combustion chamber. Small droplets of fuel begin to vaporize and mix with air. After about 1 ms any zones hot enough with the correct ratio will auto-ignite. This mixture burns very rapidly and rapid burning causes a sudden rise in pressure. This highly localized pressure causes an audible noise known as diesel knock. The knock noise level depends on the speed of the pressure rise. This pressure forces the piston down in the bore, which causes crankshaft to rotate (translation to rotation). Pressure falls as volume increases. Temperature falls, as gas does external work. The Oxygen and diesel fuel burn as the Nitrogen expands and pushes piston down during power stroke. As piston continues downward, these gases in cylinder expand and cool as they give up their energy. Power stroke is only stroke in which**

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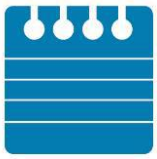 EXHAUST STROKE	**energy is used from fuel & cylinder pressure is highest.** **EXHAUST STROKE: As piston nears bottom of its travel, exhaust valve begins to open. Piston begins to rise in cylinder, beginning exhaust stroke. Upward movement of piston forces spent gases past exhaust valve & out of cylinder. As piston nears top of its movement, camshaft lobe again opens intake valve & cycle repeats itself. Exhaust valve is allowed to close, by spring pressure, shortly after piston begins-its downward movement. This is a stroke that produces no work but expends a quantity of energy to push exhaust gases from cylinder.**
	**Most simple explanations of the 4-stroke cycle: SUCK-SQUEEZE-BANG-BLOW**
 QUESTION	**QUESTION: Ask why diesel engine does not have spark plugs. (ANS: Diesel relies on heat of compression to ignite fuel instead of spark)**
	3. **SLIDE 3 EXPLAIN FIGURE 1–2** Cutaway of a diesel engine showing the cylinder, piston, connecting rod, and crankshaft.
	4. **SLIDE 4 EXPLAIN FIGURE 1–3** rotating assembly for a V-8 engine that has 8 pistons and connecting rods, and one crankshaft.
 QUESTION	**QUESTION: Ask the students why diesel engines would use 4 valves per cylinder? ANS: Additional valves provide improved breathing leading to improved performance, emissions, economy.**
	5. **SLIDE 5 EXPLAIN FIGURE 1–4** A cylinder head with four valves per cylinder, two intake valves (larger) and two exhaust valves (smaller).

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	6. **SLIDE 6 EXPLAIN. FIGURE 1–5** Diesel combustion occurs when fuel is injected into the hot, highly compressed air in the cylinder.
	7. **SLIDE 7 EXPLAIN FIGURE 1-6** indirect injection **IDI** diesel engine uses a prechamber and a glow plug. **Early light duty diesels were IDI: GM 5.7L V8 & 4.3L V6 (Oldsmobile) & 6.2L & 6.5L Diesels and Ford 6.9L & 7.3L V8 diesels. GM car & light truck diesels were used to meet CAFÉ (Corp Average Fuel Economy) standards. The IDI engine was mainly used due to its better emission compliance and operation similar to a gas engine. They tended to be quieter.**
	8. **SLIDE 8 EXPLAIN FIGURE 1–7** A direct injection diesel engine injects the fuel directly into the combustion chamber. Many designs do not use a glow plug.
	**Diesel injection is stratified; i.e., in layers. In premixed charges the Fuel-Air ratio can change the time between Flame appearance and completion of compression process. With Diesel fuel injection as long as fuel is not completely evaporated, the complete range of fuel-air ratios from 0 (no fuel) to infinite (no air, within fuel droplets) must be present, and ignition will occur where the local fuel-air ratio is most agreeable.**
	**DI 16-20% better fuel economy than IDI** **DI High thermal efficiency than IDI** **DI Lower exhaust temperature than IDI** **DI has Low surface-to-volume ratio** **No glow plugs in some DI engines** **Lower friction/heat losses from lower compression** **Combustion energy release more advanced than IDI**
	**IGNITION DELAY: time period between Start of Injection & Start of Ignition, also called Ignition Lag. After the Start of Injection, cylinder pressure follows compression curve. At the end of this period pressure rises at an increasing rate until the maximum pressure slope is reached. ID is much**

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	longer than active combustion period, particularly during the part-load operation. Also fuel injection continues during ID period. Longer Delay Period (ID), greater will be the amount of fuel accumulated in combustion chamber prior to start of combustion. This results in higher rates of pressure rise and maximum gas pressures and temperatures. Delay Period length depends mainly on the pressures and temperatures that exist in the cylinder gases during ID and the combustion chamber surface temperature against which the fuel impinges.

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	**ID affects:** **1. rate of pressure rise and maximum gas pressure. These affect noise, vibrations, and stress.** **2. The maximum gas temperature. This affects the NOx emission, fuel consumption, power, cooling system thermal loads, and the temperature and thermal stressing of the combustion chamber walls.** **3. The time for evaporation and mixing before ignition depends only on the length (time) of the Delay Period (ID).**
	**ID is changed by 4 areas:** *** Nozzle Droplet Size Diameter formation & Spray disintegration.** *** Air Temperature and combustion chamber pressure prior to Fuel Injection leading to liquid fuel heating and evaporation.** *** Turbulence of Combustion Chamber Air and diffusion of FUEL vapor into the AIR to form a combustible mixture.** *** (Chemical Reason/Fuel Composition) Cetane Number (Decomposition of Heavy HC into lighter components.**
	**NOTE: In a DIESEL engine the DELAY time (ID) is independent of SPEED (RPM). It varies according to the above four reasons and is not in direct proportion to SPEED.**
	**9. SLIDE 9 EXPLAIN FIGURE 1–8** Cutaway of an overhead valve (OHV) V-8 engine showing the lifters, pushrods, roller rocker arms, and valves.
	**SAFETY Diesel engine fuel systems operate under extremely high pressure. Severe injury can result if caution is not observed when opening fuel system. The high-pressure fuel can actually penetrate skin.**
	**DISCUSSION: Host a discussion on how Ignition Delay could affect the drivability of a diesel engine.**

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	10. **SLIDE 10 EXPLAIN FIGURE 1–9** SOHC engines usually require additional components, such as a rocker arm, to operate all of the valves. DOHC engines often operate the valves directly. 11. **SLIDE 11 EXPLAIN FIGURE 1–10** bore and stroke of pistons are used to calculate engine displacement **Changing connecting rod length does not change the stroke of an engine. Changing the connecting rod only changes position of piston in cylinder. Only the crankshaft determines stroke** **EXPLAIN TECH TIP: Think of a Two-Liter Bottle** **A two-liter bottle contains two liters of liquid. This is the volume of all four cylinders combined in a two-liter four-cylinder engine. A six-liter engine would therefore have the piston displacement of three two-liter bottles.**
 	
	**DISCUSSION:** **Host a discussion on how to change the stroke of an engine for improved torque**
	12. **SLIDE 12 EXPLAIN FIGURE 1–11** crankshaft determines the stroke of the engine, which is the difference between the centerline of the crankshaft journal and the centerline of the connecting rod journal. 13. **SLIDE 13 EXPLAIN FIGURE 1–12** compression of an engine is expressed as a ratio of the volume, with the piston at the bottom of the cylinder, to that volume when the piston is at the top of cylinder.
 	**DISCUSS FREQUENTLY ASKED QUESTION: Is torque ft-lb or lb-ft? The definition of torque is a force (lb) applied to an object times the distance from that object (ft). Therefore, based on the definition of the term, torque should be: lb-ft (a force times a distance) newton-meter (N-m) (a force times a distance). Torque is commonly labeled, even on some torque wrenches, as ft-lb.**
	**DEMONSTRATION: show the effects of torque by using a torque angle meter and torque wrench: Torque to Angle (View) (Download)**

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	14. **SLIDE 14 EXPLAIN FIGURE 1–13** Torque is a twisting force equal to distance from pivot point times force applied, expressed in units called pound-feet (lb-ft) or newton-meters (N-m). 15. **SLIDE 15 EXPLAIN FIGURE 1–14** One horsepower is equal to 33,000 foot pounds (200 lbs X 165 feet) of work per minute
	**EXPLAIN TECH TIP: How to Explain the Difference between Horsepower and Torque As Carroll Shelby, the well-known race car driver and business owner said, "Horsepower sells cars, but torque wins races." Torque determines how fast the vehicle will accelerate, and horsepower determines how fast the vehicle will go.**
	**As can be seen by the formula for horsepower, the higher the engine speed for a given amount of torque, the greater the horsepower.**
	**Show ANIMATION Math Formula Horse Power (View) (Download)**
	**Horsepower is torque times RPM divided by 5252. Horsepower =Torque X RPM/ 5252.**
	**DISCUSSION: Ask students why diesel engine doesn't generate enough vacuum to operate a vacuum-controlled device. (ANS: to generate vacuum in an engine, you need a restriction to incoming air such as a throttle plate. Since MOST diesels do not have throttle plate, there is no restriction to incoming air and very little vacuum is created OR is there a way to retain vacuum)**
	**ON-VEHICLE TASK: Locate and interpret vehicle identification numbers.**