Automotive Fuel and Emissions Control Systems 4/E

Chapter 17 Oxygen Sensors

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. Discuss the purpose and function of oxygen sensors (O2S). 2. Understand the PCM uses of O2S. 3. Explain the ways of diagnosing O2S. 4. Describe the waveform analysis of O2S. 5. Understand the voltage readings of O2S.
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 17: Chapter Images

ICONS	Ch17 Oxygen Sensors
	1. SLIDE 1 CH17 Oxygen Sensors
	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 Oxygen Sensors & EXPLAIN Figure 17-1** Many oxygen sensors are located in exhaust manifold near its outlet so that the sensor can detect the presence or absence of oxygen in the exhaust stream for all cylinders that feed into the manifold.
DEMO	**DEMONSTRATION: PUT OBD-II VEHICLE ON A LIFT, SHOW STUDENTS THE OXYGEN SENSORS. POINT OUT AND EXPLAIN UPSTREAM AND DOWNSTREAM SENSORS TO THEM. FIGURE 17-1**
QUESTION	**DISCUSSION: HAVE THE STUDENTS DISCUSS OXYGEN SENSORS. HOW DO O_2 SENSORS HELP ACHIEVE CORRECT AIR-FUEL RATIO?**
DEMO	**DEMONSTRATION: SHOW CONVENTIONAL O_2 SENSOR THAT USES ZIRCONIUM DIOXIDE. FIGURE 17-1**
	3. **SLIDE 3 EXPLAIN FIGURE 17–2** A cross-sectional view of a typical **Zirconia** oxygen sensor
	4. **SLIDE 4 EXPLAIN Figure 17-3** Most conventional Zirconia oxygen sensors and some wide-band oxygen

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	sensors use the cup (finger) type of design.
	5. **SLIDE 5 EXPLAIN Figure 17-4** oxygen sensor provides a quick response at stoichiometric air–fuel ratio of 14.7:1
	DISCUSSION: HAVE STUDENTS DISCUSS CUTAWAY VIEWS OF OXYGEN SENSORS IN FIGURES 17–2, 3, & 4. CALL THEIR ATTENTION TO ATMOSPHERE TAG IN FIGURES 17–3 4. OXYGEN SENSORS HAVE TO "BREATHE" IN ORDER TO WORK.
	DISCUSSION: HAVE THE STUDENTS TALK ABOUT 1-, 2-, 3-, & 4-WIRE OXYGEN SENSORS. WHAT IS THE SAME ABOUT THESE SENSORS, AND WHAT IS DIFFERENT?
	6. **SLIDE 6 EXPLAIN FIGURE 17–5** A typical Zirconia oxygen sensor.
	DISCUSS REAL WORLD FIX
	DEMONSTRATION: USE SCAN TOOL TO SHOW BIAS VOLTAGE. HAVE THEM WATCH DATA STREAM WHEN VEHICLE IS STARTED TO SEE HOW LONG IT TAKES FOR OXYGEN SENSOR TO OVERRIDE BIAS VOLTAGE FIGURE 17-5
	DISCUSS FREQUENTLY ASKED QUESTION
	DISCUSSION: ASK THE STUDENTS TO DISCUSS THE TITANIA OXYGEN SENSOR AND ITS OPERATING CHARACTERISTICS. HOW IS IT DIFFERENT FROM ZIRCONIA SENSOR?
	7. **SLIDE 7 EXPLAIN FIGURE 17–6** Number and label designations for oxygen sensors. Bank 1 is the bank where cylinder number 1 is located
	IT MAY BE NECESSARY TO ACCESS TUNE-UP SPECS & DIAGRAMS TO ACCURATELY IDENTIFY BANK 1 ON DIFFERENT V6 & V8 ENGINES.

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	DEMONSTRATION: SHOW THE TYPICAL LOCATIONS OF OXYGEN SENSORS ON A VEHICLE. SHOW THEM NUMBER 1, NUMBER 2, UPSTREAM, AND DOWNSTREAM SENSORS, IF APPLICABLE. FIGURE 17-6
	8. **SLIDE 8 EXPLAIN FIGURE 17–7** The OBD-II catalytic converter monitor compares the signals of the upstream and downstream oxygen sensor to determine converter efficiency
	DISCUSSION: HAVE THE STUDENTS DISCUSS OPEN-LOOP & CLOSED-LOOP ENGINE OPERATION. WILL AN ENGINE THAT RUNS WELL IN OPEN LOOP ALSO RUN WELL IN CLOSED LOOP?
	DISCUSSION: HAVE STUDENTS TALK ABOUT HOW PCM USES THE OXYGEN SENSOR TO TEST OTHER SYSTEMS. WHAT HAPPENS WITH OTHER SYSTEMS IF A FAULT OCCURS WITH AN OXYGEN SENSOR? FIGURE 17-7
	DISCUSSION: HAVE THE STUDENTS DISCUSS THE NECESSITY OF INSPECTING AN OLD OXYGEN SENSOR. WHAT CAN BE DETERMINED BY CONDITION OF SENSOR?
	9. **SLIDE 9 EXPLAIN Figure 17-8** Testing an oxygen sensor using a DMM set on DC volts. With the engine operating in closed loop, the oxygen voltage should read over 800 mV and lower than 200 mV and be constantly fluctuating.
	DEMONSTRATION: SHOW EXAMPLES OF OXYGEN SENSORS THAT HAVE FAILED DUE TO OTHER PROBLEMS WITH THE VEHICLE. ASK THEM TO IDENTIFY CAUSE OF FAILURE. WORK WITH STUDENTS TO TEST AN OXYGEN SENSOR WITH DMM. FIGURE 17-8
	TEST O2 SENSOR (VIEW) (DOWNLOAD) **O2 SENSOR VOLT CHECK (VIEW) (DOWNLOAD)** **DUAL CELL O2 SENSOR VOLTAGE CHECK (VIEW) (DOWNLOAD)**
	DEMONSTRATION: SHOW EXAMPLES OF OXYGEN SENSORS THAT HAVE FAILED.

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	**DISCUSSION:** HAVE THE STUDENTS DISCUSS THE CONDITIONS THAT CAN CAUSE A **FALSE RICH INDICATION** BY THE OXYGEN SENSOR. COULD ANYTHING ELSE BE CAUSE OF A FALSE INDICATION?
	**DISCUSSION:** HAVE THE STUDENTS DISCUSS THE CONDITIONS THAT CAN CAUSE A **FALSE LEAN INDICATION** BY THE OXYGEN SENSOR. COULD ANYTHING ELSE BE CAUSE OF A FALSE INDICATION?
	**HANDS-ON TASK:** HAVE STUDENTS SELECT AND MONITOR OXYGEN SENSOR MIN-MAX VOLTAGE WITH A DMM. HAVE THEM CHART MINIMUM AND MAXIMUM READINGS OBSERVED ON SENSORS DURING A RUN CYCLE. GRADE STUDENTS ON PROPER OPERATION OF DMM MIN AND MAX FUNCTIONS AS WELL AS THE VOLTAGE READINGS OBSERVED. **FIGURE 17-8**
	10. **SLIDE 10 EXPLAIN Figure 17-9** Using a digital multimeter to test an oxygen sensor using the MIN/MAX record function of the meter
	**DISCUSSION:** DISCUSS MIN-MAX TEST RESULTS IN **CHART 17–1**. IS IT POSSIBLE FOR A DEFECTIVE SENSOR TO WORK WELL ENOUGH THAT IT DOESN'T SET A DTC?
	**DEMONSTRATION:** SHOW HOW TO **MONITOR OXYGEN SENSOR DATA WITH A SCAN TOOL**. ASK THEM TO IDENTIFY THE LOCATION OF THE SENSORS TESTED.
	**DISCUSSION:** HAVE STUDENTS DISCUSS **FREQUENCY** AT WHICH AN OXYGEN SENSOR SWITCHES. WHAT HAPPENS IF THE SENSOR SWITCHES TOO SLOWLY?
	11. **SLIDE 11 EXPLAIN Figure 17-10** Connecting a handheld digital storage oscilloscope to an oxygen sensor signal wire. Check the instructions for the scope as some require the use of a filter to be installed in the test lead to reduce electromagnetic interference that can affect the oxygen sensor waveform.

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	DEMONSTRATION: SHOW HOW TO USE A SCOPE TO TEST AN OXYGEN SENSOR. HAVE THEM IDENTIFY THE HIGH AND LOW VOLTAGE READINGS ON THE SCOPE. FIGURE 17-10
	12. **SLIDE 12 EXPLAIN Figure 17-11** waveform of a good oxygen sensor as displayed on a **digital storage oscilloscope (DSO).** Note that the maximum reading is above 800 mV and minimum reading is < 200 mV.
	DEMONSTRATION: SHOW DATA STREAM ON A DOWNSTREAM OXYGEN SENSOR. COMPARE IT TO READING ON AN UPSTREAM SENSOR. PERFORM ALL DEMONSTRATIONS AHEAD OF TIME TO BE SURE THE RESULTS ARE APPROPRIATE FOR THE DEMONSTRATION.
	DISCUSSION: ASK STUDENTS TO STUDY FIGURE 17–12 AND COMPARE NORMAL (GOOD CONVERTER) & ABNORMAL (BAD CONVERTER) AFTER CONVERTER OXYGEN SENSOR READINGS. COULD THIS TEST BE USED TO DIAGNOSE ANY OTHER PROBLEMS? FIGURES 17-11 & 12
	DISCUSSION: HAVE THE STUDENTS DISCUSS TESTING DOWNSTREAM OXYGEN SENSOR. WHAT DOES THIS SENSOR REALLY DO?
	13. **SLIDE 13 EXPLAIN Figure 17-12** post catalytic converter oxygen sensor should display very little activity if the catalytic converter is efficient 14. **SLIDE 14 EXPLAIN FIGURE 17–13** Using the cursors on the oscilloscope, the high- and low-oxygen sensor values can be displayed on the screen 15. **SLIDE 15 EXPLAIN FIGURE 17–14** When the air–fuel mixture rapidly changes such as during a rapid acceleration, look for a rapid response. The transition from low to high should be less than 100 ms.
	DISCUSS FREQUENTLY ASKED QUESTION
	DISCUSS REAL WORLD FIX

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	DISCUSS FREQUENTLY ASKED QUESTION
	EXPLAIN TECH-TIP
	16. **SLIDE 16 EXPLAIN FIGURE 17–15** Adding propane to the air inlet of an engine operating in closed loop with a working oxygen sensor causes the oxygen sensor voltage to read high.
	17. **SLIDE 17 EXPLAIN FIGURE 17–16** When propane is shut off, the oxygen sensor should read below 200 Mv
	18. **SLIDE 18 EXPLAIN FIGURE 17–17** When the O2S voltage rises above 450 mV, the PCM starts to control the fuel mixture based on oxygen sensor activity.
	19. **SLIDE 19 EXPLAIN FIGURE 17–18** Normal oxygen sensor frequency is from about one to five times per second.
	EXPLAIN TECH-TIP
	20. **SLIDE 20 EXPLAIN FIGURE 17–19** Significant hash can be caused by faults in one or more cylinders, whereas amplified hash is not as important for diagnosis.
	21. **SLIDE 21 EXPLAIN FIGURE 17–20** Moderate hash may or may not be significant for diagnosis.
	22. **SLIDE 22 EXPLAIN FIGURE 17–21** Severe hash is almost always caused by cylinder misfire conditions.
	23. **SLIDE 3 EXPLAIN FIGURE 17–22** ignition- or mixture-related misfire can cause hash on oxygen sensor waveform.
	24. **SLIDE 24 EXPLAIN FIGURE 17–23** An injector imbalance can cause a lean or a rich misfire
	25. **SLIDE 25 EXPLAIN FIGURE 17–24** Negative reading oxygen sensor voltage can be caused by several problems
	EXPLAIN TECH-TIP
	DISCUSS FREQUENTLY ASKED QUESTION

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	27. **SLIDE 27 EXPLAIN FIGURE 17–26** The target lambda on this vehicle is slightly lower than 1.0 indicating that the PCM is attempting to supply the engine with an air–fuel mixture that is slightly richer than stoichiometric. Multiply the lambda number by 14.7 to find the actual air–fuel ratio