

# Automotive Technology 6<sup>th</sup> Edition

## Chapter 88 CATALYTIC CONVERTERS

### Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. 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, Animations, and ASEEducation (NATEF) Task Sheets.
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: <ol style="list-style-type: none"> <li>1. Explain the purpose and function plus the construction and operation of catalytic converters.</li> <li>2. Describe catalytic converter performance in OBD-II vehicles.</li> <li>3. Discuss the diagnosis of catalytic converters.</li> </ol>
Establish the Mood or Climate	Provide a <b>WELCOME</b> , 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: Lesson plan is based on 6<sup>th</sup> Edition Chapter Images found on Jim's web site @ [www.jameshalderman.com](http://www.jameshalderman.com)**

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**NOTE: You can use Chapter Images or possibly Power Point files:**

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### 1. SLIDE 1 CH88 CATALYTIC CONVERTERS

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### Videos

[Catalytic Converter Operation \(View\) \(Download\)](#)  
[Catalytic Converter \(2004+\) \(View\) \(Download\)](#)

2. **SLIDE 2 EXPLAIN Figure 88-1** Most catalytic converters are located as close to the exhaust manifold as possible, as seen in this display of a Chevrolet Corvette
3. **SLIDE 3 EXPLAIN FIGURE 88-2** base material, called the substrate, is used to support the wash coat, which is a porous material that is used to hold the catalyst materials.
4. **SLIDE 4 EXPLAIN Figure 88-3** three-way catalytic converter first separates the  $\text{NO}_x$  into nitrogen and oxygen and then converts the HC and CO into harmless water ( $\text{H}_2\text{O}$ ) and carbon dioxide ( $\text{CO}_2$ ). The nitrogen (N) passes through the converter and exits the tailpipe and enters the atmosphere which is about 78% nitrogen
5. **SLIDE 5 EXPLAIN FIGURE 88-4** The small oxidation section of the converter helps build heat for the reduction section to reduce NOx emissions in rear brick on most newer vehicles. Older catalytic converters had reduction brick first then the oxidation brick. Since about 2007, allowable NOx levels were greatly reduced and the engines became more efficient at controlling HC and CO and that was when the position of the bricks were changed.

### **DISCUSS CASE STUDY:**

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**DEMONSTRATION:** With a vehicle on lift, show installed catalytic converters & their locations. Point out the reduction catalyst & oxidizing catalyst. **FIGURES 88-1 to 4**

Because prices of precious metals used in catalytic converters have risen steeply in price, these components have become popular among thieves. Owners of trucks & 4WD vehicles have returned to their parked vehicles to find stolen catalytic converters with battery-powered reciprocating saw. Replacements can run as high as \$2,500.

6. SLIDE 6 **EXPLAIN** Figure 88-5 OBD-II catalytic converter monitor compares signals of upstream and downstream oxygen sensors to determine efficiency.
7. SLIDE 7 **EXPLAIN** Figure 88-6 waveform of a downstream HO2S sensor from a properly functioning converter shows little, if any, activity
8. SLIDE 8 **EXPLAIN** Figure 88-7 highest catalytic converter efficiency occurs when air-fuel mixture 14.7:1

**DISCUSSION:** Have the students discuss how often a PCM tests a catalytic converter. How is catalytic converter monitor classified? When will the monitor check the efficiency of converter? What will happen if the test fails?

**DISCUSS FREQUENTLY ASKED QUESTION:** *Can a Catalytic Converter Be Defective without Being Clogged?* Yes. Catalytic converters can fail by being chemically damaged or poisoned without being mechanically clogged.

Therefore, catalytic converter should be tested not only for physical damage (clogging) by performing a back pressure or vacuum test and a rattle test, but also for temperature rise, usually with a pyrometer or propane test, to check the efficiency of the converter.

**DEMONSTRATION:** Have the students talk about diagnosing catalytic converters. How are catalytic converters tested?

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**DEMONSTRATION:** Connect a digital storage oscilloscope (DSO) to an Upstream Oxygen Sensor & operate engine at normal operating temperature. Show waveform of an upstream oxygen sensor in operation. **FIGURE 88-5**

9. SLIDE 9 **EXPLAIN** Figure 88-8 catalytic converter that rattles when tapped was removed, and substrate, or what was left of it, fell out. This converter has to be replaced and the root cause of why it failed found and corrected.

**DEMONSTRATION:** After showing students a waveform of upstream oxygen sensor, connect DSO to Downstream Oxygen Sensor **FIGURE 88-6** to show students difference between sensors. OBD-II uses downstream sensor to check the efficiency of the catalytic converter. **FIGURE 88-7**

**DEMONSTRATION:** Simulate a plugged or melted converter by installing an expandable plug into a vehicle exhaust pipe. Operate vehicle on dynamometer or on a test drive with vacuum gauge taped to windshield. Show students how vacuum drops as exhaust back pressure increases, causing a substantial drop in engine performance. Remove plug and operate vehicle normally to show proper vacuum readings. **FIGURE 88-8**

10. SLIDE 10 **EXPLAIN** Figure 88-9 A back pressure tool can be made by using an oxygen sensor housing and epoxy or braze to hold the tube to the housing

**DEMONSTRATION:** Install exhaust back pressure gauge in place of an oxygen sensor **FIGURE 88-9.** Leave oxygen sensor connected while it is removed and operate engine, showing students normal back pressure. Install expandable plug in tailpipe to simulate a plugged converter and have students watch back pressure increase.

**ON-VEHICLE ASE EDUCATION TASK:** Perform exhaust system back-pressure test; determine necessary action.

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11. **SLIDE 11 EXPLAIN Figure 88-10** This partially melted catalytic converter tested okay at idle but had excessive back pressure at higher engine speeds.
12. **SLIDE 12 EXPLAIN Figure 88-11** The temperature of the outlet should be at least 10% hotter than the temperature of the inlet. If a converter is not working, the inlet temperature will be hotter than the outlet temperature.
13. **SLIDE 13 EXPLAIN FIGURE 88-12** Whenever replacing a catalytic converter with a universal unit, first measure distance between the rear brick & center of the rear oxygen sensor.

**EXPLAIN TECH TIP: *Aftermarket Catalytic Converters*** Some replacement aftermarket (nonfactory) catalytic converters do not contain the same amount of cerium as original part. Cerium is the element that is used in catalytic converters to store oxygen. As a result of the lack of cerium, the correlation between the oxygen storage and conversion efficiency may be affected enough to set a false diagnostic trouble code (P0422). **NOTE:** If an aftermarket converter is being installed, be sure that distance between rear of catalyst block is the same distance from rear oxygen sensor as factory converter to be ensured of proper operation. Always follow instructions that come with the replacement converter. • **SEE FIGURE 88-12.**

13. **SLIDE 13 EXPLAIN FIGURE 88-12** Whenever replacing a catalytic converter with a universal unit, first measure distance between the rear brick & center of the rear oxygen sensor.

**EXPLAIN TECH TIP: *Catalytic Converters Are Murdered*** Catalytic converters start a chemical reaction, but do not enter into chemical reaction. Therefore, catalytic converters neither wear out nor die of old age. If a catalytic converter is found to be defective (nonfunctioning or clogged), look for the root cause. Remember this: “Catalytic converters do not commit suicide—they’re

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murdered.” Items that should be checked when a defective catalytic converter is discovered include all components of ignition and fuel systems. Excessive unburned fuel can cause the catalytic converter to overheat and fail. The oxygen sensor must be working and fluctuating from 0.5 to 5 Hz (times per second) to provide the necessary air fuel mixture variations for maximum catalytic converter efficiency.



**DISCUSSION:** Have the students talk about **catalytic converter efficiency tests**. How are results of an oxygen level test interpreted?



**HANDS-ON TASK:** Have students operate an engine at 2,500 RPM until normal operating temperature is achieved, then **Measure Inlet & Outlet temperatures** of catalytic converter with an infrared thermometer. **FIGURE 88-11**



**ON-VEHICLE ASE EDUCATION TASK:** Inspect and test **catalytic converter** efficiency.



**DISCUSSION:** Discuss with the students that an **overly rich mixture or any malfunction such as misfire** can allow unburned hydrocarbons to enter the catalytic converter. How does this affect the catalytic converter? (Point out that this can cause the converter to melt internally and can even set the vehicle on fire)



**DEMONSTRATION:** With vehicle on a lift, create a misfire; for example, close electrodes on a spark plug. Operate at 2,500 RPM until the converter begins to overheat and students observe the smell of rotten eggs. Continue operating vehicle for a few more minutes, check converter temperature with infrared thermometer to show students extreme overheat condition. **FIGURE 88-11**

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Because heat is so critical for converter operation, and underhood space is limited, many OEMS LOCATE catalyst in exhaust manifold.

### 14. SLIDES 14-25 OPTIONAL EXPLAIN CATALYTIC CONVERTER OPERATION

Just because an aftermarket catalytic converter fits a particular vehicle, does not mean it will control emissions on particular vehicle. Many aftermarket catalytic converters are sold at reduced prices because they do not contain amount of precious metals that OEM DID, potentially causing state emissions test failure or MIL to continually illuminate indicating an emissions problem. **FIGURE 88-12**

**HANDS-ON TASK:** Have the students look up catalyst efficiency DTCs for their own vehicles. Students should be able to find conditions that must be met for DTC to set and find OEM troubleshooting procedure to diagnose DTC.

**DEMONSTRATION:** Demonstrate catalytic converter operation by testing exhaust emissions with 5-GAS analyzer before and after converter runs. Remove the upstream oxygen sensor after the engine has warmed up, then operate engine with sensor connected and insert analyzer probe into sensor boss while sampling.

**DEMONSTRATION:** Perform a converter snap-throttle test while sampling exhaust emissions. Have students pay attention to O2 readings to determine converter efficiency.

**ON-VEHICLE ASE EDUCATION TASK E6: 6.** Diagnose emission and driveability concerns caused by catalytic converter system; determine needed action.