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HOW CATALYTIC CONVERTERS WORK

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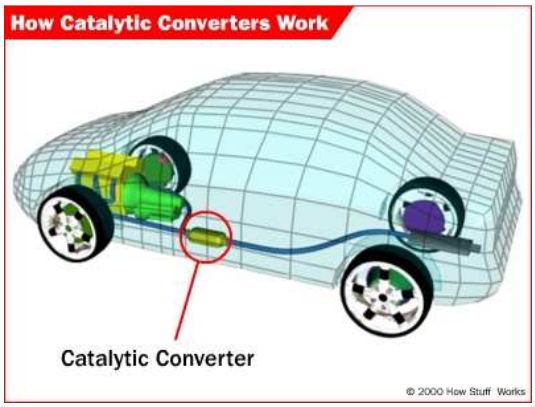
At the end of the XX th century many global problems concerning environment have arisen. The big factories, tankers, nuclear production and vehicle pollute atmosphere that eventually have lead to the global warming. The amount of pollution that all the cars produce together can create big problems especially in large cities. There are millions of cars on the road in the United States and each one is a source of air pollution.

To solve those problems, cities, states and the federal government create clean-air laws that restrict the amount of pollution that cars can produce. Over the years, automakers have made many refinements to car engines and fuel systems to keep up with these laws. One of these changes came about in 1975 with an interesting device called a **catalytic converter**. The job of the catalytic converter is to convert harmful pollutants into less harmful emissions before they ever leave the car's exhaust system.



A large pile of platinum lined catalytic converters.

Catalytic converters are amazingly simple devices, so it is incredible to see what big impact they have. In this article, you will learn which pollutants are produced by an engine and how a catalytic converter deals with each of these pollutants to help reduce vehicle emissions.

Pollutants Produced by a Car Engine

The main emissions of a car engine are:

- **Nitrogen gas** (N2) - Air is 78-percent nitrogen gas, and most of this passes right through the car engine.
- **Carbon dioxide** (CO2) - This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air.
- **Water vapor** (H2O) - This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.

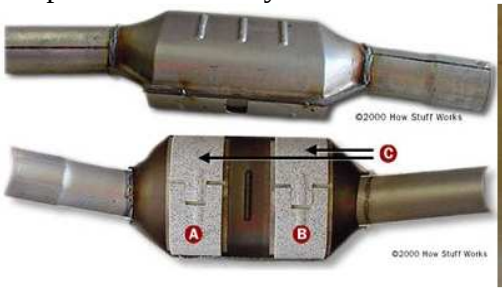
These emissions are believed to contribute to global warming. Catalytic converters are designed to reduce all three:

- **Carbon monoxide** (CO) is a poisonous gas that is colorless and odorless.
- **Hydrocarbons** or **volatile organic compounds** (VOCs) are a major component of smog produced mostly from evaporated, unburned .fuel.

- **Nitrogen oxides** (NO and NO2, together called NOx) are a contributor to smog and acid rain, which also causes irritation to human mucus membranes.

How Catalytic Converters Reduce Pollution

In chemistry, a **catalyst** is a substance that causes or accelerates a chemical reaction without itself being affected. Catalysts participate in the reactions, but are neither reactants nor products of the reaction they catalyze. In the human body enzymes are naturally occurring catalysts responsible for many essential biochemical reactions.



Ceramic honeycomb catalyst structure.

In the catalytic converter there are two different types of catalyst at work, a **reduction catalyst** and an **oxidation catalyst**. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required as the materials are extremely expensive. Some of the newest converters have even started to use gold mixed with the more traditional catalysts. Gold is cheaper than the other materials and could increase oxidation, the chemical reaction that reduces pollutants, by up to 40 percent

Most modern cars are equipped with **three-way catalytic converters**. This refers to the three regulated emissions it helps to reduce. The **reduction catalyst** is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NOx emissions. When an NO or NO2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O2. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N2.

The **oxidation catalyst** is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas.

There are two main types of structures used in catalytic converters – **honeycomb** and **ceramic beads**. Most cars today use a honeycomb structure.

Controlling Pollution and Improving Performance

The third stage of conversion is a **control system** that monitors the exhaust stream, and uses this information to control the fuel injection system. There is an oxygen sensor mounted upstream of the catalytic converter, meaning it is closer to the engine than the converter. This sensor tells the engine computer how much oxygen is in the exhaust. The engine computer can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. This control scheme allows the engine computer to make sure that the engine is running at close to the stoichiometric point, and also to make sure that there is enough oxygen in the exhaust to allow the oxidization catalyst to burn the unburned hydrocarbons and CO.

The catalytic converter does a great job at reducing the pollution, but it can still be improved substantially. One of its biggest shortcomings is that it only works at a fairly high temperature. When you start your car cold, the catalytic converter does almost nothing to reduce the pollution in your exhaust.

One simple solution to this problem is to move the catalytic converter closer to the engine. This means that hotter exhaust gases reach the converter and it heats up faster, but this may also reduce the life of the converter by exposing it to extremely high temperatures. Most carmakers position the converter under the front passenger seat, far enough from the engine to keep the temperature down to levels that will not harm it.

Preheating the catalytic converter is a good way to reduce emissions. The easiest way to preheat the converter is to use electric resistance heaters. Unfortunately, the 12-volt electrical systems on most cars don't provide enough energy or power to heat the catalytic converter fast enough. Most people would not wait several minutes for the catalytic converter to heat up before starting their car. Hybrid cars that have big, high-voltage battery packs can provide enough power to heat up the catalytic converter very quickly.

Catalytic converters in **diesel engines** do not work as well in reducing NOx. One reason is that diesel engines run cooler than standard engines, and the converters work better as they heat up. Some of the leading environmental auto experts have come up with a new system that helps to combat this. They inject a **urea** solution in the exhaust pipe, before it gets to the converter, to evaporate and mix with the exhaust and create a chemical reaction that will reduce NOx. Urea, also known as **carbamide**, is an organic compound made of carbon, nitrogen, oxygen and hydrogen. It's found in the urine of mammals and amphibians. Urea reacts with NOx to produce nitrogen and water vapor, disposing more than 90 percent of the nitrogen oxides in exhaust gases.

How do I know if my catalytic converter has failed?

In a typical passenger car, the catalytic converter, which resembles a muffler in shape, is between the engine and the muffler. It's on the underside of the car, usually underneath the passenger seat. Maybe you have felt its warmth through the floor on a long trip.

Many states and localities have legislated annual automobile emissions testing that checks the actual emissions content. The exhaust emissions test checks for the absence of a converter or a malfunctioning one during an inspection. It's illegal in some states and localities to remove a factory-installed catalytic converter. A mechanic can sometimes temporarily remove it and replace the catalytic converter with a test pipe, but the rules on this can vary from place to place.

Causes of Catalytic Converter Failure

There are two ways a converter can fail:

- It can become clogged.
- It can become poisoned.

There really is no "inspection port" for the consumer or mechanic to see an actual clog in a converter. Often, the only way to tell if a catalytic converter is malfunctioning (plugged) is to remove it and check the change in engine performance. When a clogged converter is suspected, some mechanics temporarily remove the O2 sensor from the exhaust pipe ahead of the catalytic converter and look for a change in performance.

A catalytic converter relies on receiving the proper mix of exhaust gases at the proper temperature. Any additives or malfunctions that cause the mixture or the temperature of the exhaust gases to change reduce the effectiveness and life of the catalytic converter. Leaded gasoline and the over-use of certain fuel additives can shorten the life of a catalytic converter.

A catalytic converter can also fail because of:

- Bad exhaust valves on the engine
- Fouled plugs causing unburned fuel to overheat the converter

Sometimes you can tell that a converter is clogged because you don't go any faster when you push the gas pedal. Also, there usually is a noticeable drop in gas mileage associated with a clogged catalytic converter. A partially clogged converter often acts like an

engine governor, limiting the actual RPMs to a fast idle. A totally clogged converter causes the engine to quit after a few minutes because of all the increased exhaust back pressure.