Catalytic Converter Testing

The first catalytic converter was created before the use of onboard computer systems its job was to oxidize HC and CO into CO2 and H2O. The term oxidizes means to add O2 to HC making it H20 and CO2 adding O2 to CO making it CO2. In order to have enough O2 available for the oxidizing process to work they added an air injection pump. The air injection pump added the air directly into the catalytic converter. The primary noble medals that are used are platinum and palladium. This type of catalytic converter was known as the two-way converter its limitations only allowed it to reduce HC and CO. As EPA regulations on the automakers became stricter, they were required to make a catalytic converter that is able to reduce HC, CO and NOX.

The next catalytic converter to be introduced was known as the duel bed converter. This converter has a noble metal called rhodium. This new noble metal gave it the ability to reduce. The term reduce means to take O2 away from something. Oxygen was to be removed from the NOX turning it back into N2 and O2. This reduction process can only happen in a CO rich environment. During the combustion process there will always be some harmful emissions left over as long as the internal combustion engine remains less than 100 percent efficient. One of the most harmful pollutants is NOX. NOX is formed when the temperature in the combustion chamber exceeds 2500 degrees F. The air that enters the combustion chamber consists of 78 percent nitrogen and 21 percent oxygen and 1 percent other gases. Nitrogen will pass through the combustion process inert as long as the peek temperature doesn't exceed 2500 degrees. At 2500 degrees and greater the oxygen combines with the nitrogen forming the harmful pollutant known as NOX. These duel bed converters had two compartments. The reduction bed was in the front or upstream position the oxidizing bed was in the rear. O2 was injected to the oxidizing bed to allow it to oxidize HC and CO to H20 and CO2. The O2 in the front bed was left over from the combustion process. Below is an illustration of a duel bed converter.

Three way catalytic converters where next to come out, they are a new generation of catalytic converter they have the ability to both reduce and oxidize at the same time. They consist of a ceramic honeycomb mesh that has a material deposited on it known as alumna. The alumna forms crystallized surface which the three noble metals are deposited Platinum, palladium and rhodium. There is also a new metal called cerium. Cerium has the ability to store oxygen when the mixture is lean then release the oxygen when the mixture goes rich. The cerium gives the three-way catalytic converter the ability to oxidize continuously. The only way for this converter to work is to have a fuel mixture that switches from lean to rich continuously. Therefore, this type of catalytic converter will only be found of cars with computer feedback systems. The O2 sensor in the computer feedback fuel system is what signals the computer of the mixture

condition. When the PCM sees a rich condition from the O2 sensor it will command a lean mixture and vice versa. The picture below is an example of what the honeycomb mesh looks like. The illustration below is of a three-way catalytic converter with the honeycomb mesh.

Intrusive test

A small access hole is drilled in the exhaust system before the catalytic converter. A similar hole is drilled into the exhaust just after the converter. With the small probe of the analyzer, sample the exhaust before and after the converter. There should be at least a 50 % to 60% drop in emissions between the readings before the cat and those after. This is the most accurate way to test the efficiency of the converter and the only way to determine the efficiency of the converter to reduce NOX. However it could lead to a customer dispute later. Make sure the exhaust system is in good shape before drilling holes into it. Trying to weld a rusted out exhaust will definitely try your patients.

This is by far the best test that can be used to verify catalytic converter efficiency. It is the only test that tells what the converter is doing to reduce NOX. We at smog fix have found that the catalytic converter can reduce the NOX by as much as 1500PPM. Unfortunately it is the hardest test to perform. Intrusive test can lead to major disputes with customer if the exhaust system can't be repaired after the test. It would be nice if the automaker would include pre cat taps in the exhaust system.

HC Reduction test

Run the vehicle until the catalytic converter is hot, and then shut the engine off for three minutes. Ground one spark plug wire and start the engine. The results will be a misfire, producing a high HC level.

Caution: Grounding one spark plug wire will set a misfire code on many vehicles using the OBDII computer system.

Watch the HC level on the gas analyzer. Record the highest level of HC noted. Next the HC level should start to reduce. Do not allow this condition to continue for more than two minutes. Record the peak HC level and the final HC level. Now subtract the lowest from the highest reading. The results will show the amount of reduction the converter was able to achieve. This amount of reduction must then be divided by the highest-level reading. The results will show the percentage of reduction the converter was able to produce. The minimum reduction should be at least 35% if the level of HC remains high with little or no reduction, the converter will be unable to oxidize the CO and HC to acceptable levels.

Example:

highest-level HC = 945PPM
final level HC = 355PPM

945PPM - 355PPM = 590PPM

590 divided by 945 = 62%

What is being tested is the ability of the catalytic converter to take the excessive HC emission produced by the misfire and oxidizes them. When the engine is first started it is brought up to temperature so the converter can reach the light off point around 600 degrees. The engine is shut off and a plug wire is removed, waiting three minutes allows the converter to partially cool down. When the engine is re started the converter is cool below the light off point and will not oxidize. HC will rise to the highest level. As soon as the converter reaches the light off temperature it will start oxidizing converting HC to H20 and CO2.

It is not unheard of to see a 100% reduction. We have seen cars that would pass the smog test with a plug wire disconnected. Newer style catalytic converters do well on this test. Keep in mind when performing five gas analyses that a good catalytic converter can make the worst running engine look squeaky clean out the tail pipe.

WORKSHEET

Highest level = _____

HC Final level =_____

Highest level HC ____ - Final level HC _____ =

Reduction level HC _____

Reduction level HC _____ -:- highest level HC ____ =

% Of reduction

Minimum reduction tolerance is 35%

Condition of Catalytic Converter:

Pass_____

Fail _____

Testing for OBDII vehicles

This test will only work on cars that use OBDII fuel metering system. Bring the car to normal operating temperature. You will need a DSO (digital storage oscilloscope). When using a DSO set it up in the dual trace mode and place the leads in parallel with the front and rear 02 sensor output wires start the engine. You should see the front 02-sensor voltage fluctuating up and down and the rear 02 sensor will be somewhat of a flat line. Find a large intake vacuum hose and disconnect it to create a lean condition. Both the front and the rear 02 sensors voltages should lower down to approximately .2 volts. While both 02 sensors are low, the PCM will interpret this as a lean condition. The PCM will try to richen the mixture, however the mixture will stay lean because of the substantial vacuum leak. Then reattach the vacuum hose. The mixture will immediately go rich and the front 02 should instantly increase in voltage, however the rear 02 sensor should delay about 1 second before it increases in voltage.

The reason for delayed rear 02-sensor response is the noble metal in the three-way catalytic converter (called cerium). Cerium has the ability to store the oxygen when the mixture is lean. The cerium releases oxygen when the mixture is rich. So when the vacuum hose was reattached the mixture goes rich and the cerium releases the stored oxygen. This is why there is a one second delay in the rear 02 sensor activity. The rear 02 sensor will continue to see oxygen even though the mixture is rich. Once all the oxygen has been released from the cerium in the catalytic converter the rear 02 sensor will increase in voltage until the system has stabilized then it will go back to normal readings.

This test will show us the catalytic converter's ability to store and release oxygen within the cerium. If it fails this test it could be a good indicator that the catalytic converter is weak at least in its ability to store oxygen. This storage of oxygen when the mixture is lean is what allows it to oxidize when the mixture goes rich. When rich all the oxygen is released and the catalytic converter can continue to oxidize.

Remember the purpose of the o2 sensor is to tell the PCM when the mixture is lean or rich. The PCM will respond to the signals from the 02 sensor by switching the mixture rich and lean. This switching action is what allows the catalytic converter to be efficient. When the mixture is lean it can oxidize when the mixture is rich it can reduce. The noble metal cerium inside the catalytic converter will store oxygen when the mixture is lean and release it when the mixture goes rich. This allows the catalytic converter to continually oxidize when the mixture is momentarily rich.

NOTE: the term oxidize simply means to add air to something. In the case of the catalytic converter oxidizing means to add oxygen to CO making it CO2, add oxygen to HC making H20. NOTE: the term reduce means to take air away from something. In the case of the catalytic converter oxygen is removed from NOX making it NO and 02.

This test will not tell us all we need to know about the efficiency of the catalytic converter, but when used with the other catalytic converter efficiency testing we can

come to a better estimate when we should or should not replace the catalytic converter.

Cranking CO2 test

The engine should be at normal operating temperature. The catalytic converter should be hot (run the engine at 2500 rpm for two minutes), then the engine should be stopped and the ignition disabled. Crank the engine for about 10 second while looking at the 5-gas analyzer, the CO2 level should reach at least 12.5% at the end of the ten-second cranking period. The HC should be no higher than 500 PPM. Don't be too critical of the HC reading HC readings are hardly ever below 500 PPM on this test. Make sure to add propane into the air intake system on vehicles that use carburetors. On fuel injected vehicles it is not necessary to add propane unless the fuel has been disable with the ignition.

The purpose of this test is see if the catalytic converter can convert HC into CO2 and H20.We can think of the catalytic converter as being a combustion chamber. To have combustion we need heat, air and fuel. When the catalytic converter is brought up to temperature and cranking the engine with the ignition disabled, there is air and fuel entering the catalytic converter. The catalytic converter is hot and the burning process starts. As a result of the burning process we convert the HC to CO2 and H20. This test is quick and easy to perform and give fairly consistent result on the efficiency of the catalytic converter.

Worksheet

Findings:

HC____

CO____

CO2____

O2_____

Condition of the catalytic converter?

Pass____

Fail_____

Temperature test

The traditional way of checking the efficiency of the catalytic converter was to check the temperature of the exhaust before it enters the catalytic converter. Then ck the temperature after it exits the catalytic converter and compare the differences. It is believed that the temperature exiting the catalytic converter should be hotter because of the oxidizing process within the catalyst. You should look for a temperature increase of approximately 150° to 300° Fahrenheit. This test is not very conclusive in its ability to show us the catalytic converter efficiency on three-way converter, however it can still be used on older style two-way catalytic converters. The degree at which the temperature rises within the catalytic converter depends on the amount of HC leftover in the exhaust. It's the oxidizing process within the converter converting HC to H20 that makes the exhaust hot.

However Three-way catalytic converters not only oxidize, they also reduce. The term reduces means to remove oxygen. In regards to the catalytic converter it will be stripping the oxygen air from the NOX converting it back to NO and 02. This is known an endothermic reaction. This endothermic reaction can lower the temperature inside the catalytic converter. Therefore this test is inconclusive on vehicle with three-way catalytic converters. When the engine is producing excessive NOX emissions there will be a large reduction process. This will lower the temperature within the catalytic converter.

If you create a misfire by disconnecting one plug wire there will be a large amount of HC entering the catalytic converter. This should override the reduction process and the cat will get hot in its effort to oxidize the HC emissions.

Peak O_2 test

Probe the tailpipe with the four or five gas analyzer make sure the vehicle is at normal operating temperature. Run the engine at 2200-rpm watch the CO and O2 readings. If the CO levels goes to zero and the O2 level is greater than .5% propane should be added until the CO level is at .5%. Snap accelerate the engine. When the CO peaks, the O2 should be no more than 1.2% above the low level before the snap acceleration.

The purpose of this test is to show the ability of the catalytic converter to use the oxygen that is generated by snapping the throttle to oxidize the CO that is also created by the sudden acceleration. When the throttle is snapped the PCM or the carburetor will lean the mixture on the deceleration side. This creates a unique environment that allows us to test the catalytic converter efficiency. The converter will oxidize the extra CO by

using the extra oxygen. This test is a quick and easy way to determine if the catalytic converter can oxidize CO into CO2.

WORKSHEET

Achieve 2200 rpm and O2 level of .5% for accurate results.
Read O2 level only after reaching peak CO level following snapped throttle.

Findings:

O2 before throttle snapped = _____

O2 peak level after throttle snapped = _____

O2 should not increase more than 1.2% after snapped throttle

Condition of catalytic converter?

Pass_____