Catalytic Converter Efficiency Tests

Utilizing Analysis of Exhaust Gas Measurements

Light-Off Test

Exhaust four gas measurements at the tail pipe, analyzing changes in HC, CO_2, CO, and O2 levels when the cat lights-off

Cranking Carbon Dioxide (CO_2) Efficiency Test

Snap-Throttle Oxygen (O_2) Efficiency Test

Misfire Superheated Hydrocarbons (HC) Test

Hydrocarbon (HC) "Punch Through" Test

Hydrocarbon (HC) Oxidizing Efficiency Test

Intrusive / Invasive Oxidation Efficiency Test

Oxidation efficiency calculations using pre and post cat exhaust gas measurements

Exhaust Gas Analysis
Pretest Setup and Inspections

Exhaust Analyzer Calibration and Settings

To increase the accuracy of tests requiring analysis of exhaust gas measurements of HC, CO, CO2, and O2 levels, the exhaust analyzer must be calibrated and set to capture true simultaneous readings.

1. Calibrate and zero the exhaust analyzer as needed.

2. Turn the analyzer's "Dilution Correction Factor" (DCF) **off.**

3. Enable the "print screen" function to capture simultaneous measurements.

Vehicle Inspection and Conditioning

To increase the accuracy of tests requiring exhaust gas analysis, there can be no dilution of the exhaust sample and the converter must be heated to operating temperature.

1. Check the exhaust system for leaks. Air leaking into the exhaust system will dilute the sample causing false measurements and test results.

2. While testing vehicles equipped with air injection or pulse air systems, make sure the system is not pumping or pulsing air into the exhaust system.

3. Bring the engine and catalytic converter to normal operating temperature by running the engine around 2,500 rpm for at least 3 minutes. The test must be performed as quickly as possible following the warm-up procedure.

Cranking Carbon Dioxide (CO_2) CAT Test

This test is based on the following concepts:

1. There is very little CO_2 in ambient air, less than 0.1%.
2. Any CO_2 in the exhaust stream, while cranking the engine with the ignition system disabled, can only be caused by a functioning catalytic converter oxidizing the carbon in gasoline.

Test Procedures

1. Perform the exhaust gas analysis pretest setup and inspections.
2. Quickly disable the ignition system. Do not allow the CAT to cool off.
3. Crank the engine for 10 seconds while watching the CO_2 reading.
4. When the CO_2 reading reaches its highest level, record the CO_2 and HC readings.
5. Compare the readings to the test results.

Test Results

Inaccurate Test

HC level is below 500 ppm – Insufficient fuel during the test
Repeat the test while adding propane to the air intake while cranking the engine. Carbureted engine can be enriched by pumping the accelerator while cranking the engines.

Normally functioning Catalytic Converter – Good CAT

HC is above 500 ppm and the CO_2 is 12% or higher

Deteriorated Catalytic Converter – Weak CAT

HC is well above 500 ppm and the CO_2 is considerably less than 12%

Inoperative Catalytic Converter – Dead CAT

HC is extremely high and there is very little or no CO_2

Snap-Throttle O_2 CAT Test

This test is based on the following concepts:

1. A fully functional catalytic converter will use the oxygen in the exhaust stream to oxidize unburned fuel, forming water and carbon dioxide.
2. A fully functional catalytic converter will store any excess oxygen in the cerium in the CAT.

Test Procedure

1. Perform the exhaust gas analysis pretest setup and inspections.
2. Run the engine at a steady 2,000 rpm. If the oxygen reading drops to 0.1% or lower go to step 3.
   If the O_2 reading does not drop to 0.1% or lower, is there any CO in the exhaust?
   If yes – go to step 3
   If no – disconnect the O_2 sensor B1S1 (and B2S1 if equipped) and if necessary, add propane until the CO reads about 0.5% at 2,000 rpm – go to step 3
3. Once you have obtained a near 0% oxygen reading at 2,000 rpm, snap the throttle to Wide-Open-Throttle (WOT) and let it drop back to idle.
4. Record by printing the maximum O_2 level as the **CO is rising** and compare O_2 reading to the test results.

Test Results

O_2 rise test cut point is 1.2 %

Normally functioning Catalytic Converter – Good CAT
The O_2 rise is well below 1.2%

Deteriorated Catalytic Converter – Weak CAT
The O_2 rise is close to 1.2%

Inoperative Catalytic Converter – Dead CAT
The O_2 rise is above 1.2%

Misfire Superheated CAT Hydrocarbons Test

This test is based on the following concepts:

1. An ignition misfire will increase the levels of HC and O2 in the pre-catalytic converter exhaust stream.
2. A functioning CAT will use the additional O2 to oxidize the additional HC inside the CAT.
3. The increased level of oxidation will very quickly raise the temperature inside the CAT well above the normal operating temperature (1,300 – 1,600°F).
4. A superheated CAT is more efficient than a CAT operating at normal temperatures.

Test Procedures

1. Perform the exhaust gas analysis pretest setup and inspections.
2. With the engine idling, eliminate (kill) the spark to one of the spark plugs.
3. The HC level will increase dramatically for several seconds. Record the maximum HC level obtained after killing the spark.
4. When the CAT becomes superheated and the CAT is operating more efficiently, the level of HC will drop. Record the level of HC with the CAT superheated.
5. Calculate the percentage of HC drop by dividing the level of HC obtained in step 4 by the level of HC in step 3 (e.g. 500 ppm divided by 1,000 ppm equals 0.50 which is the decimal equivalent of 50%). Compare the calculated percentage to the test results below.

Test Results

Normally functioning Catalytic Converter – Good CAT
The calculated percentage the HC dropped too is well below 50%
(Dropping to a low percentage indicates a high level of superheat)

Deteriorated Catalytic Converter – Weak CAT
The calculated percentage the HC dropped too is around 50%
(Not dropping to a low percentage indicated there was some superheat)

Inoperative Catalytic Converter – Dead CAT
The calculated percentage of HC dropped too is well above 50%
(Only dropping to a high percentage of HC indicates there was very little or no superheat)

CAT HC "Punch Through" Efficiency Test

This test is based on the following concepts:

1. The air/fuel mixture goes momentarily rich and the level of HC in the pre-CAT exhaust will be elevated upon rapid deceleration from high speed.
2. A functional CAT will use the oxygen held by the cerium to oxidize the excess HC and prevent any sizable increase in HC emissions out the tail pipe (HC "punch through").
3. This test should only be performed on fuel injected engines that do not have electronic throttle control (ETC).

Test Procedure

1. Perform the exhaust gas analysis pretest setup and inspections.
2. Run the engine around 2500 rpm until the O2 reading is stable.
3. Record the HC level and release the throttle to return to idle.
4. Watch for any change in the HC level for about 45 seconds and record the highest HC level.
5. Subtract the HC level obtained in step 3 from the HC level in step 4 to obtain the amount of HC "punch through".
6. Compare the calculated HC "punch through" to the test results.

Test Results

Normally functioning Catalytic Converter – Good CAT
The HC "punch through" is 20ppm or less

Deteriorated Catalytic Converter – Weak CAT
The HC "punch through" is between 20 and 200ppm

Inoperative Catalytic Converter – Dead CAT
The HC "punch through" is over 200ppm

CAT HC Oxidizing Efficiency Test

This test is based on the following concepts:

1. A fully functional catalytic converter will oxidize unburned fuel (HC), forming water vapor (H_2O) and carbon dioxide (CO_2).
2. An inoperative catalytic converter will not oxidize unburned fuel, leaving excessive hydrocarbons (HC) in the exhaust stream.
3. For an accurate test, the engine must be in "open-loop".

Test Procedure

1. Perform the exhaust gas analysis pretest setup and inspections.
2. Disconnect the oxygen sensor B1S1 (and B2S1 if equipped) to put the system into "open-loop" operation
3. Run the engine at 1500 rpm and record the HC level in the exhaust to serve as a "base reading".
4. Eliminate (kill) the spark to one of the spark plugs.
5. Bring the engine back to 1500 rpm and record the HC level in the exhaust with one spark dead cylinder.
6. Calculate the HC increase and compare it to the test results.
   HC increase = step 5 HC reading minus step 3 HC reading

Test Results

HC increase test cut points

4 cylinder engines	2,000 ppm
6 cylinder engines	1,600 ppm
8 cylinder engines	1,200 ppm

Normally functioning Catalytic Converter – Good CAT
The HC increase is well below the cut point

Deteriorated Catalytic Converter – Weak CAT
The HC increase is close to the cut point

Inoperative Catalytic Converter – Dead CAT
The HC increase is above the cut point

CAT Intrusive/Invasive Oxidation Efficiency Test

This test is based on the following concepts:

1. A fully functional catalytic converter will oxidize most of the HC and CO in the exhaust stream, forming CO_2 and H_2O.
2. The level of oxidation can be determined by taking exhaust gas measurements going into ("in") and out of ("out") the CAT, applying the measurements to a formula, and calculating the percentage of oxidation.

Test Procedure

1. Drill a hole in the exhaust pipe between the front O_2 sensor and the CAT just large enough to accommodate the small exhaust probe adapter.
2. Plug the hole and install the small adapter on the sample hose.
3. Perform the exhaust gas analysis pretest setup and inspections.
4. Run the engine at a steady speed above idle.
5. Record (print) the "out" readings at the tail pipe.
6. Remove the plug, insert the probe, and record (print) the "in" readings.
7. Calculate the HC and CO oxidation efficiency.

$$\frac{\text{(HC in)} - \text{(HC out)}}{\text{(HC in)}} \times 100 = \textbf{CAT HC Oxidation Efficiency}$$

$$\frac{\text{(CO in)} - \text{(CO out)}}{\text{(CO in)}} \times 100 = \textbf{CAT CO Oxidation Efficiency}$$

8. Permanently plug (weld) the hole in the exhaust pipe.

Test Results

The HC and CO oxidation efficiency should be around 90% when the O_2 "in" exceeds 1% and the O_2 "out" exceeds 0.5%.

Normally functioning Catalytic Converter – Good CAT
The oxidation efficiency is above 90%
Deteriorated Catalytic Converter – Weak CAT
The oxidation efficiency is between 10% and 90%
Inoperative Catalytic Converter – Dead CAT
The oxidation efficiency is below 10%