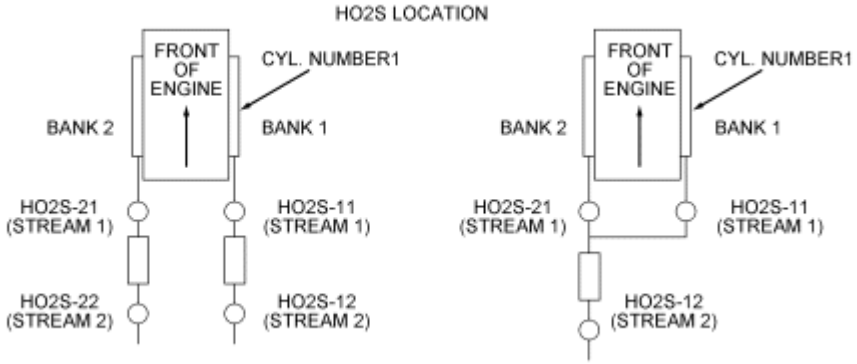
Catalyst and Exhaust Systems

Overview

The catalytic converter and exhaust systems work together to control the release of harmful engine exhaust emissions into the atmosphere. The engine exhaust gas consists mainly of nitrogen (N), carbon dioxide (CO_2) and water (H_2O). However, it also contains carbon monoxide (CO), oxides of nitrogen (NO_x), hydrogen (H), and various unburned hydrocarbons (HCs). The major air pollutants of CO, NO_x, and HCs, and their emission into the atmosphere must be controlled.

The exhaust system generally consists of an exhaust manifold, front exhaust pipe, front heated oxygen sensor (HO2S), rear exhaust pipe, catalyst HO2S, a muffler, and an exhaust tailpipe. The catalytic converter is typically installed between the front and rear exhaust pipes. On some vehicle applications, more than one catalyst is used between the front and rear exhaust pipes. Catalytic converter efficiency is monitored by the on board diagnostic (OBD) system strategy in the powertrain control module (PCM). For information on the OBD catalyst monitor, refer to the description for the Catalyst Efficiency Monitor in this section.

For most vehicles, only two HO2Ss are used in an exhaust stream. The front sensors (HO2S11/HO2S21) before the catalyst are used for primary fuel control while the ones after the catalyst (HO2S12/HO2S22) are used to monitor catalyst efficiency. However, some partial zero emission vehicles (PZEVs) use three HO2Ss. The stream 1 sensor (HO2S11) located before the catalyst is used for primary fuel control, the stream 2 sensor (HO2S12) is used to monitor the light-off catalyst, and the stream 3 sensor (HO2S13) located after the catalyst is used for long term fuel trim control to optimize catalyst efficiency (fore aft oxygen sensor control).



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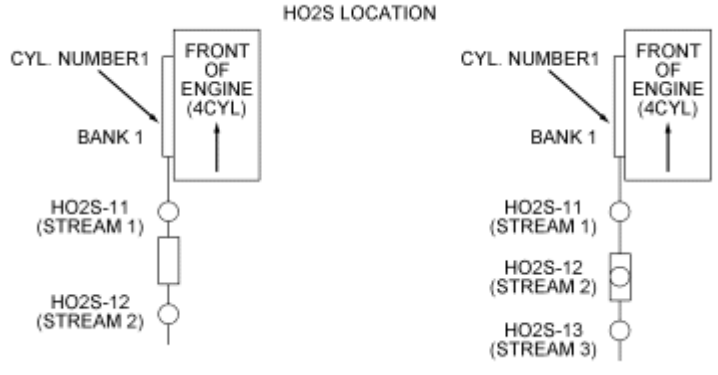
V-Engines



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In-Line Engines

Catalytic Converter

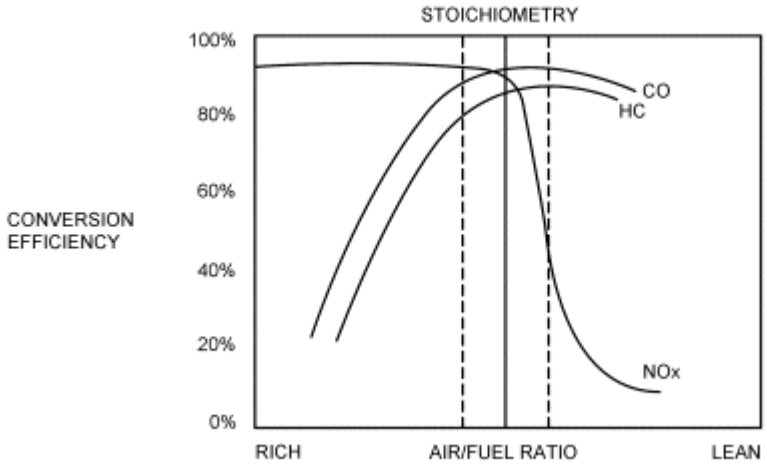
A catalyst is a material that remains unchanged when it initiates and increases the speed of a chemical reaction. A catalyst also enables a chemical reaction to occur at a lower temperature. The concentration of exhaust gas products released to the atmosphere must be controlled. The catalytic converter assists in this task. It contains a catalyst in the form of a specially treated ceramic honeycomb structure saturated with catalytically active precious metals. As the exhaust gases come in contact with the catalyst, they are changed into mostly harmless products. The catalyst initiates and speeds up heat producing chemical reactions of the exhaust gas components so they are used up as much as possible.

Light Off Catalyst

As the catalyst heats up, converter efficiency rises rapidly. The point at which conversion efficiency exceeds 50% is called catalyst light off. For most catalysts this point occurs at 246℃ to 302℃ (475℉ to 575 ℉). A fast light catalyst is a three way catalytic converter (TWC) that is located as close to the exhaust manifold as possible. Because the light off catalyst is located close to the exhaust manifold it lights off faster and reduces emissions more quickly than the catalyst located under the body. Once the catalyst lights off, the catalyst quickly reaches the maximum conversion efficiency for that catalyst.

Three Way Catalytic Converter (TWC) Conversion Efficiency

A TWC requires a stoichiometric fuel ratio, 14.7 pounds of air to 1 pound of fuel (14.7:1), for high conversion efficiency. In order to achieve these high efficiencies, the air/fuel ratio must be tightly controlled with a narrow window of stoichiometry. Deviations outside of this window greatly decrease the conversion efficiency. For example a rich mixture decreases the HC and CO conversion efficiency while a lean mixture decreases the NO_x conversion efficiency.



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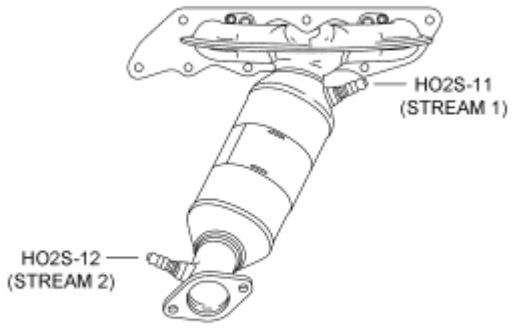
TWC Conversion Efficiency Chart

Exhaust System

The purpose of the exhaust system is to convey engine emissions from the exhaust manifold to the atmosphere. Engine exhaust emissions are directed from the engine exhaust manifold to the catalytic converter through the front exhaust pipe. A HO2S is mounted on the front exhaust pipe before the catalyst. The catalytic converter reduces the concentration of CO, unburned HCs, and NO_x in the exhaust emissions to an acceptable level. The reduced exhaust emissions are directed from the catalytic converter past another HO2S mounted in the rear exhaust pipe and then on into the muffler. Finally, the exhaust emissions are directed to the atmosphere through an exhaust tailpipe.

On some PZEV, there is a total of three HO2Ss in the exhaust stream. One near the exhaust manifold (stream 1), one in the middle of the light-off catalyst (stream 2), and the third (stream 3) is mounted after the light-off catalyst.



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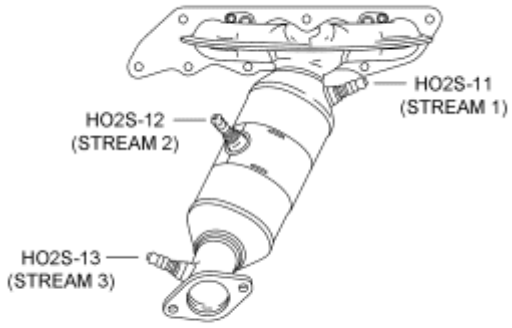
Typical Bank 1 Catalyst 2 HO2S Configuration



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Typical Bank 1 Catalyst 3 HO2S Configuration

Underbody Catalyst

The underbody catalyst is located after the light off catalyst. The underbody catalyst may be in line with the light off catalyst, or the underbody catalyst may be common to two light off catalysts, forming a Y pipe configuration. For an exact configuration of the catalyst and exhaust system for a specific vehicle, refer to the Workshop Manual Section 309-00, Exhaust System for the exhaust system exploded view.

Three Way Catalytic (TWC) Converter

The TWC contains either platinum (Pt) and rhodium (Rh) or palladium (Pd) and rhodium (Rh). The TWC catalyzes the oxidation reactions of unburned HCs and CO and the reduction reaction of NO_x. The 3-way conversion can be best accomplished by always operating the engine air fuel/ratio at or close to stoichiometry.

Exhaust Manifold Runners

The exhaust manifold runners collect exhaust gases from engine cylinders. The number of exhaust manifolds and exhaust manifold runners depends on the engine configuration and number of cylinders.

Exhaust Pipes

Exhaust pipes are usually treated during manufacturing with an anti-corrosive coating agent to increase the life of the product. The pipes serve as guides for the flow of exhaust gases from the engine exhaust manifold through the catalytic converter and the muffler.

Heated Oxygen Sensor (HO2S)

The HO2Ss provide the PCM with information related to the oxygen content of the exhaust gas. For additional information on the HO2S, refer to Engine Control Components in this section.

Muffler

Mufflers are usually treated during manufacturing with an anti-corrosive coating agent to increase the life of the product. The muffler reduces the level of noise produced by the engine, and also reduces the noise produced by exhaust gases as they travel from the catalytic converter to the atmosphere.