Exhaust System: Description and Operation
Catalyst And Exhaust Systems Standard Models (Non BI-Fuel)
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 **(CO2)** and Water Vapor **(H2O)**. However, it also contains carbon monoxide **(CO)**, Oxides Of Nitrogen **(NOx)**, Hydrogen **(H)**, and various unburned Hydrocarbons **(HCs)**. CO, NOx, and HCs are major air pollutants, 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 will be 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)**. Refer to the Catalyst Efficiency Monitor-Federal Test Procedure for specific OBD catalyst monitor information.

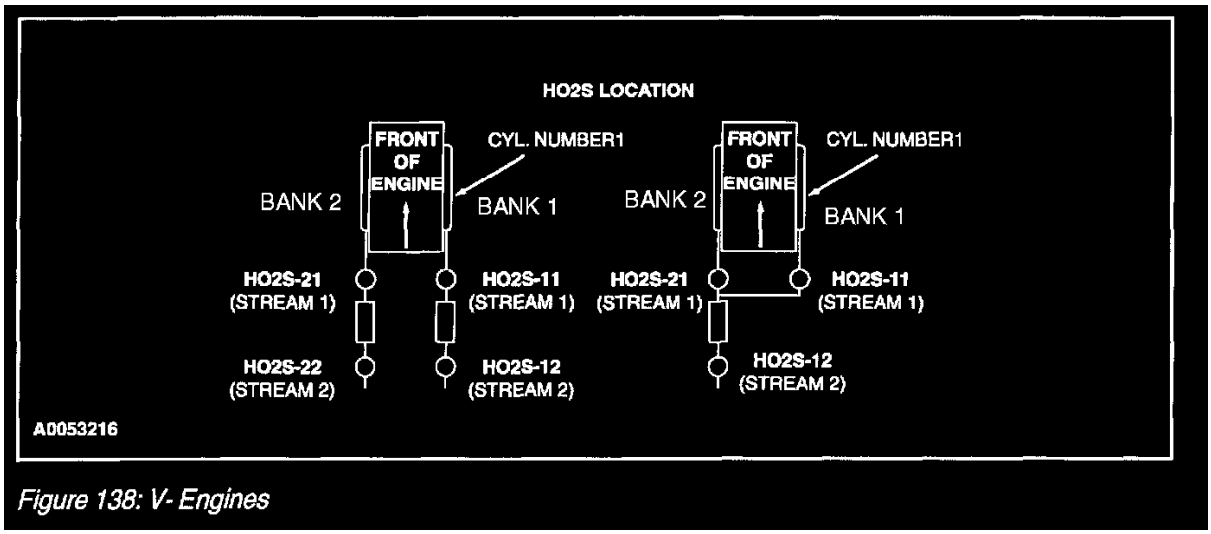

Figure 138: V- Engines

V-Engines

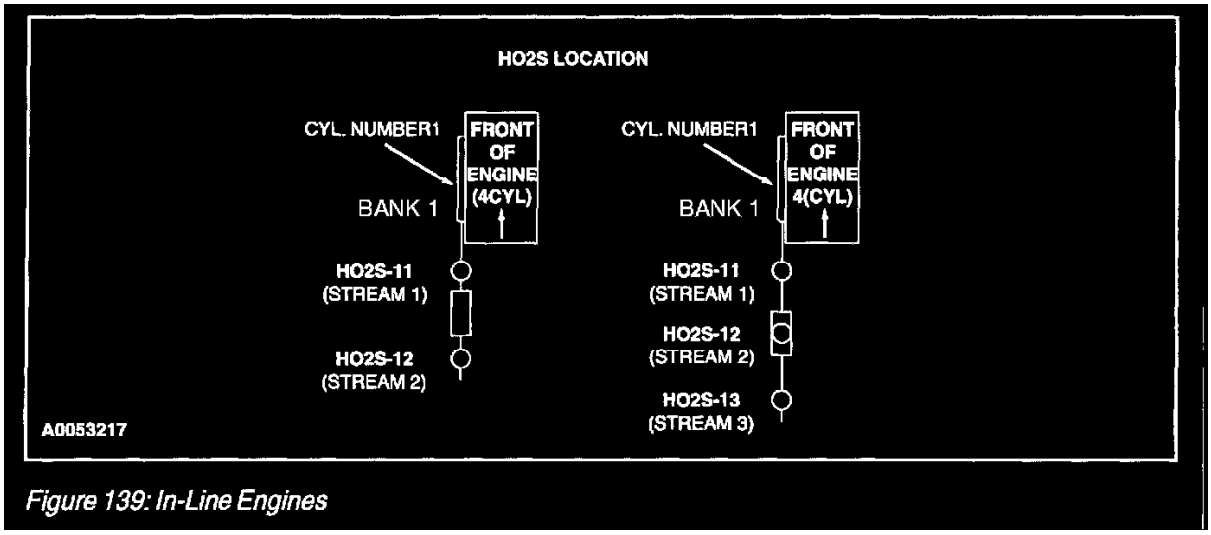

Figure 139: In-Line Engines

In-Line Engines

The number of HO2S(s) used in the exhaust stream and the location of these sensors depend on the vehicle emission certification level (i.e. LEV, ULEV, PZEV). Refer to (Figure 138) and (Figure 139) for typical HO2S stream locations and naming convention. On most vehicles only two HO2S are used in an exhaust stream. The front sensors (HO2S11/HO2S21) before the catalyst will be used for primary fuel control while the ones after the catalyst (HO2S12/HO2S22) will be utilized to monitor catalyst efficiency. However, some Partial Zero Emission Vehicles **(PZEV)** will utilize three HO2S sensors for each engine bank. The stream 1 sensors (HO2S11/HO2S21) before the catalyst will be used for primary fuel control, the next group of sensors or stream 2 (HO2S12/HO2S22) is utilized to monitor the light-off catalyst and the last group of sensors or stream 3 (HO2S13/HO2S23) is utilized for long term fuel trim control to optimize catalyst efficiency (Fore Aft Oxygen Sensor Control). Currently Ford's PZEV vehicles use only a 4-cylinder engine, so only the Bank 1 HO2S(s) will be utilized.

Catalytic Converter

A catalyst is a material that remains unchanged when it initiates and increases the speed of a chemical reaction. A catalyst will also enable 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 **475 to 575°F (246 to 301°C)**. A fast light catalyst is a Three Way Catalyst **(TWC)** that is located as close to the exhaust manifold as possible. Because the light off catalyst is located close too the exhaust manifold it will light off faster and reduce emissions quicker than the catalyst located under the body. Once the catalyst lights off, the catalyst will quickly reach the maximum conversion efficiency for that catalyst.

Three-Way Catalyst (TWC) Conversion Efficiency

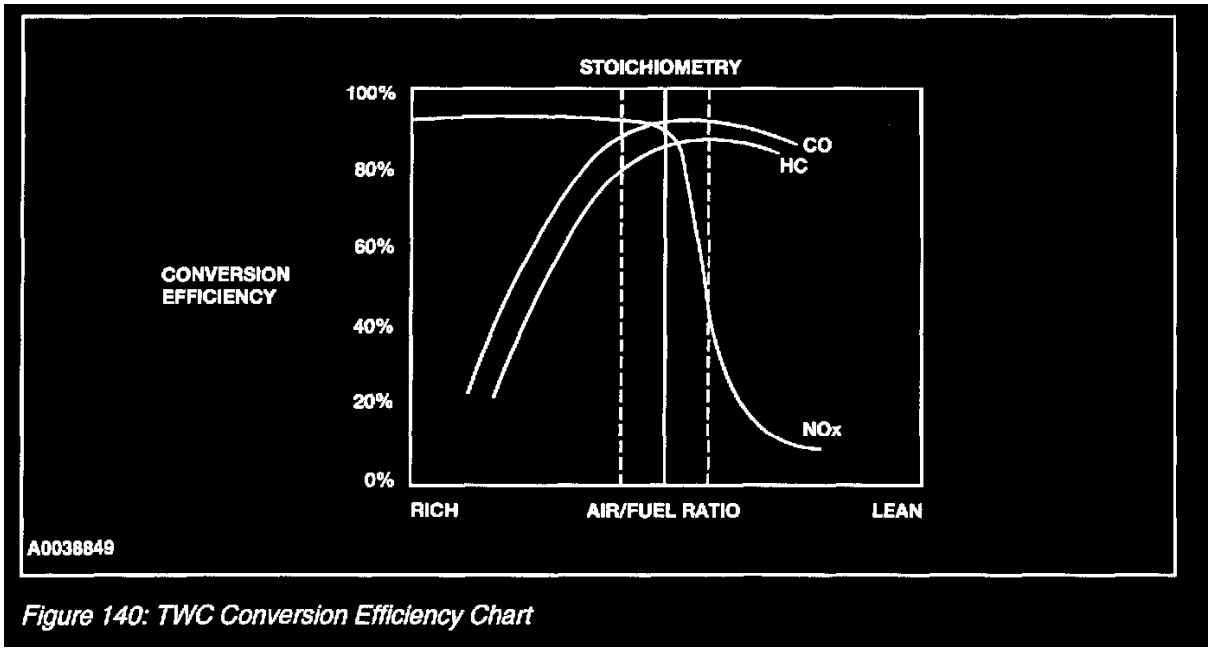

Figure 140: TWC Conversion Efficiency Chart

TWC Conversion Efficiency Chart

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 will greatly decrease the conversion efficiency (Figure 140). For example a rich mixture will decrease the HC and CO conversion efficiency while a lean mixture will decreases the NOx conversion efficiency.

Exhaust System

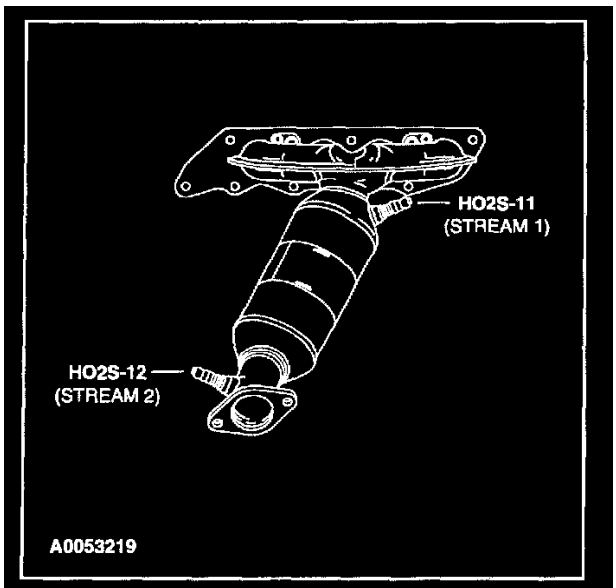

Figure 141: Typical Bank 1 Catalyst Two HO2S Configuration

Bank 1 Catalyst Two HO2S Configuration

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. An HO2S is mounted on the front exhaust pipe before the catalyst. The catalytic converter reduces the concentration of carbon monoxide (CO), unburned hydrocarbons (HCs) and oxides of nitrogen (NOx) in the exhaust emissions to an acceptable level. The reduced exhaust emissions are directed from the catalytic converter through another HO2S mounted in the rear exhaust pipe (Figure 141) and then on into the muffler. Lastly, the exhaust emissions are directed to the atmosphere through an exhaust tailpipe.

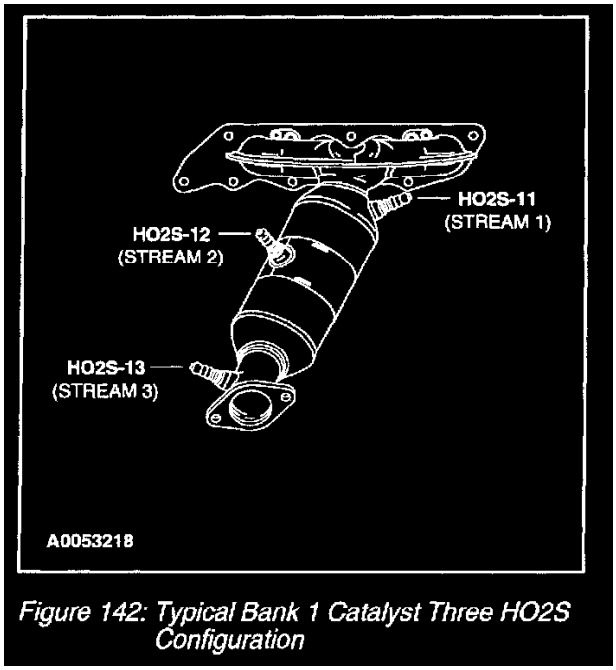

Figure 142: Typical Bank 1 Catalyst Three HO2S Configuration

Bank 1 Catalyst Three HO2S Configuration

Note on some Partial Zero Emission Vehicles (PZEV), there will be a total of 3 HO2S 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 (Figure 142).

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 Exhaust System.

Three-Way Catalytic Converter

The three-way catalytic (TWC) converter contains either platinum **(Pt)** and rhodium **(Rh)** or palladium **(Pd)** and rhodium **(Rh)**. The TWC converter catalyzes the oxidation reactions of unburned HOs and CO and the reduction reaction of NOx. The three-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 Sensors (HO2S)

The HO2S provide the powertrain control module (PCM) with voltage and frequency information related to the oxygen content of the exhaust gas. (Refer to the PCM Inputs for a description of how the HO2S operates.)

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 it also reduces the noise produced by exhaust gases as they travel from the catalytic converter to the atmosphere.