

Catalyst Efficiency Monitor

The catalyst efficiency monitor uses an oxygen sensor before and after the catalyst to infer the hydrocarbon (HC) efficiency based on the oxygen storage capacity of the catalyst. Under normal closed loop fuel conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear heated oxygen sensor (HO2S) very slow and reduces the amplitude, which provides for a shorter signal length. As the catalyst efficiency deteriorates due to thermal and chemical deterioration, the catalyst ability to store oxygen declines. The post catalyst or downstream HO2S signal begins to switch more rapidly with increasing amplitude and signal length. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposits on the front brick of the catalyst) and thermal deterioration.

The catalyst monitor calculates the rear HO2S signal lengths for 10 to 20 seconds during part throttle, closed loop fuel conditions after the engine is warmed up, the inferred catalyst temperature is within limits, and fuel tank vapor purge is disabled. The catalyst monitor is enabled for 10 to 20 seconds per drive cycle. When the catalyst monitor is active, the PCM commands a fixed fuel control routine. During monitor operation the rear HO2S signal lengths are continually calculated. The calculated rear HO2S signal length is then divided by a calibrated signal length, which has compensation for mass airflow. The calibrated signal length is based on the signal length of an HO2S placed after a catalyst without a washcoat. An index ratio near 0.0 indicates high oxygen storage capacity and high HC efficiency. An index ratio near 1.0 indicates low oxygen storage capacity and low HC efficiency. If the actual index ratio exceeds the threshold index ratio, the catalyst is considered failed.

Inputs from engine coolant temperature (ECT) or cylinder head temperature (CHT), intake air temperature (IAT), mass airflow (MAF) (if equipped), crankshaft position (CKP), throttle position (TP), and vehicle speed sensors are required to enable the catalyst efficiency monitor.

Typical Monitor Entry Conditions:

- Minimum 330 seconds since start up at 21°C (70°F)
- Engine coolant temperature is between 76.6°C - 110°C (170°F - 230°F)
- Intake air temperature is between -7°C - 82°C (20°F - 180°F)
- Time since entering closed loop is 30 seconds
- Inferred rear HO2S temperature of 482°C (900°F)
- EGR is between 1% and 12%
- Part throttle, maximum rate of change is 0.2 volts/0.050 sec
- Vehicle speed is between 8 and 112 km/h (5 and 70 MPH)
- Fuel level is greater than 15%
- First Airflow Cell
 - Engine RPM 1,000 to 1,300 RPM
 - Engine load 15 to 35%
 - Inferred catalyst temperature 454°C - 649°C (850°F - 1,200°F)
 - Number of universal HO2S switches is 50
- Second Airflow Cell
 - Engine RPM 1,200 to 1,500 RPM
 - Engine load 20 to 35%
 - Inferred catalyst temperature 482°C - 677°C (900°F - 1,250°F)
 - Number of universal HO2S switches is 70
- Third Airflow Cell
 - Engine RPM 1,300 to 1,600 RPM
 - Engine load 20 to 40%
 - Inferred catalyst temperature 510°C - 704°C (950°F - 1,300°F)
 - Number of universal HO2S switches is 30

Six drive cycles may be required to illuminate the malfunction indicator lamp (MIL) during normal customer driving, because an exponentially weighted moving average algorithm is used to determine a concern. If the keep alive memory (KAM) is reset, a concern illuminates the MIL in 2 drive cycles.

General Catalyst Monitor Operation

The catalyst monitor duration is 12 to 30 seconds, once per drive cycle. If the catalyst monitor conditions are met, the catalyst monitor may run and complete after all of the upstream HO2S functional tests are complete and the EVAP system is functional, with no stored DTCs; however, the catalyst monitor may run and complete before the downstream HO2S

deceleration fuel shut off test is complete. In this case, the catalyst monitor inspection maintenance (I/M) readiness flag may indicate complete before the O2S I/M readiness flag indicates complete. If the catalyst monitor does not complete during a particular driving cycle, the already accumulated switch/signal data is retained in the keep alive memory (KAM) and is used during the next driving cycle to allow the catalyst monitor a better opportunity to complete.

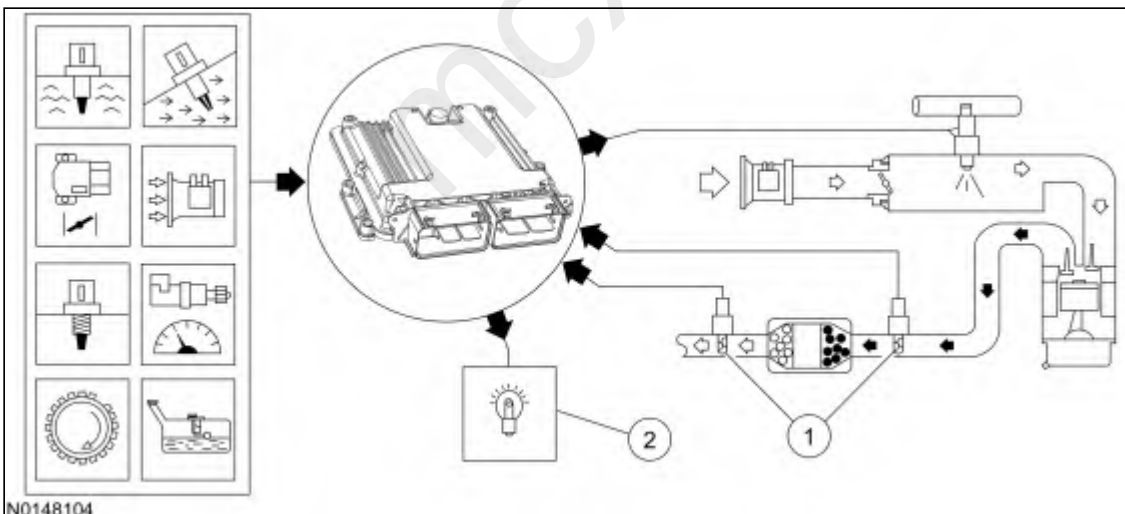
Some vehicles that are part of the low emission vehicle (LEV) catalyst monitor phase in, monitor less than 100% of the catalyst volume. Often this is the first catalyst brick of the catalyst system. Partial volume monitoring is done on LEV and ultra low emission vehicle (ULEV) vehicles in order to meet the 1.75 emission standard. The rationale for this strategy is the catalyst nearest the engine deteriorates first, allowing the catalyst monitor to be more sensitive and illuminate the MIL correctly at lower emission standards.

Some applications use partial volume monitoring, where the rear HO2S is located after the first light off catalyst can or after the second catalyst can in a three can per bank system (a few applications placed the HO2S in the middle of the catalyst can, between the first and second bricks). For additional HO2S information, refer to the [Heated Oxygen Sensor \(HO2S\) Monitor](#) in this section.

Index ratios for ethanol (flex fuel) vehicles vary based on the changing concentration of alcohol in the fuel. The threshold to determine a concern typically increases as the percent of alcohol increases. For example, a threshold of 0.5 may be used at E10 (10% ethanol) and 0.9 may be used at E85 (85% ethanol). The thresholds are adjusted based on the percentage of alcohol in the fuel. Standard fuel may contain up to 10% ethanol.

The PCM calibration prevents the catalyst monitor from running on a new vehicle until 60 minutes of time has accumulated with the catalyst temperature greater than 426°C (800°F) or 483 km (300 miles) have accumulated. A replacement PCM or updated calibration does not prevent the catalyst monitor from running.

1. The HO2S can be located in various configurations to monitor different kinds of exhaust systems. Inline engines and many V engines are monitored by their individual bank. A rear HO2S is used along with the front, fuel control universal HO2S for each bank. Two sensors are used on an inline engine and 4 sensors are used on a V engine. Some V engines have exhaust banks that combine into a single underbody catalyst. These systems are referred to as Y pipe systems. They use only one rear HO2S along with the 2 front, fuel control universal HO2S. The Y pipe system uses 3 sensors in all. For Y piped systems, the 2 front universal HO2S signals are combined by the PCM software to infer what the exhaust oxygen content would have been in front of the monitored catalyst. The inferred front exhaust oxygen content and the rear HO2S signal is then used to calculate the index ratio.
2. The malfunction indicator lamp (MIL) is activated after the first concern is detected.
When a concern is detected after a KAM reset, the MIL is activated after 2 consecutive key cycles.



Catalyst Efficiency Monitor

Integrated Air Fuel Catalyst Monitor

The integrated air fuel catalyst monitor is an on board strategy designed to monitor the oxygen storage capacity of the catalyst after a deceleration fuel shut off (DFSO) event. The monitor determines the amount of fuel needed to drive the catalyst to a rich condition when starting from an oxygen saturated, lean condition. The monitor is a measure of how much fuel is required to force the catalyst from a lean to a rich condition. The monitor runs during catalyst reactivation following a DFSO event. The monitor completes after approximately 3 DFSO monitoring events have occurred.

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