

Catalyst Efficiency Monitor

The Catalyst Efficiency Monitor uses an oxygen sensor after the catalyst to infer the hydrocarbon efficiency based on oxygen storage capacity of the ceria and precious metals in the washcoat. Under normal, closed-loop fuel conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear HO₂S very slow and reduces the amplitude of those. As catalyst efficiency deteriorates due to thermal and/or chemical deterioration, its ability to store oxygen declines and the post-catalyst HO₂S signal begins to switch more rapidly with increasing amplitude. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposition on the front brick of the catalyst), not thermal deterioration.

Index Ratio Method Using a Switching HO₂S Sensor

In order to assess catalyst oxygen storage, the catalyst monitor counts front HO₂S switches during part-throttle, closed-loop fuel conditions after the engine is warmed-up and inferred catalyst temperature is within limits. Front switches are accumulated in up to three different air mass regions or cells. While catalyst monitoring entry conditions are being met, the front and rear HO₂S signal lengths are continually being calculated. When the required number of front switches has accumulated in each cell (air mass region), the total signal length of the rear HO₂S is divided by the total signal length of front HO₂S to compute a catalyst index ratio. An index ratio near 0.0 indicates high oxygen storage capacity, hence high HC efficiency. An index ratio near 1.0 indicates low oxygen storage capacity, hence low HC efficiency. If the actual index ratio exceeds the threshold index ratio, the catalyst is considered failed.

If the catalyst monitor does not complete during a particular driving cycle, the already-accumulated switch/signal-length data is retained in Keep Alive Memory and is used during the next driving cycle to allow the catalyst monitor a better opportunity to complete, even under short or transient driving conditions.

If the catalyst monitor runs to completion during a driving cycle, it will be allowed to run again and collect another set of data during the same driving cycle. This would allow the catalyst monitor to complete up to a maximum of two times per driving cycle, however, the in-use performance ratio numerator for the catalyst monitor will only be allowed to increment once per driving cycle. For example, if the catalyst monitor completes twice during the current driving cycle, the catalyst monitor in-use performance numerator will be incremented once during the current driving cycle and will be incremented again for the second completion on the following driving cycle, after the catalyst monitor entry condition have been met.

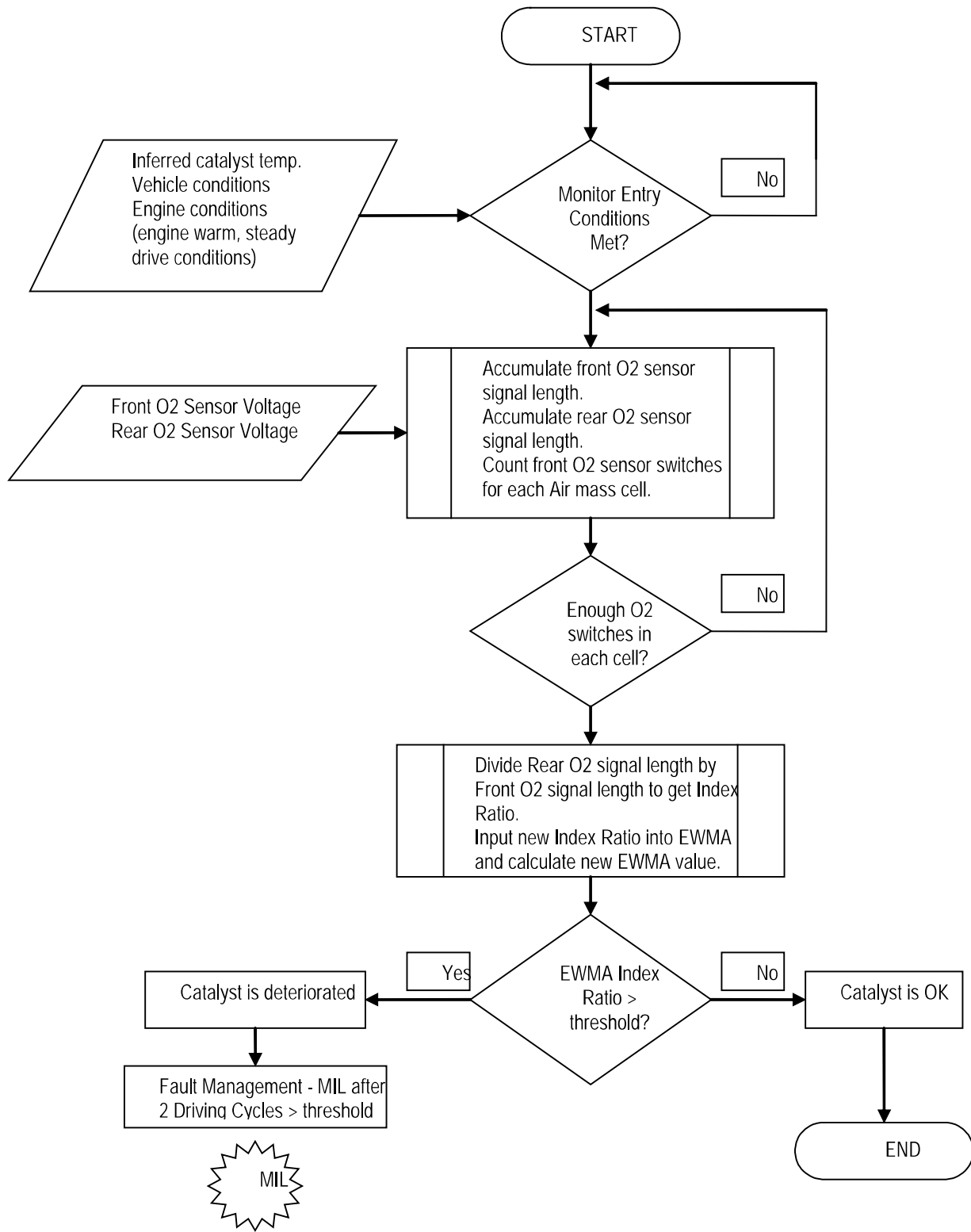
General Catalyst Monitor Operation

Rear HO₂S sensors can be located in various ways to monitor different kinds of exhaust systems. A rear HO₂S sensor is used along with the front, fuel-control HO₂S sensor for each bank. Four 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 sensor along with the two front, fuel-control HO₂S sensors. Y-pipe system use three sensors in all. For Y-pipe systems which utilize switching front O₂ sensors, the two front HO₂S sensor signals are combined by the software to infer what the HO₂S signal would have been in front of the monitored catalyst. The inferred front HO₂S signal and the actual single, rear HO₂S signal is then used to calculate the switch ratio.

Most vehicles monitor less than 100% of the catalyst volume – often the first catalyst brick of the catalyst system. Partial volume monitoring is done on LEV and LEV-II vehicles in order to meet the 1.75 * emission-standard threshold for NMHC and NO_x. The rationale for this practice is that the catalysts nearest the engine deteriorate first, allowing the catalyst monitor to be more sensitive and illuminate the MIL properly at lower emission standards.

Many applications that utilize partial-volume monitoring place the rear HO₂S sensor 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.)

Index Ratio Catalyst Monitor



CATALYST MONITOR OPERATION:	
DTCs	P0420 Bank 1 (or Y-pipe), P0430 Bank 2
Monitor execution	once per driving cycle
Monitor Sequence	HO2S response test complete and no DTCs (P0133/P0153) prior to calculating switch ratio, no SAIR pump stuck on DTCs (P0412/P1414), no evap leak check DTCs (P0442/P0456), no EGR stuck open DTCs (P0402)
Sensors OK	ECT, IAT, TP, VSS, CKP
Monitoring Duration	Approximately 700 seconds during appropriate FTP conditions (approximately 100 to 200 oxygen sensor switches are collected) for switching O2 control sensors Approximately 10 to 20 seconds for wide range O2 control sensors.

TYPICAL SWITCHING O2 SENSOR INDEX RATIO CATALYST MONITOR ENTRY CONDITIONS:		
Entry condition	Minimum	Maximum
Time since engine start-up (70 °F start)	330 seconds	
Engine Coolant Temp	170 °F	230 °F
Intake Air Temp	20 °F	180 °F
Time since entering closed loop fuel	30 sec	
Inferred Rear HO2S sensor Temperature	900 °F	
EGR flow (Note: an EGR fault disables EGR)	1%	12%
Throttle Position	Part Throttle	Part Throttle
Rate of Change of Throttle Position		0.2 volts / 0.050 s
Vehicle Speed	5 mph	70 mph
Fuel Level	15%	
First Air Mass Cell	1.0 lb/min	2.0 lb/min
Engine RPM for first air mass cell	1,000 rpm	1,300 rpm
Engine Load for first air mass cell	15%	35%
Monitored catalyst mid-bed temp. (inferred) for first air mass cell	850 °F	1,200 °F
Number of front O2 switches required for first air mass cell	50	
Second Air Mass Cell	2.0 lb/min	3.0 lb/min
Engine RPM for second air mass cell	1,200 rpm	1,500 rpm
Engine Load for second air mass cell	20%	35%
Monitored catalyst mid-bed temp. (inferred) for second air mass cell	900 °F	1,250 °F
Number of front O2 switches required for second air mass cell	70	
Third Air Mass Cell	3.0 lb/min	4.0 lb/min
Engine RPM for third air mass cell	1,300 rpm	1,600 rpm

Engine Load for third air mass cell	20%	40%
Monitored catalyst mid-bed temp. (inferred) for third air mass cell	950 °F	1,300 °F
Number of front O2 switches required for third air mass cell	30	
(Note: Engine rpm and load values for each air mass cell can vary as a function of the power-to-weight ratio of the engine, transmission and axle gearing and tire size.)		

TYPICAL WIDE RANGE O2 SENSOR INDEX RATIO CATALYST MONITOR ENTRY CONDITIONS:		
Entry condition	Minimum	Maximum
Time since engine start-up (70 °F start)	330 seconds	
Engine Coolant Temp	170 °F	230 °F
Intake Air Temp	20 °F	180 °F
Time since entering closed loop fuel	30 sec	
Inferred Rear HO2S sensor Temperature	900 °F	
EGR flow (Note: an EGR fault disables EGR)	1%	12%
Throttle Position	Part Throttle	Part Throttle
Rate of Change of Throttle Position		0.2 volts / 0.050 s
Vehicle Speed	20 mph	80 mph
Fuel Level	15%	
Air Mass	2.0 lb/min	5.0 lb/min
Engine RPM	1,000 rpm	2,000 rpm
Engine Load	20%	60%
Monitored catalyst mid-bed temp. (inferred) for first air mass cell	850 °F	1,200 °F
(Note: Engine rpm, load and air mass values can vary as a function of the power-to-weight ratio of the engine, transmission and axle gearing and tire size.)		

TYPICAL MALFUNCTION THRESHOLDS:
Catalyst monitor index ratio > 0.75 (bank monitor)
Catalyst monitor index-ratio > 0.60 (Y-pipe monitor)

J1979 CATALYST MONITOR MODE \$06 DATA			
Monitor ID	Test ID	Description for CAN	
\$21	\$80	Bank 1 index-ratio and max. limit	unitless
\$22	\$80	Bank 2 index-ratio and max. limit	unitless

** NOTE: In this document, a monitor or sensor is considered OK if there are no DTCs stored for that component or system at the time the monitor is running.