Cal/EPA
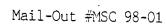
California
Environmental
Protection
Agency

Air Resources Board

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Pete Wilson
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TO: ALL PASSENGER CAR MANUFACTURERS
      ALL LIGHT-DUTY/MEDIUM-DUTY VEHICLE MANUFACTURERS
      ALL OTHER INTERESTED PARTIES

RE: ON-BOARD DIAGNOSTIC II COMPLIANCE GUIDELINES

BACKGROUND

The California Air Resources Board's (ARB) On-Board Diagnostic II
(OBD II) requirements have been in effect for all vehicles subject to its
requirements since the 1996 model year. Under these requirements,
manufacturers have implemented diagnostic systems on their vehicles to
detect the presence of emission-related malfunctions. Vehicle operators are
informed of detected malfunctions via the Malfunction Indicator Light (MIL)
on the instrument panel. Further, the OBD II system provides diagnostic
information to assist in the diagnosis and repair of detected malfunctions.

Since adoption of the requirements in 1989, the staff has worked with
vehicle manufacturers to ensure that OBD II systems are correctly
implemented and provide for maximum emission reductions from in-use
vehicles. In this effort, the staff has reported back to the Board in 1991, 1993,
1994, and most recently, in December of 1996, to address manufacturers'
implementation concerns and to strengthen the monitoring requirements
where appropriate. The staff has also found it helpful to periodically issue
OBD II compliance guidelines that offer clarification regarding details of
specific monitoring requirements. The guidance offered at this time is aimed
in part at clarifying the staff's intent regarding recent modifications to the
MIL illumination requirements for misfire detection. Clarification is also
provided regarding a few other OBD II monitoring requirements based on
recent discussions with the automotive industry.

Misfire Detection

At the December, 1996, Board Hearing, in response to testimony from manufacturers, the Board adopted modifications to the MIL illumination requirements for misfire detection. Specifically, the modifications permit longer evaluations for the presence of misfire during a driving cycle before MIL illumination is required. However, shorter evaluation periods were maintained for detection of misfire immediately after engine starting, and during conditions when catalyst damage is more likely (i.e., at engine speeds and loads greater than encountered during an FTP). The modifications were made to ensure that under most conditions misfire is sufficiently repeatable for its cause to be properly diagnosed and repaired by a service technician. However, with the increased flexibility offered by the modifications, the logic for properly setting fault codes, causing the MIL to blink or illuminate steadily, and clearing faults that are no longer present has become significantly more complex.

To facilitate proper implementation under the regulations, attached are flow charts detailing proper MIL illumination and fault code storage logic for misfire monitoring. The ARB will also accept reasonable variations with respect to this logic; however, the staff requests manufacturers to submit any alternate logic that it proposes to use to the ARB for review to ensure that the requirements of the regulation are being met. To highlight one important point illustrated in the flowcharts, if misfire is detected on consecutive driving cycles, regardless of whether similar conditions have been encountered, the regulation requires illumination of the MIL.

Coolant Temperature Sensor Monitoring

Previously issued guidance has focused on the requirements for detecting coolant temperature sensors that fail or are slow in responding as vehicle warm-up occurs. However, in reviewing manufacturers' OBD II system designs, it has become clear that coolant temperature sensors that inaccurately indicate a high coolant temperature can also have a detrimental impact on OBD II system performance.

Manufacturers have incorporated logic to disable selected monitoring strategies when the coolant temperature is too high. For some monitoring strategies (e.g., evaporative system monitoring), disablement can occur at engine starting temperatures near 100 degrees Fahrenheit. Therefore, coolant temperature sensors with readings stuck at a higher temperature or

significantly biased towards higher temperature readings may cause such monitoring strategies to be permanently disabled.

To address this concern, the ARB will require manufacturers using high temperature OBD II disablement logic to incorporate "high sided" rationality checks per section (b)(12.1.1)(A) of the OBD II regulation. This section states that computer input components should be monitored for inappropriately high or low values to the extent feasible. In this instance, the check should be capable of detecting sensor outputs that are stuck or significantly biased towards high readings. The staff believes that such monitoring can be accomplished, for example, by constructing a model of expected coolant temperature readings using information already available to the on-board computer.

Notwithstanding, ARB will not require high sided coolant temperature rationality checks on vehicles employing a temperature gauge that is driven by the same coolant temperature sensor element that provides input to the on-board computer. Staff believes in such a case that the temperature gauge itself will provide adequate notification to the vehicle operator of a stuck or significantly biased sensor reading.

Criteria for Determining a Cold-Start
When necessary, manufacturers are permitted to design certain monitoring strategies to only operate on driving cycles that begin with a cold-start. The most common example is for evaporative system leak detection. Many manufacturers choose to monitor the evaporative system only after a cold-start in order to minimize the impact of fuel vapor generation on monitoring results.

A common method to determine whether a particular driving cycle begins with a cold-start is to look at the difference between the ambient or intake air temperture and coolant temperature readings at key-on. If the difference between the two readings is small, a cold-start is inferred.

ARB accepts this method in principle as being valid, but is concerned that monitoring may be disabled more often than necessary if not implemented appropriately. Specifically, some manufacturers look at the absolute difference between the two temperature readings (i.e., disablement occurs if either temperature at key-on exceeds the other by a specified

amount). ARB understands the importance of coolant temperature not exceeding ambient air temperature by a specified amount at start-up as an indication of a cold-start. However, the need to ensure that ambient air temperature does not similarly exceed coolant temperature is not clear in many cases since this condition also indicates that the vehicle has not been operated for an extended period of-time. To address this concern, staff requests that manufacturers using this logic determine cold-starts only on the basis of coolant temperature being near or below ambient temperature unless a compelling reason is provided regarding the need for an absolute comparison between the two temperatures.

Fuel Slosh Detection for Evaporative System Monitoring

Many manufacturers have indicated that excessive fuel sloshing during testing of the evaporative system can lead to false malfunction indications due to high vapor generation rates caused by the sloshing. As a result, these manufacturers have implemented methods to disable evaporative system monitoring when fuel sloshing is excessive. The occurrence of fuel slosh is often detected using the fuel level sensor or the fuel tank pressure sensor.

The staff does not object to such methods to avoid unreliable monitoring of system performance. However, there is concern that an erratic or "noisy" reading from either sensor could cause a false and continuous indication of fuel sloshing that will result in an indefinite disablement of evaporative system leak detection systems. To address this concern, the ARB requests manufacturers under (b)(12.1.1)(A) to implement detection strategies for such failure modes or other methods to avoid improper monitoring system disablement. For example, a monitoring strategy that indicates a malfunctioning fuel level or fuel tank pressure sensor when fuel slosh is indicated for an extended amount of time after the vehicle has come to rest is considered an acceptable solution.

Mode 6 Information

Section (l)(3.0) requires for 1996 and later model year vehicles that the results of the most recent test performed by the vehicle for selected monitoring strategies be available though the standardized data link along with the limits to which each test result is compared. This data is to be transmitted in accordance with Test Mode 6 as defined in Society of Automotive Engineer's (SAE) Recommended Practice J1979.

A description of the data and scaling information are generally necessary in order to make use of the data. In order to facilitate ARB in-use evaluations of manufacturers' OBD II system designs, the staff requests manufacturers to provide information necessary to interpret Mode 6 data at or near the time of certification as provided for by section (h)(14) of the regulation.

Staff has found a few instances where Mode 6 data is not being properly stored or handled. First, figure 3 within SAE J1979 states that the format of Mode 6 test values and limits is to be decimal with a range of 0 to 65535. However, staff has found some manufacturers have stored negative number test values and/or limits. This practice can lead to incorrect interpretations of the data, especially when test values are compared to test limits (e.g., a signed test value can incorrectly appear to be greater than an unsigned maximum test limit). To avoid such confusion, it is necessary for vehicle manufacturers to adhere to the SAE J1979 specification by storing only unsigned Mode 6 test values.

Also with respect to Mode 6 information, staff has found that some manufacturers' vehicles reset Mode 6 information upon key off. As a result, only data from the current driving cycle can be accessed and the information must be obtained before engine shutdown. However, section (l)(3.0) of the regulation states that the results of the most recent test are to be available and the section does not provide for clearing of the information. Therefore, stored Mode 6 test results are to remain in memory, even over multiple engine starts, until replaced by more recent test results.

Lastly, some manufacturers have apparently developed common Mode 6 software for their entire product lines, without taking into account model-to-model differences. Therefore, on some vehicles, certain displayed Test Identification (TID) / Component Identification (CID) combinations are not actually supported by the vehicle. However, there is no indication to this effect in the data itself. Staff believes this practice will lead to unnecessary confusion in using the data, and requests manufacturers to implement Mode 6 information in such a way that each vehicle only displays TID and CID information that it truly supports.

Linear Air/Fuel Ratio Sensors

Some manufacturers are turning towards the use of linear (or wide-range) air/fuel ratio sensors (in place of conventional oxygen sensors) in order to meet low emission vehicle standards. However, the most recent published version of SAE J1979 does not provide an adequate parameter identification

(PID) for reporting information under Test Mode 1. The SAE's Electrical/Electronic Systems Diagnostic Committee is currently working on incorporating new PIDs for this purpose. The Committee's J1979 Task Force can be contacted for the most recent version of the proposed modifications.

The ARB requests that these guidelines be adhered to beginning with 1999 model vehicles. Reasonable implementation plans will be considered for models requiring additional leadtime. Questions or comments regarding these guidelines may be directed to Allen Lyons, Manager, Advanced Engineering Section, at (626) 575-6833.

Sincerely,

Robert H. Cross, Chief
Mobile Source Control Division

Attachment

Attachment

OBD II Misfire Detection Fault Handling Flow Charts

OBD II Misfire Fault Setting - FTP Misfire Rates

```
                              ┌─────────┐
                              │  Start  │
                              └─────────┘
                                   │
                                   ▼
                              ╱ End of ╲        Yes        ⎛   ⎞
                             ╱  driving  ╲ ─────────────▶  ⎝ B ⎠
                             ╲   cycle?  ╱
                              ╲         ╱
                                   │ No
                                   ▼
                 No          ╱  1000 revs. ╲
         ◀──────────────────╱   complete?  ╲
                             ╲              ╱
                                   │ Yes
                                   ▼
                          ┌──────────────────┐
                          │ Calculate misfire rate │
                          └──────────────────┘
                                   │
                                   ▼
                 No            ╱  Rate >  ╲
         ◀──────────────────  ╱ 1.5 x FTP? ╲
                              ╲            ╱
                                   │ Yes
```

(c)(2.0)   (c)(3.0)

Set MIL off driving cycle counter = zero → Set warm-up cycle counter = zero → ╱ First 1000 revs? ╲ → Yes → (b)(3.4.2)(B)

No ↓

Increment # of exceedances this driving cycle counter

(b)(3.4.2)(A)

╱ # of exceedances >= 4 ? ╲ — No ◀─────

Yes ↓

╱ MIL on for FTP misfire? ╲ — Yes ◀─────

No ↓

Store similar conditions

Set temp code off driving cycle counter = zero

Store FTP misfire temp code

╱ FTP misfire temp code stored on any previous driving cycle? ╲ — No

Yes ↓

╱ Similar conditions encountered? ╲ — No

Yes ↓

╱ FTP misfire temp code stored last driving cycle? ╲ — No

Yes ↓

Store DTC, turn on MIL, store freeze frame conditions, erase temp code

↓

Return to Start

Code/MIL Clearing for FTP Misfire Rates

(b)(3.4.2)(A)
(b)(3.4.2)(B)

(c)(2.0)

(c)(3.0)

B → FTP misfire temp code or DTC stored this driving cycle? —No→ FTP misfire temp code stored on any previous driving cycle? —No→ # Exceedances = 0? —Yes→ MIL on for FTP misfire? —No→ DTC stored for FTP misfire? —No→

Yes (from first diamond, down)

Exceedances = 0? — No (down)

FTP misfire temp code stored on any previous driving cycle? — Yes → # of exceedances >= 4 or exceedance in first 1000 revs? —Yes→ Re-store FTP misfire temp code → Re-store similar conditions → Set temp code off driving cycle counter = zero

# of exceedances >= 4 or exceedance in first 1000 revs? — No (down) → Similar conditions encountered? —No→ Increment temp code off driving cycle counter

Similar conditions encountered? — Yes → Zero exceedances in similar conditions? —No→ (down)

Zero exceedances in similar conditions? — Yes → Erase temp code → Erase stored conditions → Set temp code off driving cycle counter = zero

Increment temp code off driving cycle counter → # of driving cycles = 80? —Yes→ Erase temp code

# of driving cycles = 80? — No (down)

MIL on for FTP misfire? — Yes → Increment warm-up cycle counter → Similar conditions encountered? —No→ (down)

Similar conditions encountered? — Yes → Increment MIL off driving cycle counter → # of MIL off driving cycles = 3 ? —No→ (down)

# of MIL off driving cycles = 3 ? — Yes → Turn off MIL → Set MIL off driving cycle counter = zero

DTC stored for FTP misfire? — Yes → Increment warm-up cycle counter → Warm-up cycles = 40? —No→ (down)

Warm-up cycles = 40? — Yes → Erase DTC → Set warm-up cycle counter = zero → Erase freeze frame conditions

Set # of exceedances this driving cycle counter = zero

Return to Start

OBD II Misfire Fault Setting -- Catalyst Damage

```
                        START

              ┌─────────────┐
              │   End of    │──Yes──→ ( B )
              │   driving   │
              │   cycle?    │
              └─────────────┘
                    No
                    │
       No    ┌─────────────┐
      ←───── │  200 revs.  │
             │  complete?  │
             └─────────────┘
                   Yes
                    │
          ┌────────────────────┐
          │ Calculate misfire  │
          │       rate         │
          └────────────────────┘
                    │
             ┌─────────────┐      No    ┌──────────┐   Yes
             │   Rate >    │──────────→ │   MIL    │──────→
             │ cat. damage?│            │ blinking?│
             └─────────────┘            └──────────┘
                   Yes                       No
```

Turn MIL on steady

Stop blinking MIL and return to previous MIL status

Cat damage misfire DTC stored?   Yes / No

(c)(2.0) Set MIL off driving cycle counter = zero

(c)(3.0) Set warm-up cycle counter = zero

MIL on for cat damage misfire or temp code stored for either cat. damage or FTP misfire?   No / Yes

Blink MIL

Catalyst damage temp code stored this driving cycle?   Yes

Catalyst damage temp code stored on any previous driving cycle?   No / Yes

Catalyst damage temp code stored last driving cycle?   No / Yes

FTP misfire temp code stored from any previous driving cycle?   Yes → Erase FTP misfire temp code

No

Store catalyst damage DTC, store freeze frame conditions, erase catalyst damage temp code

Similar conditions encountered?   Yes / No

Inside max FTP speed/load cond?   No / Yes

Increment # of exceedances this driving cycle counter   (b)(3.4.1.A)

# of Exceedances = 3 ?   No / Yes

Store catalyst damage temp code

Store similar conditions

Set temp code off driving cycle counter = zero

Blink MIL

Return to Start

Code/MIL Clearing for Catalyst Damaging Misfire

(b)(3.4.1)(A)   (c)(2.0)   (c)(3.0)

B → Catalyst damage temp code or DTC stored this driving cycle? — No → Catalyst damage temp code stored from any previous driving cycle? — No → MIL blinked this driving cycle? — No → MIL on for catalyst damage misfire? — No → DTC stored for catalyst damage misfire? — No

Catalyst damage temp code or DTC stored this driving cycle? → Yes

Catalyst damage temp code stored from any previous driving cycle? → Yes → MIL blinked this driving cycle? — Yes →

MIL blinked this driving cycle? → Yes

MIL on for catalyst damage misfire? → Yes → Increment warm-up cycle counter

DTC stored for catalyst damage misfire? → Yes → Increment warm-up cycle counter

MIL blinked this driving cycle? → No

Increment temp code off driving cycle counter ← No — Similar conditions encountered?

Re-store catalyst damage temp code → Re-store similar conditions → Set temp code off driving cycle counter = zero

Similar conditions encountered? → Yes

Increment MIL off driving cycle counter

# of driving cycles = 80? — Yes → Erase catalyst damage temp code

# of driving cycles = 80? → No

Erase catalyst damage temp code → Erase stored conditions → Set temp code off driving cycle counter = zero

Similar conditions encountered? — No

Increment MIL off driving cycle counter → # of MIL off driving cycles = 3 ? — No

# of MIL off driving cycles = 3 ? → Yes → Turn off MIL → Set MIL off driving cycle counter = zero

Increment warm-up cycle counter → Warm-up cycles = 40? — No

Warm-up cycles = 40? → Yes → Erase DTC → Erase freeze frame conditions → Set warm-up cycle counter = zero

Set # of exceedances this driving cycle counter = zero

Return to Start