



# Air Resources Board



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July 7, 2009

Mail-Out #MSC 09-22

TO: All Heavy-Duty Engine/Vehicle Manufacturers  
All Other Interested Parties

SUBJECT: GUIDELINES FOR HEAVY-DUTY ON-BOARD DIAGNOSTIC (HD OBD)  
CERTIFICATION DATA

In order to expedite the HD OBD certification review process, staff has developed guidelines and templates for reporting various elements of the certification documentation. Where applicable, all HD OBD certification information shall be submitted in accordance with these templates. The formats and reporting requirements defined herein shall apply to all 2010 and newer model year HD OBD certification documentation.

## Misfire Disablement and Detection Chart

Section (j)(2.5) of title 13, California Code of Regulations, section 1971.1 (i.e., the HD OBD regulation) requires the certification application for heavy-duty gasoline engines and vehicles to include documentation of misfire monitor disablement during the Federal Test Procedure (FTP). For this documentation, a template is provided as Attachment A, "Misfire Disablement and Detection Chart." Data for these charts shall be collected from a vehicle on a chassis dynamometer with random misfire present at the FTP emission threshold level over the light-duty FTP chassis dynamometer drive cycle. For engine certified applications, the engine manufacturer must conduct the required chassis dynamometer testing on a representative vehicle as approved by the Executive Officer. These charts shall be printed as full pages in landscape format with time in seconds plotted on the x-axis and no more than 200 seconds of data on each page. The y-axis scaling shall be unique to each parameter to allow clear identification and observation of each trace. The parameters plotted on the chart shall include vehicle speed, a misfire counter (indicating the number of actual detected misfires for the current 1000-revolution evaluation interval), and a 1000-revolution counter (indicating the number of crankshaft revolutions accumulated while the misfire monitor is enabled for the current 1000-revolution evaluation interval). The FTP misfire threshold (i.e., number of detected misfires per 1000-revolution increment needed to detect a fault as defined in section (f)(2.2.2)(A)) shall be plotted as a horizontal line on the same y-axis scale as that used for the misfire counter.

*The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our website: <http://www.arb.ca.gov>.*

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A status bit indication shall be located immediately below the x-axis of the chart and shall indicate the individual status of all applicable disablements during the test cycle. The status bits shall be aligned with the x-axis of the chart to facilitate correlation of a status bit indicating disablement and the corresponding point on the chart where the disablement is active. One status bit shall indicate the overall status of the misfire monitor (enabled/disabled), a separate status bit shall indicate the point at which a fault is detected by the misfire monitor, and additional status bits shall be provided for each individual disablement that occurs during the test cycle such as fuel cut, negative torque, manual transmission gear shifts, and any other criterion that disables the misfire monitor.

#### Misfire Probability of Detection Chart

Section (j)(2.5.2) of the HD OBD regulation requires the certification application for heavy-duty gasoline engines to include documentation of misfire monitor probability of detection (Pd) in various engine speeds and loads. For this documentation, a template is provided as Attachment B, "Probability of Detection Chart." Manufacturers are required to submit data for the following misfire patterns: any one cylinder out, random misfire at the FTP threshold, and paired cylinders. Additionally, manufacturers are required to submit Pd data for misfire patterns causing misfire rates equal to or greater than two cylinders out that could be caused by the malfunction of a single component (e.g., shared coils).

The chart shall include engine speed in revolutions per minute (rpm) on the x-axis and calculated load in percent on the y-axis. Engine speed shall start at idle and continue up to redline in increments of 500 rpm. The calculated load axis shall include the following: zero torque, 15%, 30%, 50%, 65%, 80%, and wide-open-throttle (WOT). Calculated load is defined as PID \$04 Calculated Load Value in Society of Automobile Engineers (SAE) J1979 (ISO 15031-5), May 2007, "E/E Diagnostic Test Modes." For reference, the calculation is:

$$\frac{(current\_airflow)}{\left[ (peak\_airflow\_at\_WOT @ STP \_as\_a\_function\_of\_RPM) \times \frac{BARO}{29.92} \times \sqrt{\frac{298}{(AAT + 278)}} \right]}$$

For a given misfire pattern, Pd is calculated by dividing the total number of detected misfires by the total number of induced misfires. Pd shall be reported in decimal form with two significant digits. Manufacturers may not average different cylinder Pd values together and then report this average on a single chart. For example, on a four-cylinder engine, manufacturers may not report the single cylinder out misfire pattern by measuring the Pd for each of the four cylinders and then averaging these Pd values into

one chart; instead, the Pd values shall be reported separately on four different charts. In lieu of separately reporting the Pd values for each cylinder, a manufacturer may submit a chart with the worst case (lowest from all cylinders) Pd value for each speed and load point. However, a demonstration must be made by the manufacturer to show that the data submitted are representative of the worst case.

Manufacturers shall fill in all cells with data or notation as follows: manufacturers shall use the abbreviation NA for engine speed/load cells that are not achievable and shall provide reasons for not reporting data in those cells; manufacturers shall use the abbreviation NR for engine speed/load cells that do not require misfire monitoring as defined in section (f)(2.3.1)(C) of the HD OBD regulation.

### OBD Summary Tables

Section (j)(2.2) of the HD OBD regulation requires manufacturers to submit OBD calibration data in a standardized format. This format is included in this Mail-Out as Attachment C, "Summary Table." Manufacturers are reminded to use the engineering units specified in section (j)(2.2.2) of the regulation and to ensure that monitors are separated clearly in the summary tables by a horizontal line above and below each different monitor and to provide all text in size 12 pt font. Additionally, manufacturers shall use SAE J1930, "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms—Equivalent to ISO/TR 15031-2," and SAE J2403, "Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature," terms in the summary table where applicable.

Moreover, many delays in OBD certification are due to manufacturers using vague definitions and values in the summary tables. For example, manufacturers should avoid including a general secondary parameter such as "no fault present", "not defective", or "no fault codes present." Instead, manufacturers should indicate precisely which fault code(s) is required to disable the monitor and whether this fault code disablement is applicable to pending fault codes, confirmed fault codes commanding the malfunction indicator light (MIL) on, confirmed fault codes not commanding the MIL on, or other fault status. In lieu of listing every applicable disablement fault code in the summary table with each monitor, manufacturers may use notation to reference a separate table listing the applicable disablement fault code(s) for the given monitor.

As another example of vague secondary parameters, manufacturers frequently use general language in monitoring descriptions such as "front oxygen sensor status: OK." Such a description does not provide staff with enough detail to review the monitor. From this definition, staff cannot discern the criteria that the manufacturer are relying on to verify whether the sensor is "OK" or not and accordingly, cannot ensure that the OBD system is properly designed. Other commonly used terms that are not sufficient for use

in expeditious review of certification applications include qualitative, non-engineering terms such as “stable,” “noisy,” “ready”, “active”, “valid”, or “steady.” Such terms should be replaced with the actual parameters and quantitative conditions necessary to execute the monitor (e.g., instead of “oxygen sensor ready” use “oxygen sensor voltage > 0.55 volts”). Similarly, terms relating to internal flags such as “engine speed: Idle” or “idle conditions: true” should be replaced with the actual specifications using engineering units.

To avoid listing duplicate information in the summary tables, manufacturers may group fault codes together for monitors that share identical monitoring strategies and calibrations (e.g., monitors for bank 1 and bank 2 sensors). The monitoring strategy, thresholds, and secondary parameter calibrations can then be listed once and all applicable fault codes identified and grouped under the Fault Code column in the summary table.

#### Rate-Based Data Reporting

Section (l)(3) of the HD OBD regulation requires manufacturers to collect and report in-use rate-based data. Two templates are provided in this Mail-Out as Attachments D and E. Attachment D, “HD OBD Diesel Rate-Based Data,” is to be used for diesel engines and Attachment E, “HD OBD Gasoline Rate-Based Data,” is to be used for gasoline engines. These attachments are provided on the Air Resources Board (ARB) website <http://www.arb.ca.gov/msprog/obdprog/obdupdates.htm> and are required to be used by manufacturers. These data shall be reported to ARB in both hard copy and electronic format. For the electronic submittal, manufacturers may email the data to ARB staff. Manufacturers are required to fill in all fields in this template; the abbreviation NA shall not be used in this template. Manufacturers may insert additional rows in the template to report rate-based data as needed. For the calculated ratio for each monitor, the ratio shall be reported with a minimum of three decimal places. Below are additional details for each field in the rate-based table:

#### HD OBD Diesel Rate-Based Data (Attachment D):

No.: Number data sets starting from the number 1.  
MY: Report the model year for the engine in this field.  
Manufacturer: Report engine manufacturer name in this field. Manufacturer name shall be consistent for all data submitted.  
Engine Family: Report the engine family name for the certified engine.  
Engine Serial No.: Report the engine serial number in this field.  
VIN: Report the vehicle identification number (VIN) of the chassis in this field.  
MonPerfGrp: Report the monitoring performance group of the vehicle (Section 1971.1 (l)(3.2.2)): line-haul, urban delivery, or other in this field.

Date: Report the date that the data was taken in this field formatted as mm/dd/yyyy.

ODO: Report the odometer reading on the vehicle in miles.

CAL ID: Report the Calibration Identification Number (CAL ID) in this field. For engines with more than one CAL ID, the CAL ID field should be filled with the CAL ID that best represents the OBD software in the electronic controller unit (ECU); i.e., the CAL ID with the highest priority as defined in section (h)(4.6.3).

Gen Den: Report the general denominator in this field as defined in section (d)(5.6).

Ign Cycle: Report the number of ignition cycles in this field.

NMHCCatNum: Report the numerator for non-methane hydrocarbon converting (NMHC) catalyst monitor in this field.

NMHCCatDen: Report the denominator for NMHC catalyst monitor in this field.

NMHCCatRat: Report the ratio for NMHC catalyst monitor in this field.

NOxCatNum: Report the numerator for oxides of nitrogen (NOx) catalyst monitor (e.g., selective catalytic reduction) in this field.

NOxCatDen: Report the denominator for NOx catalyst monitor in this field.

NOxCatRat: Report the ratio for NOx catalyst monitor in this field.

NOxAdsNum: Report the numerator for NOx adsorber or NOx trap monitor (NOxAds) in this field.

NOxAdsDen: Report the denominator for NOxAds monitor in this field.

NOxAdsRat: Report the ratio for NOxAds monitor in this field.

DPFNum: Report the numerator for diesel particulate matter filter system (DPF) monitor in this field.

DPFDen: Report the denominator for DPF monitor in this field.

DPFRat: Report the ratio for DPF monitor in this field.

ExhGasSenNum: Report the numerator for oxygen or air/fuel ratio sensor monitor in this field.

ExhGasSenDen: Report the denominator for oxygen or air/fuel ratio sensor monitor in this field.

ExhGasSenRat: Report the ratio for oxygen or air/fuel ratio sensor monitor in this field.

EGRNum: Report the numerator for exhaust gas recirculation (EGR) monitor in this field.

EGRDen: Report the denominator for EGR monitor in this field.

EGRRat: Report the ratio for EGR monitor in this field.

VVTNum: Report the numerator for variable valve timing (VVT) monitor in this field.

VVTDen: Report the denominator for VVT monitor in this field.

VVTRat: Report the ratio for VVT monitor in this field.

BoostNum: Report the numerator for boost pressure control (Boost) monitor in this field.  
BoostDen: Report the denominator for Boost monitor in this field.  
BoostRat: Report the ratio for Boost monitor in this field.  
FuelSysNum: Report the numerator for fuel quantity and timing (FuelSys) monitors in this field.  
FuelSysDen: Report the denominator for FuelSys monitors in this field.  
FuelSysRat: Report the ratio for FuelSys monitors in this field.

HD OBD Gasoline Rate-Based Data (Attachment E):

No.: Number data sets starting from the number 1.  
MY: Report the model year for the engine in this field.  
Manufacturer: Report engine manufacturer name in this field. Manufacturer name shall be consistent for all data submitted.  
Engine Family: Report the engine family name for the certified engine.  
Engine Serial No.: Report the engine serial number in this field.  
VIN: Report the VIN of the chassis in this field.  
MonPerfGrp: Report the monitoring performance group of the vehicle (Section 1971.1 (l)(3.2.2)): line-haul, urban delivery, or other in this field.  
Date: Report the date that the data was taken in this field formatted as mm/dd/yyyy.  
ODO: Report the odometer reading on the vehicle in miles.  
CAL ID: Report the CAL ID in this field. For engines with more than one CAL ID, the CAL ID field should be filled with the CAL ID that best represents the OBD software in the ECU; i.e., the CAL ID with the highest priority as defined in section (h)(4.6.3).  
Gen Den: Report the general denominator in this field as defined in section (d)(5.6).  
Ign Cycle: Report the number of ignition cycles in this field.  
B1CatNum: Report the numerator for Bank 1 catalyst monitor in this field.  
B1CatDen: Report the denominator for Bank 1 catalyst monitor in this field.  
B1CatRat: Report the ratio for Bank 1 catalyst monitor in this field.  
B2CatNum: Report the numerator for Bank 2 catalyst monitor in this field.  
B2CatDen: Report the denominator for Bank 2 catalyst monitor in this field.  
B2CatRat: Report the ratio for the Bank 2 catalyst monitor in this field.  
B1O2Num: Report the numerator for Bank 1 front oxygen or air/fuel ratio sensor monitor in this field.  
B1O2Den: Report the denominator for Bank 1 front oxygen or air/fuel ratio sensor monitor in this field.  
B1O2Rat: Report the ratio for Bank 1 front oxygen or air/fuel ratio sensor monitor in this field.

|             |   |
|-------------|---|
| B2O2Num:    | Report the numerator for Bank 2 front oxygen or air/fuel ratio sensor monitor in this field.              |
| B2O2Den:    | Report the denominator for Bank 2 front oxygen or air/fuel ratio sensor monitor in this field.            |
| B2O2Rat:    | Report the ratio for Bank 2 front oxygen or air/fuel ratio sensor monitor in this field.                  |
| EGR/VVTNum: | Report the numerator for exhaust gas recirculation/variable valve timing (EGR/VVT) monitor in this field. |
| EGR/VVTDen: | Report the denominator for EGR/VVT monitor in this field.   |
| EGR/VVTRat: | Report the ratio for EGR/VVT monitor in this field.   |
| SAIRNum:    | Report the numerator for Secondary Air (SAIR) monitor in this field.                                      |
| SAIRDen:    | Report the denominator for SAIR monitor in this field.  |
| SAIRRat:    | Report the ratio for SAIR monitor in this field.  |
| EVAPNum:    | Report the numerator for 0.150" evaporative system leak (EVAP) monitor in this field.                     |
| EVAPDen:    | Report the denominator for 0.150" EVAP monitor in this field.   |
| EVAPRat:    | Report the ratio for 0.150" EVAP monitor in this field.   |
| B1SO2Num:   | Report the numerator for Bank 1 secondary oxygen or air/fuel ratio sensor monitor in this field.          |
| B1SO2Den:   | Report the denominator for Bank 1 secondary oxygen or air/fuel ratio sensor monitor in this field.        |
| B1SO2Rat:   | Report the ratio for Bank 1 secondary oxygen or air/fuel ratio sensor monitor in this field.              |
| B2SO2Num:   | Report the numerator for Bank 2 secondary oxygen or air/fuel ratio sensor monitor in this field.          |
| B2SO2Den:   | Report the denominator for Bank 2 secondary oxygen or air/fuel ratio sensor monitor in this field.        |
| B2SO2Rat:   | Report the ratio for Bank 2 secondary oxygen or air/fuel ratio sensor monitor in this field.              |

#### CAL ID and CVN

Section (h)(4.7.5) of the HD OBD regulation requires manufacturers to submit CAL ID and Calibration Verification Number (CVN) information. A template titled "CAL ID and CVN Data" is provided in this Mail-Out as Attachment F. Manufacturers are required to use the Microsoft Excel electronic template provided on the ARB website <http://www.arb.ca.gov/msprog/obdprog/obdupdates.htm> for reporting and electronically submitting CAL ID and CVN data to ARB. For the electronic submittal, manufacturers may email the data to ARB staff. CAL ID and CVN data shall be submitted on a quarterly basis for each engine family, including new data associated with running change and field fix calibrations. Successive reports should only include new CAL ID and CVN data not included in previous submitted reports. In cases where more than

one CAL ID and CVN pair are available for a given engine family (e.g., a single set of software in one ECU has multiple CAL IDs and CVNs, a running change software set has been released with a new CAL ID and CVN for an ECU), manufacturers shall use additional rows to report all CAL ID and CVN pairs. No distinction is required in the table between multiple CAL ID and CVN pairs for a single set of software in an ECU versus multiple sets of software available for an ECU that each have a unique CAL ID and CVN. Below are additional details for the CAL ID and CVN table:

Model Year: Report the model year for the engine in this field.  
Manufacturer: Report engine manufacturer name in this field. Manufacturer name shall be consistent for all data submitted.  
Engine Size: Report the engine size (in liters) in this field.  
Engine Family: Report the engine family for the certified engine in this field  
Engine Serial No.: Report the engine serial number in this field.  
Module ID/Address: Report the module ID/address (e.g., source address in the header bytes as defined in SAE J1979) in hexadecimal (HEX) format in this field.  
CAL ID: Report the CAL ID in ASCII format in this field.  
CVN: Report the CVN in HEX format in this field.

### OBD Checklists

To facilitate the OBD review and certification process, ARB staff has provided two checklists: one for diesel engines and one for gasoline engines. These checklists are included in this Mail-Out as Attachment G, "HD OBD Diesel Monitoring Requirements Checklist," and Attachment H, "HD OBD Gasoline Monitoring Requirements Checklist," and are available electronically at:

<http://www.arb.ca.gov/msprog/obdprog/obdupdates.htm>. They are intended to assist engine manufacturers and staff in making sure that pertinent information has been provided in the application. Attachment G lists malfunction criteria that are required to be detected for diesel engines, and requires manufacturers to identify the specific fault code(s) for the diagnostic(s) used to satisfy each criterion. Where components or systems are not supported by the engine, manufacturers shall use the abbreviation NA in the applicable field. Attachment H is similarly structured with the specific requirements for gasoline engines. While intended to be comprehensive, these checklists do not alter or supersede the regulatory requirements of the OBD regulation. These checklists focus on areas where the requirements are complex or where specific malfunction criteria are satisfied with multiple diagnostics, and are helpful to staff to quickly identify the relevant diagnostics when reviewing a system for compliance.

### Summary

All Heavy-Duty Engine/Vehicle Manufacturers  
All Other Interested Parties  
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Staff has provided these templates and guidelines to help expedite the HD OBD certification process. Any variation on these templates by a manufacturer must be approved by ARB before certification material is submitted. Staff may periodically modify these templates to further facilitate certification. Staff will send out an email informing manufacturers of modifications and provide appropriate lead time, where relevant, to incorporate the modifications. Manufacturers interested in receiving future emails should follow the instructions to subscribe to the On-Board Diagnostics Program list at the following website: <http://www.arb.ca.gov/msprog/obdprog/obdprog.htm> . Go to "Local Links" and "Join Email List." By signing up for this list serve, subscribers will also receive a notice whenever changes are made to the ARB On-Board Diagnostics Program website.

Should you have questions or comments regarding this Mail-Out, please contact Mr. Mike McCarthy, Manager, at (626) 771-3614.

Sincerely,

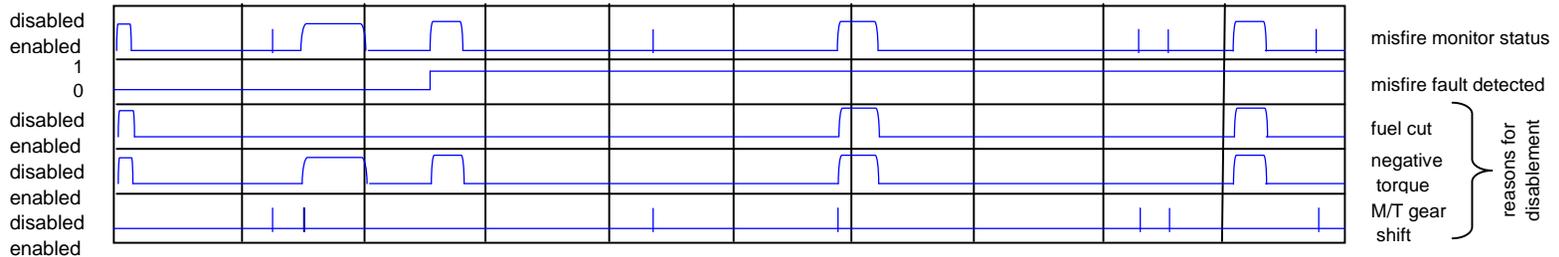
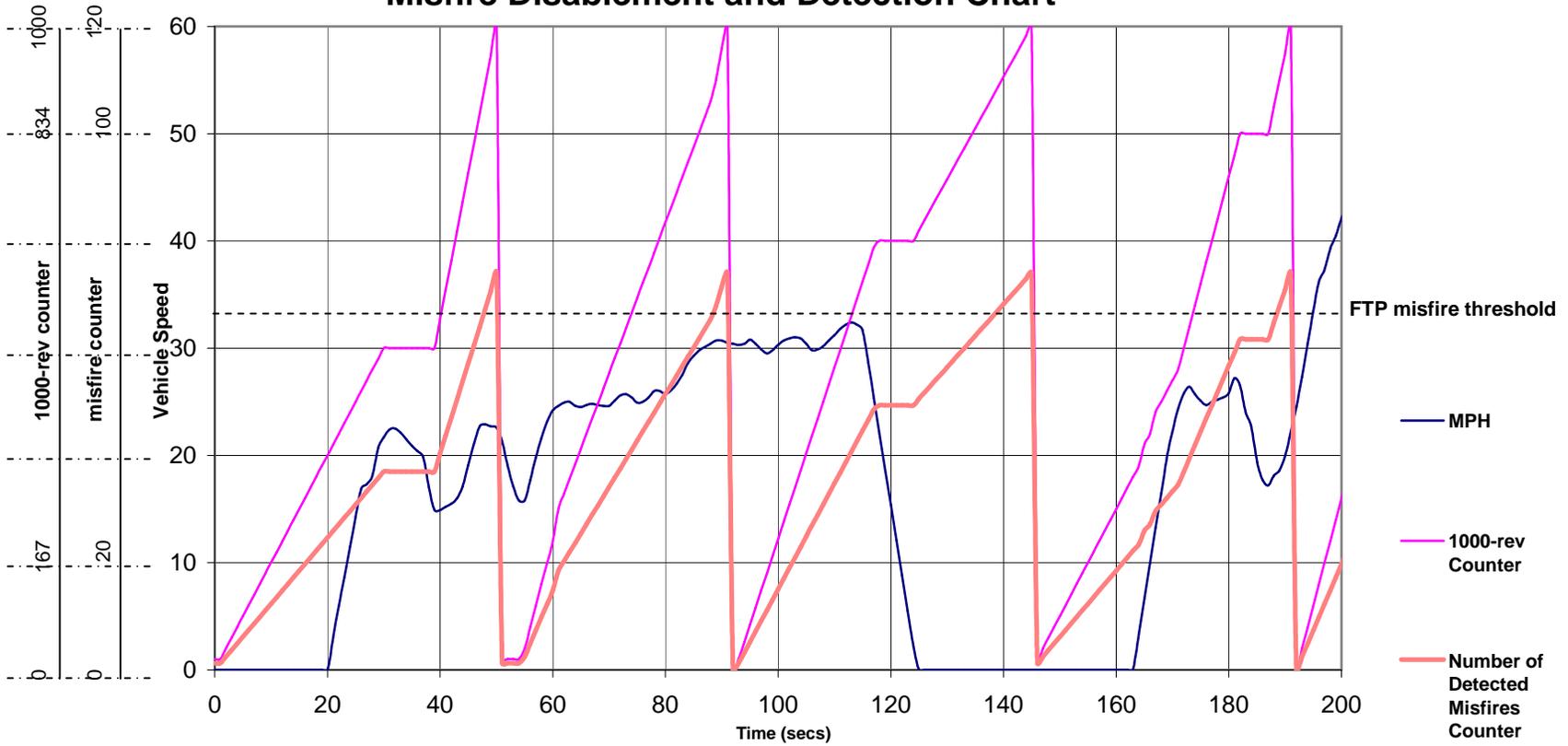
/s/

Robert H. Cross, Chief  
Mobile Source Control Division

Attachment A: Misfire Disablement and Detection Chart  
B: Probability of Detection Chart  
C: Summary Table  
D: HD OBD Diesel Rate-Based Data  
E: HD OBD Gasoline Rate-Based Data  
F: CAL ID and CVN Data  
G: HD OBD Diesel Monitoring Requirements Checklist  
H: HD OBD Gasoline Monitoring Requirements Checklist

cc: Mr. Mike McCarthy, Manager  
Advanced Engineering Section

## Attachment A: Misfire Disablement and Detection Chart



Note: Misfire data in this sample chart was collected during light-duty FTP vehicle chassis dynamometer testing.

## Attachment B: Probability of Detection Chart

Misfire Pattern: One Cylinder Out

**Engine Speed (rpm)**

| Calculated Load (%) | Engine Speed (rpm) |      |      |      |      |      |      |      |      |      |      |      |      | Redline |
|---------------------|--------------------|------|------|------|------|------|------|------|------|------|------|------|------|---------|
|                     | Idle               | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 | 5500 | 6000 |      |         |
| Zero Torque         | 1.00               | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | NR      |
| 15                  | 1.00               | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | NR      |
| 30                  | 1.00               | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | NR      |
| 50                  | 1.00               | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    |
| 65                  | 1.00               | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    |
| 80                  | NA                 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    |
| WOT                 | NA                 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    |

**NA** Not Achievable

**NR** Not Required per Section 1971.1 (f)(2.3.1)(C)

### Attachment C: Summary Table

| Engine Family                                   |   | Certification Standard or Family Emission Limit (FEL) |   |   |   |  |  |               |
|---|---|---|---|---|---|--|--|---------------|
| AARBV05.0XYZ                                    |   | (0.2 g/bhp-hr NOx, 0.01 g/bhp-hr PM, etc...)          |   |   |   |  |  |               |
| Component/<br>System                            | *SAE J2012 Fault Code or<br>J1939 SPN-FMI | Monitor Strategy<br>Description                       | Malfunction<br>Criteria   | Threshold<br>Value                                | Secondary<br>Parameters   | Enable<br>Conditions   | Time<br>Required   | MIL<br>Illum. |
| (example)<br>Three-way Catalyst                 | P0420                                     | Oxygen storage  | Rear oxygen sensor period<br>versus front oxygen sensor<br>period           | > 0.75 switch ratio<br><br>Disable<br>conditions: | Engine speed<br>Engine load<br>ECT<br>MAP<br>Fuel system status<br><br>No active DTCs:                      | 1000<rpm<4000rpm<br>>20%<br>>70C<br>> 25 kPa<br>closed loop<br><br>P0133<br>P0139<br>P0105 | 20 seconds<br>once per trip  | two trips     |
| EGR System                                      | P0401/<br>2659-18                         | Low flow by difference<br>in MAP                      | Delta MAP   | < 10 kPa<br><br>Disable<br>conditions:            | Vehicle speed<br>ECT<br>Fuel system status<br>Battery voltage<br><br>No active DTCs:                        | > 35 mph<br>> 70C<br>Fuel-cut<br>> 11.0 V<br><br>P0105                                     | 3 seconds  | two trips     |
| <b>Manifold Absolute Pressure (MAP) Sensor:</b> |   |   |   |   |   |  |  |               |
| MAP High  | P0108/<br>1692-3                          | Out of Range High                                     | MAP Voltage   | > 4.0 V (110 kPa)                                 | Engine Speed  | > 300 rpm  | Continuous   | one trip      |
| MAP Low   | P0107/<br>1692-4                          | Out of Range Low                                      | MAP Voltage   | < 0.15 V (15 kPa)                                 | Engine Speed  | > 300 rpm  | Continuous   | one trip      |
| MAP Rationality                                 | P0106/<br>1692-2                          | Comparison of<br>modeled MAP to<br>actual MAP signal  | High Rationality<br><br>MAP Voltage:<br><br>Low Rationality<br>MAP Voltage: | < 3.1 V ( 65 kPa)<br><br>> 1.0 V ( 25 kPa)        | Engine Speed<br>Vehicle Speed<br>Calculated load<br><br>Engine Speed<br>Vehicle Speed<br>Fuel System Status | 1000 to 5000 rpm<br>> 10 mph<br>> 50%<br><br>> 1500 rpm<br>> 10 mph<br>Fuel Cut            | 2 seconds<br><br>Monitor runs<br>whenever<br>enable<br>conditions are<br>met | two trips     |
|   |   |   |   |   |   |  |  |               |
|   |   |   |   |   |   |  |  |               |

\* Note: List the applicable SAE J2012 Fault Code or equivalent SAE J1939 Suspect Parameter Number (SPN) and Failure Mode Identifier (FMI)

Attachment D:

HD OBD Diesel Rate-Based Data

| No. | MY   | Manufacturer | Engine Family | Engine Serial No. | VIN               | MonPerfGrp | Date       | ODO   | CAL ID        | Gen Den | Ign Cycle | NMHCatNum | NMHCatDen | NMHCatRat |
|-----|------|--------------|---------------|-------------------|-------------------|------------|------------|-------|---------------|---------|-----------|-----------|-----------|-----------|
| 1   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748121        | XX1XX6356XX748121 | Line-Haul  | 06/12/2010 | 5000  | 12345-xyz-678 | 100     | 300       | 10        | 20        | 0.500     |
| 2   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748122        | XX1XX6356XX748122 | Line-Haul  | 06/12/2010 | 5001  | 12345-xyz-678 | 101     | 301       | 20        | 40        | 0.500     |
| 3   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748123        | XX1XX6356XX748123 | Line-Haul  | 06/12/2010 | 7000  | 12345-xyz-678 | 50      | 400       | 30        | 60        | 0.500     |
| 4   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748124        | XX1XX6356XX748124 | Line-Haul  | 06/12/2010 | 8000  | 12345-xyz-678 | 60      | 500       | 40        | 80        | 0.500     |
| 5   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748125        | XX1XX6356XX748125 | Line-Haul  | 06/12/2010 | 9000  | 12345-xyz-678 | 70      | 600       | 50        | 100       | 0.500     |
| 6   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748126        | XX1XX6356XX748126 | Line-Haul  | 06/12/2010 | 10000 | 12345-xyz-678 | 80      | 700       | 60        | 120       | 0.500     |
| 7   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748127        | XX1XX6356XX748127 | Line-Haul  | 06/12/2010 | 11000 | 12345-xyz-678 | 90      | 800       | 70        | 140       | 0.500     |
| 8   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748128        | XX1XX6356XX748128 | Line-Haul  | 06/12/2010 | 12000 | 12345-xyz-678 | 100     | 900       | 80        | 160       | 0.500     |
| 9   | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748129        | XX1XX6356XX748129 | Line-Haul  | 06/12/2010 | 13000 | 12345-xyz-678 | 110     | 1000      | 90        | 180       | 0.500     |
| 10  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748130        | XX1XX6356XX748130 | Line-Haul  | 06/12/2010 | 14000 | 12345-xyz-678 | 120     | 1100      | 100       | 200       | 0.500     |
| 11  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748131        | XX1XX6356XX748131 | Line-Haul  | 06/12/2010 | 15000 | 12345-xyz-678 | 130     | 1200      | 110       | 220       | 0.500     |
| 12  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748132        | XX1XX6356XX748132 | Line-Haul  | 06/12/2010 | 16000 | 12345-xyz-678 | 140     | 1300      | 120       | 240       | 0.500     |
| 13  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748133        | XX1XX6356XX748133 | Line-Haul  | 06/12/2010 | 17000 | 12345-xyz-678 | 150     | 1400      | 130       | 260       | 0.500     |
| 14  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748134        | XX1XX6356XX748134 | Line-Haul  | 06/12/2010 | 17000 | 12345-xyz-678 | 160     | 1500      | 140       | 280       | 0.500     |
| 15  | 2010 | ABC Motors   | ACARBV06.0XYZ | ABXX748135        | XX1XX6356XX748135 | Line-Haul  | 06/12/2010 | 5002  | 12345-xyz-678 | 102     | 302       | 21        | 42        | 0.500     |



| NOxCatNum | NOxCatDen | NOxCatRat | NOxAdsNum | NOxAdsDen | NOxAdsRat | DPFNum | DPFDen | DPFRat | ExhGasSenNum | ExhGasSenDen | ExhGasSenRat |
|-----------|-----------|-----------|-----------|-----------|-----------|--------|--------|--------|--------------|--------------|--------------|
| 10        | 20        | 0.500     | 10        | 20        | 0.500     | 10     | 20     | 0.500  | 10           | 20           | 0.500        |
| 20        | 40        | 0.500     | 20        | 40        | 0.500     | 20     | 40     | 0.500  | 20           | 40           | 0.500        |
| 30        | 60        | 0.500     | 30        | 60        | 0.500     | 30     | 60     | 0.500  | 30           | 60           | 0.500        |
| 40        | 80        | 0.500     | 40        | 80        | 0.500     | 40     | 80     | 0.500  | 40           | 80           | 0.500        |
| 50        | 100       | 0.500     | 50        | 100       | 0.500     | 50     | 100    | 0.500  | 50           | 100          | 0.500        |
| 60        | 120       | 0.500     | 60        | 120       | 0.500     | 60     | 120    | 0.500  | 60           | 120          | 0.500        |
| 70        | 140       | 0.500     | 70        | 140       | 0.500     | 70     | 140    | 0.500  | 70           | 140          | 0.500        |
| 80        | 160       | 0.500     | 80        | 160       | 0.500     | 80     | 160    | 0.500  | 80           | 160          | 0.500        |
| 90        | 180       | 0.500     | 90        | 180       | 0.500     | 90     | 180    | 0.500  | 90           | 180          | 0.500        |
| 100       | 200       | 0.500     | 100       | 200       | 0.500     | 100    | 200    | 0.500  | 100          | 200          | 0.500        |
| 110       | 220       | 0.500     | 110       | 220       | 0.500     | 110    | 220    | 0.500  | 110          | 220          | 0.500        |
| 120       | 240       | 0.500     | 120       | 240       | 0.500     | 120    | 240    | 0.500  | 120          | 240          | 0.500        |
| 130       | 260       | 0.500     | 130       | 260       | 0.500     | 130    | 260    | 0.500  | 130          | 260          | 0.500        |
| 140       | 280       | 0.500     | 140       | 280       | 0.500     | 140    | 280    | 0.500  | 140          | 280          | 0.500        |
| 21        | 42        | 0.500     | 21        | 42        | 0.500     | 41     | 82     | 0.500  | 21           | 42           | 0.500        |



| EGRNum | EGRDen | EGRat | VVTNum | VVTDen | VVTRat | BoostNum | BoostDen | BoostRat | FuelSysNum | FuelSysDen | FuelSysRat |
|--------|--------|-------|--------|--------|--------|----------|----------|----------|------------|------------|------------|
| 10     | 20     | 0.500 | 10     | 20     | 0.500  | 10       | 20       | 0.500    | 10         | 20         | 0.500      |
| 20     | 40     | 0.500 | 20     | 40     | 0.500  | 20       | 40       | 0.500    | 20         | 40         | 0.500      |
| 30     | 60     | 0.500 | 30     | 60     | 0.500  | 30       | 60       | 0.500    | 30         | 60         | 0.500      |
| 40     | 80     | 0.500 | 40     | 80     | 0.500  | 40       | 80       | 0.500    | 40         | 80         | 0.500      |
| 50     | 100    | 0.500 | 50     | 100    | 0.500  | 50       | 100      | 0.500    | 50         | 100        | 0.500      |
| 60     | 120    | 0.500 | 60     | 120    | 0.500  | 60       | 120      | 0.500    | 60         | 120        | 0.500      |
| 70     | 140    | 0.500 | 70     | 140    | 0.500  | 70       | 140      | 0.500    | 70         | 140        | 0.500      |
| 80     | 160    | 0.500 | 80     | 160    | 0.500  | 80       | 160      | 0.500    | 80         | 160        | 0.500      |
| 90     | 180    | 0.500 | 90     | 180    | 0.500  | 90       | 180      | 0.500    | 90         | 180        | 0.500      |
| 100    | 200    | 0.500 | 100    | 200    | 0.500  | 100      | 200      | 0.500    | 100        | 200        | 0.500      |
| 110    | 220    | 0.500 | 110    | 220    | 0.500  | 110      | 220      | 0.500    | 110        | 220        | 0.500      |
| 120    | 240    | 0.500 | 120    | 240    | 0.500  | 120      | 240      | 0.500    | 120        | 240        | 0.500      |
| 130    | 260    | 0.500 | 130    | 260    | 0.500  | 130      | 260      | 0.500    | 130        | 260        | 0.500      |
| 140    | 280    | 0.500 | 140    | 280    | 0.500  | 140      | 280      | 0.500    | 140        | 280        | 0.500      |
| 21     | 42     | 0.500 | 21     | 42     | 0.500  | 21       | 42       | 0.500    | 21         | 42         | 0.500      |

Attachment E:

HD OBD Gasoline Rate-Based Data

| No. | MY   | Manufacturer | Engine Family | Engine Serial No. | VIN               | MonPerfGrp     | Date       | ODO   | CAL ID        | Gen Den | Ign Cycle | B1CatNum | B1CatDen | B1CatRat |
|-----|------|--------------|---------------|-------------------|-------------------|----------------|------------|-------|---------------|---------|-----------|----------|----------|----------|
| 1   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748121        | XX1XX6356XX748121 | Urban Delivery | 06/12/2010 | 5000  | 12345-xyz-678 | 100     | 300       | 10       | 20       | 0.500    |
| 2   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748122        | XX1XX6356XX748122 | Urban Delivery | 06/12/2010 | 5001  | 12345-xyz-678 | 101     | 301       | 20       | 40       | 0.500    |
| 3   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748123        | XX1XX6356XX748123 | Urban Delivery | 06/12/2010 | 7000  | 12345-xyz-678 | 50      | 400       | 30       | 60       | 0.500    |
| 4   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748124        | XX1XX6356XX748124 | Urban Delivery | 06/12/2010 | 8000  | 12345-xyz-678 | 60      | 500       | 40       | 80       | 0.500    |
| 5   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748125        | XX1XX6356XX748125 | Urban Delivery | 06/12/2010 | 9000  | 12345-xyz-678 | 70      | 600       | 50       | 100      | 0.500    |
| 6   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748126        | XX1XX6356XX748126 | Urban Delivery | 06/12/2010 | 10000 | 12345-xyz-678 | 80      | 700       | 60       | 120      | 0.500    |
| 7   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748127        | XX1XX6356XX748127 | Urban Delivery | 06/12/2010 | 11000 | 12345-xyz-678 | 90      | 800       | 70       | 140      | 0.500    |
| 8   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748128        | XX1XX6356XX748128 | Urban Delivery | 06/12/2010 | 12000 | 12345-xyz-678 | 100     | 900       | 80       | 160      | 0.500    |
| 9   | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748129        | XX1XX6356XX748129 | Urban Delivery | 06/12/2010 | 13000 | 12345-xyz-678 | 110     | 1000      | 90       | 180      | 0.500    |
| 10  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748130        | XX1XX6356XX748130 | Urban Delivery | 06/12/2010 | 14000 | 12345-xyz-678 | 120     | 1100      | 100      | 200      | 0.500    |
| 11  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748131        | XX1XX6356XX748131 | Urban Delivery | 06/12/2010 | 15000 | 12345-xyz-678 | 130     | 1200      | 110      | 220      | 0.500    |
| 12  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748132        | XX1XX6356XX748132 | Urban Delivery | 06/12/2010 | 16000 | 12345-xyz-678 | 140     | 1300      | 120      | 240      | 0.500    |
| 13  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748133        | XX1XX6356XX748133 | Urban Delivery | 06/12/2010 | 17000 | 12345-xyz-678 | 150     | 1400      | 130      | 260      | 0.500    |
| 14  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748134        | XX1XX6356XX748134 | Urban Delivery | 06/12/2010 | 17000 | 12345-xyz-678 | 160     | 1500      | 140      | 280      | 0.500    |
| 15  | 2010 | ABC Motors   | ACARBV06.0XYZ | GSXX748135        | XX1XX6356XX748135 | Urban Delivery | 06/12/2010 | 5002  | 12345-xyz-678 | 102     | 302       | 21       | 42       | 0.500    |

| B2CatNum | B2CatDen | B2CatRat | B1O2Num | B1O2Den | B1O2Rat | B2O2Num | B2O2Den | B2O2Rat | EGR/VVNum | EGR/VVDen | EGR/VVRat |
|----------|----------|----------|---------|---------|---------|---------|---------|---------|-----------|-----------|-----------|
| 10       | 20       | 0.500    | 10      | 20      | 0.500   | 10      | 20      | 0.500   | 10        | 20        | 0.500     |
| 20       | 40       | 0.500    | 20      | 40      | 0.500   | 20      | 40      | 0.500   | 20        | 40        | 0.500     |
| 30       | 60       | 0.500    | 30      | 60      | 0.500   | 30      | 60      | 0.500   | 30        | 60        | 0.500     |
| 40       | 80       | 0.500    | 40      | 80      | 0.500   | 40      | 80      | 0.500   | 40        | 80        | 0.500     |
| 50       | 100      | 0.500    | 50      | 100     | 0.500   | 50      | 100     | 0.500   | 50        | 100       | 0.500     |
| 60       | 120      | 0.500    | 60      | 120     | 0.500   | 60      | 120     | 0.500   | 60        | 120       | 0.500     |
| 70       | 140      | 0.500    | 70      | 140     | 0.500   | 70      | 140     | 0.500   | 70        | 140       | 0.500     |
| 80       | 160      | 0.500    | 80      | 160     | 0.500   | 80      | 160     | 0.500   | 80        | 160       | 0.500     |
| 90       | 180      | 0.500    | 90      | 180     | 0.500   | 90      | 180     | 0.500   | 90        | 180       | 0.500     |
| 100      | 200      | 0.500    | 100     | 200     | 0.500   | 100     | 200     | 0.500   | 100       | 200       | 0.500     |
| 110      | 220      | 0.500    | 110     | 220     | 0.500   | 110     | 220     | 0.500   | 110       | 220       | 0.500     |
| 120      | 240      | 0.500    | 120     | 240     | 0.500   | 120     | 240     | 0.500   | 120       | 240       | 0.500     |
| 130      | 260      | 0.500    | 130     | 260     | 0.500   | 130     | 260     | 0.500   | 130       | 260       | 0.500     |
| 140      | 280      | 0.500    | 140     | 280     | 0.500   | 140     | 280     | 0.500   | 140       | 280       | 0.500     |
| 21       | 42       | 0.500    | 21      | 42      | 0.500   | 21      | 42      | 0.500   | 21        | 42        | 0.500     |

| SAIRNum | SAIRDen | SAIRRat | EVAPNum | EVAPDen | EVAPRat | B1SO2Num | B1SO2Den | B1SO2Rat | B2SO2Num | B2SO2Den | B2SO2Rat |
|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|----------|
| 5       | 5       | 1.000   | 5       | 5       | 1.000   | 10       | 20       | 0.500    | 10       | 20       | 0.500    |
| 7       | 10      | 0.700   | 7       | 10      | 0.700   | 20       | 40       | 0.500    | 20       | 40       | 0.500    |
| 9       | 15      | 0.600   | 9       | 15      | 0.600   | 30       | 60       | 0.500    | 30       | 60       | 0.500    |
| 11      | 20      | 0.550   | 11      | 20      | 0.550   | 40       | 80       | 0.500    | 40       | 80       | 0.500    |
| 13      | 25      | 0.520   | 13      | 25      | 0.520   | 50       | 100      | 0.500    | 50       | 100      | 0.500    |
| 15      | 30      | 0.500   | 15      | 30      | 0.500   | 60       | 120      | 0.500    | 60       | 120      | 0.500    |
| 17      | 35      | 0.486   | 17      | 35      | 0.486   | 70       | 140      | 0.500    | 70       | 140      | 0.500    |
| 19      | 40      | 0.475   | 19      | 40      | 0.475   | 80       | 160      | 0.500    | 80       | 160      | 0.500    |
| 21      | 45      | 0.467   | 21      | 45      | 0.467   | 90       | 180      | 0.500    | 90       | 180      | 0.500    |
| 23      | 50      | 0.460   | 23      | 50      | 0.460   | 100      | 200      | 0.500    | 100      | 200      | 0.500    |
| 25      | 55      | 0.455   | 25      | 55      | 0.455   | 110      | 220      | 0.500    | 110      | 220      | 0.500    |
| 27      | 60      | 0.450   | 27      | 60      | 0.450   | 120      | 240      | 0.500    | 120      | 240      | 0.500    |
| 29      | 65      | 0.446   | 29      | 65      | 0.446   | 130      | 260      | 0.500    | 130      | 260      | 0.500    |
| 31      | 70      | 0.443   | 31      | 70      | 0.443   | 140      | 280      | 0.500    | 140      | 280      | 0.500    |
| 8       | 11      | 0.727   | 8       | 11      | 0.727   | 21       | 42       | 0.500    | 21       | 42       | 0.500    |

## Attachment F: CAL ID and CVN Data

| Model Year | Manufacturer | Engine Size (L) | Engine Family | Engine Serial No. | Module ID/<br>Address | CAL ID        | CVN             |
|------------|--------------|-----------------|---------------|-------------------|-----------------------|---------------|-----------------|
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748121        | \$07E8                | 12345-xyz-670 | ABCDEF123456780 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748122        | \$07E8                | 12345-xyz-671 | ABCDEF123456781 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748123        | \$07E8                | 12345-xyz-672 | ABCDEF123456782 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748124        | \$07E8                | 12345-xyz-673 | ABCDEF123456783 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748125        | \$07E8                | 12345-xyz-674 | ABCDEF123456784 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748126        | \$07E8                | 12345-xyz-675 | ABCDEF123456785 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748127        | \$07E8                | 12345-xyz-676 | ABCDEF123456786 |
| 2010       | ABC Motors   | 8.0             | ACARBV8.00XYZ | ABXX748128        | \$07E8                | 12345-xyz-677 | ABCDEF123456787 |
| 2010       | ABC Motors   | 8.0             | ACARBV8.00XYZ | ABXX748129        | \$07E8                | 12345-xyz-678 | ABCDEF123456788 |
| 2010       | ABC Motors   | 8.0             | ACARBV8.00XYZ | ABXX748130        | \$07E8                | 12345-xyz-870 | ABCDEF123456789 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748131        | \$07E8                | 12345-xyz-871 | ABCDEF123456720 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748132        | \$07E8                | 12345-xyz-872 | ABCDEF123456721 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748133        | \$07E8                | 12345-xyz-873 | ABCDEF123456722 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748134        | \$07E8                | 12345-xyz-874 | ABCDEF123456723 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748135        | \$07E8                | 12345-xyz-875 | ABCDEF123456724 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748136        | \$07E8                | 12345-xyz-876 | ABCDEF123456725 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748137        | \$07E8                | 12345-xyz-877 | ABCDEF123456726 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748138        | \$07E8                | 12345-xyz-878 | ABCDEF123456727 |
| 2010       | ABC Motors   | 9.0             | ACARBV9.00XYZ | ABXX748139        | \$07E8                | 12345-xyz-879 | ABCDEF123456728 |



