Air Resources Board

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June 22, 2005

MANUFACTURERS ADVISORY CORRESPONDENCE (MAC) 2005-03

TO: ALL PASSENGER CAR MANUFACTURERS
ALL LIGHT-DUTY TRUCK MANUFACTURERS
ALL MEDIUM-DUTY VEHICLE MANUFACTURERS
ALL OTHER INTERESTED PARTIES

SUBJECT: Optional Test Procedure For Certifying 2008 and Later Model-Year Gasoline-Fueled Zero-Fuel Evaporative Vehicles

This letter notifies industry that the Air Resources Board (ARB) has approved, with modifications, the test procedure proposed by the Alliance of Automobile Manufacturers (AAM) and the Association of International Automobile Manufacturers (AIAM) for certifying 2008 and later model-year (MY) gasoline vehicles to the optional zero-fuel evaporative emission standards. Beginning with MY2008, manufacturers should use the procedure described in this MAC in lieu of the procedure outlined in MAC 2001-03 to demonstrate compliance with the zero-fuel evaporative emission standards. Other procedures may be used if approved, in advance, by the ARB.

In summary, the modifications to MAC 2001-03 include, use of 150,000 mile fuel evaporative emission level from rig tests as a deterioration factor for whole-vehicle evaporative emission standard compliance, wet and dry rig stabilization protocol, addition of manufacturer's ARB-approved bench aging procedure to age wet rig, addition of ozone exposure protocol, policy clarifying the carry-over and carry-across of 2007 and earlier MY zero-fuel evaporative rig emission data to 2008 and subsequent MY, and reordering of rig test description for overall clarity.

The Exhaust/Evaporative Emissions Trading Factors provided in MAC 2001-03 remain valid for MY2008 and later vehicles. The trading factors remain at 0.1 grams per test (g/test) of evaporative emissions per 0.002 grams per mile (g/mi) of exhaust non-methane organic gas (NMOG). The trading factors and calculations for determining the factors are included in this MAC for ease of reference.

If you have any additional questions, please contact Ms. Rhonda Runyon, Staff, On-Road Certification/Audit Section, at (626) 575-6653 or at rrunyon@arb.ca.gov.

Sincerely,

/s/

Allen Lyons, Chief
Mobile Source Operations Division

Attachment

STATE OF CALIFORNIA
AIR RESOURCES BOARD

MANUFACTURERS ADVISORY CORRESPONDENCE (MAC) 2005-03

SUBJECT: Optional Test Procedure For Certifying 2008 and Later Model-Year Gasoline-Fueled Zero-Fuel Evaporative Vehicles

APPLICABILITY: 2008 and later model-year (MY) gasoline-fueled and gasoline-fueled hybrid electric passenger cars (PC) and light-duty trucks (LDT) certified to the optional zero-fuel evaporative emission standards

REFERENCES:

1. Title 13, California Code of Regulations, (13 CCR) Section 1976, "Standards and Test Procedures for Motor Vehicle Fuel Evaporative Emissions."

2. "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles."

3. 13 CCR Section 1961, "Exhaust Emission Standards and Test Procedures -- 2004 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles."

4. "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," Part II, A, 100.3.1.

5. MAC 2001-03 – “Optional Test Procedure for Certifying Pre-2005 Model-Year (MY) Gasoline Fueled Zero-Evaporative Vehicles and For Offsetting Evaporative And NMOG Emissions For Such Vehicles.”

The following sections and topics will be presented in this MAC.

I. BACKGROUND AND DISCUSSION

Title 13 CCR Section 1976 (b)(1)(E) establishes the optional zero-fuel evaporative emission standards for the three-day and two-day diurnal-plus-hot-soak (3D+HS and 2D+HS, respectively) tests, which are:

A. "Whole vehicle"

- 0.35 grams per test (g/test) hydrocarbons (HC) for PC;
- 0.50 g/test HC for LDT with a gross vehicle weight rating (GVWR) of 6000 pounds and under; and
- 0.75 g/test HC for LDT with a GVWR from over 6000 to 8500 pounds; and

B. "Fuel-only"

Zero (0.0) g/test of HC fuel evaporative emissions.

In lieu of demonstrating compliance with the "fuel-only" zero (0.0) g/test of HC fuel evaporative emissions over the 3D+HS and 2D+HS tests, a manufacturer may submit, for advance ARB approval, a test plan to demonstrate that the vehicle has zero (0.0) grams of HC fuel evaporative emissions throughout its useful life. Manufacturers have the option of submitting for ARB approval an alternative test protocol demonstrating compliance with the zero-fuel evaporative emission requirements that is different from the one presented in this MAC.

MAC 2001-03 provided guidance to manufacturers for developing an interim test protocol to demonstrate zero evaporative emissions from the vehicle's fuel system. Several issues identified in MAC 2001-03 needed further investigation by industry to resolve concerns raised by ARB staff with the test procedure the MAC contains. Staff held several meetings with industry in 2003 and 2004 to discuss a number of industry proposals, including variations of the vehicle-minus-fuel system procedures, to resolve these concerns. During these discussions, manufacturers were allowed to continue using MAC 2001-03 for certifying MY2005-2006 gasoline zero-fuel evaporative vehicles. Ultimately, industry proposed a revised rig test for certifying MY2007 and later gasoline zero-fuel evaporative vehicles assuming accelerated approval by June, 2004. While some of the ARB's concerns are addressed in this new protocol (e.g., aged parts, ozone exposure), other issues have not been fully resolved to staff's satisfaction (e.g., rigorous permeation stabilization procedure for permeable parts, and rigorous determination of representative vapor losses from the air induction system and engine seals). However, in order to move forward with the improvements that have been identified for certification of vehicles to the 2008 and subsequent zero-fuel evaporative emission standards, the ARB is accepting the March 9, 2004, industry-proposed test protocol, with certain modifications. The ARB may revise this guidance in the future if additional data become available that warrant reassessment of the test protocol and parameters identified herein.

II. "WHOLE VEHICLE" EMISSIONS TEST PROCEDURE OVERVIEW

To demonstrate compliance with the "whole vehicle" evaporative emission standards, manufacturers shall conduct both the 3D+HS and 2D+HS test sequence with a vehicle that has been "aged" to 15 years/150,000 (150K) miles useful life. Manufacturers may use their ARB-approved evaporative bench aging procedures or may propose alternatives. When using bench aging, the degradation of the evaporative emission control system must be equivalent to 15 years or 150K miles of customer use. The 150K-mile fuel evaporative emission levels determined from rig testing may be used as the deterioration factors (DFs) when demonstrating compliance with the "whole-vehicle" evaporative emission standards.

If a manufacturer's evaporative emission control system design includes an air induction system (AIS) carbon filter, the carbon element shall not be preconditioned nor shall it be removed from the vehicle during the vehicle preconditioning prior to the 3D+HS or 2D+HS tests. (The AIS filter, which is intended to control evaporative emissions during the hot soak portion of the evaporative test procedure, will have been purged completely once the vehicle is operating, hence no additional or special preconditioning is allowed.)

III. "FUEL-ONLY" EMISSIONS TEST PLAN OVERVIEW

The "fuel only" emissions test plan includes the testing of two fuel system rigs. One is never exposed to any fuel ("dry" rig), and the other is exposed to fuel ("wet" rig). These rigs shall undergo both 3D+HS and 2D+HS tests. However, manufacturers may provide an engineering evaluation in lieu of conducting the 2D+HS test. If an engineering evaluation is used, it must include data showing that the carbon canister's state at the end of the vehicle drive in the 2-day test sequence will be sufficient to control two days worth of diurnal emissions.

The results of the "dry" rig testing are used to determine non-fuel (background) HC emissions from rig components. The "dry" rig's results are then subtracted from the "wet" rig's results to determine the total fuel-only evaporative emissions. The following procedures should be followed in the design and preparation of the rigs.

A. Fuel System Rig Design

Two rigs of identical design are assembled from the same batch of components. The manufacturer shall use good engineering judgment to ensure that the components included on the rigs cover all components that are exposed to liquid fuel or fuel vapor during the course of operation on a vehicle. Typically, these components include the fuel tank assembly (including the fill neck, fuel cap, fuel tank, and all tank fittings and valves), the fuel metering system (including the fuel pump/sender, fuel filter, fuel lines, fuel rail assembly, pressure regulator, and fuel injectors), the fuel vapor control system (including all fuel vapor tube assemblies, the purge control valve, and the carbon canister assembly), and the AIS assembly of the engine (including the intake manifold, the air "breathing" tube, air filter assembly, and any fuel vapor control device in the AIS). Any "holes" that may be present in rig components that are a result of missing vehicle components (e.g., the "hole" in the intake manifold where the cylinder head is normally located) may be sealed before testing.

To make the rigs more easily transportable, each rig may be supported on a movable fixture (e.g., tube metal or a portion of the vehicle underbody). The lengths of metallic fuel lines may be reduced to allow the rig to be more compact. However, the dimensions of all fuel-permeable components are to be production vehicle representative.

B. "Wet" Rig Aging (Prior to Testing)

1. Fuel Injector Mechanical Operation

   For the "wet" rig only, the fuel injectors must be aged to a 150K-mile test condition. This aging may be achieved by installing the injectors on a representative vehicle or engine and operating for 150K-mile equivalent, or by pulse cycling the injectors to a 150K-mile aged condition, using a bench aging procedure that has been approved by the ARB for this purpose.

2. Carbon Canister Purge/Load Cycling

   For the "wet" rig only, the carbon canister must be aged to a 150K-mile test condition. This aging may be achieved by installing the canister on a representative vehicle and driving the vehicle for 150K miles, or by cycling (loading and purging) the carbon canister to a 150K-mile aged condition, using a bench aging procedure that has been approved by the ARB for this purpose.

3. Other Critical Evaporative Component Aging

   For the "wet" rig only, besides the fuel injectors and carbon canister, all other rig components that a manufacturer bench ages for evaporative deterioration factor determination purposes shall be bench aged to a 150K-mile aged condition, using a bench aging procedure that has been approved by the ARB for establishing such DFs.

4. Ozone Exposure

   Previously, manufacturers provided data to demonstrate the robustness of materials to ozone exposure for the equivalent of 10 years of use by using ASTM test methods and exposure to 50-pphm ozone for 170 hours. Manufacturers may use the same protocol to demonstrate 15-year durability for materials vulnerable to ozone attack provided the exposure to ozone at 50 pphm is for 568 hours. This duration was determined based upon the cumulative ozone exposure expected for 15 years in the south coast air basin. Manufacturers may furnish a list of fuel system materials that are impervious to ozone or have demonstrated durability to 15-year ozone exposure. These ozone-durable materials will not be required to undergo additional ozone durability demonstrations for certification.

C. Stabilization Preparation Events for the "Wet" Rig

1. The aged fuel injectors shall be installed onto the rig (note: fuel injector seals may be replaced with new seals to ensure the injectors can be properly installed onto the rig).

2. The fuel tank shall be filled to a 40 percent nominal fill with California certification test fuel (as defined in Part II, A, 100.3.1 in "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium Duty Vehicles").

3. The fuel pump shall be operated to bleed air out of the fuel rail and to expose the injectors to fuel. The bleed air may be vented, for example, through a special (non-production) service port on the fuel rail or through the fuel injectors.

4. The special fuel rail service port (if used) shall be sealed and the fuel pump operated momentarily to pressurize the fuel rail.

5. The intake manifold may be flushed with fresh air. (This also may be conducted after stabilization, but before testing.)

D. "Wet" and "Dry" Rig Stabilization (Prior to Testing)

All components on both the "wet" and "dry" rigs shall be baked at a temperature of 40ºC for 3360 hours (140 days) cumulative. The "wet" rig shall be baked while exposed to fuel or fuel vapor as appropriate. Baking at higher temperatures (up to 60ºC) for an accelerated duration is acceptable, using the guideline that the time to reach stabilized permeation is accelerated by a factor of two (2) for each 10^{o}C increase in soak temperature (about 7% acceleration for every 1^{o}C soak temperature increase). Other methods for accelerating the permeation stabilization process may be used with advance ARB approval. Manufacturers have the option of removing both the carbon canisters and AIS components prior to this stabilization period.

IV. "FUEL-ONLY" EMISSIONS TEST PROCEDURES

The California test fuel and temperatures shall be used in all test procedures. Two separate "dry" rig tests shall be conducted to address concerns with SHED background variability. The "dry" rig is tested first, followed by "wet" rig testing, followed by repeat "dry" rig testing. All hot soak tests for both rigs are to be conducted in the same SHED, and the SHED may not be used for any other testing purposes between rig tests. All diurnal tests for both rigs are to be conducted in the same SHED, and the SHED may not be used for any other

purposes between rig tests. The requirement to conduct tests in the same SHED may be waived if the manufacturer provides a compelling reason to do so. To request a waiver, the manufacturer must provide data for advance ARB approval demonstrating SHED-to-SHED correlation of emission results.

A. "Dry" Rig Test #1

The stabilized "dry" rig shall undergo the 3D+HS and 2D+HS (if required) test procedures, including the required 6- to 36-hour soak between the hot soak and diurnal tests. All normally required vehicle procedures prior to the hot soak test, such as fuel fills, preconditioning, exhaust and running loss tests, etc., may be eliminated from the procedures. Only the first 24-hour diurnal period of the test procedure is required (i.e., the test may be stopped after 24 hours).

B. "Wet" Rig Test

The carbon canister from the stabilized and aged "wet" rig must be preconditioned to represent the state of the canister just prior to the hot soak test. This canister preconditioning may be achieved by installing the canister on a representative vehicle and preparing the vehicle for the hot soak test (including a vehicle preconditioning drive, 300-bed-volume canister purge, appropriate canister load, cold and hot start exhaust tests, and, for the 3D+HS test sequence, a 105ºF running loss test). Alternatively, the carbon canister preconditioning may be achieved by completing the following steps: 1) a 300-bed-volume canister purge, 2) appropriate canister load, and 3) a canister purge in a laboratory simulation, based on an engineering evaluation, to represent the net mass of butane desorbed from the canister during the drive cycle of the tests. This alternative method provides manufacturers flexibility for potential special cases in which canister removal is difficult.

The "wet" rig shall be temperature soaked at the required test temperature for the six hours immediately preceding the hot soak test. The carbon canister may be disconnected from sources of fuel vapor during this temperature soak to maintain its preconditioned state; however, the canister shall be properly connected during the subsequent hot soak and diurnal tests. The fuel pump shall be operated momentarily to pressurize the fuel rail prior to the hot soak test. The "wet" rig shall undergo the procedures of the 3D+HS test, and, if required, the 2D+HS test, starting with the one-hour hot soak test and including the required 6- to 36-hour soak between the hot soak and diurnal tests. Manufacturers must rely on one of the three options below in order to demonstrate the heat load from the engine which is absent from the rig:

1. Simulate Engine-Compartment Temperature

   At the beginning of the hot soak test, each fuel-permeable engine-compartment rig component will be heated to an elevated temperature. This elevated temperature used during this "pre-test heating" must be based on the engine-compartment temperature at the location of these components in a test vehicle at the beginning of the hot soak test. If these engine-compartment component temperature data are unavailable, a temperature of 220ºF shall be used.

2. Additive Temperature Correction Factor

   The "pre-test heating" described above may be excluded from the procedure if the manufacturer submits data, based on good engineering judgment, to quantify the difference in hot soak test data when comparing test data with and without the "pre-test heating." This quantity would then be added to the hot soak test data in which "pre-test" heating was not conducted, and used toward demonstrating compliance with the 0.0 grams HC standard. One acceptable method to determine this quantity is to measure the difference in permeation of the fuel-permeable engine-compartment components (including their end connections) for one hour at two separate temperature conditions: (1) a constant temperature of 105ºF, and (2) a temperature-time profile based on the temperatures these components are exposed to in a test vehicle during the hot soak test.

3. Engineering Evaluation of Temperature Effect

   If the manufacturer has submitted data demonstrating that the difference between conducting and not conducting the "engine-compartment temperature" bake results in a negligible difference in emission measurements (that is, less than 2 mg during the hot soak test), then all fuel system components may be soaked at the test temperature.

C. "Dry" Rig Test #2

   Following the completion of the "wet" rig test, the second test of the "dry" rig shall be performed in the same manner as "dry" rig test #1. (see A. above)

V. CALCULATIONS

A. Standard calculations for hot-soak and diurnal tests apply.

B. The "dry" rig's D+HS HC evaporative emission shall be the mean of the "dry" rig's test #1 and test #2 results. The "dry" rig's D+HS emission level for each test is

the sum of the HC emission level of the one-hour hot soak test and the 24-hour diurnal test HC emission level.

C. "Wet" rig's D+HS HC evaporative emission is calculated as the sum of the emission level of the one-hour hot soak test and the highest 24-hour emission level during the diurnal test. If "pre-test heating" of engine-compartment rig components is not conducted before the hot soak test, the factor developed according to section IV.B.2 (unless negligible) shall be added to the hot soak test data to account for the increase in permeation that would occur had the components been pre-heated.

D. Total fuel evaporative emissions shall be determined by subtracting the mean "dry" rig D+HS HC evaporative emissions value from the "wet" rig D+HS HC evaporative emissions value.

E. For rig testing, net enclosure volume is calculated by subtracting 5 cubic feet (or a manufacturer-determined rig volume that has received advance ARB approval) from the enclosure volume.

F. The manufacturer may submit fuel evaporative emission calculations for advance ARB approval if the test plan is expanded to include additional tests on the "dry" and "wet" rigs, as well as testing of more than one "dry" or "wet" rig.

G. Total fuel evaporative emissions less than or equal to 54 mg HC for both the 3D+HS and 2D+HS (if required) tests demonstrate compliance with the optional zero-fuel evaporative emission standard.

VI. CARRY-OVER and CARRY-ACROSS

Subject to ARB approval, carry-over (C/O) and carry-across (C/A) of zero-fuel evaporative emissions data used for MY2007 and earlier certification may be allowed for MY2008 and subsequent certification. A C/O-C/A request must include an engineering evaluation that assesses the impacts on measured evaporative emissions resulting from changes in the test protocols (data determined under the MAC 2001-03 protocol versus the protocol in this MAC or other approved protocol). The engineering evaluation must also address the impacts on evaporative emissions resulting from any differences between the current vehicle and the pre-MY2008 vehicle that provides the C/O-C/A emission results.

VII. EXHAUST/EVAPORATIVE EMISSIONS TRADING FACTORS

Title 13, CCR Section 1976 (b)(1)(E) provides manufacturers that are seeking partial zero-emission vehicle (PZEV) credits the option of having the measured fuel evaporative emissions reduced, in 0.1 gram HC increments, for all certification and in-use testing, if the measured NMOG exhaust emissions for the vehicle are proportionately increased for all certification and in-use testing. Additionally, 13 CCR Section 1961(a)(11) allows an exhaust NMOG credit to be applied against the measured NMOG emissions in certification and in-use testing for vehicles that were certified to the zero-fuel evaporative standards but did not seek a PZEV credit.

The ARB approved method for calculating the exhaust/evaporative emission trading factor for purposes of 13 CCR Section 1976(b)(1)(E) and 13 CCR Section 1961(a)(11) is explained below. The calculations establish a trading factor of 0.1 g/test HC evaporative emissions per 0.002 g/mi exhaust NMOG emissions.

A. Offset Under 13 CCR 1976(b)(1)(E)

The LEV II regulations provide manufacturers of vehicles seeking a partial ZEV credit with additional flexibility in complying with the zero-fuel evaporative emission standards, including the ability to offset a vehicle's measured HC fuel evaporative emissions by proportionately adding NMOG emissions to the vehicle's exhaust emissions test result. Manufacturers electing to use this option must offset the fuel evaporative emissions in 0.1 grams HC increments. The ARB staff has developed the following equation to calculate the appropriate increase in a vehicle's measured NMOG exhaust emissions for a corresponding 0.1 grams HC per test reduction in the vehicle's measured fuel evaporative emissions:

$$E_{exh}\ [g/mile] = \frac{E_{evap}\ [g/day] \times F_{adj}}{D_{ave}\ [mile/day]}$$

Where:

E_{exh} is the amount of NMOG emissions (to be added to the exhaust test emissions).

E_{evap} is the amount of HC evaporative emissions (in 0.1 grams HC increment) (to be subtracted from the fuel evaporative emissions).

F_{adj} is 0.67, a factor used to adjust the certification evaporative temperature conditions to southcoast ozone planning temperature

conditions (EMFAC 2000 model was used for calculating this adjustment factor).

$\mathbf{D_{ave}}$ is 36 miles per day, the average vehicle miles traveled per day in the South Coast Air Basin.

Example 1: Assume that a manufacturer is seeking to offset 0.1 grams HC per day of fuel evaporative emissions from a SULEV PC vehicle for which it is also seeking a PZEV credit. Then the following amount of NMOG emissions would be added to the vehicle's exhaust test NMOG emissions:

$$\mathbf{E_{exh}\ [g/mile] = \frac{0.1 \times 0.67}{36} = 0.002\ g/mile}$$

Example 2: Assume that the MY2007 SULEV PC vehicle in Example 1 above has the following emissions before offsets: 0.006 g/mi NMOG and 0.067 g/test fuel evaporative HC emissions during certification, and, a few years later, 0.009 g/mi NMOG and 0.078 g/test fuel evaporative HC emissions during in-use testing. Assume further that all other emissions of this vehicle comply with the SULEV PC emission standards during certification and in-use testing. Apply the 0.002 g/mi for 0.1 g/test offset. For certification purposes, this vehicle will be deemed as having the certification levels of 0.008 (=0.006+0.002) g/mi NMOG and –0.033 (=0.067-0.100) (considered 0.000) g/test fuel evaporative HC; the vehicle is qualified for and will be granted a PZEV credit. However, this vehicle will be deemed as having in-use emissions of 0.011 (=0.009+0.002) g/mi NMOG and -0.022 (=0.078-0.100) (considered 0.000) g/test fuel evaporative HC; the vehicle has exceeded its in-use NMOG standard and is subject to corrective actions.

B. Offset Under 13 CCR 1961(a)(11)

The LEV II regulations provide an NMOG offset factor, to be determined by the Executive Officer, for non-PZEV vehicles that are certified to the optional zero-fuel evaporative emission standard. This reactivity-adjusted offset factor is used for subtracting from the measured NMOG emissions during certification and in-use testing. The ARB staff has developed the NMOG offset factor of 0.002 g/mi as follows.

The basic 0.002 g/mi NMOG per 0.1 g/test evaporative HC offset is the same as that developed for 13 CCR 1976(b)(E) above. The difference between the non-zero-fuel and optional zero-fuel evaporative standards is 0.15 g/test. The NMOG offset before reactivity adjustment is, therefore, 0.003 g/mi (=0.002 * 0.15 / 0.1). Because evaporative HC emissions are less reactive than exhaust NMOG emissions, ARB staff has determined that the reactivity-adjusted

NMOG offset of 0.002 g/mi is appropriate for non-PZEV vehicles certified to the optional zero-fuel evaporative emission standard.

Example 3: Assume a MY2007 PC vehicle has 50,000- and 120,000-mile NMOG certification emissions of 0.041 and 0.050 g/mi, respectively; all other emissions comply with the PC ULEV II standards. Furthermore, the manufacturer has elected to comply with the zero-fuel evaporative standards. Apply the 0.002 g/mi offset. The vehicle is then deemed as having 50,000- and 120,000-mile NMOG certification emissions of 0.039 (=0.041-0.002) and 0.048 (=0.050-0.002) g/mi, respectively. The vehicle is therefore eligible to be certified to the ULEV II emission standards as requested by the manufacturer.