State of California
California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

# CALIFORNIA TEST PROCEDURES FOR EVALUATING SUBSTITUTE FUELS AND NEW CLEAN FUELS IN 2015 AND SUBSEQUENT YEARS

Adopted: March 22, 2012

Note: Although this is a newly proposed document, changes to this document compared to the current "California Test Procedures for Evaluating Substitute Fuels and New Clean Fuels" are shown in underline to indicate additions and ~~strikeout~~ to indicate deletions compared to the test procedures as adopted November 2, 1993.

As Adopted: March 22, 2012
Date of Hearing: January 26-27, 2012

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# CALIFORNIA TEST PROCEDURES FOR EVALUATING SUBSTITUTE FUELS AND NEW CLEAN FUELS <u>IN 2015 AND SUBSEQUENT YEARS</u>

## I. *Introduction*

### A. Purpose and Applicability of this Protocol

1. The test procedures and analyses prescribed in this document ("test protocol") shall be used to evaluate, in terms of emissions and in terms of durability of emission control systems, (i) any fuel proposed as a substitute for a clean fuel or (ii) any fuel proposed as a new clean fuel if that fuel could be used in existing vehicles certified on another fuel. (The term "candidate fuel" is used herein to refer to either a substitute or new clean fuel.) Specifications for the properties of fuels approved for use in motor vehicles under this protocol shall be set according to this protocol.

2. The pollutant measures addressed by this protocol are carbon monoxide emissions (CO, g~~m~~/mile), oxides of nitrogen emissions (NOx, g~~m~~/mile), the ozone forming potential of exhaust NMOG emissions (g~~m~~ ozone/mile), and the combined potency-weighted emissions of toxic air contaminants in the exhaust (mg/mile).

### B. Synopsis of this Protocol

The candidate fuel is represented by a test fuel. The on-road fleet of vehicles capable of using the candidate fuel (but not already using it) is represented by either one test fleet in the case of a new clean fuel or two test fleets in the case of a substitute fuel. Each test fleet is composed of vehicle categories distinguished by emission control technology, emission standards, and certification fuel.

For each test vehicle, the difference in emissions between the test fuel and the vehicle's certification fuel (test fuel emissions minus certification fuel emissions, in grams/mile) is computed from test data. This difference is averaged over all vehicles within each vehicle category. These average differences by category are combined into a mileage-weighted mean that serves as an estimate of the difference in average emissions per mile between the test and certification fuels in the relevant on-road vehicle fleet. A statistical upper bound for this mileage-weighted estimate is computed at the 85 percent confidence level. A mileage-weighted estimate of average emissions per mile from the certification fuels among the on-road vehicle fleet is also computed, using the same weights.

For each pollutant, the statistical upper bound for the average difference in emissions is compared to a "tolerance" fraction of the average emissions of that



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pollutant from the certification fuels. If the statistical upper bound is the greater of these two numbers for any pollutant, the candidate fuel cannot be approved.

C. Definitions

1. “Applicant” means the entity that seeks approval of a candidate fuel and is responsible for the demonstration described in section III.

2. “Board” means the Air Resources Board.

3. “Candidate fuel” means a fuel proposed as a substitute fuel or as a new clean fuel.

4. “CCR” means California Code of Regulations.

5. "Duplicate test" means an emission test run on a particular vehicle and a particular fuel as a repetition of the preceding test on the same vehicle and fuel, without draining and re-filling the fuel tank and without conducting pre-test dynamometer cycles, as described in VIII.D, between the tests.

6. "Executive officer" means the Executive Officer of the Air Resources Board.

7. “Light-Duty Test Procedures” means the “California 2001 through 2014 Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2009 through 2016 Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles” or the “California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles,” incorporated by reference in section 1961 and 1961.2, title 13, CCR, respectively, as applicable.

~~7~~8. "LDV" means light-duty vehicle, "MDV" means medium-duty vehicle, ~~"TLEV" means transitional low-emission vehicle, "LEV" means low-emission vehicle, and "ULEV" means ultra-low emission vehicle, all as defined in subchapter 9, Title 13, California Code of Regulations.~~ In this protocol, "low-emission vehicle" includes all vehicles certifying to the California LEV II and LEV III standards, set forth in sections 1961 and 1961,2, title 13, CCR. ~~LEVs, TLEVs, and ULEVs.~~

~~8~~9. "New clean fuel" means a fuel proposed for certifying new low-emission vehicles, as described in Part II of the applicable Light-Duty Test Procedures ~~section 12 of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light Duty Trucks, and Medium-Duty Vehicles"~~.

~~9~~10. "Primary designated clean fuel" means the designated clean fuel for which the substitute fuel under consideration has been proposed pursuant to section 2317 in subchapter 8, title 13, CCR ~~California Code of Regulations~~.

~~4~~11. "Reference fuel" means, for a particular vehicle, a fuel meeting the same specifications in the Light-Duty Test Procedures ~~"California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Trucks" (herein, "1988 Standards and Procedures")~~ as did the fuel that was used to certify the vehicle (certification fuel).

~~However, if the fuel used to certify a vehicle was gasoline meeting specifications in the 1988 Standards and Procedures as last revised July 12, 1991 (or gasoline as specified by earlier documents), "reference fuel" means a gasoline meeting the specifications, for vehicle-certifying gasoline, approved by the Board on August 14, 1992 and corresponding to the commercial gasoline standards approved by the Board on November 22, 1991.~~

For a low emission vehicle that was certified on both gasoline and another fuel, "reference fuel" means gasoline, unless the candidate fuel is a proposed substitute fuel and the other certification fuel is the primary designated clean fuel. In that case, "reference fuel" means the primary designated clean fuel.

1~~0~~2. "Replicate test" means an emission test or a set of duplicate tests run on a particular vehicle and a particular fuel as a repetition of another test or set of tests on the same vehicle and fuel, with draining and re-filling the fuel tank and with conducting pre-test dynamometer cycles, as described in VIII.D., between the tests or sets of tests.

1~~1~~3. "Substitute fuel" means a fuel used in accordance with section 2317 in subchapter 8, chapter 3, title 13, CCR ~~California Code of Regulations~~.

1~~2~~3. "Test fuel" means the particular batch of fuel representing a candidate fuel in the emission demonstration required for approval of the candidate fuel.

1~~3~~4. "Toxic air contaminant" means benzene, 1,3-butadiene, formaldehyde, or acetaldehyde.

II. *Minimal Requirements for a Candidate Fuel*

A. A candidate fuel must meet all standards enforced by the Board for the kind of fuel.

III. *Demonstrations Required for a Candidate Fuel*

A. The demonstration of no increase in emissions from the use of a candidate fuel, required of a substitute fuel in the code cited in I.C.1~~1~~3 and required of a new clean fuel in the test procedure cited in I.C.~~8~~9, shall consist of emission tests on a test fuel whose properties identified per the test plan have been accurately measured. Comparisons of the results of these tests with the results of tests on the pertinent reference fuel(s) must satisfy the criterion in section V.

B. For a proposed substitute fuel, separate demonstrations of no increase in emissions shall be made for (i) the low-emission vehicles that have been certified on the primary designated clean fuel and (ii) all other types of vehicle that could use the candidate fuel. For a proposed new clean fuel, the demonstration of no increase in emissions shall encompass all vehicles capable of using the candidate fuel.

C. The demonstration of no increase in deterioration of vehicles' emission control system, required of a substitute fuel in the code cited in I.C.1~~1~~3 and required of a new clean fuel in the test procedure cited in I.C.~~8~~9, shall be conducted per section XI of this protocol.

IV. *Emission Tests and Comparisons Required for Candidate Fuels*

A. Emission tests and comparisons shall be done on vehicles in the categories that exist on-road at the time of the testing or that are expected to exist at the time the candidate fuel would first be sold. The vehicle categories appropriate for inclusion in these fleets are defined in subsection VI.A.

B. Comparisons using the criterion in section V shall be made between emissions measured in tests using a test fuel representing the candidate fuel and emissions measured in tests using reference fuels.

C. The criterion in section V shall be applied separately to CO emissions, NOx emissions, the ozone-forming potential of exhaust NMOG emissions, and the combined potency-weighted emissions of toxic air contaminants. If the test fuel fails to meet the criterion in section V for any of these pollutants, the candidate fuel shall have failed the required demonstration.

V. *Criterion for Acceptable Emissions*

For each comparison required in section IV, the upper confidence limit (UCL) for the estimated mean difference in emissions between fuels (test fuel vs. reference fuel) among all on-road vehicles in the tested categories, computed at the significance level of 0.15 for the one-sided t-statistic, shall be less than or equal to a tolerance fraction ($\delta$) of the average emissions ($E_c$, in grams/mile) estimated

for those on-road vehicles using their reference fuels. The estimate of emission difference shall be based on the emission measurements in the test fleet. In terms of parameters calculated per section X, the criterion is expressed as:

$$UCL = D + t_{.15,nu} \times S.E. \leq \delta \times E_c$$

where $D$ is the estimate of the mean difference in emissions between the fuels, and $S.E.$ is the standard error for that estimate, calculated for nu degrees of freedom.

The values of δ shall be:

| *Pollutant Measure* | *δ* |
|---|---|
| CO | 0.040 |
| NOx | 0.020 |
| grams ozone/mile | 0.040 |
| Potency-weighted sum of toxic emissions | 0.040 |

VI. *Test Vehicles*

A. Vehicle Categories for Testing

1. Vehicle categories eligible for testing candidate fuels are only those categories subject to the LEV II and LEV III emissions standards set forth in the applicable Light-Duty Test Proceures. ~~listed in 2, 3, and 4, below. Only vehicles meeting all defining descriptors for a category are included in that category.~~

~~2. For testing a proposed substitute fuel in the low-emission vehicles certified on the primary designated clean fuel, eligible categories are:~~

| ~~*Weight Class*~~ | ~~*Model Year*~~ | ~~*Emission Std.*~~ | ~~*Cert. Fuel*~~ | ~~*Catalyst Type*~~ |
|---|---|---|---|---|
| ~~light-duty~~ | ~~1994 +~~ | ~~ULEV~~ | ~~p.d. clean *~~ | ~~any~~ |
| ~~"~~ | ~~"~~ | ~~LEV~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~"~~ | ~~TLEV~~ | ~~"~~ | ~~"~~ |
| ~~medium-duty~~ | ~~"~~ | ~~LEV or ULEV~~ | ~~"~~ | ~~"~~ |

~~* primary designated clean fuel~~

~~3. For testing a proposed substitute fuel in vehicles other than those certified on the primary designated clean fuel, eligible categories are:~~

| ~~*Weight Class*~~ | ~~*Model Year*~~ | ~~*Emission Std.*~~ | ~~*Cert. Fuel*~~ | ~~*Catalyst Type*~~ |
|---|---|---|---|---|
| ~~light-duty~~ | ~~"~~ | ~~ULEV~~ | ~~other **~~ | ~~"~~ |
| ~~"~~ | ~~"~~ | ~~LEV~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~"~~ | ~~TLEV~~ | ~~"~~ | ~~"~~ |

| | | | | |
|---|---|---|---|---|
| ~~"~~ | ~~1990 +~~ | ~~not LEV~~ | ~~gasoline~~ | ~~"~~ |
| ~~"~~ | ~~1986-1990~~ | ~~any~~ | ~~"~~ | ~~3-way, closed-loop~~ |
| ~~"~~ | ~~1981-1985~~ | ~~"~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~1975-1980~~ | ~~"~~ | ~~"~~ | ~~oxidizing~~ |
| ~~"~~ | ~~pre-1975~~ | ~~"~~ | ~~"~~ | ~~none~~ |
| ~~medium-duty~~ | ~~1994~~ | ~~LEV or ULEV~~ | ~~other **~~ | ~~any~~ |
| ~~"~~ | ~~pre-1994~~ | ~~not LEV~~ | ~~gasoline~~ | ~~any~~ |
| ~~"~~ | ~~"~~ | ~~"~~ | ~~"~~ | ~~none~~ |

~~** any fuel other than the primary designated clean fuel~~

~~4. For testing a proposed new clean fuel, eligible categories are:~~

| ~~*Weight Class*~~ | ~~*Model Year*~~ | ~~*Emission Std.*~~ | ~~*Cert. Fuel*~~ | ~~*Catalyst Type*~~ |
|---|---|---|---|---|
| ~~light-duty~~ | ~~1994+~~ | ~~ULEV~~ | ~~any~~ | ~~any~~ |
| ~~"~~ | ~~"~~ | ~~LEV~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~"~~ | ~~TLEV~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~1990 +~~ | ~~not LEV~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~1986-1990~~ | ~~any~~ | ~~gasoline~~ | ~~3-way, closed-loop~~ |
| ~~"~~ | ~~1981-1985~~ | ~~"~~ | ~~"~~ | ~~"~~ |
| ~~"~~ | ~~1975-1980~~ | ~~"~~ | ~~"~~ | ~~oxidizing~~ |
| ~~"~~ | ~~pre-1975~~ | ~~"~~ | ~~"~~ | ~~none~~ |
| ~~medium-duty~~ | ~~1994+~~ | ~~LEV or ULEV~~ | ~~any~~ | ~~any~~ |
| ~~"~~ | ~~pre-1994~~ | ~~not LEV~~ | ~~gasoline~~ | ~~"~~ |
| ~~"~~ | ~~"~~ | ~~"~~ | ~~"~~ | ~~none~~ |

~~5~~2. Within each eligible category, the only vehicles eligible for testing under this protocol shall be the vehicles that are reasonably capable of operating on the candidate fuel and for which the candidate fuel is not also the reference fuel.

~~6~~3. The Executive Officer shall maintain estimates of the total emissions from, and total annual miles travelled by, vehicles in the state in each of the LEV II and LEV III ~~categories listed in 2, 3, and 4, above~~, assuming that all the vehicles receive their reference fuels all the time. These estimates shall be for the same time as, consistent with, and updated on the same schedule as the estimates of miles travelled that the Executive Officer uses to determine the required numbers of new retail outlets for clean fuels under paragraph (d)(2)of section 2305 and paragraph (e)(2)of section 2307, Subchapter 8, Title 13, CCR ~~California Code of Regulations~~.

~~7~~4. ~~Over all vehicles in the categories in subsection VI.A.2, 3, or 4, as limited by subsection VI.A.5, t~~The Executive Officer shall sum the estimates of

exhaust NMOG emissions and miles travelled in the state over all eligible vehicle categories.

~~8~~5. Each test fleet ~~required by subsection IV.A~~ shall consist of each vehicle category contributing at least 3 percent of the sum of NMOG emissions described in subsection VI.A.~~7~~4 or at least 5 percent of the sum of miles travelled described in that sub-section.

B. Number, Descriptions, and Preparation of Vehicles

1. Within each vehicle category to be tested per subsection VI.A.~~8~~5, the emission comparisons described in subsection IV.B shall be conducted in at least five vehicles. Over all categories tested, the total number of vehicles shall be at least 20. When, per subsection III.B, the vehicle categories for a substitute fuel are divided between two separate emission demonstrations, there shall be at least 10 vehicles in each demonstration.

2. Except in the case described in subsection VI.B.6, the group of vehicles within each test category shall meet these restrictions:

   (a) no two vehicles shall be the same model and model year.

   (b) not more than 20 percent shall have the same owner or the same manufacturer.

3. Except as provided in subsection VI.B.6, within each vehicle category, the test vehicles shall have distributions of engine displacement, types of fuel/air metering, catalyst technology, emission control system, and California vs. U.S. (49-state) certification that the Executive Officer deems are sufficiently representative of California's on-road fleet to make significant bias of the overall test results unlikely.

4. Except as provided in subsection VI.B.6, each vehicle used under this protocol shall have accumulated at least the following miles travelled:

| *Age of vehicle, as determined by model year* | *Minimum miles travelled* |
|---|---|
| 0 to 1 | 4,000 |
| 2 to 5 | 18,000 |
| 6 to 10 | 41,000 |
| 11 to 15 | 61,000 |
| > 15 | 76,000 |

5. Each vehicle shall be tested in its as-received condition; except, any routine maintenance scheduled to occur per the manufacturer's recommendation may be performed.

6. The Executive Officer may relax for any vehicle category any requirement in this subsection VI.B if the applicant demonstrates that the requirement is unreasonably difficult to meet and if ~~either:~~

   ~~a)~~ the requirement is unnecessary to provide a group of vehicles that reasonably represents the vehicle category~~, or~~

   ~~b) the category is TLEV, LEV, or ULEV~~.

7. Instead of following paragraphs 2 through 5 of this subsection B, the applicant may compose each category of test vehicles required by subsection VI.A.~~8~~5 through random sampling of on-road vehicles. This option may be followed only after approval by the Executive Officer of the proposed sampling method as part of the plan described in section VII.

VII. *Test Plan*

A. The applicant shall submit to the Executive Office a test plan including the following information:

1. identification of properties of the fuel that affect exhaust emissions and would require specification in commercially available fuel; these shall include (but are not limited to) all properties for which the Air Resources Board has adopted specifications for fuel of the type of the candidate fuel;

2. identification of the appropriate form of specification for each property identified in VII.A.1; each specification shall be of one of the following forms, as necessary to ensure that all candidate fuels made to the specification would not cause greater emissions of the pollutants addressed by the protocol than would the test gasoline:

   (a) allowable value of property < [specified value]

   (b) allowable value of property > [specified value]

   (c) [specified value] < property < [specified value]

3. the engine families, model years, California or U.S. certification, and sources of vehicles with which the applicant proposes to satisfy subsection VI.B (if the option in subsection VI.B.7 is not exercised);

4. if the option in subsection VI.B.7 is exercised, the method by which random sampling will be accomplished;

5. the identities of any contractors who will conduct emission tests or analyses of samples;

6. quality control provisions consistent with good laboratory procedures in testing for the emission levels expected to be encountered in the tests;

7. the number of emission tests (duplicates and replicates) to be run in each vehicle within each vehicle category;

8. an approximate description of the test fuel, including all properties described in subsection VII.A.1;

9. a test method for determining the value of each property described in VII.A.1 that does not have a test method adopted by the Air Resources Board; and

10. a description of any statistical test by which the applicant would analyze individual test data to identify and discard statistical outliers.

B. ~~Except as provided in subsection VII.D, i~~If a specification is of the kind in subsection VII.A.2(a) or (b), the value of [specified value] shall be the value measured for that property in the test fuel.

C. ~~Except as provided in subsection VII.D, i~~If a specification is of the kind in subsection VII.A.2(c), the values of [specified value] shall be stated in the test plan.

~~D. The specifications approved for gasoline by the Board on November 22, 1991, may be proposed for a substitute fuel. In this case, the test fuel representing the candidate fuel shall be meet the specifications for certification gasoline in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Trucks", paragraph 86.113-90, sub-paragraph (a)(1)(ii), approved by the Board on August 14, 1992.~~

~~E~~D. Unless the option in subsection VI.B.7 is exercised, after the Executive Officer's approval of the plan, the applicant shall specify to the Executive Officer the vehicle identification numbers of the vehicles to be tested. These numbers shall become part of the approved plan.

~~F~~E. After the Executive Officer's approval of the plan, the applicant shall supply measurements of the properties of the test fuel, including all properties described in subsection VII A.1.

~~G~~F. No datum shall be considered valid for the purpose of a demonstration controlled by this protocol unless that datum has been produced according to a plan approved by the Executive Officer before the datum has been taken.

~~H~~G. Except as provided by section IX, no demonstration shall be valid unless all data corresponding to an approved plan have been taken and included in the calculations prescribed in section X.

~~I~~H. Except as provided by section IX, deviations from an approved plan shall not be permitted except by the prior permission of the Executive Officer.

~~J~~I. No more than 20 working days after receiving a proposed test plan, the Executive Officer shall either inform the applicant that the plan is complete or advise the applicant of necessary additions or changes. No more than 15 working days after receiving requested additions or changes, the Executive Officer shall advise the applicant that the amended plan is complete or further advise the applicant of necessary additions or changes. No more than 20 working days after advising the applicant that a plan is complete, the Executive Officer shall either approve or reject the plan. A rejection shall be accompanied by specifications of deficiencies.

K. The Executive Officer shall not approve a test plan unless he or she finds that it would produce a valid emission demonstration, as required by section III, by the procedures described in this protocol.

L. If requested by the Executive Officer, the applicant shall supply a sample of the test fuel or of the reference fuel(s).

VIII. *Emission Testing Procedures*

A. All emission tests shall be done according to the "California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for ~~1988 and Subsequent Model~~ Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", incorporated by reference in Title 13, CCR ~~California Code of Regulations~~, section ~~1960.1~~ 1961.2.

B. Within any vehicle category, the same number of replicate tests and the same number of duplicate tests within each replicate test shall be run on each test vehicle on both the reference fuel and the test fuel. The number of replicate tests and the number of duplicate tests shall be determined by the applicant (subject to approval as part of the test plan) and may vary among the vehicle categories.

C. The order in which fuels are tested in any vehicle shall be determined randomly.

D. Whenever the fuel to be tested in a vehicle differs from the current fuel in the vehicle, and whenever a replicate test is to be run, the test vehicle's fuel tank and fuel delivery system shall be drained of fuel to the extent that is practicable. The fuel tank shall then receive a 40 percent fill of the fuel to be tested. The vehicle shall then be run though one Highway Fuel Economy Driving Cycle (HFEDC) (40 Code of Federal Regulations, Part 600, Subpart B). The fuel tank and fuel delivery system shall again be drained, and the tank shall receive a 40 percent fill of the test fuel. Finally, the vehicle shall undergo another HFEDC and two consecutive LA4 cycles. The test vehicle shall not be operated again before the tests required in VIII.A are run.

E. Pre-testing procedures alternative to subsection VIII.D may be used if they are part of the approved plan described in section VII. Such alternatives may be approved only if judged by the Executive Officer to be equivalent or superior in achieving a valid test of the fuel under test.

F. In each test run, the NMOG emissions shall be speciated for determining the ozone-forming potential of the vehicle's exhaust. Species in the NMOG emissions shall be identified and quantified by the procedures in the "California Non-Methane Organic Gas Test Procedures," incorporated by reference in section 1961.2, title 13, CCR. ~~(referred to in the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles").~~ Exhaust emissions of benzene, 1-3 butadiene, formaldehyde, and acetaldehyde shall be identified and quantified using the procedures in the same document.

IX. *Exclusion of Data or Vehicles*

A. Any datum from an individual run may be excluded as an outlier relative to its duplicate data (or to its replicate data if replicates do not contain duplicate tests) if so indicated by a statistical test approved by the Executive Officer as part of the test plan. If an analysis is used to exclude one or more datum for a pollutant, the same analysis shall be applied to all data for that pollutant.

B. Any vehicle may be excluded from the test program if it cannot be tested safely. In such a case, a similar vehicle shall be tested.

C. No datum shall be used in an emission demonstration under this protocol if:

1. test procedures during the generation of the datum differed from the procedures required in section VIII.A, or

2. the datum was taken without adherence to the quality control requirements in the test plan, or

3. the vehicle used to generate the datum can be shown to have operated in a way different from the way it operated during other tests, and such a difference can reasonably be expected to affect emissions, or

4. either the testing equipment or the chemical analytical equipment can be shown to have functioned differently during the generation of the datum than during other tests, and such difference in function can reasonably be expected to affect emission measurements.

D. A datum deleted according to one of the disqualifying conditions in IX.C shall be replaced by a new test unless the vehicle used to generate the datum is no longer in the possession of the applicant or the applicant's contractor or unless the vehicle has been used in ordinary service since testing was completed.

However, if the original vehicle cannot be tested and the deletion of a datum leaves no data for a particular vehicle/fuel combination, a similar vehicle shall be obtained and all tests on the original vehicle shall be repeated with the replacement vehicle.

## X. *Calculations*

### A. Summary and Explanation of Calculations

This procedure calculates a statistical upper bound on the difference in average emissions per mile from the test fuel and from the reference fuel(s) for the relevant on-road vehicle fleet. The emissions of all the pollutants measured during testing are expressed in units of mass per mile. The calculation procedure is the same for all pollutants.

For each vehicle, the difference in emissions per mile is calculated as the average emissions per mile from tests with the test fuel minus the average emissions per mile from tests with the reference fuel, where the averages are over all data, whether duplicate test data or replicate test data.

Within each vehicle category, the difference in emissions between the two fuels is the mean value of the difference values among vehicles. Within each vehicle category, the standard deviation of the difference among vehicles is also calculated.

The expectation value of the relevant on-road vehicle fleet's average difference in emissions per mile is the weighted average of the differences in emissions among the vehicle categories. The weights used in the averaging are the estimates of total miles travelled by vehicles in the various categories.

Estimates of the standard error and degrees of freedom corresponding to the fleet average difference in emissions are calculated from the weights, the numbers of test vehicles in the categories, and the standard deviations within categories.

The upper bound on the average difference in emissions for the on-road fleet is calculated from the expectation value, the standard error, and the one-sided student-t value for the 0.15 significance level and the calculated degrees of freedom.

The tolerance value for the upper bound is a tolerance fraction times the weighted average value of the average emissions measured within vehicle categories on the reference fuel.

The type of statistical upper bound computed by this procedure is called an "upper confidence limit" in the statistical literature. Upper confidence limits for a statistical result have a high probability of exceeding the unknown true value of

the quantity being measured. The probability is approximately 85 percent that the (unknown) true value of the mileage-weighted average difference of emissions per mile is less than its corresponding upper confidence limit. Consequently, if the true value of the difference in average emissions per mile is greater than the tolerance value, approximately 85 percent, or more, of all possible upper confidence limits will exceed this true value and therefore exceed the tolerance value. It follows that a candidate fuel with a true difference of emissions of a certain pollutant greater than the tolerance value will satisfy the criterion, and be accepted (with respect to that pollutant, only) as causing no increase in emissions, only about 15 percent of the time.

The upper confidence limits computed by this procedure are 85 percent one-sided upper confidence limits for a weighted average of normally distributed random variables. They are based on an approximate t- distribution. The degrees-of-freedom parameter of this distribution is calculated by Welch's approximation.

B. Test Run Results

1. Emission rates of CO, NOx, and NMOG, expressed as "g/mile", and the emission rate of each toxic pollutant, expressed as "mg/mile", shall be determined in each test by the procedure described in the "California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for ~~1988 and Subsequent Model~~ Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles".

2. Values of ozone-forming potential, in "g ozone per mile", shall be determined for exhaust emissions in each test according to Appendix VIII of the regulation stated in subsection X.B.1, above.

3. In each test, the emission rate of each toxic pollutant shall be multiplied by its relative potency, as shown in the following table, and the four products shall be summed.

| | *Relative Potency* |
|---|---|
| 1,3-butadiene | 1.0 |
| benzene | 0.17 |
| formaldehyde | 0.035 |
| acetaldehyde | 0.016 |

C. Upper Confidence Limit for Mean Emission Difference

1. The procedures in this section shall be followed for each test fleet required by section IV.A. The procedures shall be followed separately for CO,

NOx, the ozone-forming potential of exhaust NMOG, and the combined potency-weighted toxic emissions.

2. For each vehicle, the results (g/mile for CO and NOx, g ozone/mile for the ozone-forming potential of NMOG, or mg/mile for combined potency-weighted toxic emissions) from all tests (whether duplicates or replicates) on the test fuel shall be averaged, as shall the results from all tests on the reference fuel. The average result when the vehicle is tested on the reference fuel shall be subtracted from the average when the vehicle is tested on the test fuel. The result of the subtraction is a difference value for the vehicle, $d_v$, for the pollutant measure.

3. Within each vehicle category, the mean value and squared standard deviation of mean difference values shall be calculated over all vehicles:

$m_{d,i}$ = mean value of $d_v$ over all ($n_i$) vehicles in category i.

$s_d^2$ = square of standard deviation corresponding to $m_{d,i}$

= sum over vehicles of $\{(d_v - m_{d,i})^2/(n_i - 1)\}$

4. The population-weighted mean value of $m_d$ shall be calculated over all tested vehicle categories:

D = Sum over all categories (i) of $\{m_{d,i} \times p_i\}$

where $p_i$ is total miles travelled by on-road vehicles in vehicle category i divided by the sum of total miles travelled by on-road vehicles in all categories that have been tested within the fleet. The values of "p" shall be determined with the values of NMOG emissions and miles travelled described in subsections VI.A.~~6~~3.

5. The standard error of the weighted mean emission difference shall be calculated from the standard deviations within emission categories:

S.E.$^2$ = Sum over all categories (i) of $\{p_i^2 \times s_{d,i}^2/n_i\}$

where $n_i$ is the number of test vehicles in category$_i$

6. The number of degrees of freedom associated with D shall be calculated as:

$$nu = \frac{(S.E.^2)^2}{Sum\ over\ all\ categories\ of\ \{p_i^4 \times s_{d.i}^4/[n_i^2 \times (n_i - 1)]\}}$$

7. The upper confidence limit for the population mean emission difference shall be calculated as:

$$UCL = D + t_{.15,\,nu} \times S.E.$$

where t is the one-tailed "student's t" value for significance level (alpha) = .15 and degrees of freedom nu.

8. "t" shall be calculated as:

$$t_{.15,nu} = U + \frac{U^3 + U}{4 \times nu} + \frac{(5 \times U^5 + 16 \times U^3 + 3 \times U)}{(96 \times nu)}$$

where $U = 1.036$

D. Emissions from the Use of Reference Fuel

1. Within each test vehicle category, the average of all emission results (mass/mile) when the reference fuel is used, as described in X.B.2, shall be averaged over all vehicles. The result, $e_{c,i}$, is the emission rate for category i.

2. The estimate of the relevant on-road fleet emissions from the use reference fuel shall be the weighted sum over categories of $e_{c,i}$, using the same weights, $p_i$, as in the calculation of D.

$E_c$ = sum over all categories (i) of $\{p_i - e_{c,i}\}$

XI. *Demonstration Regarding Durability*

A. The applicant shall satisfy the requirements of paragraph (a)(3)(C), section 2317, Subchapter 8, Title 13, CCR ~~of the California Code of Regulations~~ or paragraph (a)(2), section ~~12~~ 100.3.9, Part II of the "California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for ~~1988 and Subsequent Model~~ Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" (both concerning deterioration of emission control), whichever applies, by the procedures in this section.

B. If the applicant demonstrates to the Executive Officer that the candidate fuel is substantially similar to an existing in-use or certification fuel for motor vehicles, with regard to properties that may affect the durability of emission controls, the candidate fuel shall be deemed to not increase deterioration.

C. If the demonstration of substantial similarity described in XI.B cannot be made, the applicant shall provide to the Executive Officer all information available to the

applicant related to the possible effects of the candidate fuel and its constituents upon the durability of the emission controls in the vehicles that could use the candidate fuel. If this information is reasonably complete and does not indicate that the candidate fuel would increase deterioration of emission controls, the candidate fuel shall be deemed to not increase deterioration.

D. If the available information for the candidate fuel does not allow a conclusion that no increase in deterioration of the emission control system is likely to occur, or if the information indicates a potential for other undesirable effects, satisfaction of the regulations cited in XI.A shall require address of the shortcomings by further information. Such information shall be developed according to a plan, described in XI.E, that shall be approved by the Executive Officer before its implementation.

E. The plan referred to in XI.D may include, but is not limited, to the following:

-- emission testing

-- 150,000-mile durability testing with emission tests every 5,000 miles

-- bench tests, including immersion tests and vapor tests for a variety of automotive materials and components

-- recommendations on statistical tests to be applied to data

F. Upon receipt of the information in the plan, the Executive Officer shall determine whether or not an increase in deterioration of emission control systems is likely to occur.

G. If excessive deterioration of emission control systems from the use of an approved substitute fuel or new clean fuel becomes apparent, any person may submit a petition, accompanied by supportive data, for a hearing by the Executive Officer to reconsider the approval of the fuel. The Executive Officer may hold a hearing after notification of all interested parties.

H. As a result of findings from a hearing described in XI.G, the Executive Officer may require the original applicant to do additional testing of the approved fuel, per a plan to be approved by the Executive Officer, or rescind the approval for fuel.

I. After 180 days from the date of an Executive Order rescinding approval for a fuel per XI.H, no person shall sell that fuel for use in California, unless a new approval has been obtained under this protocol. By the first day of the month that is 19 calendar months after the month of the Executive Order, all owners of retail gasoline outlets who had complied with subchapter 8, chapter 3, title 13, CCR ~~California Code of Regulations~~ by using the fuel as a substitute fuel shall reach and maintain compliance with that regulation. Between the date of the Executive Order and the first day of the calendar month that is 19 months after the month of the Executive Order, the number of primary designated clean fuel outlets calculated for a major gasoline supplier according to section 2305(c), title

13, CCR, or calculated for an owner/lessor according to section 2307(d), title 13, CCR, shall be reduced by the number of outlets in which the major gasoline supplier or owner/lessor offered the substitute fuel to comply with section 2301 or 2302, title 13, CCR. During that period, no gasoline service station that had offered the substitute fuel shall be a selected retail clean fuel outlet of the primary designated clean fuel for the purposes of subchapter 8, Title 13 CCR.

XII. *Submission of Results*

By means agreed upon by the Executive Officer and the applicant, the applicant shall submit documentation of adherence to the plan described in section VII and to the procedures specified in section VIII., the calculations required in section X, any outlier analyses conducted per paragraph IX.A, the output from all test runs, all speciations of NMOG, and the information required by section XI.

XIII. *Approval of Candidate Fuels*

A. No more than 20 working days after receiving the information described in section XII, the Executive Officer shall either inform the applicant that the information is complete or advise the applicant of necessary additions or changes. No more than 15 working days after receiving requested additions or changes, the Executive Officer shall advise the applicant that the amended information is complete or further advise the applicant of necessary additions or changes. No more than 20 working days after advising the applicant that the information is complete, the Executive Officer shall deem the demonstrations required by section III either to be accomplished or not accomplished. A rejection shall be accompanied by specifications of deficiencies.

B. If the Executive Officer determines that an applicant has accomplished the required demonstration, the Executive Officer shall approve the candidate fuel. The Executive Officer shall include in the approval order specifications on properties according to subsections VII.A.1, VII.B, and VII.C. The Executive Officer shall notify interested parties of the approval within 10 working days of issuing the order.

C. An approval shall be in force for five years, at which time the reapproval process in section XIV shall be followed.

XIV. *Periodic Re-approval*

A. Every five years after the initial approval of a candidate fuel, test data shall be provided for any vehicle category previously exempted from testing pursuant to section VI.A.~~8~~5 if the exempting criteria (less than 3 percent of emissions and

less than 5 percent of miles travelled) are no longer met. Test data shall also be provided for any previously tested vehicle category for which the Executive Office determines that the vehicles tested no longer provide a reasonable representation of the on-road vehicles in that category.

B. Every five years, the upper confidence limit specified in subsection X.C and the emissions from the use of reference fuel specified in subsection X.D shall be re-calculated for the test fleets required by subsections VI.A.~~8~~5. The calculations shall use the original test data, any new test data provided pursuant to subsection XIV.A or XV.A, and the current statistical weights (p) as described in subsection X.C.4. If the upper confidence level exceeds the criterion in section V for any pollutant, approval for the fuel shall be rescinded.

C. After January 1 of the year that is three calendar years after the year of the Executive Order rescinding approval for a fuel under this section, no person shall sell that fuel for use in California, unless a new approval has been obtained under this protocol.

## XV. *Augmentation of the Original Test Data*

A. An applicant who made the petition that led to the approval may augment any portion of the information in the original test plan or the submission required in section XII. All new information shall be developed according to this test protocol.

B. If new information or proposed changes are submitted, the Executive Officer shall evaluate and either accept or reject them by standards consistent with the requirements in this procedure for the original approval.