**State of California**
**California Environmental Protection Agency**
**AIR RESOURCES BOARD**

# California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model

**Adopted: June 16, 2000**
**Amended: April 25, 2001**
**Amended: November 18, 2004**
**Amended: August 7, 2008**
**Last Amended: August 24, 2012**

THIS PAGE LEFT INTENTIONALLY BLANK

## Table of Contents

## Table of Contents (continued)

## List of Tables

# I. INTRODUCTION

## A. Purpose and Applicability

1. The predictive model prescribed in this document may be used to evaluate gasoline specifications as alternatives to the Phase 3 California Reformulated Gasoline (RFG) flat and averaging limits in the gasoline specifications set forth in Title 13, California Code of Regulations (13 CCR), section 2262.

   This procedure:

   - ♦ prescribes the range of specifications that may be utilized to select a set of candidate Phase 3 RFG alternative gasoline specifications for evaluation,
   - ♦ defines the Phase 3 RFG reference specifications,
   - ♦ prescribes the calculations to be used to predict the emissions from the candidate fuel specifications and the reference Phase 3 RFG specifications,
   - ♦ prescribes the calculations to be used to compare the emissions resulting from the candidate fuel specifications to the reference Phase 3 RFG specifications,
   - ♦ establishes the requirements for the demonstration and approval of the candidate fuel specifications as an alternative Phase 3 RFG formulation,
   - ♦ establishes the notification requirements, and
   - ♦ identifies when the exhaust hydrocarbon equations models and the evaporative hydrocarbon emissions equations must be used.

2. Gasoline properties for which alternative gasoline specifications may be set by this procedure include all eight Phase 3 RFG properties.

3. The Phase 3 RFG specifications, established in 13 CCR, section 2262, are shown in Table 1.

4. The pollutant emissions addressed by these procedures and the units of model predictions are shown in Table 2.

**Table 1**
**Properties and Specifications for Phase 3 Reformulated Gasoline**

| Fuel Property | Units | Flat Limit | Averaging Limit | Cap Limit |
|---|---|---|---|---|
| Reid vapor pressure (RVP) | psi, max. | 6.90[1]/7.00 | none | 7.20 |
| Sulfur (SUL) | ppmw, max. | 20 | 15 | 60/30[3]/20[3] |
| Benzene (BENZ) | vol.%, max. | 0.80/1.00[2] | 0.70 | 1.10 |
| Aromatic HC (AROM) | vol.%, max. | 25.0/35.0[2] | 22.0 | 35.0 |
| Olefin (OLEF) | vol.%, max. | 6.0 | 4.0 | 10.0 |
| Oxygen (OXY) | wt. % | 1.8 (min)<br>2.2 (max) | none | 1.8(min)[4]<br>3.5(max)[5] |
| Temperature at 50 % distilled (T50) | deg. F, max. | 213/220[2] | 203 | 220 |
| Temperature at 90% distilled (T90) | deg. F, max. | 305/312[2] | 295 | 330 |

1 The flat limit for RVP is 7.00 psi. The flat limit for RVP is 6.90 when the fuel being certified is blended without ethanol. The Reid vapor pressure (RVP) standards apply only during the warmer weather months identified in section 2262.4.

2 The higher value is the small refiner CaRFG flat limit for qualifying small refiners only, as specified in section 2272.

3 The CaRFG Phase 3 sulfur content cap limits of 60, 30, and 20 parts per million are phased in starting December 31, 2003, December 31, 2005, and December 31, 2011, respectively, in accordance with section 2261(b)(1)(A).

4 Applicable only during specified winter months in the areas identified in 13 CCR, section 2262.5(a).

5 If the gasoline contains more than 3.5 percent by weight oxygen but not more than 10 volume percent ethanol, the maximum oxygen content cap is 3.7 percent by weight.

**Table 2**
**Predictive Model Pollutants and Their Units of Measurement**

| Pollutant Predictions | Units |
|---|---|
| Oxides of Nitrogen (NOx) | gm/mile |
| Exhaust Hydrocarbons (ExHC) | gm/mile |
| Evaporative Hydrocarbons | Percent Change (Candidate Fuel Relative to Reference Fuel) |
| Exhaust Potency-Weighted Toxics (PWT) | mg/mile |
| Evaporative Benzene | mg/mile |
| Carbon Monoxide (CO) | gm/mile |

## B. Synopsis of Procedure

The predictive model is used to predict the emissions for gasoline meeting the Phase 3 RFG specifications (reference fuel specifications) and the emissions for a candidate gasoline meeting alternative specifications (candidate fuel specifications). The predicted emissions are functions of the regulated fuel properties shown in Table 1. The candidate gasoline is deemed acceptable as Phase 3 RFG if its predicted emissions for each pollutant is less than or equal (within round-off) to the predicted emissions for a fuel meeting the Phase 3 RFG specifications.

### 1. What is the Predictive Model?

The predictive model consists of a number of sub-models. The sub-models are equations which relate gasoline properties to the exhaust emissions and evaporative emissions changes which result when the gasoline is used to fuel a motor vehicle. The emissions predictions are expressed in the units shown in Table 2.

Twenty-one separate exhaust sub-models have been developed for seven pollutants (NOx, hydrocarbon (HC), CO, benzene, 1,3-butadiene, formaldehyde, and acetaldehyde). Three exhaust sub-models have been developed for each of the seven pollutants: one sub-model for each of three vehicle emissions control technology “Tech” classes (Tech 3, Tech 4, and Tech 5).

In addition, six sub-models have been developed for evaporative emissions. Three sub-models have been developed for evaporative hydrocarbon emissions and three sub-models have been developed for evaporative benzene emissions. For both evaporative hydrocarbon emissions and evaporative benzene emissions, one sub-model has been developed for each of the following evaporative emission processes: 1) Diurnal/Resting Losses, 2) Hot Soak Emissions, and 3) Running Losses.

2. **Combination of Sub-Model Predictions for Exhaust Emissions Across Tech Classes** (referred to as the Exhaust Hydrocarbon Model (ExHC Model) in this procedures document)

In the ExHC Model, the exhaust emissions of the reference fuel specifications and the candidate fuel specifications for each Tech class of vehicles are predicted by the sub-models of the predictive model. The differences between the predicted exhaust emissions for the reference fuel specifications and the candidate fuel specifications are combined to yield Tech class-weighted predicted emissions differences. These predicted differences represent the predicted differences in exhaust emissions between the reference fuel specifications and the candidate fuel specifications for the entire California vehicle fleet. For NOx and ExHC emissions, the differences in predictions for each Tech class are combined using Tech class weighting factors which represent the fraction of the total emissions originating from each Tech class.

For the exhaust toxics emissions, the predicted emissions for Tech classes are weighted both by fractions and by potencies. The potency weights represent the relative carcinogenicity of the toxic pollutants. For each toxic pollutant, the predicted exhaust emissions for each Tech class is weighted by the HC exhaust Tech group weighting factor which represents the fraction of the total vehicle miles traveled by each Tech class. Then, the Tech class-weighted emissions prediction for each toxic pollutant is multiplied by the relative potency for that pollutant. The Tech class-weighted, potency-weighted predictions for each toxic pollutant are then summed to yield the predicted total potency-weighted exhaust toxics emissions. Finally, an emissions prediction for evaporative benzene emissions is added to the prediction for total potency-weighted exhaust toxics emissions to yield a prediction for total potency-weighted toxics emissions. This calculation is performed for both the reference fuel specifications and the candidate fuel specifications.

3. **Combination of Evaporative HC Emissions Predictions, Exhaust Hydrocarbon Emissions Predictions, and CO Emissions Predictions** (referred to as the Total Hydrocarbon Model (THC Model) in this procedures document)

The THC Model includes predictions for differences in exhaust and evaporative HC emissions and CO emissions between the candidate fuel specifications and the Phase 3 RFG reference fuel in the evaluation of the equivalency of the candidate fuel. In the THC Model, the Tech class-weighted difference in the predicted ExHC emissions between the reference fuel specifications and the candidate fuel specifications is combined with the predicted difference in evaporative HC emissions and CO emissions between the two fuels when evaluating the equivalency of the candidate fuel specifications. This combination estimates the difference in total HC emissions (exhaust plus evaporative) and CO emissions between the reference fuel specifications and the candidate fuel specifications.

In the THC Model, when combining the Tech class-weighted difference in the predicted ExHC emissions with the predicted difference in evaporative HC emissions, the greater ozone-forming potential of the exhaust emissions is recognized by the inclusion of a “reactivity adjustment” factor for the evaporative HC emissions. Also, the ozone-forming potential of CO emissions is recognized in the THC Model by the inclusion of emissions in the sum of exhaust and evaporative HC emissions. Thus, in the THC Model, the combination of the model predictions for ExHC emissions, evaporative HC emissions changes, and CO emissions yields a number which represents a prediction for the change in ozone-forming potential (OFP) between the reference fuel specifications and the candidate fuel specifications. The flat and cap RVP limits for the THC Model are 7.00 psi, and 7.20 psi, respectively for fuels containing ethanol, and flat and cap RVP limits of 6.90 and 7.20 psi, respectively for fuels not containing ethanol.

### 4. Determination of Emissions Equivalency

The candidate fuel specifications are deemed equivalent to the reference fuel specifications if, for each pollutant (NOx, total OFP or ExHC, and potency-weighted toxics (PWT)), the predicted percent change in emissions between the candidate fuel specifications and the reference Phase 3 RFG specifications is equal to or less than 0.04%. If the applicant is using or is required to use the THC Model in the evaluation of the emissions equivalency, the 0.04% criteria must be met for NOx, OFP, and PWT. If the applicant is using or is required to use the ExHC Model, the 0.04% criteria must be met for NOx, ExHC, and PWT. If, for any of the three pollutants in the criteria, the predicted percent change in emissions between the candidate fuel specifications and the reference Phase 3 RFG specifications is equal to or greater than 0.05%, the candidate specifications are deemed unacceptable and may not be a substitute for Phase 3 RFG. [Note: All final values of the percent change in emissions shall be reported to the nearest hundredth using conventional rounding.]

## C. Definitions

1. **Alternative gasoline formulation** means a final blend of gasoline that is subject to a set of alternative specifications deemed acceptable pursuant to the *California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model*.

2. **Alternative fuel specifications** means the specifications for the following gasoline properties, as determined in accordance with California Code of Regulations, title 13, section 2263:
    - ♦ maximum Reid vapor pressure, expressed in the nearest hundredth of a pound per square inch;
    - ♦ maximum sulfur content, expressed in the nearest parts per million by weight;
    - ♦ maximum benzene content, expressed in the nearest hundredth of a percent by volume;
    - ♦ maximum olefin content, expressed in the nearest tenth of a percent by volume;
    - ♦ minimum and maximum oxygen content, expressed in the nearest tenth of a percent by weight;
    - ♦ maximum T50, expressed in the nearest degree Fahrenheit;
    - ♦ maximum T90, expressed in the nearest degree Fahrenheit; and
    - ♦ maximum aromatic hydrocarbon content, expressed in the nearest

tenth of a percent by volume.

3. **Applicant** means the party seeking approval of alternative gasoline specifications and responsible for the demonstration described herein.

4. **Aromatic hydrocarbon content (Aromatic HC, AROM)** means the amount of aromatic hydrocarbons in the fuel expressed to the nearest tenth of a percent by volume in accordance with 13 CCR, section 2263.

5. **ASTM** means the American Society of Testing and Materials.

6. **Averaging Limit** means a limit for a fuel property that must be achieved in accordance with 13 CCR, section 2264.

7. **Benzene content (BENZ or Benz)** means the amount of benzene contained in the fuel expressed to the nearest hundredth of a percent by volume in accordance with 13 CCR, section 2263.

8. **Candidate fuel or candidate fuel specifications** means the fuel or set of specifications which are being evaluated for its emission performance using these procedures.

9. **Cap limit** means a limit that applies to all California gasoline throughout the gasoline distribution system, in accordance with 13 CCR, sections 2262.3 (a), 2262.4 (a), and 2262.5 (a) and (b).

9.5. **Carbon Monoxide (CO) Emissions Equations** means the equations that relate gasoline properties to carbon monoxide emissions which result when the gasoline is used to fuel a motor vehicle.

10. **EMFAC2007** means the EMFAC2007 motor vehicle emission inventory and emissions calculation system maintained by the ARB.

11. **Ethanol content** means the amount of ethanol in the fuel expressed to the nearest tenth of a percent by volume.

11.5. **Evaporative hydrocarbon emissions equations (Evaporative HC emissions equations)** means the equations that relate gasoline properties to evaporative hydrocarbon emissions which result when the gasoline is used to fuel a motor vehicle.

12. **Executive Officer** means the executive officer of the Air Resources Board, or his or her designee.

12.5 **Exhaust hydrocarbon emissions Equations (ExHC emissions equations)** means the equations that relate gasoline properties to exhaust hydrocarbon emissions which result when the gasoline is used to fuel a motor vehicle.

13. **Exhaust Hydrocarbon Model (ExHC Model)** means the model which uses only the exhaust hydrocarbon emissions models in the evaluation of the HC emissions equivalency of the candidate fuel specifications.

14. [Reserved]

15. **Flat limit** means a single limit for a fuel property that applies to all California gasoline sold or supplied from a California production facility or import facility.

16. **Intercept** means the average vehicle effect for a particular Tech class and a

particular pollutant. The intercept represents the average emissions across vehicles in the Tech class, for a fuel with properties equal to the average values of all fuels in the data base for that Tech class.

17. **MTBE content (MTBE)** means the amount of methyl tertiary-butyl ether in the fuel expressed in the nearest tenth of a percent by volume.

17.5 **Non-RVP-controlled gasoline** means gasoline sold or supplied from a production or import facility outside the applicable RVP control periods set forth in California Code of Regulations, title 13, section 2262.4 or gasoline subject to 2262.4(c)(1) or (2).

18. **Olefin content (OLEF)** means the amount of olefins in the fuel expressed in the nearest tenth of a percent by volume in accordance with 13 CCR, section 2263.

19. **Oxygen content (OXY)** means the amount of oxygen contained in the fuel expressed in the nearest tenth of a percent by weight in accordance with 13 CCR, section 2263.

20. **Phase 3 reformulated gasoline (Phase 3 RFG)** means gasoline meeting the flat or averaging limits of the Phase 3 RFG regulations.

21. **Potency-weighted exhaust toxics (PWT)** means the mass exhaust emissions of benzene, 1,3-butadiene, formaldehyde, and acetaldehyde multiplied by the relative potency with respect to 1,3-butadiene.

22. **Predictive model** means a set of equations that relate the properties of a particular gasoline formulation to the predicted exhaust and evaporative emissions that result when that gasoline is combusted in a motor vehicle engine.

23. **Reference fuel or reference fuel specifications** means a gasoline meeting the flat or average specifications for Phase 3 RFG.

24. **Reid vapor pressure (RVP)** means the vapor pressure of the fuel expressed in the nearest hundredth of a pound per square inch in accordance with 13 CCR, section 2263.

24.5 **RVP-controlled gasoline** means gasoline sold or supplied from a production or import facility during the applicable RVP control period set forth in California Code of Regulations, title 13, section 2262.4 or gasoline subject to paragraph III.B.4 below.

25. **Sulfur content (SUL)** means the amount of sulfur contained in the fuel expressed in the nearest part per million in accordance with 13 CCR, section 2263.

26. **Technology class (Tech 3, Tech 4, and Tech 5)** means a classification of vehicles by model year based on the type of technology used to control gasoline exhaust emissions.

26.5 **Total Hydrocarbon Model (THC Model)** means the model which uses the exhaust hydrocarbon emissions equations, evaporative hydrocarbon emissions equations, and the carbon monoxide emissions equations in the evaluation of the emissions equivalency of the candidate fuel specifications.

27. **50% distillation temperature (T50)** means the temperature at which 50% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with *California Code of Regulations, title 13,* section 2263.

28. **90% distillation temperature (T90)** means the temperature at which 90% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with *California Code of Regulations, title 13*, section 2263.

29. **Total potency-weighted toxics (PWT)** means the sum of the mass exhaust emissions of benzene, 1,3-butadiene, formaldehyde, and acetaldehyde, and the evaporative benzene emissions, multiplied by the relative potency with respect to 1,3-butadiene.

30. **Toxic air contaminants** means exhaust emissions of benzene, 1,3-butadiene, formaldehyde, and acetaldehyde, and evaporative benzene emissions.

## II. VEHICLE TECHNOLOGY CLASS AND WEIGHTING FACTORS

### A. Vehicle Technology Groups

For the purpose of these procedures, exhaust sub-models have been developed for three categories of light-duty vehicles (passenger cars and light-duty trucks) using the vehicle model year as an indicator of the type of emission controls used. Table 3 shows the three vehicle categories.

**Table 3**
**Vehicle Categories**

| Technology Class | Model Year | Emission Controls |
|---|---|---|
| Tech 3 | 1981-1985 | older closed-loop three-way catalyst |
| Tech 4 | 1986-1995 | closed-loop three-way catalyst |
| Tech 5 | 1996-2015 | three-way catalyst, adaptive learning, LEVs |

### B. Emission-Weighting Factors

Emission-weighting factors are used~~,~~ for NOx, ExHC, and CO emissions~~,~~ to weight the model predictions for each technology class. These weightings represent, for each of the three pollutants, the fractional contribution of exhaust emissions from on-road gasoline-fueled vehicles in a particular Tech class to the total emissions from these vehicles from all three Tech classes in the year 2015. The year 2015 was selected because it approximately represents the midpoint year over which the Phase 3 reformulated gasoline regulations will be most effective. The factors were calculated using the information in EMFAC2007. The emission-weighting factors (EWF) are shown in Table 4 and are used in the combination of the sub-models for NOx, ExHC, and CO emissions.

**Table 4**
**Emission-Weighting Factors**

| Pollutant | Tech 3 | Tech 4 | Tech 5 |
|---|---|---|---|
| NOx | 0.052 | 0.325 | 0.622 |
| HC | 0.075 | 0.380 | 0.546 |
| CO | 0.063 | 0.288 | 0.649 |

## C. Toxics Weighting Factors

Since toxics emissions are also ExHC, the hydrocarbon weighting factors are used to weight the model predictions for each technology class. The values were calculated for the year 2015 using the ARB's EMFAC2007 motor vehicle emissions inventory. The toxics weighting factors (TWFs) are shown in Table 5 and are used in the combination of the exhaust toxics emissions sub-models.

**Table 5**
**Toxics Weighting Factors (TWFs)**

| Pollutant | Tech 3 | Tech 4 | Tech 5 |
|---|---|---|---|
| **Benzene** | 0.075 | 0.380 | 0.546 |
| **1,3-Butadiene** | 0.075 | 0.380 | 0.546 |
| **Formaldehyde** | 0.075 | 0.380 | 0.546 |
| **Acetaldehyde** | 0.075 | 0.380 | 0.546 |

## III. GENERAL EQUATIONS FOR CALCULATING PERCENT CHANGES IN EMISSIONS

### A. Summary and Explanation

- ♦ With certain limited exceptions, which are described in paragraph B below, beginning December 31, 2009, a candidate fuel that is designated as “non-RVP-controlled gasoline” must use the ExHC model in determining the emissions equivalency of the candidate fuel specifications. A candidate fuel that is designated as “RVP-controlled gasoline” must use the THC model in determining the emissions equivalency of the candidate fuel specifications.

- ♦ The applicant will select a candidate specification for each property, and will identify whether the specification represents a flat limit or an averaging limit. The Phase 3 RFG reference specification is identified for each property using the flat/average limit compliance option selected for the corresponding candidate specification. (See III.B.)

- ♦ The selected candidate specifications and the comparable Phase 3 RFG reference specifications are inserted into the predictive model equations to determine the predicted candidate and reference emissions by Tech class. (See III.C.)

- ♦ Because oxygen is specified in the form of a range, emissions predictions are, in a majority of the cases, made for two oxygen levels, the upper level of the specified range for the candidate fuel specifications and the lower level. The emissions of the candidate fuel are compared to the emissions of the reference fuel at both of these oxygen levels. When the range between the upper and lower oxygen levels is less than or equal to 0.4 percent then the prediction is only made for two oxygen levels. If the range is greater than 0.4 percent, then the prediction is based on the individual upper and lower levels.

- ♦ For NOx and ExHC, the ratio of the predicted emissions for the candidate fuel specifications to the predicted emissions for the reference fuel specifications is emissions weighted according to the relative contribution of each technology class. These emissions-weighted ratios are summed, reduced by 1, and multiplied by 100 to represent the Tech class-weighted percent change in emissions. The resulting values represent the predicted percent change in NOx or ExHC emissions between the candidate fuel specifications and reference fuel specifications. (See III.D.)

- ♦ If the THC Model is used or is required to be used, the predicted percent change in evaporative HC emissions between the candidate fuel specifications and the reference fuel specifications is computed using the equations given in Section VII*I*.A. The predicted change is computed for each evaporative emissions process. (See VII*I*.A)

- ♦ If the THC Model is used or is required to be used, the CO emissions are calculated in accordance with the equations given in Section VI.A. (See VI.A)

- ♦ If the THC Model is used or is required to be used, the predicted percent changes in ExHC emissions, evaporative HC emissions, and the CO emissions are combined in accordance with the equation given in Section X to yield the predicted percent change in ozone-forming potential (OFP) between the reference fuel specifications and the candidate fuel specifications. (See X)

- ♦ For exhaust toxics emissions, the predicted emissions for the candidate fuel specifications and the reference fuel specifications (for each pollutant and each Tech class) are weighted using the toxics weighting factors and potency-weighted, in accordance with the equations given in VII.B. (See VII.B)

- ♦ The evaporative benzene emissions predictions for the reference fuel specifications and the candidate fuel specifications are calculated in accordance with the equations given in Section IX.A. Note that emissions predictions for evaporative benzene emissions are made even if the applicant is not using the THC Model. (See IX.A)

- ♦ For both the reference fuel specifications and the candidate fuel specifications, the potency-weighted exhaust toxics emissions predictions are combined with the potency-weighted evaporative benzene emissions predictions, in accordance with the equations given in Sections XI.A and XI.B. This yields the total potency-weighted toxics emissions prediction for the reference fuel specifications and for the candidate fuel specifications. (See XI.A and XI.B)

- ♦ The percent change in the predicted total potency-weighted toxics emissions between the reference fuel specifications and the candidate fuel specifications is calculated in accordance with the equation given in Section XI.C. (See XI.C)

## B. Selection by Applicant of Candidate and Reference Specifications

### 1. RVP-Controlled Period

Beginning December 31, 2009, for gasoline that is sold or supplied from a production or import facility during the applicable RVP control period set forth in California Code of Regulations, title 13, section 2262.4 for that facility, the applicant must designate the gasoline as “RVP-controlled gasoline” and use the THC Model in determining the HC emissions equivalency of the candidate fuel specifications.

### 2. RVP-Controlled Period with assurances that the gasoline will be

**delivered during the Non-RVP-Controlled Period**

Notwithstanding paragraph 1, above, the applicant must designate gasoline, which is subject to California Code of Regulations, title 13, section 2262.4(c)(1) or (2) as "non-RVP-controlled gasoline." The applicant must use the ExHC model in determining the HC emissions equivalency of these candidate fuel specifications for this "non-RVP-controlled gasoline." Gasoline produced in California and sold or supplied to the South Coast Air Basin, Ventura County, or the San Diego Air Basin must also meet the requirements in Section 2262.4(c)(4).

**3. Non-RVP-Controlled Period**

For gasoline that is sold or supplied from a production or import facility during the time period other than the applicable RVP control period for that facility, the applicant must designate the gasoline as "non-RVP-controlled gasoline" and use the ExHC Model in determining the HC emissions equivalency of the candidate fuel specifications.

**4. Low RVP gasoline during the Non-RVP-Controlled Period**

Notwithstanding paragraph 3, above,, if an applicant submits candidate fuel specifications for a final blend of gasoline that includes an RVP value equal to or less than 7.20 psi (or, correspondingly, an RVP value equal to or less than 5.99 psi for a final blend of CARBOB) and that is sold or supplied from a production or import facility during the time period other than the applicable RVP control period for that facility, the applicant must designate this gasoline as "RVP-controlled gasoline" and use the THC model in determining the HC emissions equivalency of these candidate fuel specifications . Gasoline produced in California and sold or supplied to the South Coast Air Basin, Ventura County, or the San Diego Air Basin must also meet the requirements in Section 2262.4(c)(4)

When the applicant uses, or is required to use, the THC Model, the applicable Phase 3 RVP limits are a flat limit of 7.00 psi and a cap limit of 7.20 psi. When the applicant uses the ExHC Model, the applicable Phase 3 RVP limit is a flat (and cap) limit of 7.00 psi. If the applicant selects to certify an alternative formulation produced without ethanol, then the applicable flat limit for either compliance option is 6.90 psi RVP.

Next, the applicant shall, for each fuel property, select a candidate specification and indicate whether this specification represents a flat limit or an averaging limit. The appropriate corresponding Phase 3 RFG reference specifications (flat or average) are then identified. Table 7 provides an optional worksheet to assist the applicant in selecting the candidate and reference specifications. These steps are summarized below.

1. Identify the value of the candidate specification for each fuel property and

insert the values into Table 7. The candidate specifications may have any value for RVP, sulfur, benzene, aromatic hydrocarbons, olefins, T50, and T90 as long as each specification is less than or equal to the cap limits shown in Table 1. Note that, if the applicant is not using the THC Model, no value is entered for RVP into the "Candidate Fuel Specifications" column of Table 7 (In this case the RVP is 7.00). The candidate specification may have any value for oxygen as long as the specification is within the range of the cap limits shown in Table 1.

2. When the range between the upper and lower oxygen levels is less than or equal to 0.4 percent, then the prediction is only made for the average of the two oxygen levels. If the range is greater than 0.4 percent, then the prediction is based on the individual upper and lower levels. If the range between the upper and lower oxygen levels is greater than 0.4 percent, then the oxygen contents of the reference fuel specifications can be found from Table 6. Since oxygen is specified in the form of a range, there are usually two candidate fuel specifications for oxygen, the upper end of the range (maximum) and the lower end of the range (minimum).

3. The hot soak benzene emissions model contains a MTBE content term. The relevant oxygen content value is the oxygen content as MTBE, not the total oxygen content as in the case of the exhaust emissions predictions. The result is that, if the candidate fuel does not contain MTBE, the oxygen content as MTBE for the reference fuel is 2.0 percent, and the oxygen content as MTBE for the candidate fuel is zero percent. The reason it is assumed that the reference fuel contains MTBE is that MTBE was the oxygenate used while the Phase 2 regulations were in effect, and this assumption helps ensure that potency-weighted toxics emissions from Phase 3 gasoline will not be greater than those from Phase 2 gasoline.

4. For each property other than oxygen and RVP, indicate whether the candidate specification will represent a flat limit or an averaging limit.

5. For each candidate specification identified in 1., identify the appropriate corresponding Phase 3 RFG reference specifications (flat or average). Circle the appropriate flat or average limit for the reference fuel in Table 7. The circled values are the reference specifications which will be used in the predictive model.

   When the range between the upper and lower oxygen levels is less than or equal to 0.4 percent, then the oxygen level of the reference fuel is 2.0 wt%. If the range is greater than 0.4 percent, then Table 6 gives the oxygen contents of the reference fuel specifications. Because oxygen is specified in the form of a range, there are two reference fuel oxygen specifications. In most cases they are the same, but in two cases they are not. These two cases are: 1) If the minimum oxygen content of the candidate fuel specifications is within 1.8 to 2.2 percent (inclusive) and the maximum oxygen content of the candidate is greater than 2.2 percent, and 2) If the minimum oxygen content of the candidate fuel specifications is less than 1.8 percent and the maximum oxygen content of the candidate is between 1.8 and 2.2 percent (inclusive). In case 1), the oxygen contents of the reference fuel specifications are 1.8 and 2.0 percent. In case 2), the oxygen contents of the reference fuel specifications are 2.0 and 2.2 percent. (See Table 6)

**Table 6**
**Candidate and Reference Specifications for Oxygen**

| Oxygen Content for Candidate Fuel Specified by Applicant | | Number of Reference vs. Candidate Comparisons Required | Values to be Used in Comparison in Equations | |
|---|---|---|---|---|
| **Minimum** | **maximum** | | **Candidate** | **Reference** |
| > 1.8, < 2.2 | > 2.2 | 2 | minimum | 1.8 |
| | | | maximum | 2.0 |
| < 1.8 | > 1.8, < 2.2 | 2 | minimum | 2.0 |
| | | | maximum | 2.2 |
| < 1.8 | > 2.2 | 2 | minimum | 2.0 |
| | | | maximum | 2.0 |
| < 1.8 | < 1.8 | 2 | minimum | 2.0 |
| | | | maximum | 2.0 |
| > 2.2, < 2.5 | > 2.2 | 2 | maximum | 2.0 |
| | | | minimum | 2.0 |
| > 2.5 | > 2.9 | 2 | minimum | 2.0 |
| | | | maximum | 2.0 |

**Table 7**
**Optional Worksheet for Candidate and Reference Fuel Specifications**

**Is this an RVP-controlled gasoline? YES ___ NO ___**

**If the above question is answered yes, the applicant must use the Total Hydrocarbon Model and the reference fuel flat RVP limit is 7.00 psi and the RVP cap is 7.20 psi, unless the gasoline does not contain ethanol in which case the reference fuel flat RVP limit is 6.90 psi and the RVP cap is 7.20 psi.**

**If the above question is answered no, the applicant must use the Exhaust Hydrocarbon Model and 7.00 psi is the flat RVP limit and the candidate fuel RVP specification.**

| **Fuel Property** | **Candidate Fuel[1]: Specifications** | **Compliance Option: Flat or Average** | **Reference Fuel: Phase 3 RFG Specifications** (Circle Option Chosen) | |
|---|---|---|---|---|
| | | | **Flat** | **Average** |
| **RVP** | | Flat | 7.00[5] / 6.90[5] | None |
| **Sulfur** | | | 20 | 15 |
| **Benzene** | | | 0.80/1.00[6] | 0.70 |
| **Aromatic** | | | 25.0/35.0[6] | 22.0 |
| **Olefin** | | | 6.0 | 4.0 |
| **Oxygen[2] (Total)** | (min)<br>(max) | Flat-Range | (min)<br>(max) | None |
| **Oxygen[3] (as MTBE)** | (min)<br>(max) | Not Applicable | Not Applicable | None |
| **Oxygen[4] (as EtOH)** | (min)<br>(max) | Not Applicable | Not Applicable | None |
| **T50** | | | 213/220[6] | 203 |
| **T90** | | | 305/312[6] | 295 |

Note: Footnotes are on the next page

Footnotes for Table 7

[1] The fuel property value must be within or equal to the cap limit.

[2] When the range between the upper and lower oxygen levels is less than or equal to 0.4 percent, then the prediction for the candidate fuel is only made for the average of the two oxygen levels, and the reference fuel oxygen value is 2.0. If the range is greater than 0.4 percent, then the prediction for the candidate fuel is based on the individual upper and lower levels, and the reference fuel oxygen value is obtained from Table 6.

[3] The oxygen content (as MTBE) is reported because the hot soak evaporative benzene emissions model includes an MTBE content term (See VIII.A.2).

[4] The oxygen content (as EtOH) is reported because the exhaust formaldehyde and the exhaust acetaldehyde models include EtOH content terms for the predictions for the candidate fuel specifications (See VI.A.1.c & d., VI.A.2.c & d., VI.A.3.c & d.). The EtOH content term is not included in the exhaust formaldehyde and acetaldehyde predictions for the reference fuel specifications because it is assumed that, for the reference fuel specifications, MTBE is the oxygenate used to meet the oxygen requirement.

[5] If the applicant elects to certify an alternative formulation without the use of ethanol, then the appropriate flat limit will be 6.90 psi; otherwise, the flat limit for RVP is 7.00 psi.

[6] The higher value is the small refiner CaRFG flat limit for qualifying small refiners only, as specified in section 2272.

## C. General Equations for Calculating Exhaust Emissions by Pollutant and by Technology Class

The selected candidate specifications and set reference specifications are inserted into the predictive model equations to determine the predicted pollutant emissions generated from each fuel formulation by Tech Class. The following is the general form of the equations used to calculate exhaust emissions of the candidate and reference fuel specifications for each pollutant and for each technology class.

$ln\ y_{Tech}$ = intercept + Σ [(fuel effects coefficient) x (standardized fuel property)]

or

$y_{Tech}$ = Exp {intercept + Σ [(fuel effects coefficient) x (standardized fuel property)]}

where

***ln*** is the natural logarithm.

**Exp** is the exponential.

$\mathbf{y_{Tech}}$ is the exhaust emission prediction in grams per mile (for NOx, HC, and CO), and milligrams per mile (for benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) for a particular technology class. (Note: $\mathbf{y_{Tech\text{-}REF}}$ is the emissions prediction for the reference fuel specifications and $\mathbf{y_{Tech\text{-}CAND}}$ is the emissions prediction for the candidate fuel specifications.)

**intercept** represents the average vehicle effect for a particular Tech class and a particular pollutant. The intercepts are provided in Table 13, Coefficients for NOx, ExHC, and CO Equations, and Table 14, Coefficients for Toxics Equations.

**fuel effects coefficient** represents the average fuel effects across all vehicles in the database for a particular Tech class and a particular pollutant. The fuel effect coefficients are provided in Table 13, Coefficients for NOx, ExHC, and CO Equations, and Table 14, Coefficients for Exhaust Toxics Equations.

**standardized fuel property** is defined as:

standardized fuel property =

$$\frac{\text{[(actual fuel property) - (mean fuel value)]}}{\text{standard deviation of the value for the fuel property}}$$

**actual fuel property** represents the candidate or reference fuel property selected by the applicant in Table 7, Worksheet for Candidate and Reference Specifications.

Note that the actual fuel property may represent the minimum value of selected candidate fuel properties and is established by the linearization equations defined in sections IV. A. 2 & 3 and V. A. 2 & 3.

**mean fuel value** represents the average fuel values from all data that are used in developing the California Predictive Model. The mean and standard deviation are provided in Table 12, Standardization of Fuel Properties-Mean and Standard Deviation.

**standard deviation** of the value for the fuel property is the standard deviation from all data that are used in developing the California Predictive Model.

The equations include a term for the RVP effect, however, this term has been made a constant. This was done by computing the standardized RVP value at an actual RVP value of 7.0, and then multiplying this standardized RVP value by the RVP effect coefficient, thereby yielding an additional constant in the equations. Thus, the RVP term is shown as an additional constant (in addition to the intercept) in the exhaust emissions equations. This effectively removes from the exhaust models RVP as fuel property which effects exhaust emissions.

## D. General Equations for Calculating Percent Change of Exhaust Emissions Between Candidate and Reference Specifications

To calculate the percent change of NOx, ExHC, and CO emissions, the ratio of the predicted emissions for the candidate specifications to the predicted emissions from reference specifications is multiplied by the technology class emission-weighting factors for NOx, HC, and CO. These weighted ratios are summed. The sum is reduced by 1 and multiplied by 100 to give the percent change in NOx, HC, and CO emissions.

The following is the general form of the equations used to calculate percent change in exhaust emissions between the candidate fuel specifications and the reference fuel specifications for each pollutant.

% Change in NOx, ExHC, and CO Emissions:

%CE = percent change in emissions =

$$\{[(y_{Tech\ 3\text{-}CAND} / y_{Tech\ 3\text{-}REF}) \times EWF_{3q}] + [(y_{Tech\ 4\text{-}CAND} / y_{Tech\ 4\text{-}REF}) \times EWF_{4q}] + [(y_{Tech\ 5\text{-}CAND} / y_{Tech\ 5\text{-}REF}) \times EWF_{5q}]\} - 1\} \times 100$$

where

$\mathbf{y_{Tech\ 3}}$, $\mathbf{y_{Tech\ 4}}$, and $\mathbf{y_{Tech\ 5}}$ are the pollutant emissions in grams per mile of a particular pollutant and particular Tech class,

$\mathbf{y_{Tech\text{-}CAND}}$ is the emissions for the candidate specifications, and
$\mathbf{y_{Tech\text{-}REF}}$ is the emissions for the reference specifications.

$\mathbf{EWF_{3q}}$, $\mathbf{EWF_{4q}}$, and $\mathbf{EWF_{5q}}$ are the technology class 3, technology class 4, and technology class 5 weighting factors for the particular pollutant q. The Vehicle Technology Class Weighting Factors are provided in Table 4.

**E. General Equations for Calculating Percent Change of Exhaust Emissions Between Candidate and Reference Specifications**

The total Tech class-weighted, potency-weighted exhaust toxics emissions are calculated as shown below.

$E_{PWT\text{-}CAND}$ = Exhaust PWT emissions for candidate specifications =

$$\sum\{[((y_{Tech\ 3q\text{-}CAND}) \times (TWF_3)) + ((y_{Tech\ 4q\text{-}CAND}) \times (TWF_4)) + ((y_{Tech\ 5q\text{-}CAND}) \times (TWF_5))] \times (PWF_q)\}$$

$E_{PWT\text{-}REF}$ = Exhaust PWT emissions for reference specifications =

$$\sum\{[((y_{Tech\ 3q\text{-}REF}) \times (TWF_3)) + ((y_{Tech\ 4q\text{-}REF}) \times (TWF_4)) + ((y_{Tech\ 5q\text{-}REF}) \times (TWF_5))] \times (PWF_q)\}$$

where

The summations are performed across the q number of toxics pollutants, that is: **($y_{Tech\ 3q}$)**, **($y_{Tech\ 4q}$)**, **($y_{Tech\ 5q}$)** are the predicted emissions in milligrams per mile for each toxic air contaminant for Tech classes 3, 4, and 5.

$y_{Tech\text{-}CAND}$ is the emissions for the candidate fuel specifications, and
$y_{Tech\text{-}REF}$ is the emissions for the reference fuel specifications

**$TWF_3$, $TWF_4$, $TWF_5$** are the toxics weighting factors for Tech classes 3, 4 and 5, respectively. These values are shown in Table 5.

**$PWF_q$** is the potency-weighting factor for each toxic air contaminant q provided in Table 8.

These equations are shown again in more detail in Section VII.B.1 for the candidate fuel specifications and Section VII.B.2 for the reference fuel specifications.

**Table 8**
**Toxic Air Contaminant Potency-Weighting Factors**

| **Pollutant** | **Potency-Weighting Factor** |
|---|---|
| Benzene | 0.170 |
| 1,3-Butadiene | 1.000 |
| Formaldehyde | 0.035 |
| Acetaldehyde | 0.016 |

## IV. OXIDES OF NITROGEN (NOx) EXHAUST EMISSIONS CALCULATIONS

### A. NOx Emissions by Technology Class

The property values from the Table 7 worksheet are used to calculate NOx emissions for the candidate and reference specifications.

#### 1. NOx Emissions for Tech 3

The NOx emissions for the candidate ($y_{\text{Tech 3-CAND}}$) and reference ($y_{\text{Tech 3-REF}}$) specifications for Tech 3 are calculated as follows:

NOx emissions Tech 3 = $y_{\text{Tech 3}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-0.159800 | + |
| RVP | (0.0424915) | + |
| Sulfur | $(0.028040)\,\dfrac{(\text{SULFUR} - 139.691080)}{126.741459}$ | + |
| Aromatic HC | $(0.047060)\,\dfrac{(\text{AROM} - 30.212969)}{8.682044}$ | + |
| Olefin | $(0.021110)\,\dfrac{(\text{OLEF} - 7.359624)}{5.383804}$ | + |
| Oxygen | $(0.014910)\,\dfrac{(\text{OXY} - 0.892363)}{1.235405}$ | + |
| T50 | $(-0.007360)\,\dfrac{(\text{T50} - 212.245188)}{15.880385}$ | + |
| T90 | $(0.000654)\,\dfrac{(\text{T90} - 312.121596)}{23.264684}$ | } |

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

### 2. NOx Emissions for Tech 4

The NOx emissions for the candidate ($y_{\text{Tech 4-CAND}}$) and reference ($y_{\text{Tech 4-REF}}$) specifications for Tech 4 are calculated as follows:

NOx emissions Tech 4 = $y_{\text{Tech 4}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | $\{-0.634694$ | + |
| RVP | $(-0.007046)$ | + |
| Sulfur | $(0.051043)\,\dfrac{(\text{SULFUR} - 154.120828)}{136.790450}$ | + |
| Aromatic HC | $(0.011366)\,\dfrac{(\text{AROM} - 27.317137)}{6.880833}$ | + |
| Olefin | $(0.017193)\,\dfrac{(\text{OLEF} - 6.549450)}{4.715345}$ | + |
| Oxygen | $(0.028711)\,\dfrac{(\text{OXY} - 1.536017)}{1.248887}$ | + |
| T50 | $(-0.002431)\,\dfrac{(\text{T50} - 205.261051)}{17.324472}$ | + |
| T90 | $(0.002087)\,\dfrac{(\text{T90} - 310.931422)}{20.847425}$ | + |
| T50T50 | $(0.006268)\,\dfrac{(\text{T50} - 205.261051)}{17.324472}\,\dfrac{(\text{T50} - 205.261051)}{17.324472}$ | + |
| T90ARO | $(-0.002892)\,\dfrac{(\text{T90} - 310.931422)}{20.847425}\,\dfrac{(\text{AROM} - 27.317137)}{6.880833}$ | + |
| OXYOXY | $(0.010737)\,\dfrac{(\text{OXY} - 1.536017)}{1.248887}\,\dfrac{(\text{OXY} - 1.536017)}{1.248887}$ | $\}$ |

where

For calculating the reference fuel NOx emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating candidate fuel NOx emissions, SULFUR, AROM, OLEF, OXY, and T90 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for T50 is determined as follows:

If the value for the candidate T50 specification in the Table 7 worksheet is greater than 213 then 213 is the value for T50.

If the value for the candidate T50 specification in the Table 7 worksheet is less than or equal to 213, the T50 specification in the Table 7 worksheet is the value for T50.

### 3. NOx Emissions for Tech 5

The NOx emissions for the candidate ($y_{\text{Tech 5-CAND}}$) and reference ($y_{\text{Tech 5-REF}}$) specifications for Tech 5 are calculated as follows:

NOx emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-1.599255 | + |
| RVP | (-0.000533) | + |
| Sulfur | $(0.947915)\left(\frac{\text{SULFUR} - 144.6289001}{140.912234}\right)$ | + |
| Aromatic HC | $(0.013671)\left(\frac{\text{AROM} - 26.875944}{6.600312}\right)$ | + |
| Olefin | $(0.017335)\left(\frac{\text{OLEF} - 6.251891}{4.431845}\right)$ | + |
| Oxygen | $(0.016036)\left(\frac{\text{OXY} - 1.551772}{1.262823}\right)$ | + |
| T50 | $(0.012397)\left(\frac{\text{T50} - 206.020870}{16.582090}\right)$ | + |

T90 $(0.000762)\left(\frac{T90 - 310.570200}{22.967591}\right)$ +

T50T50 $(-0.022211)\left(\frac{T50 - 206.020870}{16.582090}\right)\left(\frac{T50 - 206.020870}{16.582090}\right)$ +

T50OXY $(-0.015564)\left(\frac{T50 - 206.020870}{16.582090}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ +

OXYOXY $(0.015199)\left(\frac{OXY - 1.551772}{1.262823}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ }

where

For calculating the reference fuel NOx emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating candidate fuel NOx emissions, SULFUR, AROM, OLEF, and T90 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for OXY and T50 are determined as follows:

If the value of the candidate fuel Oxygen specification in the Table 7 worksheet is less than the $OXYGEN_{(LIN)}$ value, then the $OXYGEN_{(LIN)}$ value is the value for OXY, where $OXYGEN_{(LIN)}$ is calculated as follows:

$$OXYGEN_{(LIN)} = -7.148 + (0.039 \times T50)$$

If the value for the candidate Oxygen specification in the Table 7 worksheet is greater than or equal to the $OXYGEN_{(LIN)}$ value, then the Oxygen specification in the Table 7 worksheet is the value for OXY.

If the value of the candidate fuel T50 specification in the Table 7 worksheet is less than the $T50_{(LIN)}$ value, then the $T50_{(LIN)}$ value is the value for T50, where $T50_{(LIN)}$ is calculated as follows:

$$T50_{(LIN)} = 217.8 - (4.6 \times OXY)$$

If the value for the candidate T50 specification in the Table 7 worksheet is greater than or equal to the $T50_{(LIN)}$ value, then the T50 specification in the Table 7 worksheet is the value for T50.

### B. Percent Change in NOx Emissions

The percent change in NOx emissions between the candidate specifications and the reference specifications is calculated as follows:

$$\%CE_{NOx} = \{\{[(y_{Tech\ 3\text{-}CAND} / y_{Tech\ 3\text{-}REF}) \times EWF_{3\text{-}NOx}] + [(y_{Tech\ 4\text{-}CAND} / y_{Tech\ 4\text{-}REF}) \times EWF_{4\text{-}NOx}] + [(y_{Tech\ 5\text{-}CAND} / y_{Tech\ 5\text{-}REF}) \times EWF_{5\text{-}NOx})]\} - 1\} \times 100$$

where

$y_{Tech\ 3\text{-}CAND}$, $y_{Tech\ 4\text{-}CAND}$, and $y_{Tech\ 5\text{-}CAND}$ are the NOx emissions for the candidate specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

$y_{Tech\ 3\text{-}REF}$, $y_{Tech\ 4\text{-}REF}$, and $y_{Tech\ 5\text{-}REF}$ are the NOx emissions for the reference specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

The NOx emissions for Tech 3 are calculated in accordance with the equations in section IV. A. 1.

The NOx emissions for Tech 4 are calculated in accordance with the equations in section IV. A. 2.

The NOx emissions for Tech 5 are calculated in accordance with the equations in section IV. A. 3.

$EWF_{3\text{-}NOx}$, $EWF_{\text{-}4\text{-}NOx}$, and $EWF_{\text{-}5\text{-}NOx}$ are the emission-weighting factors for NOx as shown in Table 4.

## V. EXHAUST HYDROCARBONS (HC) EMISSIONS CALCULATIONS

### A. ExHC Emissions by Technology Class

The property values from the Table 7 worksheet are used to calculate HC emissions for the candidate and reference specifications.

#### 1. ExHC Emissions for Tech 3

The HC emissions for the candidate ($y_{\text{Tech 3-CAND}}$) and reference ($y_{\text{Tech 3-REF}}$) specifications for Tech 3 are calculated as follows:

HC emissions Tech 3 = $y_{\text{Tech 3}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-0.752270 | + |
| RVP | (0.000013) | + |
| Sulfur | $(0.038207)\left(\frac{SULFUR - 139.691080}{126.741459}\right)$ | + |
| Aromatic HC | $(0.014103)\left(\frac{AROM - 30.212969}{8.682044}\right)$ | + |
| Olefin | $(-0.016533)\left(\frac{OLEF - 7.359624}{5.383804}\right)$ | + |
| Oxygen | $(-0.026365)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | + |
| T50 | $(0.015847)\left(\frac{T50 - 212.245188}{15.880385}\right)$ | + |
| T90 | $(0.011768)\left(\frac{T90 - 312.121596}{23.264684}\right)$ | + |
| T90ARO | $(0.016606)\left(\frac{T90 - 312.121596}{23.264684}\right)\left(\frac{AROM - 30.212969}{8.682044}\right)$ | + |

T90OLE (-0.007995) $\frac{(T90 - 312.121596)}{23.264684}$ $\frac{(OLEF - 7.359624)}{5.383804}$ }

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

### 2. ExHC Emissions for Tech 4

The HC emissions for the candidate ($y_{\text{Tech 4-CAND}}$) and reference ($y_{\text{Tech 4-REF}}$) specifications for Tech 4 are calculated as follows:

HC emissions Tech 4 = $y_{\text{Tech 4}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-1.142182 | + |
| RVP | (-0.019335) | + |
| Sulfur | (0.079373) $\frac{(SULFUR - 154.120828)}{136.790450}$ | + |
| Aromatic HC | (0.002047) $\frac{(AROM - 27.317137)}{6.880833}$ | + |
| Olefin | (-0.010716) $\frac{(OLEF - 6.549450)}{4.715345}$ | + |
| Oxygen | (-0.019880) $\frac{(OXY - 1.536017)}{1.248887}$ | + |
| T50 | (0.052939) $\frac{(T50 - 205.261051)}{17.324472}$ | + |
| T90 | (0.037684) $\frac{(T90 - 310.931422)}{20.847425}$ | + |
| T50ARO | (0.019031) $\frac{(T50 - 205.261051)}{17.324472}$ $\frac{(AROM - 27.317137)}{6.880833}$ | + |

T50T50 $(0.017086)\left(\frac{T50 - 205.261051}{17.324472}\right)\left(\frac{T50 - 205.261051}{17.324472}\right)$ +

T50OXY $(0.013724)\left(\frac{T50 - 205.261051}{17.324472}\right)\left(\frac{OXY - 1.536017}{1.248887}\right)$ +

T90T90 $(0.013914)\left(\frac{T90 - 310.931422}{20.847425}\right)\left(\frac{T90 - 310.931422}{20.847425}\right)$ +

AROARO $(-0.010999)\left(\frac{AROM - 27.317137}{6.880833}\right)\left(\frac{AROM - 27.317137}{6.880833}\right)$ +

AROOXY $(0.007221)\left(\frac{AROM - 27.317137}{6.880833}\right)\left(\frac{OXY - 1.536017}{1.248887}\right)$ }

where

For calculating the reference fuel HC emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating the candidate fuel HC emissions, SULFUR, OLEF, and OXY are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The values for AROM, T50, and T90 are determined as follows:

If the value for the candidate Aromatics specification in the Table 7 worksheet is greater than $AROM_{(LIN)}$ then $AROM_{(LIN)}$ is the value for AROM where $AROM_{(LIN)}$ is calculated as follows:

$$AROM_{(LIN)} = -45.3466 + (1.8086 \times OXY) + (0.3436 \times T50)$$

If the value for the candidate T50 specification in the Table 7 worksheet is less than or equal to $AROM_{(LIN)}$, the Aromatics specification in the Table 7 worksheet is the value for AROM.

If the value for the candidate T50 specification in the Table 7 worksheet is less than $T50_{(LIN)}$ then $T50_{(LIN)}$ is the value for T50 where $T50_{(LIN)}$ is calculated as follows:

$$T50_{(LIN)} = 225.3 - (1.4 \times AROM) - (5.6 \times OXY)$$

If the value for the candidate T50 specification in the Table 7 worksheet is greater than or equal to $T50_{(LIN)}$, the T50 specification in the Table 7 worksheet is the value for T50.

If the value for the candidate fuel T90 specification in the Table 7 worksheet is less than the 283 value, then the 283 value is the value for T90.

If the value for the candidate T90 specification in the Table 7 worksheet is greater than or equal to the 283 value, then the T90 specification in the Table 7 worksheet is the value for T90.

### 3. ExHC Emissions for Tech 5

The HC emissions for the candidate ($y_{\text{Tech 5-CAND}}$) and reference ($y_{\text{Tech 5-REF}}$) specifications for Tech 5 are calculated as follows:

HC emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-2.671187 | + |
| RVP | (-0.012824) | + |
| Sulfur | $(0.242238) \left(\frac{SULFUR - 144.628901}{140.912204}\right)$ | + |
| Aromatic HC | $(0.003039) \left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| Olefin | $(-0.010908) \left(\frac{OLEF - 6.251891}{4.431845}\right)$ | + |
| Oxygen | $(-0.007528) \left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T50 | $(0.056796) \left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |
| T90 | $(0.010803) \left(\frac{T90 - 310.570200}{22.967591}\right)$ | + |
| T50ARO | $(0.016761) \left(\frac{T50 - 206.020870}{16.582090}\right) \left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| T50T50 | $(0.019563) \left(\frac{T50 - 206.020870}{16.582090}\right) \left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |

| | | |
|---|---|---|
| T50OXY | $(0.014082)\left(\frac{T50 - 206.020870}{16.582090}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T90T90 | $(0.015216)\left(\frac{T90 - 310.570200}{22.967591}\right)\left(\frac{T90 - 310.570200}{22.9675901}\right)$ | + |
| T90OXY | $(0.013372)\left(\frac{T90 - 310.570200}{22.967590}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| AROARO | $(-0.009740)\left(\frac{AROM - 26.875944}{6.600312}\right)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| AROOXY | $(0.006902)\left(\frac{AROM - 26.875944}{6.600312}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | } |

where

For calculating the reference fuel HC emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating the candidate fuel HC emissions, SULFUR, OLEF, and OXY are equal to the corresponding values for the candidate specifications in the Table 7 worksheet.  The values for AROM, T50, and T90 are determined as follows:

If the value for the candidate Aromatics specification in the Table 7 worksheet is greater than $AROM_{(LIN)}$ then $AROM_{(LIN)}$ is the value for AROM where $AROM_{(LIN)}$ is calculated as follows:

$$AROM_{(LIN)} = -45.5269 + (1.8518 \times OXY) + (0.3425 \times T50)$$

If the value for the candidate Aromatics specification in the Table 7 worksheet is less than or equal to $AROM_{(LIN)}$, the Aromatics specification in the Table 7 worksheet is the value for AROM.

If the value for the candidate T50 specification in the Table 7 worksheet is less than $T50_{(LIN)}$, then $T50_{(LIN)}$ is the value for T50, where $T50_{(LIN)}$ is calculated as follows:

$$T50_{(LIN)} = 218.2 - (1.1 \times AROM) - (4.7 \times OXY)$$

If the value for the candidate T50 specification in the Table 7 worksheet is greater than or equal to $T50_{(LIN)}$, the T50 specification in the Table 7 worksheet is the value for T50.

If the value for the candidate fuel T90 specification in the Table 7 worksheet is less than the $T90_{(LIN)}$ value, then the $T90_{(LIN)}$ value is the value for T90 where $T90_{(LIN)}$ is calculated as follows:

$$T90_{(LIN)} = 314.8 - (8.0 \times OXY)$$

If the value for the candidate T90 specification in the Table 7 worksheet is greater than or equal to the $T90_{(LIN)}$ value, then the T90 specification in the Table 7 worksheet is the value for T90.

## B. Percent Change in ExHC Emissions

The percent change in ExHC emissions between the candidate fuel specifications and the reference fuel specifications is calculated as follows:

$$\%CE_{ExHC} = \{\{[(y_{Tech\ 3\text{-}CAND} / y_{Tech\ 3\text{-}REF}) \times EWF_{3\text{-}HC}] + [(y_{Tech\ 4\text{-}CAND} / y_{Tech\ 4\text{-}REF}) \times EWF_{4\text{-}HC}] + [(y_{Tech\ 5\text{-}CAND} / y_{Tech\ 5\text{-}REF}) \times EWF_{5\text{-}HC}]\} - 1\} \times 100$$

where

$\mathbf{y_{Tech\ 3\text{-}CAND}}$, $\mathbf{y_{Tech\ 4\text{-}CAND}}$, and $\mathbf{y_{Tech\ 5\text{-}CAND}}$ are the ExHC emissions for the candidate specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

$\mathbf{y_{Tech\ 3\text{-}REF}}$, $\mathbf{y_{Tech\ 4\text{-}REF}}$, and $\mathbf{y_{Tech\ 5\text{-}REF}}$ are the ExHC emissions for the reference specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

The ExHC emissions for Tech 3 are calculated according to the equations in section V. A. 1.

The ExHC emissions for Tech 4 are calculated according to the equations in section V. A. 2.

The ExHC emissions for Tech 5 are calculated according to the equations in section V. A. 3.

$\mathbf{EWF_{3\text{-}HC}}$, $\mathbf{EWF_{\text{-}4\text{-}HC}}$, and $\mathbf{EWF_{\text{-}5\text{-}HC}}$ are the emission-weighting factors for HC as shown in Table 4.

## VI. CARBON MONOXIDE (CO) EMISSIONS CALCULATIONS

### A. CO Emissions by Technology Class

The property values from the Table 6 worksheet are used to calculate CO emissions for the candidate and reference specifications.

#### 1. CO Emissions for Tech 3

The CO emissions for the candidate ($y_{\text{Tech 3-CAND}}$) and reference ($y_{\text{Tech 3-REF}}$) specifications for Tech 3 are calculated as follows:

CO emissions Tech 3 = $y_{\text{Tech 3}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {1.615613 | + |
| RVP | (0.012087) | + |
| Sulfur | $(0.031849)\left(\frac{\text{SULFUR} - 139.691080}{126.741459}\right)$ | + |
| Aromatic HC | $(0.085541)\left(\frac{\text{AROM} - 30.212969}{8.682044}\right)$ | + |
| Olefin | $(0.002416)\left(\frac{\text{OLEF} - 7.359624}{5.383804}\right)$ | + |
| Oxygen | $(-0.068986)\left(\frac{\text{OXY} - 0.892363}{1.235405}\right)$ | + |
| T50 | $(0.009897)\left(\frac{\text{T50} - 212.245188}{15.880385}\right)$ | + |
| T90 | $(-0.025449)\left(\frac{\text{T90} - 312.121596}{23.264684}\right)$ | + |
| T50T90 | $(0.017463)\left(\frac{\text{T50} - 212.245188}{15.880385}\right)\left(\frac{\text{T90} - 312.121596}{23.264684}\right)$ | } |

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

### 2. CO Emissions for Tech 4

The CO emissions for the candidate ($y_{\text{Tech 4-CAND}}$) and reference ($y_{\text{Tech 4-REF}}$) specifications for Tech 4 are calculated as follows:

CO emissions Tech 4 = $y_{\text{Tech 4}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {1.195246 | + |
| RVP | (-0.025878) | + |
| Sulfur | $(0.073616)\left(\frac{\text{SULFUR} - 154.120828}{136.790450}\right)$ | + |
| Aromatic HC | $(0.025960)\left(\frac{\text{AROM} - 27.317137}{6.880833}\right)$ | + |
| Olefin | $(0.001263)\left(\frac{\text{OLEF} - 6.549450}{4.715345}\right)$ | + |
| Oxygen | $(-0.052530)\left(\frac{\text{OXY} - 1.536017}{1.248887}\right)$ | + |
| T50 | $(0.022750)\left(\frac{\text{T50} - 205.261051}{17.324472}\right)$ | + |
| T90 | $(-0.008820)\left(\frac{\text{T90} - 310.931422}{20.847425}\right)$ | + |
| OXYOXY | $(-0.016510)\left(\frac{\text{OXY} - 1.536017}{1.248887}\right)\left(\frac{\text{OXY} - 1.536017}{1.248887}\right)$ | + |
| T50ARO | $(0.009884)\left(\frac{\text{T50} - 205.261051}{17.324472}\right)\left(\frac{\text{AROM} - 27.317137}{6.880833}\right)$ | + |
| T90OLE | $(-0.007360)\left(\frac{\text{T90} - 310.931422}{20.847425}\right)\left(\frac{\text{OLEF} - 6.549450}{4.715345}\right)$ | + |

| | | |
|---|---|---|
| T90T90 | $(0.007767) \left(\frac{T90 - 310.931422}{20.847425}\right) \left(\frac{T90 - 310.931422}{20.847450}\right)$ | } |

where

For calculating the reference fuel CO emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating the candidate fuel CO emissions, SULFUR, AROM, OLEF, OXY, and T50 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for T90 is determined as follows:

If the value for the candidate fuel T90 specification in the Table 7 worksheet is greater than the $T90_{(LIN)}$ value, then the $T90_{(LIN)}$ value is the value for T90 where $T90_{(LIN)}$ is calculated as follows:

$$T90_{(LIN)} = 308.3 + (2.5 \times OLEF)$$

If the value for the candidate T90 specification in the Table 7 worksheet is less than or equal to the $T90_{(LIN)}$ value, then the T90 specification in the Table 7 worksheet is the value for T90.

### 3. CO Emissions for Tech 5

The CO emissions for the candidate ($y_{\text{Tech 5-CAND}}$) and reference ($y_{\text{Tech 5-REF}}$) specifications for Tech 5 are calculated as follows:

CO emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {-0.240521 | + |
| RVP | (-0.014137) | + |
| Sulfur | $(0.123649) \left(\frac{SULFUR - 144.628901}{140.91224}\right)$ | + |

| | | |
|---|---|---|
| Aromatic HC | $(0.025775)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| Olefin | $(0.005001)\left(\frac{OLEF - 6.251891}{4.431845}\right)$ | + |
| Oxygen | $(-0.087967)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T50 | $(0.018195)\left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |
| T90 | $(-0.128296)\left(\frac{T90 - 310.570200}{22.967591}\right)$ | + |
| OXYOXY | $(0.026309)\left(\frac{OXY - 1.551772}{1.262823}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T50ARO | $(0.009797)\left(\frac{T50 - 206.020870}{16.582090}\right)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| T50OXY | $(0.021763)\left(\frac{T50 - 206.020870}{16.582090}\right)\left(\frac{OXY - 1.551772}{1.262823}\right)\}$ | |

where

For calculating the reference fuel CO emissions, SULFUR, AROM, OLEF, OXY, T50, and T90 are equal to the corresponding values for the reference specifications in the Table 7 worksheet.

For calculating the candidate fuel CO emissions, SULFUR, AROM, OLEF, T50, and T90 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for OXY is determined as follows:

If the value for the candidate fuel Oxygen specification in the Table 7 worksheet is greater than the $OXY_{(LIN)}$ value, then the $OXY_{(LIN)}$ value is the value for OXY where $OXY_{(LIN)}$ is calculated as follows:

$$OXY_{(LIN)} = 10.152 - (0.0315 \times T50)$$

If the value for the candidate Oxygen specification in the Table 7 worksheet is less than or equal to the $OXY_{(LIN)}$ value, then the Oxygen specification in the Table 7 worksheet is the value for OXY.

## B. Percent Change in CO Emissions

The percent change in CO emissions between the candidate fuel specifications and the reference fuel specifications is calculated as follows:

$$\%CE_{CO} = \{\{[(y_{Tech\ 3\text{-}CAND} / y_{Tech\ 3\text{-}REF}) \times EWF_{3\text{-}CO}] + [(y_{Tech\ 4\text{-}CAND} / y_{Tech\ 4\text{-}REF}) \times EWF_{4\text{-}CO}] + [(y_{Tech\ 5\text{-}CAND} / y_{Tech\ 5\text{-}REF}) \times EWF_{5\text{-}CO}]\} - 1\} \times 100$$

where

$y_{Tech\ 3\text{-}CAND}$, $y_{Tech\ 4\text{-}CAND}$, and $y_{Tech\ 5\text{-}CAND}$ are the CO emissions for the candidate specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

$y_{Tech\ 3\text{-}REF}$, $y_{Tech\ 4\text{-}REF}$, and $y_{Tech\ 5\text{-}REF}$ are the CO emissions for the reference specifications in grams per mile for Tech 3, Tech 4, and Tech 5 respectively.

The CO emissions for Tech 3 are calculated according to the equations in section VI. A. 1.

The CO emissions for Tech 4 are calculated according to the equations in section VI. A. 2.

The CO emissions for Tech 5 are calculated according to the equations in section VI. A. 3.

$EWF_{3\text{-}CO}$, $EWF_{4\text{-}CO}$, and $EWF_{5\text{-}CO}$ are the emission-weighting factors for CO as shown in Table 4.

## VII. POTENCY-WEIGHTED TOXICS (PWT) EXHAUST EMISSIONS CALCULATIONS

### A. Mass Emissions of Toxics by Technology Class

The property values from the Table 7 worksheet are used to calculate mass toxic emissions for the candidate and reference specifications.

#### 1. Mass Emissions for Tech 3

The mass emissions for each toxic for Tech 3 are calculated as follows:

a. Benzene mass emissions Tech 3 = $y_{\text{Tech 3}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {2.95676525 | + |
| Sulfur | $(0.0683768)\left(\frac{SULFUR - 139.691080}{126.741459}\right)$ | + |
| Aromatic HC | $(0.15191575)\left(\frac{AROM - 30.212969}{8.682044}\right)$ | + |
| Oxygen | $(-0.03295985)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | + |
| BENZ | $(0.12025037)\left(\frac{BENZ - 1.36412}{0.513051}\right)$ | } |

b. 1,3-Butadiene mass emissions Tech 3 = $y_{Tech\ 3}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {0.67173886 | + |
| Olefin | $(0.18408319) \left(\frac{OLEF - 7.359624}{5.383804}\right)$ | + |
| T50 | $(0.11391774) \left(\frac{T50 - 212.245188}{15.880385}\right)$ | } |

c. Formaldehyde mass emissions Tech 3 = $y_{Tech\ 3}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {2.16836424 | + |
| Aromatic HC | $(-0.07537099)\left(\frac{AROM - 30.212969}{8.682044}\right)$ | + |
| Oxygen | $(0.12278577)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | + |
| Oxygen (as EtOH)[1] | $(-0.12295089)(Type)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | + |
| BENZ | $(-0.1423482)\left(\frac{BENZ - 1.36412}{0.513051}\right)$ | } |

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

d. Acetaldehyde mass emissions Tech 3 = $y_{Tech\ 3}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {1.10122139 | + |
| Aromatic HC | $(-0.09219416)\left(\frac{AROM - 30.212969}{8.682044}\right)$ | + |
| Oxygen | $(0.00122983)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | + |
| Oxygen (as EtOH)[1] | $(0.54678495)(Type)\left(\frac{OXY - 0.892363}{1.235405}\right)$ | } |

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

### 2. Mass Emissions for Tech 4

The mass emissions for each toxic for Tech 4 are calculated as follows:

a. Benzene mass emissions Tech 4 = $y_{\text{Tech 4}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {2.3824773 | + |
| | Exp | |
| intercept | {2.3824773 | + |
| RVP | (-0.04782469) | + |
| Sulfur | $(0.09652526)\left(\frac{SULFUR - 154.120828}{136.790450}\right)$ | + |
| Aromatic HC | $(0.15517085)\left(\frac{AROM - 27.317137}{6.880833}\right)$ | + |
| Olefin | $(-0.02548759)\left(\frac{OLEF - 6.549450}{4.715345}\right)$ | + |
| T50 | $(0.04666208)\left(\frac{T50 - 205.261051}{17.324472}\right)$ | + |
| BENZ | $(0.11689441)\left(\frac{BENZ - 1.014259}{0.537392}\right)$ | } |

b. 1,3-Butadiene mass emissions Tech 4 = $y_{Tech\ 4}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {0.43090426 | + |
| Aromatic HC | $(-0.03604344)\left(\frac{AROM - 27.317137}{6.880833}\right)$ | + |
| Olefin | $(0.10354089)\left(\frac{OLEF - 6.549450}{4.715345}\right)$ | + |
| Oxygen | $(-0.02511374)\left(\frac{OXY - 1.536017}{1.248887}\right)$ | + |
| T50 | $(0.03707822)\left(\frac{T50 - 205.261051}{17.324472}\right)$ | + |
| T90 | $(0.09454201)\left(\frac{T90 - 310.931422}{20.847425}\right)$ | + |
| BENZ | $(0.03644387)\left(\frac{BENZ - 1.01425}{0.537392}\right)$ | } |

c. Formaldehyde mass emissions Tech 4 = $y_{\text{Tech 4}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {1.05886661 | + |
| Sulfur | $(-0.04135075)\left(\frac{\text{SULFUR} - 154.120828}{136.790450}\right)$ | + |
| Aromatic HC | $(-0.05466283)\left(\frac{\text{AROM} - 27.317137}{6.880833}\right)$ | + |
| Oxygen | $(0.06370091)\left(\frac{\text{OXY} - 1.536017}{1.248887}\right)$ | + |
| Oxygen (as EtOH)[1] | $(-0.09819814)(\text{Type})\left(\frac{\text{OXY} - 1.536017}{1.248887}\right)$ | + |
| T90 | $(0.06037698)\left(\frac{\text{T90} - 310.981422}{20.847425}\right)$ | } |

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

d. Acetaldehyde mass emissions Tech 4 = $y_{Tech\ 4}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {0.16738341 | + |
| Sulfur | $(0.02788263)\ \frac{(SULFUR - 154.120828)}{136.790450}$ | + |
| Aromatic HC | $(-0.05552641)\ \frac{(AROM - 27.317137)}{6.880833}$ | + |
| Oxygen | $(0.02382123)\ \frac{(OXY - 1.536017)}{1.248887}$ | + |
| Oxygen (as EtOH)[1] | $(0.46699012)\ (Type)\ \frac{(OXY - 1.536017)}{1.248887}$ | + |
| T50 | $(0.04314573)\ \frac{(T50 - 205.261051)}{17.324472}$ | + |
| T90 | $(0.06252964)\ \frac{(T90 - 310.931422)}{20.847425}$ | + |
| BENZ | $(0.06148653)\ \frac{(BENZ - 1.014259)}{0.537392}$ | } |

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the values for the candidate and reference specifications in the Table 7 worksheet.

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

### 3. Mass Emissions for Tech 5

The mass emissions for each toxic for Tech 5 are calculated as follows:

a. Benzene mass emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {2.3824773 | + |
| RVP | (-0.04214049) | + |
| Sulfur | $(0.09652526)\left(\frac{SULFUR - 144.628901}{140.91224}\right)$ | + |
| Aromatic HC | $(0.15517085)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| Olefin | $(-0.02548759)\left(\frac{OLEF - 6.251891}{4.431845}\right)$ | + |
| T50 | $(0.04666208)\left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |
| BENZ | $(0.11689441)\left(\frac{BENZ - 0.969248}{0.504325}\right)$ | } |

b. 1,3-Butadiene mass emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
|---|---|---|
| | Exp | |
| intercept | {0.43090426 | + |
| Aromatic HC | $(-0.03604344)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| Olefin | $(0.10354089)\left(\frac{OLEF - 6.251891}{4.431845}\right)$ | + |
| Oxygen | $(-0.02511374)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T50 | $(0.03707822)\left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |
| T90 | $(0.09454201)\left(\frac{T90 - 310.570200}{22.967591}\right)$ | + |
| BENZ | $(0.03644387)\left(\frac{BENZ - 0.969248}{0.504325}\right)$ | } |

c. Formaldehyde mass emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
| --- | --- | --- |
| | Exp | |
| intercept | {1.05886661 | + |
| Sulfur | $(-0.04135075)\left(\frac{SULFUR - 144.628901}{140.91224}\right)$ | + |
| Aromatic HC | $(-0.05466283)\left(\frac{AROM - 26.875940}{6.600312}\right)$ | + |
| Oxygen | $(0.06370091)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| Oxygen (as EtOH)[1] | $(-0.09819814)(Type)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T90 | $(0.06037698)\left(\frac{T90 - 310.570200}{22.967591}\right)$ | } |

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

d. Acetaldehyde mass emissions Tech 5 = $y_{\text{Tech 5}}$ =

| Description | Equation | |
| --- | --- | --- |
| | Exp | |
| intercept | {0.16738341 | + |
| Sulfur | $(0.02788263)\left(\frac{SULFUR - 144.628901}{140.91224}\right)$ | + |
| Aromatic HC | $(-0.05552641)\left(\frac{AROM - 26.875944}{6.600312}\right)$ | + |
| Oxygen | $(0.02382123)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| Oxygen (as EtOH)[1] | $(0.46699012)(Type)\left(\frac{OXY - 1.551772}{1.262823}\right)$ | + |
| T50 | $(0.04314573)\left(\frac{T50 - 206.020870}{16.582090}\right)$ | + |
| T90 | $(0.06252964)\left(\frac{T90 - 310.570200}{22.967591}\right)$ | + |
| BENZ | $(0.06148653)\left(\frac{BENZ - 0.969248}{0.504325}\right)$ | } |

where

SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the values for the candidate and reference specifications in the Table 7 worksheet.

1 — The Oxygen (as EtOH) term is an indicator variable term which is included only in the model prediction for the candidate fuel specifications, and only if the oxygen originates from the use of ethanol. This term is not included in the calculation for the reference fuel specifications because it is assumed that the oxygen from the reference fuel originates from the use of MTBE. Mathematically, this means that the value of Type in the above equation is 1.0 for the prediction for the candidate fuel specifications if ethanol is used, 0 for the prediction for the candidate fuel specifications if ethanol is not used, and 0 for all predictions for reference fuel specifications.

## B. Computation of Total Potency-Weighted Exhaust Toxics Emissions

### 1. Calculation of Potency-weighted Exhaust Toxics Emissions for Candidate Specifications

$EX_{PWT\text{-}CAND}$ =

$$\{((y_{BZ\text{-}TECH3} \times TWF_3)+(y_{BZ\text{-}TECH4} \times TWF_4)+(y_{BZ\text{-}TECH5} \times TWF_5))x(PWF_{BZ})\} +$$

$$\{((y_{BD\text{-}TECH3} \times TWF_3)+(y_{BD\text{-}TECH4} \times TWF_4)+(y_{BD\text{-}TECH5} \times TWF_5))x(PWF_{BD})\} +$$

$$\{((y_{FOR\text{-}TECH3} \times TWF_3)+(y_{FOR\text{-}TECH4} \times TWF_4)+(y_{FOR\text{-}TECH5} \times TWF_5))x(PWF_{FOR})\} +$$

$$\{((y_{ACE\text{-}TECH3} \times TWF_3)+(y_{ACE\text{-}TECH4} \times TWF_4)+(y_{ACE\text{-}TECH5} \times TWF_5))x(PWF_{ACE})\}$$

where

**$EX_{PWT\text{-}CAND}$** is the PWT emissions for the candidate specifications.

**$y_{BZ\text{-}TECH}$** is the benzene emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{BD\text{-}TECH}$** is the 1,3-butadiene emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{FOR\text{-}TECH}$** is the formaldehyde emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{ACE\text{-}TECH}$** is the acetaldehyde emissions prediction for Tech 3, Tech 4, or Tech 5.

**$TWF_3$**, **$TWF_4$**, and **$TWF_5$** are the toxics weighting factors for Tech class 3, Tech class 4, and Tech class 5 vehicles, respectively. These values are shown in Table 5.

**$PWF_q$** is the potency weighting factor for toxic pollutant q provided in Table 8.

### 2. Calculation of Potency-Weighted Emissions for Reference Specifications

$EX_{PWT\text{-}REF}$ =

$$\{((y_{BZ\text{-}TECH3} \times TWF_3)+(y_{BZ\text{-}TECH4} \times TWF_4)+(y_{BZ\text{-}TECH5} \times TWF_5))x(PWF_{BZ})\} +$$

$$\{((y_{BD\text{-}TECH3} \times TWF_3)+(y_{BD\text{-}TECH4} \times TWF_4)+(y_{BD\text{-}TECH5} \times TWF_5))x(PWF_{BD})\} +$$

$$\{((y_{FOR\text{-}TECH3} \times TWF_3)+(y_{FOR\text{-}TECH4} \times TWF_4)+(y_{FOR\text{-}TECH5} \times TWF_5))x(PWF_{FOR})\} +$$

$$\{((y_{ACE\text{-}TECH3} \times TWF_3)+(y_{ACE\text{-}TECH4} \times TWF_4)+(y_{ACE\text{-}TECH5} \times TWF_5))x(PWF_{ACE})\}$$

where

**$EX_{PWT\text{-}REF}$** is the PWT emissions for the reference specifications.

**$y_{BZ\text{-}TECH}$** is the benzene emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{BD\text{-}TECH}$** is the 1,3-butadiene emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{FOR\text{-}TECH}$** is the formaldehyde emissions prediction for Tech 3, Tech 4, or Tech 5,
**$y_{ACE\text{-}TECH}$** is the acetaldehyde emissions prediction for Tech 3, Tech 4, or Tech 5.

**$TWF_3$**, **$TWF_4$**, and **$TWF_5$** are the toxics weighting factors for Tech class 3, Tech class 4, and Tech class 5 vehicles, respectively. These values are shown in Table 5.

**$PWF_q$** is the potency-weighting factor for toxic pollutant q provided in Table 8.

## VIII. CALCULATIONS FOR CHANGES IN EVAPORATIVE HYDROCARBON (HC) EMISSIONS

### A. Evaporative HC Emissions by Process

The evaporative HC emissions models predict the percent change in evaporative HC emissions as a function of RVP in psi, relative to a reference fuel's RVP. As stated in Table 1, the RVP of the reference fuel is 7.0 psi for an ethanol blended candidate fuel or 6.9 psi for a non-oxygenated candidate fuel. Thus, the models predict the percent change in evaporative HC emissions of the candidate fuel relative to a particular reference fuel. There are three evaporative HC emissions models for each type of candidate fuel, i.e., oxygenated (ethanol) and non-oxygenated candidate fuels. The three HC models are for each of the following three evaporative emissions processes: 1) Diurnal/Resting Loss Emissions, 2) Hot Soak Emissions, and 3) Running Loss Emissions.

#### 1. Diurnal/Resting Loss Emissions

a. The predicted percent change in Diurnal/Resting Loss Emissions (% $CE_{DIRES}$) of an oxygenated candidate fuel is:

$$\% \mathbf{CE}_{DIRES} = \frac{100 \times [43.589427 + (3.730921 \times RVP)]}{[34.535116 + (3.730921 \times 7.0)]} - 100$$

where RVP is the RVP of the candidate fuel.

b. The predicted percent change in Diurnal/Resting Loss Emissions (% $\mathbf{CE}_{DIRES}$) of a non-oxygenated candidate fuel is:

$$\% \mathbf{CE}_{DIRES} = \frac{100 \times [34.535116 + (3.730921 \times RVP)]}{[34.535116 + (3.730921 \times 6.9)]} - 100$$

where RVP is the RVP of the candidate fuel.

#### 2. Hot Soak Emissions

a. The predicted percent change in Hot Soak Emissions (% $CE_{HS}$) of an oxygenated candidate fuel is:

$$\% \mathbf{CE}_{HS} = \frac{100 \times [10.356585 + (4.369978 \times RVP)]}{[9.228675 + (4.369978 \times 7.0)]} - 100$$

where RVP is the RVP of the candidate fuel.

b. The predicted percent change in Hot Soak Emissions (% $\mathbf{CE}_{HS}$) of a non-oxygenated candidate fuel is:

$$\% \mathbf{CE}_{HS} = \frac{100 \times [9.228675 + (4.369978 \times RVP)]}{[9.228675 + (4.369978 \times 6.9)]} - 100$$

where RVP is the RVP of the candidate fuel.

### 3. Running Loss Emissions

a. The predicted percent change in Running Loss (% $\mathbf{CE}_{RL}$) of an oxygenated candidate fuel is:

$$\% \mathbf{CE}_{RL} = \frac{100 \times [42.517912 + (9.744935 \times RVP)]}{[40.567912 + (9.744935 \times 7.0)]} - 100$$

where RVP is the RVP of the candidate fuel.

b. The predicted percent change in Running Loss (% $\mathbf{CE}_{RL}$) of a non-oxygenated candidate fuel is:

$$\% \mathbf{CE}_{RL} = \frac{100 \times [40.567912 + (9.744935 \times RVP)]}{[40.567912 + (9.744935 \times 6.9)]} - 100$$

where RVP is the RVP of the candidate fuel.

## IX. EVAPORATIVE BENZENE EMISSIONS CALCULATIONS

### A. Evaporative Benzene Emissions by Process

The evaporative benzene models predict the evaporative benzene emissions (in units of milligrams per mile) as a function of RVP, gasoline benzene content, and gasoline MTBE content (for Hot Soak Benzene Emissions). There are three evaporative benzene models, one for each of the following three processes of evaporative benzene emissions: 1) Diurnal/Resting Loss Emissions, 2) Hot Soak Emissions, and 3) Running Loss Emissions.

#### 1. Diurnal/Resting Loss Emissions

The predicted Diurnal/Resting Loss Benzene Emissions ($EVBenz_{DIRES}$) of an ethanol containing fuel is calculated as follows:

$$EVBenz_{DIRES} = \{592 \times [(3.730921 \times RVP + 43.589427) \times 907.18 / 939430)] \times [(0.0294917804 \times Benz) - (0.0017567009 \times Benz \times RVP)]\}$$

The predicted Diurnal/Resting Loss Benzene Emissions ($EVBenz_{DIRES}$) of a non-ethanol containing fuel is calculated as follows:

$$EVBenz_{DIRES} = \{592 \times [(3.730921 \times RVP + 34.535116) \times 907.18 / 939430)] \times [(0.0294917804 \times Benz) - (0.0017567009 \times Benz \times RVP)]\}$$

where

$EVBenz_{DIRES}$ is the predicted evaporative Diurnal/Resting Loss benzene emissions and is calculated for both the reference and candidate fuel specifications,

Benz is the benzene content of the gasoline, in percent by volume, and

RVP is the RVP of the gasoline, in psi.

#### 2. Hot Soak Loss Emissions

The predicted Hot Soak Benzene emissions ($EVBenz_{HS}$) is calculated as follows:

$$EVBenz_{HS} = \{592 \times [(4.369978 \times RVP + 10.356585) \times 907.18 / 939430] \times [(0.0463141591 \times Benz) - (0.0027179513 \times Benz \times RVP) - (0.0008184128 \times Benz \times MTBE)]\}$$

The predicted Hot Soak Benzene emissions ($EVBenz_{HS}$) of a non-ethanol containing gasoline is calculated as follows:

$$EVBenz_{HS} = \{592 \times [(4.369978 \times RVP + 9.228675) \times 907.18 / 939430] \times [(0.0463141591 \times Benz) - (0.0027179513 \times Benz \times RVP) - (0.0008184128 \times Benz \times MTBE)]\}$$

where

| | |
|---|---|
| $EVBenz_{HS}$ | is the predicted evaporative Hot Soak benzene emissions and is calculated for both the reference and candidate fuel specifications, |
| Benz | is the benzene content of the gasoline, in percent by volume, |
| RVP | is the RVP of the gasoline, in psi, and |
| MTBE | is the MTBE content of the gasoline, in percent by volume. |

### 3. Running Loss Emissions

The predicted Running Loss Benzene emissions ($EVBenz_{RL}$) of an ethanol containing gasoline is calculated as follows:

$$EVBenz_{RL} = \{592 \times [(9.744935 \times RVP + 42.517912) \times 907.18 / 939430] \times [(0.0648391842 \times Benz) - (0.005622979 \times Benz \times RVP)]\}$$

The predicted Running Loss Benzene emissions ($EVBenz_{RL}$) of a non-ethanol containing gasoline is calculated as follows:

$$EVBenz_{RL} = \{592 \times [(9.744935 \times RVP + 40.567912) \times 907.18 / 939430] \times [(0.0648391842 \times Benz) - (0.005622979 \times Benz \times RVP)]\}$$

where
$EVBenz_{RL}$ is the predicted evaporative Running Loss benzene emissions and is calculated for both the reference and candidate fuel specifications,
Benz is the benzene content of the gasoline, in percent by volume, and
RVP is the RVP of the gasoline, in psi.

## X. COMBINATION OF EXHC EMISSIONS PREDICTIONS, EVAPORATIVE HC EMISSIONS PREDICTIONS, AND CO EMISSIONS PREDICTIONS

In combining the model predictions for ExHC, evaporative HC, and CO emissions, the ozone-forming potential of each of the three processes is recognized. The predicted percent change in emissions for each process is multiplied by a factor which represents, for that process, the ozone-forming potential of the emissions. For purposes of this discussion, this ozone-forming potential value will be referred to as relative reactivity. The predicted percent change for each process is also multiplied by a factor which represents the relative contribution of the process to the total inventory of reactive ozone precursors (HC and CO) from gasoline vehicles. The products of the predicted changes in emissions, relative reactivities, and contribution factors are then added. This sum is then divided by the sum of the products of the individual reactivities and emissions contribution fractions for each process. This quotient represents the percent change in the ozone-forming potential of the candidate fuel specifications relative to the reference fuel specifications.

The predicted percent change in ExHC emissions is the Tech class-weighted predicted change computed in accordance with the equation shown in Section V.B. For evaporative HC emissions, each of the individual evaporative processes (Diurnal/Resting, Hot Soak, and Running) has a different relative reactivity. Thus, for the evaporative emissions processes, the products of the predicted change in emissions and relative reactivity are computed separately. These three products are included individually in the overall sum. The predicted percent change in the three evaporative HC emissions processes are those computed in accordance with the equations given in Sections VIII.A.1, VIII.A.2, and VIII.A.3. The predicted percent change in CO emissions is the prediction computed in accordance with the equation given in section VI.B.

The combination of the ExHC, the evaporative HC, and the CO emissions models predictions can be illustrated mathematically as follows: (Note that this calculation is performed only if the applicant selects the compliance option which provides for the use of the evaporative HC emissions models and the CO emissions models.)

$$\%CE_{OFP} = [(\%CE_{ExHC} \times R_{ExHC} \times F_{ExHC}) + (\%CE_{DIRES} \times R_{DIRES} \times F_{DIRES}) + (\%CE_{HS} \times R_{HS} \times F_{HS}) + (\%CE_{RL} \times R_{RL} \times F_{RL}) + (\%CE_{CO} \times R_{CO} \times F_{CO})] \,/\, [(R_{ExHC} \times F_{ExHC}) + (R_{DIRES} \times F_{DIRES}) + (R_{HS} \times F_{HS}) + (R_{RL} \times F_{RL}) + (R_{CO} \times F_{CO})]$$

where

$\%CE_{OFP}$ is the net percent change in ozone-forming potential of the reference fuel specifications relative to the candidate fuel specifications,

$\%CE_{ExHC}$ is the predicted percent change in Tech-class weighted ExHC as given by the equation in Section V.B,

$\%CE_{DIRES}$ is the predicted percent change in Diurnal/Resting Loss emissions as given by the equation in Section VIII.A.1,

$\%CE_{HS}$ is the predicted percent change in Hot Soak emissions as given by the equation in Section VIII.A.2,

$\%CE_{RL}$ is the predicted percent change in Running Loss emissions as given by the equation in Section VIII.A.3,

$\%CE_{CO}$ is the predicted percent change in CO emissions as given by the equation in Section VI.B, and

the R's are the relative reactivities as shown below in Table 9, and the F's are the fractions of emissions from gasoline vehicles for each process in the year 2015, as given by the ARB's EMFAC2007 motor vehicle emissions model and shown below in Table 10.

**Table 9**
**Relative Reactivity Values**

| Process | R Value |
|---|---|
| ExHC | 1.00 |
| Diurnal/Resting HC | 0.68 |
| Hot Soak HC | 0.78 |
| Running Loss HC | 0.68 |
| CO | 0.015 |

**Table 10**
**Emissions Fractions**

| Process | F Value |
|---|---|
| ExHC | 0.0454 |
| Diurnal/Resting HC | 0.0174 |
| Hot Soak HC | 0.0113 |
| Running Loss HC | 0.0310 |
| CO | 0.8949 |

## XI. COMBINATION OF EXHAUST TOXICS EMISSIONS PREDICTIONS WITH EVAPORATIVE BENZENE EMISSIONS PREDICTIONS

The Diurnal/Resting Loss, Hot Soak, and Running Loss evaporative benzene predictions are each multiplied by the toxic air contaminant potency-weighting factor for benzene given in Table 8, and then summed to give the total potency-weighted evaporative benzene prediction. This prediction is then added to the total Tech class-weighted, potency-weighted exhaust toxics predictions computed in accordance with the equations given in Section V.B to give the total Tech class-weighted, potency-weighted toxics emissions predictions. The addition is performed for both the candidate fuel and the reference fuel. The combination is shown mathematically below:

### A. Total Toxics for the Candidate Fuel Specifications:

Total Potency-Weighted Evaporative Benzene Prediction

$$\mathbf{EVBENZ_{TOT\text{-}CAND} = (EVBENZ_{DIRES\text{-}CAND} + EVBENZ_{HS\text{-}CAND} + EVBENZ_{RL\text{-}CAND}) \times PWF_{BENZ}}$$

Total Potency-Weighted Toxics Prediction

$$E_{PWT\text{-}CAND} = EX_{PWT\text{-}CAND} + EVBENZ_{TOT\text{-}CAND}$$

where

$EVBENZ_{TOT\text{-}CAND}$ is the total potency-weighted evaporative benzene emission prediction for the candidate fuel specifications,

$EVBENZ_{DIRES\text{-}CAND}$ is the diurnal/resting loss benzene emission prediction for the candidate fuel specifications, as given by the equation in Section IX.A.1,

$EVBENZ_{HS\text{-}CAND}$ is the hot soak benzene emission prediction for the candidate fuel specifications, as given by the equation in Section IX.A.2,

$EVBENZ_{RL\text{-}CAND}$ is the running loss benzene emission prediction for the candidate fuel specifications, as given by the equation in Section IX.A.3,

$PWF_{BENZ}$ is the potency-weighting factor for benzene shown in Table 8,

$E_{PWT\text{-}CAND}$ is the total potency-weighted toxics prediction for the candidate fuel specifications, and

$EX_{PWT\text{-}CAND}$ is the total Tech class-weighted, potency-weighted exhaust toxics prediction for the candidate fuel specifications computed in accordance with the equation give in Section VII.B.1.

## B. Total Toxics for the Reference Fuel Specifications

Total Potency-Weighted Evaporative Benzene Prediction

$$EVBENZ_{TOT\text{-}REF} = (EVBENZ_{DIRES\text{-}REF} + EVBENZ_{HS\text{-}REF} + EVBENZ_{RL\text{-}REF}) \times PWF_{BENZ}$$

Total Potency-Weighted Toxics Prediction

$$E_{PWT\text{-}REF} = EX_{PWT\text{-}REF} + EVBENZ_{TOT\text{-}REF}$$

where

$EVBENZ_{TOT\text{-}REF}$ is the total potency-weighted evaporative benzene emission prediction for the reference fuel specifications,

$EVBENZ_{DIRES\text{-}REF}$ is the diurnal/resting loss benzene emission prediction for the reference fuel specifications, as given by the equation in Section IX.A.1,

$EVBENZ_{HS\text{-}REF}$ is the hot soak benzene emission prediction for the reference fuel specifications, as given by the equation in Section IX.A.2,

$EVBENZ_{RL\text{-}REF}$ is the running loss benzene emission prediction for the reference fuel specifications, as given by the equation in Section IX.A.3,

$PWF_{BENZ}$ is the potency-weighting factor for benzene shown in Table 8

$E_{PWT\text{-}REF}$ is the total potency-weighted toxics prediction for the reference fuel specifications, and

$EX_{PWT\text{-}REF}$ is the total Tech class-weighted, potency-weighted exhaust toxics prediction for the reference fuel specifications computed in accordance with the equation give in Section VII.B.2.

## C. Calculation of the Percent Change in Total Predicted Toxics Emissions

The percent change in the total predicted toxics emissions between the candidate fuel specifications and the reference fuel specification is calculated as follows:

$$\%CE_{PWT} = \left[\left(E_{PWT\text{-}CAND} - E_{PWT\text{-}REF}\right) / E_{PWT\text{-}REF}\right] \times 100$$

## XII. DETERMINATION OF ACCEPTABILITY

If, for each pollutant (NOx, Ozone-forming Potential (OFP) or exhaust HC (ExHC), and Potency-Weighted Toxics (PWT)), the percent difference in emissions between the candidate fuel specifications and the reference Phase 3 RFG specifications is equal to or less than 0.04%, the candidate specifications are deemed acceptable as an alternative to Phase 3 RFG. If the applicant uses, or is required to use, the THC Model, the candidate fuel specifications must pass for NOx, OFP, and PWT to be acceptable as an alternative Phase 3 RFG formulation. If the uses, or is required to use the ExHC Model, the candidate fuel specifications must pass for NOx, E~~X~~xHC, and PWT to be acceptable as an alternative Phase 3 RFG formulation.

These criteria are mathematically shown below.

Applicant uses, or is required to use, the THC Model for RVP-Controlled Gasoline

$\%CE_{NOx} \leq 0.04\%$, and
$\%CE_{OFP} \leq 0.04\%$, and
$\%CE_{PWT} \leq 0.04\%$.

Applicant uses, or is required to use, the ExHC Model for non-RVP-Controlled Gasoline

$\%CE_{NOx} \leq 0.04\%$, and
$\%CE_{E\not{X}\underline{x}HC} \leq 0.04\%$, and
$\%CE_{PWT} \leq 0.04\%$.

where

$\%CE_{NOx}$ is given by the equation in Section IV.B,
$\%CE_{OFP}$ is given by the equation in Section X,
$\%CE_{E\not{X}\underline{x}HC}$ is given by the equation in Section V.B, and
$\%CE_{PWT}$ is given by the equation in Section XI.C.

If the percent change in emission between the candidate specifications and the reference Phase 3 RFG specifications is equal to or greater than 0.05% for any pollutant (NOx, OFP, ExHC, PWT) in the above equivalency criteria, then the candidate specifications are deemed unacceptable and may not be a substitute for Phase 3 RFG. [Note: All final values of the percent change in emissions shall be reported to the nearest hundredth using conventional rounding.]

If the candidate specifications are deemed acceptable, the property values and the compliance options of the candidate specifications become the property values and compliance options for the alternative gasoline formulation.

## XIII. NOTIFICATION OF INTENT TO OFFER AN ALTERNATIVE GASOLINE FORMULATION

A producer or importer intending to sell or supply an alternative gasoline formulation of California gasoline from its production facility or import facility shall notify the executive officer in accordance with 13 CCR, section 2265(a).

Table 11, Alternative Specifications for Phase 3 RFG Using the California Predictive Model Notification, has been provided as an example of the minimum information required.

**Table 11**
**Alternative Specifications for Phase 3 RFG**
**Using California Predictive Model Notification**

Name of Producer/Importer:__________________Facility Location:
Name of Person Reporting:______________________Telephone No:
Date/Time of This Report:____________ I.D. of 1st Batch with this Specification:
Notification Date:______________Notification Time:_______________
Start Production Date:____________Start Production Time:______________
Batch Number:________________Tank Number:________________

- All California gasoline transferred from this facility will meet the specifications listed below until the next Alternative Specifications report to the ARB.
- Fuel properties that will be averaged will be reported as the "Designated Alternative Limit and Volume of Gasoline Report" separately to the ARB.

Type of gasoline (check one):

____ RVP-controlled gasoline; using the THC Model
____ non-RVP-controlled gasoline; using the ExHC Model

| **Fuel Property** | **Candidate Fuel Property Value** | **Compliance Option**: | **Reference Fuel: Phase 3 RFG Property Value** | |
|---|---|---|---|---|
| | | | **Flat** | **Average** |
| RVP | | **Flat** | **6.90/7.00** | **None** |
| Sulfur | | | **20** | **15** |
| Benzene | | | **0.80** | **0.70** |
| Aromatic HC | | | **25.0** | **22.0** |
| Olefin | | | **6.0** | **4.0** |
| Oxygen[1] | **(min.)**<br>**(max.)** | **Flat Range** | **(min.)**<br>**(max.)** | **None** |
| T50 | | | **213** | **203** |
| T90 | | | **305** | **295** |

1- See Table 6 in the Predictive Model Procedures for the specification of candidate and reference oxygen levels.

| **Pollutant[2]** | **Percent Change in Emissions[3]** |
|---|---|
| **Oxides of Nitrogen** | |
| **OFP or ExHC** | |
| **Potency-Weighted Toxics** | |

2- Where Applicable, a %CE must be reported for both the candidate fuel minimum and maximum oxygen specifications. See Table 6 for explanation of when both %CE's must be reported.

3- Percent change calculated using equations presented in sections IV.B, V.B, VI.B, and X of the Phase 3 Predictive Model Procedures Document.

**Table 12**
**Standardization of Fuel Properties - Mean and Standard Deviation**

| Fuel Property | Tech 3 | | Tech 4 | | Tech 5 | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| **RVP** | 8.670892 | 0.635066 | 8.365415 | 0.889114 | 8.221700 | 0.902838 |
| **Sulfur** | 139.691080 | 126.741459 | 154.120828 | 136.790450 | 144.628901 | 140.912204 |
| **Aromatic HC** | 30.212969 | 8.682044 | 27.317137 | 6.880833 | 26.875944 | 6.600312 |
| **Olefin** | 7.359624 | 5.383804 | 6.549450 | 4.715345 | 6.251891 | 4.431845 |
| **Oxygen** | 0.892363 | 1.235405 | 1.536017 | 1.248887 | 1.551772 | 1.262623 |
| **T50** | 212.245188 | 15.880385 | 205.261051 | 17.324472 | 206.020870 | 16.582090 |
| **T90** | 312.121596 | 23.264684 | 310.931422 | 20.847425 | 310.570200 | 22.967591 |
| **Benzene** | 1.36412 | 0.513051 | 1.014259 | 0.537392 | (0.969248) | (0.504325) |

**Table 13**
**Coefficients for NOx, ExHC, and CO Equations**

| Model Term | Tech 3 | | | Tech 4 | | | Tech 5 | | |
|---|---|---|---|---|---|---|---|---|---|
| | NOx | HC | CO | NOx | HC | CO | NOx | HC | CO |
| Intercept | -0.159800 | -0.752270 | 1.615613 | -0.634694 | -1.142182 | 1.195246 | -1.599255 | -2.671187 | -0.240521 |
| RVP | 0.0424915 | 0.000013 | 0.012087 | -0.007046 | -0.019335 | -0.025878 | -0.000533 | -0.012824 | -0.014137 |
| Sulfur | 0.028040 | 0.038207 | 0.031849 | 0.051043 | 0.079373 | 0.073616 | 0.947915 | 0.242238 | 0.123649 |
| Aromatic HC | 0.047060 | 0.014103 | 0.085541 | 0.011366 | 0.002047 | 0.025960 | 0.013671 | 0.003039 | 0.025775 |
| Olefin | 0.021110 | -0.016533 | 0.002416 | 0.017193 | -0.010716 | 0.001263 | 0.017335 | -0.010908 | 0.005001 |
| Oxygen | 0.014910 | -0.026365 | -0.068986 | 0.028711 | -0.019880 | -0.052530 | 0.016036 | -0.007528 | -0.087967 |
| T50 | -0.007360 | 0.015847 | 0.009897 | -0.002431 | 0.052939 | 0.022750 | 0.012397 | 0.056796 | 0.018195 |
| T90 | 0.000654 | 0.011768 | -0.025449 | 0.002087 | 0.037684 | -0.008820 | 0.000762 | 0.010803 | -0.128296 |
| T90ARO | | 0.016606 | | -0.002892 | | | | | |
| T90OLE | | -0.007995 | | | | -0.007360 | | | |
| T50T90 | | | 0.017463 | | | | | | |
| T50T50 | | | | 0.006268 | 0.017086 | | -0.022211 | 0.019563 | |
| OXYOXY | | | | 0.010737 | | -0.016510 | 0.015199 | | 0.026309 |
| T50ARO | | | | | 0.019031 | 0.009884 | | 0.016761 | 0.009797 |
| T50OXY | | | | | 0.013724 | | -0.015564 | 0.014082 | 0.021763 |
| T90T90 | | | | | 0.013914 | 0.007767 | | 0.015216 | |
| AROARO | | | | | -0.010999 | | | -0.009740 | |
| AROOXY | | | | | 0.007221 | | | 0.006902 | |
| T90OXY | | | | | | | | 0.013372 | |

**Table 14**
**Coefficients for Exhaust Toxics Equations**

| Model Term | Tech 3 | | | |
|---|---|---|---|---|
| | Benzene | Butadiene | Formaldehyde | Acetaldehyde |
| Intercept | 2.95676525 | 0.67173886 | 2.16836424 | 1.10122139 |
| RVP (constant) | | | | |
| Sulfur | 0.0683768 | | | |
| Aromatic HC | 0.15191575 | | -0.07537099 | -0.09219416 |
| Olefin | | 0.18408319 | | |
| Oxygen | -0.03295985 | | 0.12278577 | 0.00122983 |
| Oxygen (as EtOH) | | | -0.12295089 | 0.54678495 |
| T50 | | 0.11391774 | | |
| T90 | | | | |
| Benzene | (0.12025037) | | -0.1423482 | |
| Model Term | Tech 4 | | | |
| | Benzene | Butadiene | Formaldehyde | Acetaldehyde |
| Intercept | 2.3824773 | 0.43090426 | 1.05886661 | 0.16738341 |
| RVP (constant) | (-0.04782469) | | | |
| Sulfur | 0.09652526 | | -0.04135075 | 0.02788263 |
| Aromatic HC | 0.15517085 | -0.03604344 | -0.05466283 | -0.05552641 |
| Olefin | -0.02548759 | 0.10354089 | | |
| Oxygen | | -0.02511374 | 0.06370091 | 0.02382123 |
| Oxygen (as EtOH) | | | -0.09819814 | 0.46699012 |
| T50 | 0.04666208 | 0.03707822 | | 0.04314573 |
| T90 | | 0.09454201 | 0.06037698 | 0.06252964 |
| Benzene | 0.11689441 | 0.03644387 | | 0.06148653 |
| | Tech 5 | | | |
| | | | | |

| Model Term | Benzene | Butadiene | Formaldehyde | Acetaldehyde |
|---|---|---|---|---|
| **Intercept** | 2.3824773 | 0.43090426 | 1.05886661 | 0.16738341 |
| **RVP (constant)** | (-0.04214049) | | | |
| **Sulfur** | 0.09652526 | | -0.04135075 | 0.02788263 |
| **Aromatic HC** | 0.15517085 | -0.03604344 | -0.05466283 | -0.05552641 |
| **Olefin** | -0.02548759 | 0.10354089 | | |
| **Oxygen** | | -0.02511374 | 0.06370091 | 0.02382123 |
| **Oxygen (as EtOH)** | | | -0.09819814 | 0.46699012 |
| **T50** | 0.04666208 | 0.03707822 | | 0.04314573 |
| **T90** | | 0.09454201 | (0.06037698) | 0.06252964 |
| **Benzene** | 0.11689441 | 0.03644387 | | 0.06148653 |