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

Note: The preexisting text is set forth below in normal type. The amendments are shown in *underline italic* to indicate additions and ~~strikeout~~ to indicate deletions.

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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, and
   - ♦ establishes the notification requirements.

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) 2.2 (max)	none	1.8(min)[4] 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 Applicable during the summer months identified in 13 CCR, sections 2262.4(b). If the applicant elects to comply with the regulatory option which provides for the use of the evaporative HC emissions model, the flat RVP limit is 6.90. That is, all predictions for evaporative emissions increases or decreases made using the evaporative HC emissions models are made relative to 6.90 psi. If the applicant elects to comply with the regulatory option which provides for the use of only the exhaust HC emissions model, the flat RVP limit and the candidate fuel RVP specification is 7.00. Also, under the federal Reformulated Gasoline Regulations, the U.S. EPA enforces a minimum RVP limit of 6.4 psi.~~

~~The exhaust models contain an RVP term, but this has been made constant by fixing the RVP for both the reference and candidate fuels at 7.00 psi in the calculation of the standardized RVP values used in the exhaust emission equations. This fixing of the RVP takes RVP out of the exhaust models as a fuel property which effects exhaust emissions. Thus, RVP effects only evaporative HC emissions.~~

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 ~~RFG~~ sulfur content cap limits of 60,~~ and~~ 30*, and 20* parts per million are phased in starting December 31, ~~2002~~*2003*, *December 31, 2005,* and December 31, ~~2004~~*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.

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

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

Pollutant Predictions	**Units**
Oxides of Nitrogen (NOx)	gm/mile
Exhaust Hydrocarbons (HC)	gm/mile
Evaporative Hydrocarbons (HC)	Percent Change (Candidate Fuel Relative to Reference Fuel)
Exhaust Potency-Weighted Toxics (PWT)	mg/mile
Evaporative Benzene	mg/mile
Exhaust CO (Adjustment Factor for Oxygen)	~~Percent Change (Relative to 2.0 Percent Oxygen)~~*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 accepted as equivalent to Phase 3 RFG if its predicted emissions for each pollutant is less than or equal (within roundoff) 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.

~~Eighteen~~*Twenty-one* separate exhaust sub-models have been developed for ~~six~~*seven* pollutants (NOx, HC, *CO,* benzene, 1,3-butadiene, formaldehyde, and acetaldehyde). Three exhaust sub-models have been developed for each of the ~~six~~*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. Finally, an adjustment factor has been developed to predict the effect of ~~gasoline oxygen content~~*changing fuel properties* on exhaust CO emissions.

2. Combination of Sub-Model Predictions for Exhaust Emissions Across Tech Classes

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 exhaust HC 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 ~~a VMT (vehicle miles traveled)~~*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 with Exhaust HC Emissions Predictions (Optional)

Two compliance options are available to applicants. The first compliance option includes predictions for differences in evaporative HC emissions between the candidate fuel specifications and the Phase 3 RFG reference fuel in the evaluation of the HC emissions equivalency of the candidate fuel. The second option does not, and the HC emissions equivalency of the candidate fuel specifications is based only on the predictions of the exhaust HC emissions models, as is the case in the Phase 2 RFG regulations. In the first compliance option, the Tech class-weighted difference in the predicted exhaust HC emissions between the reference fuel specifications and the candidate fuel specifications is combined with the predicted difference in evaporative HC emissions between the two fuels when evaluating the HC emissions equivalency of the candidate fuel specifications. This combination estimates the difference in total HC emissions (exhaust plus evaporative) between the reference fuel specifications and the candidate fuel specifications. In the second compliance option, the predicted evaporative HC emissions changes are not included and the HC emissions equivalency of the candidate fuel specifications is based only on the Tech class-weighted difference in the predicted exhaust HC emissions. This was the only compliance option available in the Phase 2 RFG regulations. The second option is being offered for applicants who are not interested in using the evaporative HC emissions model in the evaluation of the HC emissions equivalency of the alternative fuel specifications.

Under the first compliance option, when combining the Tech class-weighted difference in the predicted exhaust HC 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 this compliance option by the inclusion of ~~a~~ CO ~~adjustment factor~~ *emissions* in the sum of exhaust and evaporative HC emissions. Thus, under this compliance option, the combination of the model predictions for exhaust HC emissions, evaporative HC emissions changes, and ~~the~~ CO ~~adjustment factor~~ *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 this compliance option are ~~6.90~~*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*.

Under the second compliance option, only the Tech class-weighted difference in the predicted exhaust HC emissions is used in comparing the HC emissions of the reference fuel specifications to the HC emissions of the candidate fuel specifications. Under this option, evaporative HC emissions of the candidate fuel are limited by the imposition of a flat (and cap) RVP limit of 7.0. The CO adjustment factor also is not used under the second compliance option.

Either the first or second compliance options can be used during the RVP control season until December 31, 2009. Beginning December 31, 2009, only the first compliance option can be used during the RVP control season. Only the second compliance option can be used outside of the RVP control season.

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 exhaust HC, 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 has elected to use the evaporative HC emissions model in the evaluation of the emissions equivalency, the 0.04% criteria must be met for NOx, OFP, and PWT. If the applicant has elected not to use the evaporative HC emissions model, the 0.04% criteria must be met for NOx, exhaust HC, 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.] ~~In addition to satisfying the 0.04% emissions difference criteria, the candidate fuel specifications are required to meet the Phase 3 RFG specification for driveability index (DI) of 1225.~~

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 <u>California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model</u>.

2. **Alternative fuel specifications** means the specifications for the following gasoline properties, as determined in accordance with 13 CCR, 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).

10. **EMFAC~~/BURDEN 7G~~ *2007*** means the EMFAC~~/BURDEN 7G~~ *2007* 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~~*12*. **Executive Officer** means the executive officer of the Air Resources Board, or his or her designee.

~~12~~*13*. **Exhaust-only option** means the compliance option available to applicants which uses only the exhaust HC emissions models in the evaluation of the HC emissions equivalency of the candidate fuel specifications.

~~13~~*14*. **Evap option** means the compliance option available to applicants which uses the evaporative HC emissions models and the CO adjustment factor in the evaluation of the HC emissions equivalency of the candidate fuel specifications.

~~14~~*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.

~~15~~*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.

~~16~~*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~~*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.

~~18~~*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.

~~19~~*20*. **Phase 3 reformulated gasoline (Phase 3 RFG)** means gasoline meeting the flat or averaging limits of the Phase 3 RFG regulations.

~~20~~*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.

~~21~~*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.

~~22~~*23*. **Reference fuel or reference fuel specifications** means a gasoline meeting the flat or average specifications for Phase 3 RFG.

~~23~~*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~~*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.

~~25~~*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~~*27*. **50% distillation temperature (T50)** means the temperature at which 50% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with 13 CCR, section 2263.

~~27~~*28*. **90% distillation temperature (T90)** means the temperature at which 90% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with 13 CCR, section 2263.

28*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.

29*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 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 ~~for NOx and Exhaust HC~~

Emission-weighting factors are used, for ~~both~~ NOx*,* ~~and~~ exhaust HC*, and CO* emissions, to weight the model predictions for each technology class. These weightings represent, for each of the ~~two~~*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 ~~2005~~*2015*. The year ~~2005~~*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 EMFAC~~/BURDEN 7G~~ *2007*. The emission-weighting factors (EWF) are shown in Table 4 and are used in the combination of the sub-models for NOx*,* ~~and~~ exhaust HC*, and CO* emissions.

Table 4
Emission~~s~~-Weighting Factors

Pollutant	Tech 3	Tech 4	Tech 5
NOx	~~0.122~~*0.052*	~~0.348~~*0.325*	~~0.530~~*0.622*
HC	~~0.166~~*0.075*	~~0.540~~*0.380*	~~0.294~~*0.546*
CO	*0.063*	*0.288*	*0.649*

C. ~~VMT~~*Toxics* Weighting Factors ~~for Exhaust Toxics~~

~~For exhaust~~*Since* toxics emissions~~, vehicle miles traveled (VMT)~~ *are also exhaust HC, the hydrocarbon* weighting factors are used to weight the model predictions for each technology class. ~~The VMT weightings represent the fractional VMT contribution from vehicles in each of the three Tech classs.~~ The values were calculated for the year ~~2005~~*2015* using the ARB's EMFAC~~/BURDEN 7G~~ *2007* motor vehicle emissions inventory. The ~~VMT~~*toxics* weighting factors (~~VM~~TWFs) are shown in Table 5 and are used in the combination of the exhaust toxics emissions sub-models.

Table 5
~~Vehicle Miles Traveled~~*Toxics* Weighting Factors (~~VM~~TWFs)

Pollutant	Tech 3	Tech 4	Tech 5
Benzene	~~0.021~~*0.075*	~~0.180~~*0.380*	~~0.799~~*0.546*
1,3-Butadiene	~~0.021~~*0.075*	~~0.180~~*0.380*	~~0.799~~*0.546*
Formaldehyde	~~0.021~~*0.075*	~~0.180~~*0.380*	~~0.799~~*0.546*
Acetaldehyde	~~0.021~~*0.075*	~~0.180~~*0.380*	~~0.799~~*0.546*

III. GENERAL EQUATIONS FOR CALCULATING PERCENT CHANGES IN EMISSIONS

A. Summary and Explanation

- The applicant will first select ~~which~~*one* of two compliance options ~~he/she wishes to be subject to~~. The first compliance option, referred to as the exhaust and evap model option, uses the exhaust HC emissions models, the evaporative HC emissions changes models, and the CO adjustment ~~factor~~ in determining the HC emissions equivalency of the candidate fuel specifications *based on ozone forming potential*. The second option, referred to as the exhaust-only option, *is set to sunset December 31, 2009 and* uses only the exhaust HC emissions model in the determination of the HC emissions equivalency of the candidate fuel specifications. (See III.B)

  The exhaust and evap model option may only be used for final blends of California gasoline or CARBOB where some part of the final blend is physically transferred from its production or import facility during the Reid vapor pressure control period for the production or import facility set forth in section 2262.4, title 13, California Code of Regulations, or within 15 days before the start of such period.

- 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. ~~The only two cases where two emissions predictions are not~~ *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 ~~candidate fuel specifications is if the oxygen range~~*average* of the ~~candidate fuel specifications is within the range of 1.8 to 2.2 percent (inclusive) or within the range of 2.5 to 2.9 percent (inclusive). In either of these cases, the predicted emissions for the candidate fuel specifications are~~

~~compared to the predicted emissions for the reference fuel specifications at only one~~*two* oxygen level*s*. *If the range is greater than 0.4 percent, then the prediction is based on the individual upper and lower levels.*

- For NOx and exhaust HC, 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 exhaust HC emissions between the candidate fuel specifications and reference fuel specifications. (See III.D.)

- If the exhaust and evap model option has been selected, 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 exhaust and evap model option has been selected, the ~~credit resulting from the reduction of~~ CO emissions a calculated in accordance with the ~~equation~~*equations* given in Section ~~IX~~*VI*.A. (See ~~IX~~*VI*.A)

- If the exhaust and evap model option has been selected, the predicted percent changes in exhaust HC emissions, evaporative HC emissions, and the CO ~~credit~~ *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 ~~VMT~~ weighted *using the toxics weighting factors* and potency-weighted, in accordance with the equations given in VI*I*.B. (See VI*I*.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 ~~VIII~~*IX*.A. Note that emissions predictions for evaporative benzene emissions are made even if the applicant is not using the compliance option which provides for the use of the evaporative HC emissions models. (See ~~VIII~~*IX*.A)

- For both the reference fuel specifications and the candidate fuel specifications, the ~~VMT and~~ 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

Before December 31, 2009, the applicant shall first select ~~which~~*one* of two compliance options ~~he/she wishes to be subject to~~. The first compliance option uses the exhaust HC emissions models, the evaporative HC emissions models, and the CO ~~adjustment factor~~ *emissions model* in determining the HC emissions equivalency of the candidate fuel specifications. The second option uses only the exhaust HC emissions model in the determination of the HC emissions equivalency of the candidate fuel specifications. *After December 31, 2009, the second compliance option sunsets and the first compliance option that uses the exhaust HC emissions models, the evaporative HC emissions models, and the CO emissions model in determining the HC emissions equivalency of the candidate fuel specifications becomes the only compliance option during the RVP control season.*

If the applicant selects the first compliance option, the applicable Phase 3 RVP limits are a flat limit of ~~6.90~~*7.00* and a cap limit of 7.20. That is, if the applicant elects to use the evaporative HC emissions predictive model, all evaporative HC emissions changes predicted by the model for the candidate fuel will be based on the use of ~~6.90~~*7.00* psi as the RVP of the Phase 3 reference fuel. If the applicant selects the second compliance option, the applicable Phase 3 RVP limit is a flat (and cap) limit of 7.00. *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 compliance option which

provides for the use of the evaporative HC emissions models, 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. ~~The oxygen contents of the candidate fuel specifications can be found from Table 6. Note that, because~~ *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). ~~There are two exceptions to this, in which cases it is assumed that the candidate fuel specifications have a single oxygen content. If the oxygen range of the candidate fuel specifications is within the range of 1.8 to 2.2 percent (inclusive), the oxygen content of the candidate fuel specifications is assumed to be 2.0 percent. If the oxygen range of the candidate fuel specifications is within the range of 2.5 to 2.9 percent, the oxygen content of the candidate fuel specifications is assumed to be 2.7 percent. Also, the predictive model equations assume that only one oxygenate is being blended into the gasoline. Thus, it is assumed that the total oxygen content is equal to either the total oxygen content as MTBE or the total oxygen content as ethanol. If the refiner is blending both MTBE and ethanol into a gasoline, a small error will be introduced in the predictive model predictions for formaldehyde and acetaldehyde.~~

3. The hot soak benzene emissions model contains ~~an~~*a* MTBE content term. ~~Thus, for hot soak benzene emissions predictions, it is necessary to specify the oxygen content as MTBE for the candidate and reference fuel. Table 6 is used as in 2. above, using the oxygen content as MTBE of the candidate fuel, to specify the oxygen content as MTBE for the candidate and reference fuel specifications. That is, the~~*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.

6. 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) *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)*

Examples:

If you elect to meet a sulfur limit of 10 for the candidate fuel and elect to comply with a flat limit, the reference fuel sulfur limit would be 20. However, if you elect to meet a sulfur limit of 10 on average, the reference fuel sulfur limit would be 15.

If the oxygen range of the candidate fuel specifications is 2.0 percent to 2.5 percent, the maximum oxygen content of the candidate fuel is 2.5 percent and the minimum oxygen content of the candidate fuel is 2.0 percent. The maximum oxygen content of the reference fuel is 2.0 percent and the minimum oxygen content of the reference fuel is 1.8 percent. The predicted

~~emissions from the candidate fuel specifications with 2.5 percent oxygen are compared to the predicted emissions from the reference fuel specifications with 2.0 percent oxygen, and the predicted emissions from the candidate fuel specifications with 2.0 percent oxygen are compared to the predicted emissions from the reference fuel specifications with 1.8 percent oxygen. These comparisons are described by row 2 of 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	≥ 1.8, ≤ 2.2	1	2.0	2.0
≥ 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
≥ 2.5, ≤ 2.9	≥ 2.5, ≤ 2.9	1	2.7	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

<u>Table 6</u>

<u>Candidate and Reference Specifications for Oxygen</u>

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

Does the applicant which to use the evaporative HC emissions model and the CO adjustment factor in the evaluation of the equivalency of the candidate fuel specifications? YES ___ NO ___

If the above question is answered yes, the *reference fuel* flat RVP limit is ~~6.90~~*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, 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] ~~/ 7.00~~	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) (max)	Flat-Range	(min) (max)	None
Oxygen[3] (as MTBE)	(min) (max)	Not Applicable	Not Applicable	None
Oxygen[4] (as EtOH)	(min) (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 ~~If the oxygen content range for the candidate fuel is ≥ 1.8 and ≤ 2.2, the candidate fuel and reference fuel oxygen value used in the predictive model equation is 2.0. For all other cases, see Table 6, Candidate and Reference Specifications for Oxygen.~~ *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 use the evaporative HC emissions models, the flat RVP limit is 6.90. That is, all predictions for evaporative emissions increases or decreases are made relative to 6.90 psi. If the applicant has elected not to use the evaporative HC emissions models, the flat RVP limit is 7.00. The exhaust models contain an RVP term, but this term has been made constant by fixing the RVP for both the reference and candidate fuels at 7.00 psi in the calculation of the standardized RVP values used in the exhaust emissions equations. This fixing of the RVP takes RVP out of the exhaust models as a fuel property which effects exhaust emissions.~~ *If the applicant elects to certify an alternative formulation without theuse 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.

$$ln\ y_{Tech} = \text{intercept} + \Sigma\ [(\text{fuel effects coefficient}) \times (\text{standardized fuel property})]$$

or

$$y_{Tech} = \text{Exp}\ \{\text{intercept} + \Sigma\ [(\text{fuel effects coefficient}) \times (\text{standardized fuel property})]\}$$

where

ln is the natural logarithm.

Exp is the exponential.

$\mathbf{y_{Tech}}$ is the exhaust emission prediction in grams per mile (for NOx, ~~and~~ 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, ~~and~~*Exhaust* HC*, 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, Exhaust HC*, and CO* Equations, and Table 14, Coefficients for Exhaust Toxics Equations.

standardized fuel property is defined as:

standardized fuel property =

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

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, ~~and~~ exhaust HC*, 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, ~~and~~ 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, ~~or~~ HC*, or 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, Exhaust HC, *and CO* Emissions:

%CE = *percent* change in emissions =

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

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 is calculated as shown below.

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

$$\sum\{[((y_{\text{Tech 3q-CAND}}) \times (\cancel{V}MTWF_3)) + ((y_{\text{Tech 4q-CAND}}) \times (\cancel{V}MTWF_4)) + ((y_{\text{Tech 5q-CAND}}) \times (\cancel{V}MTWF_5))] \times (PWF_q)\}$$

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

$$\sum\{[((y_{\text{Tech 3q-REF}}) \times (\cancel{V}MTWF_3)) + ((y_{\text{Tech 4q-REF}}) \times (\cancel{V}MTWF_4)) + ((y_{\text{Tech 5q-REF}}) \times (\cancel{V}MTWF_5))] \times (PWF_q)\}$$

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

~~VM~~TWF$_3$, **~~VM~~TWF**$_4$, **~~VM~~TWF**$_5$ are the ~~VMT~~*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 VI*I*.B.1 for the candidate fuel specifications and Section VI*I*.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~~	~~{-0.0794329063 +~~
~~RVP (constant)~~	~~(-0.037472865) +~~
~~Sulfur~~	~~$(0.0159437432)\ \frac{(SULFUR - 195.344776)}{131.660328}$ +~~
~~Aromatic HC~~	~~$(0.0532102243)\ \frac{(AROM - 30.908412)}{9.487116}$ +~~
~~Olefin~~	~~$(0.0230182271)\ \frac{(OLEF - 8.433311)}{5.873226}$ +~~
~~Oxygen~~	~~$(0.0172437318)\ \frac{(OXY - 0.877509)}{1.233789}$ +~~
~~T50~~	~~$(-0.0098269256)\ \frac{(T50 - 211.692062)}{16.882813}$ +~~
~~T90~~	~~$(-0.0005174949)\ \frac{(T90 - 315.301357)}{25.72665}$ +~~
~~RVPT50~~	~~$(-0.0080077184)\ \frac{(7 - 8.626364)}{0.588437}\ \frac{(T50 - 211.692062)}{16.882813}$ +~~

~~T50T90 (0.0075452045) (T50 - 211.692062) (T90 - 315.301357) +~~
~~16.882813 25.72665~~

~~AROT90 (-0.0096828310) (ARO - 30.908412) (T90 - 315.301357)~~ }
~~9.487116 25.72665~~

Exp

intercept {-0.159800 +

RVP (0.424915) +

Sulfur (0.028040) (SULFUR - 139.691080) +
126.741459

Aromatic HC (0.047060) (AROM - 30.212969) +
8.682044

Olefin (0.021110) (OLEF - 7.359624) +
5.383804

Oxygen (0.014910) (OXY - 0.892363) +
1.235405

T50 (-0.007360) (T50 - 212.245188) +
15.880385

T90 (0.000654) (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 {-0.6016053913 +~~

~~RVP (constant) (-0.009882551) +~~

~~Sulfur (0.0432360679) (SULFUR - 180.770373) / 147.006156 +~~

~~Aromatic HC (0.0090548129) (AROM - 27.849881) / 7.004743 +~~

~~Olefin (0.0184655971) (OLEF - 6.806801) / 4.665131 +~~

~~Oxygen (0.0137833705) (OXY - 1.355654) / 1.224639 +~~

~~T50 (-0.0001960893) (T50 - 207.019049) / 17.195294 +~~

~~T90 (-0.0005521256) (T90 - 311.785331) / 21.595186 +~~

~~AROOXY (-0.0058732618) (AROM - 27.849881) / 7.004743 (OXY - 1.355654) / 1.224639 +~~

~~OXYOXY (0.0102435186) (OXY - 1.355654) / 1.224639 (OXY - 1.355654) / 1.224639~~ }

Exp

intercept {-0.634694 +

RVP (-0.007046) +

Sulfur (0.051043) (SULFUR - 154.120828) / 136.790450 +

Aromatic HC (0.011366) (AROM - 27.317137) / 6.880833 +

Olefin (0.017193) (OLEF - 6.549450) / 4.715345 +

Oxygen $(0.028711)\dfrac{(OXY - 1.536017)}{1.248887}$ +

T50 $(-0.002431)\dfrac{(T50 - 205.261051)}{17.324472}$ +

T90 $(0.002087)\dfrac{(T90 - 310.931422)}{20.847425}$ +

T50T50 $(0.006268)\dfrac{(T50 - 205.261051)}{17.324472}\dfrac{(T50 - 205.261051)}{17.324472}$ +

T90ARO $(-0.002892)\dfrac{(T90 - 310.931422)}{20.847425}\dfrac{(AROM - 27.317137)}{6.880833}$ +

OXYOXY $(0.010737)\dfrac{(OXY - 1.536017)}{1.248887}\dfrac{(OXY - 1.536017)}{1.248887}$ }

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, ~~T50~~*OXY*, and T90 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for ~~OXY~~*T50* is 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 $_{(LIN)}$ = -0.895 + (0.0512 x AROM)~~

~~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~~*6* ~~worksheet is the value for OXY.~~ *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 ($y_{Tech\ 5\text{-}CAND}$) and reference ($y_{Tech\ 5\text{-}REF}$) specifications for Tech 5 are calculated as follows:

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

Description	Equation	
	~~Exp~~	
~~intercept~~	~~{-1.728220052~~	~~+~~
~~RVP (constant)~~	~~(-0.010505860)~~	~~+~~
~~Sulfur~~	~~(0.432840567) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(0.010121940) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Olefin~~	~~(0.018827975) (OLEF - 6.806801) / 4.665131~~	~~+~~
~~Oxygen~~	~~(0.013712404) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T50~~	~~(-0.001476484) (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90~~	~~(-0.004765110) (T90 - 311.785331) / 21.595186~~	~~+~~
~~AROOXY~~	~~(-0.005918359) (AROM - 27.849881) / 7.004743 (OXY - 1.355654) / 1.224639~~	~~+~~
~~OXYOXY~~	~~(0.010133923) (OXY - 1.355654) / 1.224639 (OXY - 1.355654) / 1.224639~~ }	
	Exp	
intercept	*{-1.599255*	+
RVP	*(-0.000533)*	+

$$\text{Sulfur} \quad \frac{(0.947915)\,(SULFUR - 144.6289001)}{140.912234} \; +$$

$$\text{Aromatic HC} \quad \frac{(0.013671)\,(AROM - 26.875944)}{6.600312} \; +$$

$$\text{Olefin} \quad \frac{(0.017335)\,(OLEF - 6.251891)}{4.431845} \; +$$

$$\text{Oxygen} \quad \frac{(0.016036)\,(OXY - 1.551772)}{1.262823} \; +$$

$$\text{T50} \quad \frac{(0.012397)\,(T50 - 206.020870)}{16.582090} \; +$$

$$\text{T90} \quad \frac{(0.000762)\,(T90 - 310.570200)}{22.967591} \; +$$

$$\text{T50T50} \quad (-0.022211)\,\frac{(T50 - 206.020870)}{16.582090}\,\frac{(T50 - 206.020870)}{16.582090} \; +$$

$$\text{T50OXY} \quad (-0.015564)\,\frac{(T50 - 206.020870)}{16.582090}\,\frac{(OXY - 1.551772)}{1.262823} \; +$$

$$\text{OXYOXY} \quad (0.015199)\,\frac{(OXY - 1.551772)}{1.262823}\,\frac{(OXY - 1.551772)}{1.262823} \; \}$$

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, ~~T50,~~ and T90 are equal to the corresponding values for the candidate specifications in the Table 7 worksheet. The value for OXY *and T50* ~~is~~*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) = -0.895 + (0.0512 x AROM)*~~ *$OXYGEN_{(LIN)} = -7.148 + (0.039 \times T50)$*

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

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

$\mathbf{y_{Tech\ 3\text{-}REF}}$, $\mathbf{y_{Tech\ 4\text{-}REF}}$, and $\mathbf{y_{Tech\ 5\text{-}REF}}$ 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.

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

V. EXHAUST HYDROCARBONS (HC) EMISSIONS CALCULATIONS

A. Exhaust HC 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. Exhaust HC 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~~	~~{-0.79146931~~ ~~+~~
~~RVP (constant)~~	~~(-0.001311794)~~ ~~+~~
~~Sulfur~~	~~(0.0055023672)~~ ~~$\left(\frac{\text{SULFUR} - 195.344776}{131.660328}\right)$~~ ~~+~~
~~Aromatic HC~~	~~(-0.0437495823)~~ ~~$\left(\frac{\text{AROM} - 30.908412}{9.487116}\right)$~~ ~~+~~
~~Olefin~~	~~(-0.0306356465)~~ ~~$\left(\frac{\text{OLEF} - 8.433311}{5.873226}\right)$~~ ~~+~~
~~Oxygen~~	~~(-0.0268848312)~~ ~~$\left(\frac{\text{OXY} - 0.877509}{1.233789}\right)$~~ ~~+~~
~~T50~~	~~(0.0108590213)~~ ~~$\left(\frac{\text{T50} - 211.692062}{16.882813}\right)$~~ ~~+~~
~~T90~~	~~(0.0021787792)~~ ~~$\left(\frac{\text{T90} - 315.301357}{25.72665}\right)$~~ ~~+~~
~~SULARO~~	~~(-0.0456568399)~~ ~~$\left(\frac{\text{SULFUR} - 195.344776}{131.660328}\right)\left(\frac{\text{AROM} - 30.908412}{9.487116}\right)$~~ ~~+~~

~~RVPT50 (-0.0174815748) (7 - 8.626364) (T50 - 211.692062)~~ }

~~0.588437 16.882813~~

Exp

intercept {-0.752270 +

RVP (0.000013) +

Sulfur (0.038207) (SULFUR - 139.691080) +
126.741459

Aromatic HC (0.014103) (AROM - 30.212969) +
8.682044

Olefin (-0.016533) (OLEF - 7.359624) +
5.383804

Oxygen (-0.026365) (OXY - 0.892363) +
1.235405

T50 (0.015847) (T50 - 212.245188) +
15.880385

T90 (0.011768) (T90 - 312.121596) +
23.264684

T90ARO (0.016606) (T90 - 312.121596) (AROM - 30.212969) +
23.264684 8.682044

T90OLE (-0.007995) (T90 - 312.121596) (OLEF - 7.359624) }
23.264684 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. Exhaust HC 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 = $y_{\text{Tech 4}}$ =

<u>Description</u>	<u>Equation</u>
	~~Exp~~
~~intercept~~	~~{-1.131422309 +~~
~~RVP (constant)~~	~~(0.022383518) +~~
~~Sulfur~~	~~(0.092788380)~~ $\left(\frac{SULFUR - 180.770373}{147.006156}\right)$ ~~+~~
~~Aromatic HC~~	~~(0.000103714)~~ $\left(\frac{AROM - 27.849881}{7.004743}\right)$ ~~+~~
~~Olefin~~	~~(-0.009384652)~~ $\left(\frac{OLEF - 6.806801}{4.665131}\right)$ ~~+~~
~~Oxygen~~	~~(-0.013881563)~~ $\left(\frac{OXY - 1.355654}{1.224639}\right)$ ~~+~~
~~T50~~	~~(0.060684722)~~ $\left(\frac{T50 - 207.019049}{17.195294}\right)$ ~~+~~
~~T90~~	~~(0.040077769)~~ $\left(\frac{T90 - 311.785331}{21.595186}\right)$ ~~+~~
~~AROARO~~	~~(-0.008602222)~~ $\left(\frac{AROM - 27.849881}{7.004743}\right)\left(\frac{AROM - 27.849881}{7.004743}\right)$ ~~+~~
~~AROT90~~	~~(0.008466012)~~ $\left(\frac{AROM - 27.849881}{7.004743}\right)\left(\frac{T90 - 311.785331}{21.595186}\right)$ ~~+~~
~~OXYT90~~	~~(0.010447976)~~ $\left(\frac{OXY - 1.355654}{1.224639}\right)\left(\frac{T90 - 311.785331}{21.595186}\right)$ ~~+~~
~~T50T50~~	~~(0.020099767)~~ $\left(\frac{T50 - 207.019049}{17.195294}\right)\left(\frac{T50 - 207.019049}{17.195294}\right)$ ~~+~~
~~T90T90~~	~~(0.016985255)~~ $\left(\frac{T90 - 311.785331}{21.595186}\right)\left(\frac{T90 - 311.785331}{21.595186}\right)$ }
	<u>*Exp*</u>

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	$(0.017086) \frac{(T50 - 205.261051)}{17.324472} \frac{(T50 - 205.261051)}{17.324472} +$
T50OXY	$(0.013724) \frac{(T50 - 205.261051)}{17.324472} \frac{(OXY - 1.536017)}{1.248887} +$
T90T90	$(0.013914) \frac{(T90 - 310.931422)}{20.847425} \frac{(T90 - 310.931422)}{20.847425} +$
AROARO	$(-0.010999) \frac{(AROM - 27.317137)}{6.880833} \frac{(AROM - 27.317137)}{6.880833} +$
AROOXY	$(0.007221) \frac{(AROM - 27.317137)}{6.880833} \frac{(OXY - 1.536017)}{1.248887} \}$

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, ~~AROM,~~ 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 ~~181.1~~ *T50 $_{(LIN)}$* then ~~181.1~~ *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 ~~181.1~~ *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 $_{(LIN)}$~~*283* value, then the ~~T90 $_{(LIN)}$~~*283* value is the value for T90. ~~where T90 $_{(LIN)}$ is calculated as follows:~~

~~$T90_{(LIN)} = 316.9 - (0.8235 \times AROM) - (5.41 \times OXY)$~~

If the value for the candidate T90 specification in the Table 7 worksheet is greater than or equal to the ~~T90 $_{(LIN)}$~~*283* value, then the T90 specification in the Table 7 worksheet is the value for T90.

3. Exhaust HC 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~~	~~{-2.506947412~~	~~+~~
~~RVP (constant)~~	~~(0.023617461)~~	~~+~~
~~Sulfur~~	~~(0.255035043) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(0.000975711) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Olefin~~	~~(-0.009675903) (OLEF - 6.806801) / 4.665131~~	~~+~~
~~Oxygen~~	~~(-0.014748918) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T50~~	~~(0.057474407) (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90~~	~~(0.038464284) (T90 - 311.785331) / 21.595186~~	~~+~~
~~AROARO~~	~~(-0.008618124) (AROM - 27.849881) / 7.004743 (AROM - 27.849881) / 7.004743~~	~~+~~
~~AROT90~~	~~(0.008824753) (AROM - 27.849881) / 7.004743 (T90 - 311.785331) / 21.595186~~	~~+~~
~~OXYT90~~	~~(0.010141739) (OXY - 1.355654) / 1.224639 (T90 - 311.785331) / 21.595186~~	~~+~~
~~T50T50~~	~~(0.019045885) (T50 - 207.019049) / 17.195294 (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90T90~~	~~(0.016517838) (T90 - 311.785331) / 21.595186 (T90 - 311.785331) / 21.595186~~	}

Exp

intercept	*{-2.671187*	+
RVP	*(-0.012824)*	+

Sulfur	$\frac{(0.242238)\ (SULFUR - 144.628901)}{140.912204}$	+
Aromatic HC	$\frac{(0.003039)\ (AROM - 26.875944)}{6.600312}$	+
Olefin	$\frac{(-0.010908)\ (OLEF - 6.251891)}{4.431845}$	+
Oxygen	$\frac{(-0.007528)\ (OXY - 1.551772)}{1.262823}$	+
T50	$\frac{(0.056796)\ (T50 - 206.020870)}{16.582090}$	+
T90	$\frac{(0.010803)\ (T90 - 310.570200)}{22.967591}$	+
T50ARO	$\frac{(0.016761)\ (T50 - 206.020870)\ (AROM - 26.875944)}{16.582090 \qquad 6.600312}$	+
T50T50	$\frac{(0.019563)\ (T50 - 206.020870)\ (T50 - 206.020870)}{16.582090 \qquad 16.582090}$	+
T50OXY	$\frac{(0.014082)\ (T50 - 206.020870)\ (OXY - 1.551772)}{16.582090 \qquad 1.262823}$	+
T90T90	$\frac{(0.015216)\ (T90 - 310.570200)\ (T90 - 310.570200)}{22.967591 \qquad 22.9675901}$	+
T90OXY	$\frac{(0.013372)\ (T90 - 310.570200)\ (OXY - 1.551772)}{22.967590 \qquad 1.262823}$	+
AROARO	$\frac{(-0.009740)\ (AROM - 26.875944)\ (AROM - 26.875944)}{6.600312 \qquad 6.600312}$	+
AROOXY	$\frac{(0.006902)\ (AROM - 26.875944)\ (OXY - 1.551772)}{6.600312 \qquad 1.262823}$	}

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, ~~AROM,~~ 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 ~~181.1~~ $T50_{(LIN)}$, then ~~181.1~~ $T50_{(LIN)}$ 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 ~~181.1~~ $T50_{(LIN)}$, 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:
>
> ~~$T90_{(LIN)} = 316.9 - (0.8235 \times AROM) - (5.41 \times OXY)$~~ $T90_{(LIN)} = 314.8 - (8.0 \times OXY)$
>
> 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 Exhaust HC Emissions

The percent change in exhaust HC 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

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

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

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

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

$EWF_{3\text{-}HC}$, $EWF_{4\text{-}HC}$, and **$EWF_{5\text{-}HC}$** 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 ($y_{Tech\ 3\text{-}CAND}$) and reference ($y_{Tech\ 3\text{-}REF}$) specifications for Tech 3 are calculated as follows:

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

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

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. 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	$(0.073616)\frac{(SULFUR - 154.120828)}{136.790450}$	+
Aromatic HC	$(0.025960)\frac{(AROM - 27.317137)}{6.880833}$	+
Olefin	$(0.001263)\frac{(OLEF - 6.549450)}{4.715345}$	+
Oxygen	$(-0.052530)\frac{(OXY - 1.536017)}{1.248887}$	+
T50	$(0.022750)\frac{(T50 - 205.261051)}{17.324472}$	+
T90	$(-0.008820)\frac{(T90 - 310.931422)}{20.847425}$	+
OXYOXY	$(-0.016510)\frac{(OXY - 1.536017)}{1.248887}\frac{(OXY - 1.536017)}{1.248887}$	+
T50ARO	$(0.009884)\frac{(T50 - 205.261051)}{17.324472}\frac{(AROM - 27.317137)}{6.880833}$	+
T90OLE	$(-0.007360)\frac{(T90 - 310.931422)}{20.847425}\frac{(OLEF - 6.549450)}{4.715345}$	+

T90T90 (0.007767) (T90 - 310.931422) (T90 - 310.931422) }
20.847425 20.847450

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

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

Description	*Equation*
	Exp
intercept	*{-0.240521 +*
RVP	*(-0.014137) +*
Sulfur	*(0.123649) (SULFUR - 144.628901) / 140.91224 +*
Aromatic HC	*(0.025775) (AROM - 26.875944) +*

$$\frac{}{6.600312}$$

Olefin (0.005001) (OLEF - 6.251891) +

$$\frac{(0.005001)(OLEF - 6.251891)}{4.431845} +$$

Oxygen

$$\frac{(-0.087967)(OXY - 1.551772)}{1.262823} +$$

T50

$$\frac{(0.018195)(T50 - 206.020870)}{16.582090} +$$

T90

$$\frac{(-0.128296)(T90 - 310.570200)}{22.967591} +$$

OXYOXY

$$(0.026309)\frac{(OXY - 1.551772)}{1.262823}\frac{(OXY - 1.551772)}{1.262823} +$$

T50ARO

$$(0.009797)\frac{(T50 - 206.020870)}{16.582090}\frac{(AROM - 26.875944)}{6.600312} +$$

T50OXY

$$(0.021763)\frac{(T50 - 206.020870)}{16.582090}\frac{(OXY – 1.551772)}{1.262823} \}$$

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.

VI~~I~~. 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) (SULFUR - 195.344776) / 131.660328~~	~~+~~
~~Aromatic HC~~	~~(0.15191575) (AROM - 30.908412) / 9.487116~~	~~+~~
~~Oxygen~~	~~(-0.03295985) (OXY - 0.877509) / 1.233789~~	~~+~~
~~BENZ~~	~~(0.12025037) (BENZ - 1.389446) / 0.436822~~ }	
Sulfur	*(0.0683768) (SULFUR – 139.691080) / 126.741459*	+
Aromatic HC	*(0.15191575) (AROM - 30.212969) / 8.682044*	+
Oxygen	*(-0.03295985) (OXY - 0.892363) / 1.235405*	+
BENZ	*(-0.12025037) (BENZ - 1.36412) / 0.513051*	}

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

Description	Equation	
	Exp	
intercept	{0.67173886	+
~~Olefin~~	~~(0.18408319) (OLEF - 8.433311) / 5.873226~~	~~+~~
~~T50~~	~~(0.11391774) (T50 - 211.692062) / 16.882813~~ }	
Olefin	*(0.18408319) (OLEF - 7.359624) / 5.383804*	+
T50	*(0.11391774) (T50 - 212.245188) / 15.880385* }	

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

Description	Equation
	~~Exp~~
~~intercept~~	~~{2.16836424 +~~
~~BENZ~~	~~(-0.1423482) (BENZ - 1.389446) / 0.436822 +~~
~~Aromatic HC~~	~~(-0.07537099) (AROM - 30.908412) / 9.487116 +~~
~~Oxygen~~	~~(0.12278577) (OXY - 0.877509) / 1.233789 +~~
~~Oxygen (as EtOH)[1]~~	~~(-0.12295089) (Type) (OXY - 0.877509) / 1.233789~~ }
	Exp
intercept	*{2.16836424 +*
Aromatic HC	*(-0.07537099) (AROM - 30.212969) / 8.682044 +*
Oxygen	*(0.12278577) (OXY - 0.892363) / 1.235405 +*
Oxygen (as EtOH)[1]	*(-0.12295089) (Type) (OXY - 0.892363) / 1.235405 +*
BENZ	*(-0.1423482) (BENZ - 1.36412) / 0.513051* }

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

Description	Equation
	~~Exp~~
~~intercept~~	~~{1.10122139 +~~
~~Oxygen~~	~~(0.00122983) (OXY - 0.877509) / 1.233789 +~~
~~Oxygen (as EtOH)[1]~~	~~(0.54678495) (Type) (OXY - 0.877509) / 1.233789 +~~
~~Aromatic HC~~	~~(-0.09219416) (AROM - 30.908412) / 9.487116 }~~
	Exp
intercept	*{1.10122139 +*
Aromatic HC	*(-0.09219416) (AROM - 30.212969) / 8.682044 +*
Oxygen	*(0.00122983) (OXY - 0.892363) / 1.235405 +*
Oxygen (as EtOH)[1]	*(0.54678495) (Type) (OXY - 0.892363) / 1.235405 }*

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	+
~~RVP (constant)~~	~~(-0.048140014)~~	~~+~~
~~Sulfur~~	~~(0.09652526) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(0.15517085) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Olefin~~	~~(-0.02548759) (OLEF - 6.806801) / 4.665131~~	~~+~~
~~T50~~	~~(0.04666208) (T50 - 207.019049) / 17.195294~~	~~+~~
~~BENZ~~	~~(0.11689441) (BENZ - 1.009607) / 0.530184~~ }	
	Exp	
intercept	*{2.3824773*	*+*
RVP	*(0.07392876)*	*+*
Sulfur	*(0.09652526) (SULFUR - 154.120828) / 136.790450*	*+*
Aromatic HC	*(0.15517085) (AROM - 27.317137) / 6.880833*	*+*
Olefin	*(-0.02548759) (OLEF - 6.549450) / 4.715345*	*+*

T50 $$\frac{(0.04666208)\,(T50 - 205.261051)}{17.324472} +$$

BENZ $$\frac{(0.11689441)\,(BENZ - 1.014259)}{0.537392} \Big\}$$

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

Description	Equation	
	Exp	
intercept	{0.43090426	+
~~BENZ~~	~~$(0.03644387)\frac{(BENZ - 1.009607)}{0.530184}$~~	~~+~~
~~Aromatic HC~~	~~$(-0.03604344)\frac{(AROM - 27.849881)}{7.004743}$~~	~~+~~
~~Olefin~~	~~$(0.10354089)\frac{(OLEF - 6.806801)}{4.665131}$~~	~~+~~
~~Oxygen~~	~~$(-0.02511374)\frac{(OXY - 1.355654)}{1.224639}$~~	~~+~~
~~T50~~	~~$(0.03707822)\frac{(T50 - 207.019049)}{17.195294}$~~	~~+~~
~~T90~~	~~$(0.09454201)\frac{(T90 - 311.785331)}{21.595186}$~~ }	
Aromatic HC	*$(-0.03604344)\frac{(AROM - 27.317137)}{6.880833}$*	+
Olefin	*$(0.10354089)\frac{(OLEF - 6.549450)}{4.715345}$*	+
Oxygen	*$(-0.02511374)\frac{(OXY - 1.536017)}{1.248887}$*	+
T50	*$(0.03707822)\frac{(T50 - 205.261051)}{17.324472}$*	+
T90	*$(0.09454201)\frac{(T90 - 310.931422)}{20.847425}$*	+

BENZ (0.03644387) (BENZ - 1.01425) }

0.537392

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

Description	Equation	
	Exp	
intercept	{1.05886661	+
~~Sulfur~~	~~(-0.04135075) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(-0.05466283) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Oxygen~~	~~(0.06370091) (OXY - 1.355654) / 1.224639~~	~~+~~
~~Oxygen (as EtOH)[1]~~	~~(-0.09819814) (Type) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T90~~	~~(0.06037698) (T90 - 311.785331) / 21.595186~~	}
Sulfur	*(-0.04135075) (SULFUR - 154.120828) / 136.790450*	+
Aromatic HC	*(-0.05466283) (AROM - 27.317137) / 6.880833*	+
Oxygen	*(0.06370091) (OXY - 1.536017) / 1.248887*	+
Oxygen (as EtOH)[1]	*(-0.09819814) (Type) (OXY - 1.536017) / 1.248887*	+
T90	*(0.06037698) (T90 - 310.981422) / 20.847425*	}

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

Description	Equation	
	Exp	
intercept	{0.16738341	+
~~Aromatic HC~~	~~(-0.05552641) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Sulfur~~	~~(0.02788263) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~BENZ~~	~~(0.06148653) (BENZ - 1.009607) / 0.530184~~	~~+~~
~~Oxygen~~	~~(0.02382123) (OXY - 1.355654) / 1.224639~~	~~+~~
~~Oxygen (as EtOH)[1]~~	~~(0.46699012) (Type) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T50~~	~~(0.04314573) (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90~~	~~(0.06252964) (T90 - 311.785331) / 21.595186~~ }	
Sulfur	*(0.02788263) (SULFUR - 154.120828) / 136.790450*	*+*
Aromatic HC	*(-0.05552641) (AROM - 27.317137) / 6.880833*	*+*
Oxygen	*(0.02382123) (OXY - 1.536017) / 1.248887*	*+*
Oxygen (as EtOH)[1]	*(0.46699012) (Type) (OXY - 1.536017) / 1.248887*	*+*

T50 (0.04314573) (T50 - 205.261051) / 17.324472 +

T90 (0.06252964) (T90 - 310.931422) / 20.847425 +

BENZ (0.06148653) (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 (constant)~~	~~(-0.0480140014)~~	~~+~~
~~Sulfur~~	~~(0.09652526) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(0.15517085) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Olefin~~	~~(-0.02548759) (OLEF - 6.806801) / 4.665131~~	~~+~~
~~T50~~	~~(0.04666208) (T50 - 207.019049) / 17.195294~~	~~+~~

~~BENZ (0.11689441) (BENZ - 1.009607)~~ }
~~0.530184~~

RVP (0.06514198) +

Sulfur (0.09652526) (SULFUR - 144.628901) +
140.91224

Aromatic HC (0.15517085) (AROM - 26.875944) +
6.600312

Olefin (-0.02548759) (OLEF - 6.251891) +
4.431845

T50 (0.04666208) (T50 - 206.020870) +
16.582090

BENZ (0.11689441) (BENZ - 0.969248) }
0.504325

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

Description	Equation	
	Exp	
intercept	{0.43090426	+
~~BENZ~~	~~(0.03644387) (BENZ - 1.009607) / 0.530184~~	~~+~~
~~Aromatic HC~~	~~(-0.03604344) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Olefin~~	~~(0.10354089) (OLEF - 6.806801) / 4.665131~~	~~+~~
~~Oxygen~~	~~(-0.02511374) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T50~~	~~(0.03707822) (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90~~	~~(0.09454201) (T90 - 311.785331) / 21.595186~~ }	
Aromatic HC	*(-0.03604344) (AROM - 26.875944) / 6.600312*	+
Olefin	*(0.10354089) (OLEF - 6.251891) / 4.431845*	+
Oxygen	*(-0.02511374) (OXY - 1.551772) / 1.262823*	+
T50	*(0.03707822) (T50 - 206.020870) / 16.582090*	+
T90	*(0.09454201) (T90 - 310.570200) / 22.967591*	+

BENZ (0.03644387) (BENZ - 0.969248) }

0.504325

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

Description	Equation	
	Exp	
intercept	{1.05886661	+
~~Sulfur~~	~~(-0.04135075) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~Aromatic HC~~	~~(-0.05466283) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Oxygen~~	~~(0.06370091) (OXY - 1.355654) / 1.224639~~	~~+~~
~~Oxygen (as EtOH)[1]~~	~~(-0.09819814) (Type) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T90~~	~~(0.06037698) (T90 - 311.785331) / 21.595186~~ }	
Sulfur	*(-0.04135075) (SULFUR - 144.628901) / 140.91224*	+
Aromatic HC	*(-0.05466283) (AROM - 26.875940) / 6.600312*	+
Oxygen	*(0.06370091) (OXY - 1.551772) / 1.262823*	+
Oxygen (as EtOH)[1]	*(-0.09819814) (Type) (OXY - 1.551772) / 1.262823*	+
T90	*(0.000000) (T90 - 310.570200) / 22.967591* }	

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	+
~~Aromatic HC~~	~~(-0.05552641) (AROM - 27.849881) / 7.004743~~	~~+~~
~~Sulfur~~	~~(0.02788263) (SULFUR - 180.770373) / 147.006156~~	~~+~~
~~BENZ~~	~~(0.06148653) (BENZ - 1.009607) / 0.530184~~	~~+~~
~~Oxygen~~	~~(0.02382123) (OXY - 1.355654) / 1.224639~~	~~+~~
~~Oxygen (as EtOH)[1]~~	~~(0.46699012) (Type) (OXY - 1.355654) / 1.224639~~	~~+~~
~~T50~~	~~(0.04314573) (T50 - 207.019049) / 17.195294~~	~~+~~
~~T90~~	~~(0.06252964) (T90 - 311.785331) / 21.595186~~ }	
Sulfur	*(0.02788263) (SULFUR - 144.628901) / 140.91224*	+
Aromatic HC	*(-0.05552641) (AROM - 26.875944) / 6.600312*	+
Oxygen	*(0.02382123) (OXY - 1.551772) / 1.262823*	+
Oxygen (as EtOH)[1]	*(0.046699012) (Type) (OXY - 1.551772) / 1.262823*	+
T50	*(0.04314573) (T50 - 206.020870)*	+

16.582090

T90 (0.06252964) (T90 - 310.570200) +
22.967591

BENZ (0.06148653) (BENZ - 0.969248) }
0.504325

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 ~~VMT-Weighted and~~ Potency-weighted *Exhaust Toxics* Emissions for Candidate Specifications

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

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

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

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

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

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.

$\cancel{VM}TWF_3$, **$\cancel{VM}TWF_4$**, and **$\cancel{VM}TWF_5$** are the ~~VMT~~ *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 ~~Percent VMT and~~ Potency-Weighted Emissions for Reference Specifications

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

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

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

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

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

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.

$\cancel{VM}TWF_3$, **$\cancel{VM}TWF_4$**, and **$\cancel{VM}TWF_5$** are the ~~VMT~~ *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 ~~OF~~FOR CHANGES IN EVAPORATIVE HYDROCARBON (HC) EMISSIONS

A. Evaporative HC Emissions by Process

The evaporative HC models predict the percent change in evaporative HC emissions as a function of RVP *in psi*, relative to ~~an~~*a reference fuel's* RVP ~~of 6.9 psi~~. 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 ~~the~~*a particular* reference fuel. There are three evaporative HC models~~, one~~ *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*:*

~~$\% CE_{DIRES} = 100 \times Exp[-1.6175913018 + (0.234433522 \times RVP)] - 100$~~

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

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:

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

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*:*

~~$\% CE_{HS} = 100 \times Exp[-5.57770591578 + (1.14227006 \times RVP) - (0.048392302 \times RVP^2)] - 100$~~

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

where RVP is the RVP of the candidate fuel.

*b. The predicted percent change in Hot Soak Emissions (% **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 (% **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 (% **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.

~~**3. Running Loss Emissions**~~

~~The predicted percent change in Running Loss Emissions (% CE_{RL}) is~~

~~$\% \ CE_{RL} = (10.636 \times RVP^2) - (112.211 \times RVP) + 267.87594$~~

~~where RVP is the RVP of the candidate fuel.~~

~~VIII~~*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:

$EVBenz_{DIRES}$= {~~572 x [Exp(-4.304062385 + (0.234434005 x RVP))]~~ *592 x [(3.730921 x RVP + 43.589427) x 907.18 / 939430)]* x
[(0.0294917804 x Benz) - (0.0017567009 x Benz x RVP)]}

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

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

$EVBenz_{HS}$= {~~572 x [Exp(-8.498652909 + (1.142251184 x RVP)~~ *592 x [(4.369978 x RVP + 10.356585) x 907.18 / 939430]* ~~-~~
~~(0.048390975 x RVP2))]~~ x [(0.0463141591 x Benz) -
(0.0027179513 x Benz x RVP) ~~-~~*=* (~~0.00014358120~~*0.0008184128* x

Benz x 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:

~~$EVBenz_{RL} = \{572 \times [0.3925594957 - (0.1197399622 \times RVP) + (0.011349611 \times RVP^2)] \times [(0.0648391842 \times Benz) - (0.005622979 \times Benz \times RVP)]\}$~~

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

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.

~~If the applicant elects not to use the compliance option which provides for the use of the evaporative HC emissions models, the RVP of both the reference fuel and candidate fuel is assumed to be 7.00 for purposes of using the equations in this section to calculate evaporative benzene emissions.~~

IX. CREDIT FOR REDUCTIONS IN CO EMISSIONS

In recognition of the ozone-forming potential of CO emissions, the Phase 3 RFG regulations and the predictive model calculations allow a HC reduction credit for the reductions in CO emissions which result from the addition of oxygen to gasoline. The amount of the credit is proportional to the oxygen content of the candidate predictive model gasoline. However, the credit is allowed only if the oxygen content of the candidate predictive model gasoline is greater than a nominal 2.0 percent. Because the Phase 3 RFG gasoline regulations and these Predictive Model Procedures regard any actual oxygen content between 1.8 percent and 2.2 percent, inclusive, as a nominal 2.0 percent, the CO credit would not be given until the actual oxygen content of the gasoline is greater than 2.2 percent (The credit would be 0 for actual oxygen contents less than or equal to 2.2 percent). There is no penalty, or debit, assessed for candidate predictive model gasolines with oxygen contents less than a nominal 2.0 percent.

A. Equation for Computing the CO Reduction Credit

The CO emissions reduction credit is a function only of the oxygen content of the candidate predictive model gasoline and is computed using the following equation:

$$\%CE_{CO} = (OXY - 2.0) \times (-5.93333) \qquad \text{If } OXY > 2.2$$
$$\%CE_{CO} = 0 \qquad \text{If } OXY \leq 2.2$$

where

$\%CE_{CO}$ is the predicted percent reduction in CO emissions relative to the nominal 2.0 percent oxygen, and

OXY is the oxygen content of the candidate gasoline, in percent by weight.

X. COMBINATION OF EXHAUST HC EMISSIONS PREDICTION*S*, EVAPORATIVE HC EMISSIONS PREDICTIONS, AND CO ~~REDUCTION CREDIT~~*EMISSIONS PREDICTIONS*

In combining the model predictions for exhaust HC, 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 exhaust HC 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 VII*I*.A.1*,* ~~,~~ VII*I*.A.2, and VII*I*.A.3. The predicted percent change in CO emissions is the prediction computed in accordance with the equation given in section ~~IX.A~~*VI.B*.

The combination of the exhaust HC*,* ~~and~~ the evaporative HC*, and the CO* model predictions~~, and the CO reduction credit~~ 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 adjustment factor.)

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

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 exhaust HC 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 VII*I*.A.1,

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

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

$\%CE_{CO}$ is the predicted percent change in CO emissions as given by the equation in Section ~~IX.A~~*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 ~~2005~~*2015*, as given by the ARB's EMFAC~~/BURDEN 7G~~ *2007* motor vehicle emissions model and shown below in Table 10.

Table 9
Relative Reactivity Values

Process	R Value
Exhaust HC	1.00
Diurnal/Resting HC	~~0.65~~*0.68*
Hot Soak HC	~~0.86~~*0.78*
Running Loss HC	~~0.60~~*0.68*
CO	~~0.021~~*0.015*

Table 10
Emissions Fractions

Process	F Value
Exhaust HC	~~0.070~~*0.0454*
Diurnal/Resting HC	~~0.0101~~*0.0174*
Hot Soak HC	~~0.0082~~*0.0113*
Running Loss HC	~~0.0157~~*0.0310*
CO	~~0.896~~*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~~

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 ~~VIII~~*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 ~~VIII~~*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 ~~VIII~~*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 VI*I*.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~~

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 ~~VIII~~*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 ~~VIII~~*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 ~~VIII~~*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 ~~candidate~~*reference* fuel specifications, and

$EX_{PWT\text{-}REF}$ is the total Tech class-weighted, potency-weighted exhaust toxics prediction for the ~~candidate~~*reference* fuel specifications computed in accordance with the equation give in Section VI*I*.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 selects the compliance option which provides for the use of the evaporative HC emissions models, the candidate fuel specifications must pass for NOx, OFP, and PWT to be acceptable as an alternative Phase 3 RFG formulation. If the applicant does not select the compliance option which provides for the use of the evaporative HC emissions models, the candidate fuel specifications must pass for NOx, EXHC, and PWT to be acceptable as an alternative Phase 3 RFG formulation.

These criteria are mathematically shown below.

Applicant Elects to Use the Evaporative HC Emissions Model Compliance Option *During the RVP Control Season*

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

Applicant Elects not to Use the Evaporative HC Emissions Model Compliance Option *During the RVP Control Season, or Outside of the RVP Control Season*

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

Compliance Option (check one): Evap. Option_______Exhaust-Only Option

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.)**	**Flat Range**	**(min.)**	**None**
	(max.)		**(max.)**	
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 Exhaust HC	
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.

~~Please FAX this report to the ARB Enforcement Division at (916) 445-0884~~

Table 12
Standardization of Fuel Properties - Mean and Standard Deviation

Fuel Property	Tech 3		Tech 4 ~~and Tech 5~~		***Tech 5***	
	Mean	Std. Dev.	Mean	Std. Dev.	***Mean***	***Std. Dev.***
RVP	~~8.626364~~ *8.670892*	~~0.588437~~ *0.635066*	~~8.308910~~ *8.365415*	~~0.846737~~ *0.8891114*	*8.221700*	*0.902838*
Sulfur	~~195.344776~~ *139.691080*	~~131.660328~~ *126.741459*	~~180.770373~~ *154.120828*	~~147.006156~~ *136.790450*	*144.628901*	*140.912204*
Aromatic HC	~~30.908412~~ *30.212969*	~~9.487116~~ *8.682044*	~~27.849881~~ *27.317137*	~~7.004743~~ *6.880833*	*26.875944*	*6.600312*
Olefin	~~8.433311~~ *7.359624*	~~5.873226~~ *5.383804*	~~6.806801~~ *6.549450*	~~4.665131~~ *4.715345*	*6.251891*	*4.431845*
Oxygen	~~0.877509~~ *0.892363*	~~1.233789~~ *1.235405*	~~1.355654~~ *1.536017*	~~1.224639~~ *1.248887*	*1.551772*	*1.262623*
T50	~~211.692062~~ *212.245188*	~~16.882813~~ *15.880385*	~~207.019049~~ *205.261051*	~~17.195294~~ *17.324472*	*206.020870*	*16.582090*
T90	~~315.301357~~ *312.121596*	~~25.72665~~ *23.264684*	~~311.785331~~ *310.931422*	~~21.595186~~ *20.847425*	*310.570200*	*22.967591*
Benzene	~~1.389446~~ *1.36412*	~~0.436822~~ *0.513051*	~~1.009607~~ *1.014259*	~~0.530184~~ *0.537392*	*1.014259*	*0.537392*

Table 13
Coefficients for NOx, Exhaust HC, 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	0.424915	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	

Model Term	Tech 3			Tech 4			Tech 5		
	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO
T90OXY								0.013372	

Table 13
Coefficients for NOx and Exhaust HC Equations

Model Term	Tech 3		Tech 4		Tech 5	
	NOx	HC	NOx	HC	NOx	HC
Intercept	-0.0794329063	-0.79146931	-0.6016053913	-1.131422309	-1.728220052	-2.506947412
RVP (constant)	-0.037472865	-0.001311794	-0.009882551	0.022383518	-0.01050586	0.023617461
Sulfur	0.0159437432	0.0055023672	0.0432360679	0.092788380	0.432840567	0.255035043
Aromatic HC	0.0532102243	-0.0437495823	0.0090548129	0.000103714	0.010121940	0.000975711
Olefin	0.0230182271	-0.0306356465	0.0184655971	-0.009384652	0.018827975	-0.009675903
Oxygen	0.0172437318	-0.0268848312	0.0137833705	-0.013881563	0.013712404	-0.014748918
T50	-0.0098269256	0.0108590213	-0.0001960893	0.060684722	-0.001476484	0.057474407
T90	-0.0005174949	0.0021787792	-0.0005521256	0.040077769	-0.004765110	0.038464284
AROARO				-0.008602222		-0.008618124
AROOXY			-0.0058732618		-0.005918359	
OXYT90				0.010447976		0.010141739
T50T50				0.020099767		0.019045885
T50T90	0.0075452045					
T90T90				0.016985255		0.016517838
SULARO		-0.0456568399				
RVPT50	-0.0080077184	-0.0174815748				
AROT90	-0.0096828310			0.008466012		0.008824753
OXYOXY			0.0102435186		0.010133923	

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~~ <u>*-0.12025037*</u>		-0.1423482	
Model Term	**Tech 4 ~~and Tech 5~~**			
	Benzene	**Butadiene**	**Formaldehyde**	**Acetaldehyde**
Intercept	2.3824773	0.43090426	1.05886661	0.16738341
RVP (constant)	~~-0.048140014~~ <u>*0.07392876*</u>			
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

Model Term	*Tech 5*			
	Benzene	*Butadiene*	*Formaldehyde*	*Acetaldehyde*
Intercept	*2.3824773*	*0.43090426*	*1.05886661*	*0.16738341*
RVP (constant)	*0.06514198*			
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*	*0.046699012*
T50	*0.04666208*	*0.03707822*		*0.04314573*
T90		*0.09454201*	*0.000000*	*0.06252964*
Benzene	*0.11689441*	*0.03644387*		*0.06148653*