



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105-2498

OFFICE OF
AIR AND RADIATION

February 27, 2012

CD-12-03 (LDV/LDT/ICI/LIMO)

SUBJECT: Analytically Derived CO₂ and Carbon-Related Exhaust Emissions (CREE) for Light-Duty Vehicles

Dear Manufacturer:

The enclosed letter to the Alliance of Automobile Manufacturers (AAM) is provided for your information as we believe it is of general interest to all manufacturers. This guidance outlines a method of calculating analytically derived CO₂ and CREE values for light-duty vehicles based on the analytically-derived fuel economy (ADFE) of the vehicle subconfiguration, ref. EPA guidance letter CCD-04-06, March 11, 2004.

Regulatory Background – The basis for determining analytically derived fuel economy, CO₂ and CREE values is outlined in the provisions of 40 CFR 600.006(e), which read in part:

“.....Additionally, in lieu of submitting actual data from a test vehicle, a manufacturer may provide fuel economy, CO₂ emissions, and carbon-related exhaust emission values derived from an analytical expression, e.g., regression analysis. In order for fuel economy, CO₂ emissions, and carbon-related exhaust emission values derived from analytical methods to be accepted, the expression (form and coefficients) must have been approved by the Administrator.”

Also enclosed are the August 8 and November 25, 2011 letters from AAM requesting approval of their proposed calculation method.

If you have questions about this letter, please contact Dave Good via email at good.david@epa.gov (telephone 734-214-4450) or your certification team representative.

Sincerely,

A handwritten signature in black ink, appearing to read "Byron J. Bunker".

Byron J Bunker, Acting Director
Compliance Division
Office of Transportation and Air Quality

Enclosures



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105-2498

OFFICE OF
AIR AND RADIATION

February 23, 2012

Giedrius Ambrozaitis
Alliance of Automobile Manufacturers
2000 Town Center, Suite 1140
Southfield, MI 48075

Dear Mr. Ambrozaitis:

This letter responds to your August 8 and November 25, 2011 letters requesting approval of your proposed method to calculate analytically derived Carbon Related Exhaust Emissions (ADCREE or ADOCREE¹) and analytically derived CO₂ (ADCO₂). Your letters propose to calculate ADCREE, ADOCREE and ADCO₂ at the test vehicle level² as follows:

$ADCREE \ \& \ ADCO_2 = \text{Fuel Conversion Factor} / ADFE$

$ADOCREE = (\text{Fuel Conversion Factor} / ADFE) + 298 \times N_2O + [25 - (CWF/0.273)] \times CH_4$

Where:

ADCREE = analytically derived CREE;

ADOCREE = analytically derived Optional CREE where CH₄ and N₂O emissions are included in the CREE equation, ref. 40 CFR 86.1818(f)(2);

ADCO₂ = analytically derived CO₂ emissions in grams/mile;

ADFE = analytically derived fuel economy calculated according to the method outlined in EPA guidance letter CCD-04-06, March 11, 2004;

N₂O = N₂O emissions in grams/mile

CH₄ = CH₄ emissions in grams/mile

CWF = Carbon weight factor of the test fuel; ref. 40 CFR 600.113-12(f)(1)(ii);

Fuel Conversion Factors:

- Gasoline test fuel: 8887 grams/gallon
- Diesel test fuel: 10,180 grams/gallon
- Ethanol (E85) test fuel: 6295 grams/gallon
- California Phase II test fuel: 8730 grams/gallon

¹ ADCREE means analytically derived CREE. ADOCREE means analytically derived Optional CREE where CH₄ and N₂O emissions are included in the CREE equation, ref. 40 CFR 86.1818(f)(2).

² When used in fleet average calculations, ADCREE and ADOCREE values are full useful life terms which must include applicable deterioration factors or be obtained from test vehicles equipped with aged emission control system components, ref. 40 CFR 600.113-12(g)(2).

EPA staff has reviewed the technical merits of your proposal and concur with your proposed methodology. The basis for our concurrence includes the following:

- Your proposed methodology is consistent with the methodology used to derive analytically derived fuel economy (ADFE) for light-duty vehicles, ref. EPA guidance letter CCD-04-06, March 11, 2004.
- Since your proposed methodology is based on the ADFE of a vehicle, it inherently incorporates the 95% confidence limits (used to determine ADFE of the vehicle) into the analytically derived CREE, OCREE and CO2 equations for the vehicle.
- Your proposal uses fuel conversion factors for gasoline, diesel fuel and ethanol (E85) test fuel which have been previously accepted by EPA, ref. light-duty greenhouse gas final rule (75 FR 25324 May 7, 2010); heavy-duty greenhouse gas final rule (76 FR 37106, Sept. 15, 2011); and SmartWay document “Guidance for Implementing Section 141 of the Energy Independence and Security Act of 2007,” Table 1 on page 3, available at <http://www.epa.gov/greenvehicles/download/420B10008.pdf>.
- Your proposal uses fuel conversion factors for California Phase II test fuel based on fuel properties of five batches of manufacturer test fuel. Those fuel properties are consistent with fuel properties of EPA Phase II test fuel. In addition, your proposed fuel conversion factor is similar to one developed for Phase II test fuel by the California Air Resources Board (ref. Oct 19, 2011 email message from Paul Hughes, ARB to Dave Good, EPA).

Therefore, based on the provisions of 40 CFR 40 CFR 600.006(e) as revised in the 2013 FE Label final rule (76 FR 39528, July 6, 2011), we hereby approve the use of your proposed calculation method. Our approval is effective immediately and is applicable to model year 2009 and later analytically derived data for light-duty vehicles (passenger cars), light-duty trucks and medium-duty passenger vehicles (MDPVs). The details and conditions of our approval are outlined in Enclosure I.

If you have questions about this letter, please contact Dave Good via email at good.david@epa.gov or at 734-214-4450.

Sincerely,



Linc Wehrly, Center Director
Light-Duty Vehicle Center
Compliance Division
Office of Transportation and Air Quality

Enclosure

Analytically Derived CREE/CO₂ Guidelines

Without prior EPA approval, manufacturers may select the baseline test to be used for analytically derived fuel economy (ADFE), analytically derived CREE (ADCREE), analytically derived optional CREE (ADOCREE) and analytically derived CO₂ (ADCO₂), provided the following guidelines are followed:

1. The ADFE used in the ADCREE, ADOCREE and ADCO₂ equations must be determined using the method outlined in EPA guidance letter CCD-04-06, March 11, 2004 (or any subsequent updates to that guidance letter). All conditions outlined in Enclosure 1 of CCD-04-06 must be satisfied.
2. ADCREE, ADOCREE and ADCO₂ may be used to calculate FTP (city), highway, US06, SC03 and cold temperature FTP tests, provided that ADFE is calculated for US06, SC03 and cold temperature FTP tests according to the guidelines provided in Section 6 of EPA guidance letter CISC-10-04, February 22, 2010.
3. If the fuel economy of a vehicle subconfiguration is based on ADFE, the CREE and CO₂ values for that vehicle subconfiguration must also be based on applicable ADCREE, ADOCREE and ADCO₂ calculations, (and visa-versa).
4. When used in fleet average calculations, ADCREE and ADOCREE are full-useful life terms which must include applicable deterioration factors or be obtained from test vehicles equipped with aged emission control system components, ref. 40 CFR 600.113-12(g)(2).
5. ADCREE, ADOCREE and ADCO₂ values cannot be used for the emission data vehicle.
6. Vehicles considered for selection for the baseline test for ADFE must pass applicable N₂O and CH₄ emission standards, ref EPA guidance letter CISC-04-06, Enclosure 1, item 1.a. If the manufacturer didn't measure N₂O or CH₄ emissions, the manufacturer shall base compliance on their good engineering judgment.
7. To limit the impact of ADCREE or ADOCREE on fleet average CREE calculations, no more than 20 percent of the subconfigurations tested in a manufacturer's greenhouse gas final fleet average model year report may be represented by ADCREE or ADOCREE. For example, if the manufacturer has 100 subconfigurations which are tested (or represented through data substitutions and equivalencies) only 20 of the 100 may be based on ADCREE or ADOCREE calculations (or represented through data substitutions or equivalencies from ADCREE or ADOCREE generated data points).
8. Manufacturers must retain for five years (under the provisions of 40 CFR 600.005(a)(3) the pool of tests, the vehicle description and tests chosen for the ADCREE/ADOCREE/ADCO₂ subconfiguration and the calculated ADCREE/ADOCREE/ADCO₂ values. EPA may request this information as part of an audit.
9. If EPA determines that it is necessary to assure the integrity of the emissions and fuel

economy database or if EPA has concerns about compliance with emission standards, EPA retains the right to order a confirmatory test of the subconfiguration covered by the ADCREE/ADOCREE/ADCO₂.

For labeling purposes, if the manufacturer chooses, EPA will accept a temporary Fuel Economy Label based on the manufacturer's ADCO₂ data while a suitable data vehicle is being procured. However, if the confirmatory test value results in higher CO₂ value for any model type, the label must be updated. The updated label value shall be used on all vehicles produced more than 15 days following its submission.

10. EPA is presenting this option as a manufacturer self-approval process. EPA will not be responding to routine submissions of ADCREE/ADOCREE/ADCO₂ data indicating our acceptance of the calculation or waiver of confirmatory testing. If EPA later discovers that the procedures for self-approval were not followed, EPA may rescind the use of ADCREE/ADOCREE/ADCO₂ data and require actual test data be generated and require recalculation of label values and greenhouse gas final fleet average model year reports.



August 8, 2011

David Good
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Re: Request for Approval of Analytically Derived Carbon Related Exhaust Emission and Carbon Dioxide Factors

Dear Mr. Good:

This is to follow-up to our June 15, 2011, email which proposed that EPA approve the use of factors to convert analytically derived fuel economy (ADFE) values to carbon related exhaust emission (CREE) and carbon dioxide (CO₂) emission values. Specifically, this letter submits the additional information you requested regarding the proposal.

On March 11, 2004, EPA published a Dear Manufacturer guidance letter (CCD-04-06) which updated the well established ADFE policy for 2005 MY and newer vehicles (please see the March 2004 letter for a comprehensive listing of all historical ADFE guidances starting in the 1980's). The March 2004 guidance letter updated the existing ADFE equation coefficients using a statistical analysis of 3642 EPA fuel economy tests of then recent vintage 2000-2004 MY vehicles (Enclosure 2 to the March 2004 guidance letter). An update to the coefficients was required at that time due to the change to single-roll dynamometers; the statistical analysis was developed using only single-roll dynamometer data. Because there have been no further major test procedure changes (such as a dynamometer change), the Alliance is proposing that both the ADFE coefficients and the ADFE formula contained in the March 2004 guidance continue to be used on current and future model year vehicles.

The need to develop analytically derived CREE (ADCREE) comes from the implementation of the 2012-2016 greenhouse gas (GHG) rule which adopts a fleet-average CREE standard in terms of grams per mile (g/mi) and which requires that all test data that is used in CAFE calculations also be used in the calculation of fleet-average CREE. In order to accommodate the use of CAFE ADFE data in CREE space, it is necessary to develop a method to calculate analytically

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derived CREE. The need to develop analytically derived CO₂ (ADCO₂) values comes from the new fuel economy label rule which requires a CO₂ value to appear on the label. In order to accommodate the use of ADFE data in FE labels, it is now necessary to also develop a method to calculate analytically derived CO₂. An appropriate and efficient method of deriving analytically derived CREE and CO₂ values would be to divide a fuel conversion factor by the ADFE value. We are proposing to use the same fuel conversion factors in determining both ADCREE and ADCO₂.

The calculation method is as follows:

$$\text{Analytically Derived CREE \& CO}_2 = \text{Fuel Conversion factor} / \text{ADFE Value}$$

The Alliance proposes the following fuel conversion factors:

- Gasoline : 8887 grams/gallon
EPA and NHTSA determined that 8887 is the appropriate value and have used this value in calculations for the 2012-2016 GHG rule (see Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25330, f.n. 20 (May 7, 2010)).
- Diesel : 10180 grams/gallon
EPA and NHTSA determined that 10180 is the appropriate value and have used this value in calculations for the 2012-2016 GHG rule (see footnote 20, cited above).
- E85: 6262 grams/gallon
This is the average value from a statistical analysis of E85 fuel properties from actual test fuels used by manufacturers. (See Attachment for this statistical analysis.)
- California RFG2: 8730 grams/gallon
This is the average value from a statistical analysis of RFG2 fuel properties from actual test fuels used by manufacturers. (See Attachment for this statistical analysis.)

Regarding your question about the applicability of the heavy-duty (HD) vehicle approach to analytically derived CREE and also to light-duty (LD), we believe that EPA's HD GHG NPRM (75 Fed. Reg. 74262 (November 30, 2010)) actually proposed that HD adopt the LD approach, but with a greater fraction of possible subconfigurations and using lower confidence limits. As we noted above, the Alliance is not proposing any changes to the existing March 2004 LD guidance and therefore the HD approach is not applicable to LD and HD should be treated separately from LD.

In summary, the Alliance requests that EPA approve the use of the above factors for converting ADFE values to ADCREE and ADCO₂ values and release this information via a new Dear Manufacturer guidance letter. Please let me know if I can answer any further questions.

Best regards,



Giedrius Ambrozaitis
Alliance of Automobile Manufacturers
(248) 915-8836

cc: Linc Wehrly, US EPA

Attachment - Statistical Analysis of E85 and RFG2 Fuel Properties

"Carbon Balance Equation" for Federal Tier 2 (FAT2) Gasoline (40 CFR 600.113-12(h)(1)):

$$\text{mpg} = (51740000 \cdot \text{CWF} \cdot \text{SG}) / (((\text{CWF} \cdot \text{HC}) + (0.429 \cdot \text{CO}) + (0.273 \cdot \text{CO}_2)) \cdot ((0.6 \cdot \text{SG} \cdot \text{NHV}) + 5471))$$

Solving for CO₂:

$$\text{CO}_2 = ((51740000 \cdot \text{CWF} \cdot \text{SG}) / (0.273 \cdot ((0.6 \cdot \text{SG} \cdot \text{NHV}) + 5471) \cdot \text{mpg})) - ((\text{CWF} \cdot \text{HC}) / 0.273) - ((0.429 \cdot \text{CO}) / 0.273)$$

Ignoring minimal contribution from HC and CO:

$$\text{CO}_2 \cdot \text{mpg} = (51740000 \cdot \text{CWF} \cdot \text{SG}) / ((0.1638 \cdot \text{SG} \cdot \text{NHV}) + 1493.583)$$

"Carbon Balance Equation" for E85 (ED85) (40 CFR 600.113(l)(1)):

$$\text{mpg} = (3781.8 \cdot \text{CWF} \cdot \text{SG}) / ((\text{CWF} \cdot \text{HC}) + (0.429 \cdot \text{CO}) + (0.273 \cdot \text{CO}_2) + (0.375 \cdot \text{CH}_3\text{OH}) + (0.400 \cdot \text{HCHO}) + (0.521 \cdot \text{C}_2\text{H}_5\text{OH}) + (0.545 \cdot \text{C}_2\text{H}_4\text{O}))$$

Solving for CO₂:

$$\text{CO}_2 = ((3781.8 \cdot \text{CWF} \cdot \text{SG}) / (0.273 \cdot \text{mpg})) - ((\text{CWF} \cdot \text{HC}) + (0.429 \cdot \text{CO}) + (0.375 \cdot \text{CH}_3\text{OH}) + (0.400 \cdot \text{HCHO}) + (0.521 \cdot \text{C}_2\text{H}_5\text{OH}) + (0.545 \cdot \text{C}_2\text{H}_4\text{O})) / 0.273$$

Ignoring minimal contribution from HC, CO, CH₃OH, HCHO, C₂H₅OH and C₂H₄O:

$$\text{CO}_2 \cdot \text{mpg} = (3781.8 \cdot \text{CWF} \cdot \text{SG}) / 0.273$$

"Carbon Balance Equation" for California Phase 2 (PHS2) Gasoline (EPA Letter CD-95-09):

$$\text{mpg} = (51740000 \cdot \text{CWF} \cdot \text{SG}) / (((1.03 \cdot \text{CWF} \cdot \text{HC}) + (0.429 \cdot \text{CO}) + (0.273 \cdot \text{CO}_2)) \cdot ((0.6 \cdot \text{SG} \cdot \text{NHV}) + 5471))$$

Solving for CO₂:

$$\text{CO}_2 = ((51740000 \cdot \text{CWF} \cdot \text{SG}) / (0.273 \cdot ((0.6 \cdot \text{SG} \cdot \text{NHV}) + 5471) \cdot \text{mpg})) - ((1.03 \cdot \text{CWF} \cdot \text{HC}) / 0.273) - ((0.429 \cdot \text{CO}) / 0.273)$$

Ignoring minimal contribution from HC and CO:

$$\text{CO}_2 \cdot \text{mpg} = (51740000 \cdot \text{CWF} \cdot \text{SG}) / ((0.1638 \cdot \text{SG} \cdot \text{NHV}) + 1493.583)$$

"Carbon Balance Equation" for Diesel (40 CFR 600.113-12(i)(1)):

$$\text{mpg} = 2778 / ((.866 \cdot \text{HC}) + (0.429 \cdot \text{CO}) + (0.273 \cdot \text{CO}_2))$$

Solving for CO₂:

$$\text{CO}_2 = (10176 / \text{mpg}) - (3.17 \cdot \text{HC}) - (1.57 \cdot \text{CO})$$

Ignoring minimal contribution from HC and CO:

$$\text{CO}_2 \cdot \text{mpg} = 10176$$

Fuel Type	Net Heating Value (NHV)	Carbon Weight Fraction (CWF)	Specific Gravity (SG)	CO ₂ *MPG (gm/gal)
<u>Based on 9 batches of E85:</u>				
Average ED85	12636.44	0.576867	0.783556	6261.539856
High				6329
Low				6185
<u>Based on 5 batches of CA Phase 2 fuel:</u>				
Average PHS2	18144.4	0.843	0.7378	8729.602988
High				8756
Low				8708



November 25, 2011

David Good
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Re: Revised Request for Approval of Analytically Derived Carbon Related Exhaust Emission and Carbon Dioxide Factors

Dear Mr. Good:

This letter is a revised request to EPA for the use of conversion factors to convert analytically derived fuel economy (ADFE) to carbon related exhaust emissions (ADCREE), optional carbon related exhaust emissions (ADOCREE) and carbon dioxide (ADCO₂). The Alliance requests that EPA approve the use of the factors for converting ADFE values to ADCREE, ADOCREE and ADCO₂ and the associated agreements described in the August 8, 2011 letter and this revised request. We also request that EPA release this information via a new Dear Manufacturer guidance letter,

Attached is the original Alliance request letter from August 8, 2011, with the analysis of fuel properties attachment. As part of this revised request, the Alliance requests the following revisions:

1. The Alliance agrees that the equation on page two of the August 8, 2011, letter should include ADOCREE (optional CREE) where CH₄ and N₂O are included in the CREE equation as outlined in 86.1818(f)(2)). We propose the following equation to calculate the Analytically Derived OCREE (ADOCREE) more accurately for all fuels.

$$\text{ADOCREE} = (\text{Fuel Conversion Factor} / \text{ADFE}) + 298 \times \text{N}_2\text{O} + [25 - (\text{CWF}/0.273)] \times \text{CH}_4$$

The justification of using the above equation for all fuels is as follows (Gasoline Example):

$$\text{OCREE} = [(\text{CWF}/0.273) \times \text{NMHC}] + 1.571 \times \text{CO} + \text{CO}_2 + 298 \times \text{N}_2\text{O} + 25 \times \text{CH}_4$$

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$$\begin{aligned}
&= [(CWF/0.273) \times NMHC] + 1.571 \times CO + CO_2 + 298 \times N_2O + 25 \times CH_4 + \\
&(CWF/0.273) \times CH_4 - (CWF/0.273) \times CH_4; (CWF/0.273) \times CH_4 \text{ added and subtracted at} \\
&\text{the same time (no effect on the above equation)} \\
&= [(CWF/0.273) \times NMHC] + (CWF/0.273) \times CH_4 + 1.571 \times CO + CO_2 + 298 \times N_2O + \\
&25 \times CH_4 - (CWF/0.273) \times CH_4 \\
&= [(CWF/0.273) \times (NMHC + CH_4)] + 1.571 \times CO + CO_2 + 298 \times N_2O + [25 - (CWF/0.273)] \\
&\times CH_4 \\
&= [(CWF/0.273) \times HC] + 1.571 \times CO + CO_2 + 298 \times N_2O + [25 - (CWF/0.273)] \times CH_4 \\
&= CREE + 298 \times N_2O + [25 - (CWF/0.273)] \times CH_4
\end{aligned}$$

$$ADOCREE = ADCREE + 298 \times N_2O + [25 - (CWF/0.273)] \times CH_4$$

OR

(If ADFE is used to calculate ADCREE then all components of hydrocarbons are included in the FE number and this equation becomes useful for all fuels)

$$ADOCREE = (\text{Fuel Conversion Factor} / \text{ADFE}) + 298 \times N_2O + [25 - (CWF/0.273)] \times CH_4$$

2. Regarding EPA's concern about demonstrating compliance with applicable N₂O and CH₄ emission standards, one of the conditions to use ADFE is that "Vehicles considered for selection for the baseline test must pass all applicable emission standards in the model year associated with the ADFE." ref. EPA guidance letter CISC-04-06, Enclosure 1, item 1.a. The Alliance believes that as a prerequisite to the use of ADFE, manufacturers should treat N₂O and CH₄ compliance similarly to any other emission constituent. The only issue may be if the manufacturer did not collect N₂O or CH₄ data for the base test. If that is the case, the manufacturer should be able to use good engineering judgment in addressing compliance to N₂O and CH₄ emission standards.
3. The Alliance believes that current advanced technology vehicles fit under the existing ADFE guidelines and that the coefficients are applicable. If EPA believes that some future advanced technologies may not be a good fit, then the applicability of the guidance should be revisited at that time.
4. The Alliance agrees that the use of ADFE, ADCREE, ADOCREE and ADCO₂ should be limited to light-duty vehicles (e.g. which are required to demonstrate compliance with light-duty greenhouse gas and 2013 FE Label requirements).
5. For the conversion factors, the Alliance now believes that the value used by EPA for E85 SmartWay calculations is an applicable value for E85 fuel. Therefore the E85 value should be 6295 grams/gallon, instead of 6262 grams/gallon as in the Alliance fuels

analysis attachment. The values for the other fuels remain as in the fuels analysis attachment.

Sincerely,

A handwritten signature in blue ink, appearing to read "G. Ambrozaitis".

Giedrius Ambrozaitis
Alliance of Automobile Manufacturers
(248) 915-8836

Attachment – Alliance August 8, 2011 request with fuels analysis attachment