



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
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OFFICE OF
AIR AND RADIATION

March 17, 2005

CCD-05-06 HDHwyDiesel

Dear Manufacturer:

Subject: Averaging Calculations for Model Year 2007 Through 2009 Heavy-duty Highway Diesel Engines

EPA has received a number of questions from highway heavy-duty engine manufacturers regarding the 2007 model year phase-in requirements for diesel engines. Specifically, EPA has received questions regarding the method which should be used for calculating Family Emission Limits (FELs) under the optional "split family" provisions allowed under 40 CFR 86.007-15(m)(9).

Enclosed with this letter is a guidance document (CCD-05-06) which gives several example calculations addressing the generation of NO_x+NMHC credits by phase-out engines, the conversion of NO_x+NMHC credits to NO_x credits, and the use of NO_x credits for phase-in engines during model years 2007 through 2009 under the "split family" option of 40 CFR 86.007-15(m)(9). We have provided two example calculations for heavy-duty diesel engines.

The examples cover the two situations which may be used by engine manufacturers: (1) the general case of a split family, in which emission credits may be generated or used, and for which engine tracking and counting is required; and (2) the special case of an evenly split engine family, for which no credits can be brought into the family and no emission credits will be generated by the family, and for which tracking and counting of engines is not required.

If you have any questions about this guidance, please contact your certification team representative.

Sincerely,

A handwritten signature in black ink, appearing to read "Merrylin Zaw-Mon".

Merrylin Zaw-Mon, Director
Certification and Compliance Division
Office of Transportation and Air Quality

Enclosure

Averaging Calculations for Model Year 2007 Through 2009
Heavy-duty Highway Diesel Engines
CCD-05-06

Example 1: General Split Families

The regulations in 40 CFR 86.007-15(m)(9) allow manufacturers to certify phase-in and phase-out engines in the same engine family. Under this option manufacturers are allowed to label all engines identically. Final determination of whether an engine is to be counted as a phase-in or phase-out engine is made at the end of the model year. In many cases, phase-in and phase-out engines in such a family are not physically distinguishable from one another (as in the example below, where the engine family consists of a single power rating). Each engine in the family must be certified as meeting both the phase-in and phase-out standards. Thus the manufacturer must specify both a NO_x FEL (to two decimal places) and a NO_x+NMHC FEL (to one decimal place). These phase-in and phase-out engines are only treated separately for the purpose of credit calculations. Engine families certified under this option must comply with all other ABT requirements.

While engines certified under the split family option must be certified to both a NO_x FEL and a NO_x+NMHC FEL, only one of these FELs is required on the label. For all SEAs and in-use compliance testing, the FEL that is on the label is considered to be the applicable FEL for the family. The other FEL would then only be applicable for certification and for credit calculation.

Sample calculations are shown in Table 1 for a credit using medium-heavy duty engine family that has a single horsepower rating of 260 hp. Based on the example calculation, this engine family would require 2,987.01 Megagrams of NO_x credit.

Inputs for Example 1 Sample Calculations:

Number of engines in the family = 10,000

Number of Engines in Family Assigned as Phase-in Engines = 7,000

Number of Engines in Family Assigned as Phase-out Engines = 3,000

Deteriorated Certification Emission Level for NO_x (g/bhp-hr) = 1.43 g/bhp-hr

Deteriorated Certification Emission Level for NMHC (g/bhp-hr) = 0.03 g/bhp-hr

Measured Integrated Brake-horsepower Hour during the transient FTP = 16.9 bhp-hr

UL = useful life = 185,000 miles

Phase-in NO_x standard = 0.20 g/bhp-hr NO_x

Phase-out NO_x+NMHC standard = 2.5 g/bhp-hr NO_x+NMHC

Table 1. Sample Credit Calculation for Split Families		
Calculated or Determined Value	Calculation and Citation	Calculated Value for Example
1) NO _x FEL for Phase-in Engines (g/bhp-hr)	≥ 1.43 [the NO _x FEL cannot be less than the rounded Deteriorated Certification Emission Level for NO _x]	1.43 g/bhp-hr
2) NO _x +NMHC FEL for Phase-out Engines (g/bhp-hr)	≥ 1.43 + 0.03 ≥ 1.46 ≥ 1.5 [the NO _x +NMHC FEL cannot be less than the rounded sum of the Deteriorated Certification Emission Levels for NMHC and NO _x]	1.5 g/bhp-hr
3) Conversion Factor (bhp/mi)	= (measured integrated brake-horsepower hour)/miles = 16.9/6.5 [See 40 CFR 86.004-15(c)(2)]	2.60 bhp/mi
4) NO _x Credits Used by Phase-in Engines	= (FEL-STD)(CF)(UL)(Vol)(10 ⁻⁶) = (1.43 - 0.20)(2.60)(185,000)(7,000)(10 ⁻⁶) [See 40 CFR 86.004-15(c)(1)]	4,141.41 Megagrams ¹
5) NO _x +NMHC Credits Generated by Phase-out Engines	= (STD-FEL)(CF)(UL)(Vol)(10 ⁻⁶) = (2.5-1.5)(2.60)(185,000)(3,000)(10 ⁻⁶) [See 40 CFR 86.004-15(c)(1)]	1,443.00 Megagrams ¹
6) Conversion of NO _x +NMHC credits to NO _x Credits	= (NO _x +NMHC)(0.8) = (1,443.00)(0.8) [See 40 CFR 86.007-15(m)(2)]	1,154.40 Megagrams ¹
7) Net NO _x Credits Needed by Family	= 4,141.41 - 1,154.40	2,987.01 Megagrams ¹

¹ Credits are rounded to the nearest one-hundredth of a megagram.

Example 2: Special Case of Equally-Split Family without Tracking

The regulations in 40 CFR 86.007-15(m)(9) subparagraph(i) allow manufacturers to certify phase-in and phase-out engines in the same engine family without tracking the number of engines in the family for ABT calculations, provided the engine family does not use credits from other engine families or other model years. These families also may not generate emission credits. If a manufacturer wishes to generate or use credits in an evenly split family, it must use the general calculations above and track U.S.-directed sales volumes for the family.

Under this option manufacturers also label all engines identically so that phase-in and phase-out engines in such families are not distinguishable from one another, physically or otherwise. Each engine in the family must be certified as meeting both the phase-in (NMHC, NO_x, PM, and CO) and phase-out standards (NO_x+NMHC, PM, and CO). The manufacturer must specify both a NO_x FEL (to two decimal places) and a NO_x+NMHC FEL (to one decimal place). Unlike the general split family case, these phase-in and phase-out engines are not treated separately for the purpose of credit calculations. The only calculation that is performed is that necessary to demonstrate that the family would be able to generate enough credits from its phase-out engines to offset the credits needed by the phase-in engines. Given the applicable standards, NO_x FELs may vary from 1.16 to 1.24 g/bhp-hr in this special case. A sample credit calculation is shown below. Note that in this case, the engine's primary intended service class and horsepower rating are not relevant. Thus, the simplified calculation is based on equivalent "credits" specified in units of g/bhp-hr. These equivalent credits can be converted to actual credits according to the following formula:

$$\text{Actual credits} = (\text{g/bhp-hr "credits"}) (\text{CF}) (\text{UL}) (\text{Vol}) (10^{-6})$$

Inputs for Example 2 Sample Calculations:

Deteriorated Certification Emission Level for NO_x (g/bhp-hr) = 1.16 g/bhp-hr

Deteriorated Certification Emission Level for NMHC (g/bhp-hr) = 0.10 g/bhp-hr

Phase-in NO_x standard = 0.20 g/bhp-hr NO_x

Phase-out NO_x+NMHC standard = 2.5 g/bhp-hr NO_x+NMHC

Table 2. Sample Credit Calculation for Equally-Split Families without Tracking

Calculated or Determined Value	Calculation and Citation	Calculated Value for Example
1) NO _x FEL for Phase-in Engines (g/bhp-hr)	≥ 1.16 [the NO _x FEL cannot be less than the rounded Deteriorated Certification Emission Level for NO _x]	1.16 g/bhp-hr
2) NO _x +NMHC FEL for Phase-out Engines (g/bhp-hr)	$\geq 1.16 + 0.10$ ≥ 1.26 ≥ 1.3 [the NO _x +NMHC FEL cannot be less than the rounded sum of the Deteriorated Certification Emission Levels for NMHC and NO _x]	1.3 g/bhp-hr
3) Brake-Specific Equivalent NO _x "Credits" Used by Phase-in Engines (g/bhp-hr)	$= (\text{FEL-STD})$ $= (1.16 - 0.20)$ [The factors (CF), (UL), and (Vol) are identical and can be ignored for calculations 3, 4, and 5. Alternatively, actual credits can be calculated with these factors according to 40 CFR 86.004-15(c).]	0.96 g/bhp-hr
4) Brake-Specific Equivalent NO _x +NMHC "Credits" Generated by Phase-out Engines (g/bhp-hr)	$= (\text{STD-FEL})$ $= (2.5-1.3)$ [The factors (CF), (UL), and (Vol) are identical and can be ignored for calculations 3, 4, and 5. Alternatively, actual credits can be calculated with these factors according to 40 CFR 86.004-15(c).]	1.2 g/bhp-hr
5) Conversion of NO _x +NMHC "Credits" to NO _x "Credits"	$= (\text{NO}_x+\text{NMHC})(0.80)$ $= (1.2)(0.80)$ [The factors (CF), (UL), and (Vol) are identical and can be ignored for calculations 3, 4, and 5. Alternatively, actual credits can be calculated with these factors according to 40 CFR 86.004-15(c).]	0.96 g/bhp-hr
6) Internal NO _x Credit Balance For Family	$(\text{NO}_x \text{ "Credits"})_{\text{generated}} - (\text{NO}_x \text{ "Credits"})_{\text{used}} \geq 0$ $= 0.96 - 0.96$	0.00 g/bhp-hr

The 1.16 g/bhp-hr in this example represents the practical lower limit for NO_x FELs in this special case, and 1.3 g/bhp-hr represents the practical upper limit for NO_x+NMHC FELs. With these FELs, a family would have enough NO_x+NMHC credits to offset the needed NO_x credits. Although NO_x FELs less than 1.16 g/bhp-hr are allowed, there is no emissions ABT incentive for a manufacturer to claim a NO_x FEL lower than 1.16 g/bhp-hr under the evenly split family option because no credits can be generated under this approach. In addition, there is no incentive for a NO_x+NMHC FEL above 1.3 g/bhp-hr since the family must also comply with the 0.14 g/bhp-hr NMHC standard.

For NO_x FELs above 1.16 g/bhp-hr the NO_x+NMHC FEL must be 1.2 g/bhp-hr or lower. As shown in the example, a family with a NO_x+NMHC FEL of 1.3 g/bhp-hr would have precisely enough NO_x+NMHC credits to offset the NO_x credits needed for a 1.16 g/bhp-hr NO_x FEL. Additional NO_x+NMHC credits are thus needed for all higher NO_x FELs, which requires an FEL lower than 1.3.

Given the applicable standards, NO_x FELs may not be above 1.24 g/bhp-hr in this special case. With that FEL, the family would be 1.04 g/bhp-hr over the 0.20 NO_x standard and must be 1.3 (i.e., 1.04/0.8) g/bhp-hr below the 2.5 g/bhp-hr NO_x+NMHC standard, which means the family may not have a NO_x+NMHC FEL above 1.2 g/bhp-hr.

Thus, the NO_x+NMHC FEL will be 1.2 or 1.3, depending on the level of the NO_x FEL. The corresponding NO_x FELs would be 1.24 g/bhp-hr or 1.16 g/bhp-hr, respectively. The allowable NMHC level is also limited by the applicable 0.14 g/bhp-hr NMHC emission standard. The calculations supporting these FELs are shown in Table 3.

Table 3. Calculation of NO_x+NMHC FELs for Engine Families Using the Evenly Split Family Option

Solving the equation: $\text{NO}_x \text{ FEL} - 0.20 \leq 0.8(2.5 - \text{NMHC} + \text{NO}_x \text{ FEL})$
with two decimal places on both sides of the equation

Column 1	Column 2	Column 3	Column 4	Column 5
Declared NO _x FEL	The amount of NO _x Credit needed	Intermediate Calculated Values: The amount of NMHC+NO _x credit needed before discounting. After discounting, this credit must be at least as large as the NO _x credit needed (Column 2 value)	Intermediate Calculated Values: The difference between the NMHC+NO _x standard and the NMHC+NO _x credit needed, expressed to two decimal places	Maximum NO _x +NMHC FEL
NO _x FEL	Column 1 value - 0.20	Column 2 value/0.8	2.5 - Column 3 value	Column 5 value is the maximum value, expressed to one decimal point, which is \leq Column 4 value
1.16	0.96	1.20	1.30	1.3
1.17	0.97	1.21	1.29	1.2
1.18	0.98	1.23	1.28	1.2
1.19	0.99	1.24	1.26	1.2
1.20	1.00	1.25	1.25	1.2
1.21	1.01	1.26	1.24	1.2
1.22	1.02	1.28	1.23	1.2
1.23	1.03	1.29	1.21	1.2
1.24	1.04	1.30	1.20	1.2