Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b

United States Environmental Protection Agency

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Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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1 Introduction

The nonroad module in MOVES estimates air pollution from more than 80 types of compression ignition (CI) and spark ignition (SI) nonroad engines including such items as lawnmowers, motorboats, portable generators and construction equipment. By bringing together information on engine populations, equipment use, and emission factors, the MOVES-Nonroad model estimates nonroad emissions for specific states and counties for past and future years, providing a flexible tool that can be applied to a wide variety of air quality modeling and planning functions.

The MOVES-Nonroad calculations rely on emission factors – estimates of the amount of pollution emitted by a particular type of equipment during a unit of use. Typically, emission factors for nonroad engines are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile, grams per hour, and grams per gallon. The CI emission factors in the MOVES-Nonroad model are reported in g/hp-hr and are based on emissions test data where available and adjusted when necessary to account for in-use operation that differs from the typical test conditions. These emission factors are stored in MOVES-Nonroad's data input files. Emission changes with the age of the engine, often called 'deterioration,' are also applied by the model.

This report describes and documents exhaust emission factors used for compression ignition (CI) engines in the nonroad module of MOVES2014b. The term "compression ignition" is synonymous with "diesel" for the purposes of this report. Pollutants covered include hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM), carbon dioxide (CO_2), and sulfur dioxide (SO_2). Brake specific fuel consumption (BSFC), which is a fuel rate measurement, is also discussed.

An overview of the CI exhaust emission standards is provided in Section 2. Section 3 discusses the methodology MOVES-Nonroad uses for calculating emission rates. Zero-hour, steady-state emission factors for HC, CO, NO_x, PM, and BSFC are discussed in Section 4 and 5, followed by adjustments (where applicable) to account for transient operation in Section 6, deterioration (Section 7), and adjustments to particulate matter emissions due to variations in fuel sulfur level (Section 8). There are no additional adjustments to CI emissions for temperature, altitude, or for other fuel parameters. Derivation of CO_2 and SO_2 emission factors follows in Section 9. Crankcase HC emission factors are then discussed in Section 10. Exhaust particulate matter emissions are reported in both PM_{10} (particulate matter smaller than 10 microns) and $PM_{2.5}$ (particulate matter smaller than 2.5 microns) as discussed in Section 11.

Emission factors for spark ignition engines (including gasoline and natural gas/propane) are covered in a separate report[1]. Emission factors for different organic aggregates of hydrocarbons (e.g. volatile organic compounds, total organic gases) and toxics are also documented in a separate report[2].

For the nonroad module of MOVES2014b, we have updated the nonroad emission factors and engine technology fractions for 2011+ model year nonroad engines subject to Tier 4 emission standards. As discussed in Section 2, many of the default values for Tier 2, Tier 3, and Tier 4 emission standards and technology fractions had been based on projections made when developing NONROAD2005. With limited resources, we focused our current efforts on updating the 2011+ nonroad engine emission rates and technology classifications. Updating values for Tier 4 was a higher priority than updating values for Tier 2 and 3 for several reasons: First, engine certification information, including emission factors, descriptions, and projected sales volumes was more accessible for the 2011+ CI nonroad engines[3]. Second, updating the Tier 4 emission rates will have a larger impact on future inventories than updating the Tier 2 and Tier 3 emission rates. The PM and NOx emission reductions for Tier 4 engines are much larger than Tier 2/Tier 3 reductions and Tier 4 standards are the current and future emission standards for most CI engines, contributing an increasingly large fraction of future emissions inventories.

Other than updates to the emission rates for model year 2011+ Tier 4 engines, the data and algorithms described here are unchanged from those documented in the July 2010 version of this report[4], including the exhaust emission factors and technology fractions for pre-2010 nonroad engines, and inputs for all model years of recreational marine engines and underground mining equipment. In addition, no updates were made to the exhaust adjustment factors (transient adjustment factors and fuel sulfur adjustments) or to crankcase emission factors.

2 Emission Standards and Technology Types

MOVES-Nonroad defines technology types according to applicable emission standards. This section provides an overview of the applicable nonroad compression ignition emission standards, definitions of nonroad technology types, and methods used to estimate the population distribution of nonroad engines within different technology types.

2.1 Summary of Nonroad Compression Ignition Emission Standards and Technology Types

In addition to estimating emissions from uncontrolled engines, the MOVES-Nonroad model is designed to account for the effect of federal emissions standards. MOVES-Nonroad does not cover California emission standards. The nonroad module of MOVES2014b accounts for emission factors under five regulations that establish up to four tiers of nonroad emission standards:

- "Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression Ignition Engines at or above 37 Kilowatts." This rule establishes "Tier 1" standards for CI engines at or above 50 hp (37 kW)[5].

- "Control of Emissions from Nonroad Diesel Engines." This rule lists "Tier 1" and "Tier 2" standards for CI engines below 50 hp, and "Tier 2" and "Tier 3" standards for engines of 50 hp and greater[6].

- “Control of Emissions from Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based).” This rule establishes “Tier 2” equivalent standards for recreational marine diesel engines over 50 hp[7].

- “Control of Emissions from Nonroad Diesel Engines and Fuel.” This rule establishes “Tier 4" standards for CI engines covering all hp categories, and also regulates diesel fuel sulfur content[8].

- “Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less Than 30 Liters per Cylinder; Republication.” This rule establishes “Tier 3" standards for recreational marine diesel engines[9].

The emission standards with the affected model years and the corresponding model tech types are provided in Table 2-1. Table 2-1 covers all CI engines except recreational marine engines, and reflects the new tech type definitions for Tier 4. The standards and emission factors for recreational marine CI engines are discussed separately. Tech types are defined for unique sets of standards and/or certification fuel sulfur levels. The certification fuel sulfur levels are presented in Table 4-1 in Section 4.1 of this report.

Table 2-1. Nonroad CI Engine Emission Standard[a]

Engine Power (hp)	Model Years	Regulation	Emission Standards (g/hp-hr)					Nonroad Tech Types[g]
			HC [b]	NMHC+NO_x	CO	NO_x	PM	
<11	2000-2004	Tier 1		7.8	6.0		0.75	T1
	2005-2007	Tier 2		5.6	6.0		0.60	T2
	2008+	Tier 4		5.6	6.0		0.30	T4A, T4B
≥11 to <25	2000-2004	Tier 1		7.1	4.9		0.60	T1
	2005-2007	Tier 2		5.6	4.9		0.60	T2
	2008+	Tier 4		5.6	4.9		0.30	T4A, T4B
≥25 to <50	1999-2003	Tier 1		7.1	4.1		0.60	T1
	2004-2007	Tier 2		5.6	4.1		0.45	T2
	2008-2012	Tier 4 transitional		5.6	4.1		0.22	T4A
	2013+	Tier 4 final		3.5	4.1		0.02	T4FA/T4FB/T4FC/TF4D
≥50 to <75	1998-2003	Tier 1				6.9		T1
	2004-2007	Tier 2		5.6	3.7		0.30	T2
	2008-2011	Tier 3 [c]		3.5	3.7		0.30	T3
	2008-2012	Tier 4 transitional (Option 1) [d]		3.5	3.7		0.22	T4A
	2012	Tier 4 transitional (option 2) [d]		3.5	3.7		0.02	T4IA/T4IB/T4IC/TI4D
	2013+	Tier 4 final		3.5	3.7		0.02	T4FA/T4FB/T4FC/TF4D
≥75 to <100	1998-2003	Tier 1				6.9		T1
	2004-2007	Tier 2		5.6	3.7		0.30	T2
	2008-2011	Tier 3		3.5	3.7		0.30	T3B
	2012-2013	Tier 4 transitional [e]		3.5	3.7		0.01	T4IA/T4IB/T4IC/TI4D

Table 2-1. Nonroad CI Engine Emission Standard (cont.)[a]

Engine Power (hp)	Model Years	Regulation	Emission Standards (g/hp-hr)					Nonroad Tech Types[g]
			HC [b]	NMHC+NO_x	CO	NO_x	PM	
	2014+	Tier 4 final [f]	0.14		3.7	0.30	0.01	T4FA/T4FB/T4FC/TF4D
≥100 to <175	1997-2002	Tier 1				6.9		T1
	2003-2006	Tier 2		4.9	3.7		0.22	T2
	2007-2011	Tier 3		3.0	3.7		0.22	T3
	2012-2013	Tier 4 transitional [e]		3.0	3.7		0.01	T4IA/T4IB/T4IC/TI4D
	2014+	Tier 4 final [f]	0.14		3.7	0.30	0.01	T4FA/T4FB/T4FC/TF4D
≥175 to <300	1996-2002	Tier 1	1.0		8.5	6.9	0.4	T1
	2003-2005	Tier 2		4.9	2.6		0.15	T2
	2006-2010	Tier 3		3.0	2.6		0.15	T3
	2011-2013	Tier 4 transitional [e]		3.0	2.6		0.01	T4IA/T4IB/T4IC/TI4D
	2014+	Tier 4 final [f]	0.14		2.6	0.30	0.01	T4FA/T4FB/T4FC/TF4D
≥300 to <600	1996-2000	Tier 1	1.0		8.5	6.9	0.4	T1
	2001-2005	Tier 2		4.8	2.6		0.15	T2
	2006-2010	Tier 3		3.0	2.6		0.15	T3
	2011-2013	Tier 4 transitional [e]		3.0	2.6		0.01	T4IA/T4IB/T4IC/TI4D
	2014+	Tier 4 final [f]	0.14		2.6	0.30	0.01	T4FA/T4FB/T4FC/TF4D
≥600 to ≤750	1996-2001	Tier 1	1.0		8.5	6.9	0.4	T1
	2002-2005	Tier 2		4.8	2.6		0.15	T2
	2006-2010	Tier 3		3.0	2.6		0.15	T3
	2011-2013	Tier 4 transitional [e]		3.0	2.6		0.01	T4IA/T4IB/T4IC/TI4D

Table 2-1. Nonroad CI Engine Emission Standard (cont.)[a]

Engine Power (hp)	Model Years	Regulation	Emission Standards (g/hp-hr)					Nonroad Tech Types[g]
			HC [b]	NMHC+NO_x	CO	NO_x	PM	
	2014+	Tier 4 final [f]	0.14		2.6	0.30	0.01	T4FA/T4FB/T4FC/TF4D
>750 except generator sets	2000-2005	Tier 1	1.0		8.5	6.9	0.4	T1
	2006-2010	Tier 2		4.8	2.6		0.15	T2
	2011-2014	Tier 4 transitional	0.30		2.6	2.6	0.075	T4IA/T4IB/T4IC/TI4D
	2015+	Tier 4 final [f]	0.14		2.6	2.6	0.03	T4FA/T4FB/T4FC/TF4D
Generator sets >750 to ≤1200	2000-2005	Tier 1	1.0		8.5	6.9	0.4	T1
	2006-2010	Tier 2		4.8	2.6		0.15	T2
	2011-2014	Tier 4 transitional	0.30		2.6	2.6	0.075	T4IA/T4IB/T4IC/TI4D
	2015+	Tier 4 final [f]	0.14		2.6	0.5	0.02	T4FA/T4FB/T4FC/TF4D
Generator sets >1200	2000-2005	Tier 1	1.0		8.5	6.9	0.4	T1
	2006-2010	Tier 2		4.8	2.6		0.15	T2
	2011-2014	Tier 4 transitional	0.30		2.6	0.5	0.075	T4IA/T4IB/T4IC/TI4D
	2015+	Tier 4 final [f]	0.14		2.6	0.5	0.02	T4FA/T4FB/T4FC/TF4D

[a] The standards for recreational marine diesel engines are provided in Table 5-1 .
[b] Tier 4 standards are in the form of NMHC.
[c] These Tier 3 standards apply only to manufacturers selecting Tier 4 Option 2. Manufacturers selecting Tier 4 Option 1 will be meeting those standards in lieu of Tier 3 standards.
[d] A manufacturer may certify all their engines to either Option 1 or Option 2 sets of standards starting in the indicated model year. Manufacturers selecting Option 2 must meet Tier 3 standards in the 2008-2011 model years.
[e] These standards are phase-out standards. Not more than 50 percent of a manufacturer's engine production is allowed to meet these standards in each model year of the phase out period. Engines not meeting these standards must meet the final Tier 4 standards.
[f] These standards are phased in during the indicated years. At least 50 percent of a manufacturer's engine production must meet these standards during each year of the phase in. Engines not meeting these standards must meet the applicable phase-out standards.
[g] The Tier 4 transitional (also called interim) technology T4I and the Tier 4 final technology T4F use sub-categories A, B, C and D as defined in Table 2-2.

2.2 Tier 4 Technology Types

In the nonroad module of MOVES2014b, we have modified how Tier 4 technology types are defined:

For both transitional (interchangeably called as "interim") Tier 4 and final Tier 4, MOVES2014b now subdivides the tech types – 4I (for interim) and 4F (for final) – based on engine after-treatment configuration.* The sub-category indices "A", "B", "C" and "D" are used to indicate whether the after-treatment configuration includes a diesel particular filter ("DPF") and/or a selective catalytic reduction ("SCR"), yielding four possible combinations as shown in Table 2-2.

Table 2-2. Tier 4 Technology Type Sub-Category

T4I/T4F Sub-category Index	DPF	SCR
A	No	No
B	No	Yes
C	Yes	No
D	Yes	Yes

This new Tier 4 tech type definition makes it possible to model the varying emission characteristics from different after-treatment technology employed by engine manufacturers to comply with Tier 4 standards. It also provides more flexibility in terms of modeling speciation and toxics as described in detail in a separate technical report on Speciation Profiles and Toxic Emission Factors for Nonroad Engines[2].

2.3 Technology Type Distributions

For emission calculations, MOVES-Nonroad requires the distributions of the technology types as input data. The distributions are calculated by considering the engine standards listed in Table 2-1, together with flexibility allowances for equipment manufacturers. Under the percentage phase-in allowance, the flexibility program (also known as Transition Program for Equipment Manufacturers – TPEM)[10], a manufacturer may exempt to a cumulative total of eighty percent of the production over the first seven years in which a new emission standard applies. In addition, there are allowances for manufacturers producing a small volume of equipment[11], as well as engineering or technical hardship relief allowances[12]. These apply separately to each regulatory power category. The engines used in such exempted equipment only have to meet the previous standard.

In MOVES2014b, the technology distribution calculation accounts for the Tier-2/3 flexibility

* For engine power categories where hp ≤ 75, tech types T4A and/or T4B are still used for some model years for compatibility with previous NONROAD models.

program in the same way as NONROAD2008a: engines used in exempted equipment only have to meet the previous standard, which is either the Tier 1 standard in the case of equipment at or above 50 hp, or unregulated in the case of equipment under 50 hp. For categories of engines where there is an overlap in standards (this only occurs in equipment at or above 50 hp), the standard for the exempted equipment continues to be the Tier 1 standard.

The following example illustrates the percent exemptions applied during the introduction of Tier 2 and Tier 3 standards for equipment <100 to 175 hp. As listed in Table 2-1, Tier 2 is nominally required for this engine size class in 2003, and Tier 3 is required in 2007. Under TPEM, the standard required for the exempted equipment is the Tier 1 standard.

Table 2-3. Tier 2/3 TPEM Example for Equipment <100 to 175 hp

Model Year	Technology Distributions
2002	100% Tier 1
2003	20% Tier 1; 80% Tier 2
2004	20% Tier 1; 80% Tier 2
2005	10% Tier 1; 90% Tier 2
2006	10% Tier 1; 90% Tier 2
2007	10% Tier 1; 90% Tier 3
2008	10% Tier 1; 90% Tier 3
2009	100% Tier 3
Total exemption	80%

For the purposes of emissions modeling, we assumed that the manufacturers took full advantage of the Percentage Phase-in Allowance provisions under Tier 2/3 flexibility program.

In MOVES2014b, we have updated the way the Tier 4 technology distributions are calculated since newly introduced Tier 4 tech types are now based on the after-treatment configuration in addition to the horsepower category and the model year. The calculation was done in two steps:

In the first step, we analyzed the Tier 4 nonroad compression ignition engine certification data extracted from EPA VERIFY database[3] for model years from 2011 thru 2017.* The composition of the sample data is shown in Table 2-4 where the numbers of the certified engine families are broken down by model year and engine power categories. The compliance data set includes information that the manufacturers reported to EPA about engine family, power category, applicable certification tier, after-treatment device types, and emission rates. In addition, confidential business information on projected engine sale volumes was also available for analysis.

* Only partial data was available for model year 2011. It was combined with model year 2012 data set for analysis.

Table 2-4. Tier 4 Certification Data Sample Size (Number of Engine Families)

Model Year	HP<25	25≤ HP<50	50≤ HP<75	75≤HP<175	175≤HP≤750	750<HP
2011+2012	147	121	83	45	83	12
2013	78	24	40	45	83	16
2014	70	42	58	53	60	20
2015	73	49	70	34	79	17
2016	78	52	76	39	84	22
2017	82	46	82	47	100	26

Using these available data, we calculated the projected-sales-volume-averaged fractions of the Tier 4 engines in each engine technology category per power category and model year group. In the calculation, the engine families certified for "stationary use only" were excluded because the MOVES-Nonroad model only considers mobile engine populations as described in the Nonroad Engine Population Estimate technical report[13].

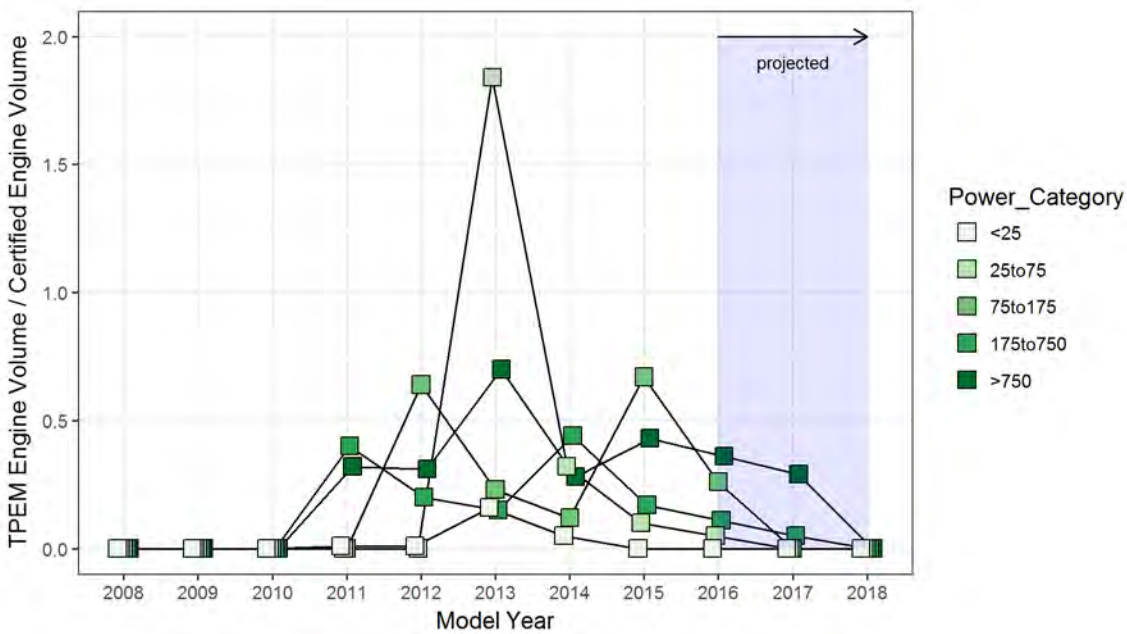
Once the technology distributions among Tier 4 engines were calculated, the second step accounted for impact of the Tier 4 flexibility program. The Tier 4 transition program for equipment manufacturers (TPEM[10]) has a framework similar to the previously mentioned Tier 2/3 flexibility program. It provides a temporary exemption that allows equipment manufacturers to delay installing Tier-4 compliance engines in their products for up to seven years. Manufacturers who decide to voluntarily participate in the TPEM also provide annual production volume reports to EPA. We used the information extracted from the production reports (data available up to 2016 model year) in order to estimate the annual ratio of the total certified engine production to that of the TPEM engine production for each horsepower category as shown in Table 2-5. The ratios for model year 2017 are projected values obtained by linearly extrapolating the slope connecting 2015 and 2016 model year ratios. When either a projected ratio for model years past 2016 reaches a level below 0, or the regular TPEM allowance is no longer available in a projected year[*], the ratio is set to 0 as shown in . These ratios were then applied to derive the final technology distributions provided in Appendix A, Table A1.

[*] The regular TPEM program ends in 2014 for engines <75HP, in 2018 for engines between 75 and 175 HP, and in 2017 for engines greater than 175 HP.

Table 2-5. Certified Engine vs. TPEM Engine Volume Ratios

Model Year	HP<25	25≤HP<75	75≤HP<175	175≤HP≤750	750<HP
2008	0.00	0.00	0.00	0.00	0.00
2009	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00
2011	0.01	0.00	0.00	0.40	0.32
2012	0.01	0.00	0.64	0.20	0.31
2013	0.16	1.84	0.23	0.15	0.70
2014	0.05	0.32	0.12	0.44	0.28
2015	0.00	0.10	0.67	0.17	0.43
2016	0.00	0.05	0.26	0.11	0.36
2017 (projected)	0.00	0.00	0.00	0.05	0.29
2018 (projected)	0.00	0.00	0.00	0.00	0.00

Figure 1. Trends of Certified Engine vs. TPEM Engine Volume Ratios



3 Methodology for Calculation of Emission Factors

For HC, CO, and NO_x, the exhaust emission factor for a given diesel equipment type in a given model year/age is calculated as follows:

$$EF_{adj(HC,CO,NOx)} = EF_{ss} \times TAF \times DF \qquad \textbf{Equation 1}$$

Where:

EF_{adj} = final emission factor used in model, after adjustments to account for transient operation and deterioration (g/hp-hr)
EF_{ss} = zero-hour, steady-state emission factor (g/hp-hr)
TAF = transient adjustment factor (unitless)
DF = deterioration factor (unitless)

The zero-hour, steady-state emission factors (EF_{ss}) are mainly a function of model year and horsepower category, which defines the technology type. The transient adjustment factors (TAFs) vary by equipment type. The deterioration factor (DF) is a function of the technology type and age of the engine.

Since PM emissions are dependent on the sulfur content of the fuel the engine is burning, the equation used for PM is slightly modified from equation [1] as follows:

$$EF_{adj(PM)} = EF_{ss} \times TAF \times DF \times S_{PMadj} \qquad \textbf{Equation 2}$$

Where:

$S_{PM\ adj}$ = adjustment to PM emission factor to account for variations in fuel sulfur content (g/hp-hr)

PM and SO_2 are the only diesel pollutants that are dependent on fuel sulfur content.

For BSFC, there is no deterioration applied, so the equation is simplified to:

$$EF_{adj(BSFC)} = EF_{ss} \times TAF \qquad \textbf{Equation 3}$$

Where:

$EF_{adj\ (BSFC)}$ = final brake specific fuel consumption used in model, after adjustments to account for transient operation (lb/hp-hr)
EF_{ss} = steady-state brake specific fuel consumption (lb/hp-hr)
TAF = transient adjustment factor (unitless)

Emission factors for CO_2 and SO_2 are calculated based on brake-specific fuel consumption; therefore, the model does not require CO_2 or SO_2 emission factor input files. The equations for computing these emissions are discussed in detail later in this report.

Crankcase HC emissions are simply a fraction (2 percent) of exhaust HC emissions for Tier 3 and earlier engines[14]. For Tier 4 engines, zero crankcase emissions are assumed. Crankcase

emissions are discussed in more detail later in this report.

For ease of reference, the model inputs for EF_{ss}, TAFs, and DFs are included with the technology model year fractions in Appendix A.

4 Zero-Hour, Steady State Emission Factors – HC, CO, NO_x, PM and BSFC

This section describes the steady-state fuel consumption and emission factors for HC, CO, NO_x, and PM. These emission factors are listed in Table A4 in Appendix A. We have used engine model year and horsepower as categories to group MOVES-Nonroad emission factors. These groupings are consistent with emission standards for CI engines with a few exceptions. One exception is that the pre-control engines have been split into two groups, pre-1988 MY engines, and 1988 MY to Tier 1 engines. The pre-1988 MY engines are referred to as "Base" engines and the 1988 MY to Tier 1 engines are referred to as "Tier 0" engines. This distinction was made based on data indicating a difference in emission rates. Another exception is a minor difference in the horsepower categories used in MOVES-Nonroad versus those used for standard setting. The MOVES-Nonroad horsepower categories follow the general formula, $x<hp\leq y$, whereas the CI standards generally follow the formula, $x\leq hp<y$. By making this minor modification, the MOVES-Nonroad CI horsepower categories are consistent with those used for spark ignition equipment. For Tier 4 engines, we have developed Tier 4 emission factors that are based on the applicable emission standard, horsepower size and aftertreatment configuration as discussed in Section 4.4

4.1 Default Certification Fuel Sulfur Level

As mentioned previously, fuel sulfur levels affect PM emissions. MOVES-Nonroad users can adjust for local (episodic) fuel sulfur levels. The default fuel sulfur levels for nonroad diesel (fuelTypeID 23) and marine diesel (fuelTypeID 24) are presented in the MOVES Fuel Supply Report[15].

The adjustment for fuel sulfur is made relative to the default certification fuel sulfur level in the model. The national average for nonroad diesel estimated as of 1997 is 3300 ppm[16], and the Tier 1 and pre-control emission factors in MOVES-Nonroad's input files are adjusted to be consistent with this default fuel sulfur level. The available Tier 2 emission factors are intended to be consistent with a default fuel sulfur level of 0.20 mass percent, in order to attain a 0.15 g/hp-hr PM standard. Where emission tests were known to have been performed with fuels with other sulfur contents, the test results have been adjusted, as described in Appendix C.

The default certification fuel sulfur levels in the model for Tier 3 and Tier 4 engines are provided in Table 4-1. In addition to adjusting for local fuel sulfur levels, the model allows the user to input alternative certification diesel fuel sulfur levels for Tier 2 and later engines.

Table 4-1. Default Certification Diesel Fuel Sulfur Content for Tier 3 and Tier 4 Engines

Engine Power	Model Years	Regulation	MOVES-Nonroad Tech Types	Modeled Default Fuel Sulfur Content (ppm)
hp ≤ 75	2008-2012	Tier 4 transitional	T4A	500
	2013+	Tier 4	T4B, T4F	15
75 < hp ≤ 100	2008-2011	Tier 3 transitional [a]	T3B	500
	2012+	Tier 4 transitional and final	T4IA/T4IB/T4IC/T4IC, T4FA/T4FB/T4FC/T4FD	15
100 < hp ≤ 175	2007-2011	Tier 3	T3	2000
	2012+	Tier 4 transitional and final	T4IA/T4IB/T4IC/T4IC, T4FA/T4FB/T4FC/T4FD	15
175 < hp ≤ 750	2006-2010	Tier 3	T3	2000
	2011+	Tier 4 transitional and final	T4IA/T4IB/T4IC/T4IC, T4FA/T4FB/T4FC/T4FD	15
hp > 750	2011+	Tier 4 transitional and final	T4IA/T4IB/T4IC/T4IC, T4FA/T4FB/T4FC/T4FD	15

[a] Since the Tier 3 standard begins in 2008, it is assumed that this new technology introduction will allow manufacturers to take advantage of the availability of 500 ppm fuel that year.

4.2 Brake-Specific Fuel Consumption

Due to lack of data, the brake-specific fuel consumption (BSFC) for the 1988-and-later pre-control (Tier 0) engines is used for all engines, both earlier pre-control engines and later engines subject to emissions standards. The derivation of the BSFC values is described in Appendix C. While it is likely that fuel consumption varies between these categories, there is not sufficient data available at this time for EPA to specify alternate values.

4.3 HC, CO, NO_x, PM Emission Factors for Base (Pre-1998), Tier 0, Tier 1, Tier 2, and Tier 3 Engines

There is little test data available on nonroad engines. In developing the emission factors for MOVES-Nonroad, we have considered data from various sources. The basis for the emission factors by model year/hp category is described below and summarized in Table 4-2 thru Table 4-5.

<u>Base (Pre-1988), Engines ≤50 hp:</u>
There are no known tests of pre-1988 CI engines of less than or equal to 50 hp. Thus, MOVES-Nonroad will use the same emission factors as for the 1988 through Tier 1 years for engines of this size described below.

Table 4-2. Summary of the Basis for the HC Zero-Hour Nonroad Steady-State CI Emission Factors in MOVES2014b

HP	HC g/hp-hr									
	Tier 0[a]	**T0 Basis**	**Tier 1**	**T1 Basis**	**Tier 2[b]**	**T2 Basis[c]**	**Tier 3[b]**	**T3 Basis[c]**	**Tier 4[e]**	**T4 Basis**
>0 to 11	1.5	OFFROAD	0.7628	cert	0.5508[d]	(5) 10% default margin from 0.6 equivalent std (since T1 EF exceeds T2 std, cannot be used)	na		varies by tech type	cert
>11 to 16	1.7	OFFROAD	0.4380	cert	0.4380	(3) Same as T1 (since T1 EF still below 0.6 T2 equivalent std)	na		varies by tech type	cert
>16 to 25	1.7	OFFROAD	0.4380	cert	0.4380	(3) Same as T1 (since T1 EF still below 0.6 T2 equivalent std)	na		varies by tech type	cert
>25 to 50	1.8	OFFROAD	0.2789	cert	0.2789	(3) Same as T1 (since T1 EF still below 0.6 T2 equivalent std)	na		varies by tech type	cert
>50 to 75	0.99	EF data	0.5213	cert	0.3672[d]	(5) 10% default margin from 0.4 equivalent std (since T1 EF exceeds T2 std, cannot be used)	0.1836[d]	(5) 10% margin from 0.2 eqv std	varies by tech type	cert
>75 to 100	0.99	EF data	0.5213	cert	0.3672[d]	(5) 10% default margin from 0.4 equivalent std (since T1 EF exceeds T2 std, cannot be used)	0.1836[d]	(5) 10% margin from 0.2 eqv std	varies by tech type	cert
>100 to 175	0.68	EF data	0.3384	cert	0.3384	(3) Same as T1 (since T1 EF still below 0.4 T2 equivalent std)	0.1836[d]	(5) 10% margin from 0.2 eqv std	varies by tech type	cert
>175 to 300	0.68	EF data	0.3085	cert	0.3085	(3) Same as T1 (since T1 EF still below 0.4 T2 equivalent std)	0.1836[d]	(5) 10% margin from 0.2 eqv std	varies by tech type	cert
>300 to 600	0.68	EF data	0.2025	cert	0.1669	cert	0.1669	(3) Same as T2	varies by tech type	cert
>600 to 750	0.68	EF data	0.1473	cert	0.1669	(1 and 2) Same as the >300 to 600hp category. Rationale:	0.1669	(3) Same as T2	varies by tech type	cert

HP	HC g/hp-hr									
	Tier 0[a]	**T0 Basis**	**Tier 1**	**T1 Basis**	**Tier 2[b]**	**T2 Basis[c]**	**Tier 3[b]**	**T3 Basis[c]**	**Tier 4[e]**	**T4 Basis**
>750 except gen sets	0.68	EF data	0.2861	cert	0.1669	a) All these HP categories meet same 0.3 HC eqv std. b) The NOx T1 EFs exceed the T2 std. To meet NOx T2, changes are likely to increase HC. c) EF based on actual cert data.	na		varies by tech type	cert
Gen sets >750 to 1200	0.68	EF data	0.2861	cert	0.1669		na		varies by tech type	cert
Gen sets >1200	0.68	EF data	0.2861	cert	0.1669		na		varies by tech type	cert

[a] Tier 0 represents 1988+ MY engines for MYs prior to Tier 1. Separate EFs are also provided for Base (pre-1988 MY) engines. For ≤50hp engines, Base EF = Tier 0 EF. For >50hp engines, the Base EFs vary by application, so are not provided in this table.
[b] The Tier 2 and Tier 3 standards are expressed as a combined NMHC + NO_x standard. The NMHC assumed fractions of these combined standards are taken from the RIA. The resulting NMHC portion of the combined standard is referred to here as the "equivalent" standard.
[c] Numbers in parentheses correspond to the option selected, which is briefly described here. For more details regarding the options, consult the text.
[d] An adjustment of 1.02 (1/0.984) is also applied to convert from NMHC to THC, since the standards apply to NMHC. This adjustment is described in report NR-002b.
[e] Tier 4 emission factors are considered to be transient, rather than steady-state.

Table 4-3. Summary of the Basis for the CO Zero-Hour Steady-State Nonroad CI Emission Factors in MOVES2014b

HP	CO g/hp-hr									
	Tier 0[a]	T0 Basis	Tier 1	T1 Basis	Tier 2	T2 Basis[b]	Tier 3	T3 Basis[b]	Tier 4[d]	T4 Basis
>0 to 11	5	OFFROAD	4.1127	cert	4.1127	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>11 to 16	5	OFFROAD	2.1610	cert	2.1610	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>16 to 25	5	OFFROAD	2.1610	cert	2.1610	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>25 to 50	5	OFFROAD	1.5323	cert	1.5323	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>50 to 75	3.49	EF data	2.3655	cert	2.3655	Same as T1 (since T1 EF still below T2 std)	2.3655	Same as T1	varies by tech type	cert
>75 to 100	3.49	EF data	2.3655	cert	2.3655	Same as T1 (since T1 EF still below T2 std)	2.3655	Same as T1	varies by tech type	cert
>100 to 175	2.7	EF data	0.8667	cert	0.8667	Same as T1 (since T1 EF still below T2 std)	0.8667	Same as T1	varies by tech type	cert
>175 to 300	2.7	EF data	0.7475	cert	0.7475	Same as T1 (since T1 EF still below T2 std)	0.7475	Same as T1	varies by tech type	cert
>300 to 600	2.7	EF data	1.3060	cert	0.8425	cert	0.8425	Same as T2	varies by tech type	cert
>600 to 750	2.7	EF data	1.3272	cert	1.3272	Same as T1 (since T1 EF still below T2 std)	1.3272	Same as T1	varies by tech type	cert
>750 except gen sets	2.7	EF data	0.7642	cert	0.7642	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
Gen sets >750 to 1200	2.7	EF data	0.7642	cert	0.7642	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
Gen sets >1200	2.7	EF data	0.7642	cert	0.7642	Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert

a Tier 0 represents 1988+ MY engines for MYs prior to Tier 1. Separate EFs are also provided for Base (pre-1988 MY) engines. For ≤50hp engines, Base EF = Tier 0 EF. For >50hp engines, the Base EFs vary by application, so are not provided in this table.
b The Tier 2 and Tier 3 CO emission factors are based on application of option 2, the carryover of emission factors derived from nonroad certification data. For more detail regarding this option, consult the text.
c For >25 to 75 hp engines, CO emissions for engines meeting the Tier 4 transitional PM standard of 0.22 g/hp-hr in 2008-2012 are unchanged from Tier 1. In 2013+, when the Tier 4 PM standard of 0.02 g/hp-hr takes effect, the corresponding CO EFs are reduced by 90 percent.

d Tier 4 emission factors are considered to be transient, rather than steady-state.

Table 4-4. Summary of the Basis for the NOx Zero-Hour Steady-State Nonroad CI Emission Factors in MOVES2014b

HP	NOx g/hp-hr									
	Tier 0[a]	**T0 Basis**	**Tier 1**	**T1 Basis**	**Tier 2[b]**	**T2 Basis[c]**	**Tier 3[b]**	**T3 Basis[c]**	**Tier 4[d]**	**T4 Basis**
>0 to 11	10	OFFROAD	5.2298	cert	4.3	(4) 14% hwy margin from 5.0 equivalent std	na		varies by tech type	cert
>11 to 16	8.5	OFFROAD	4.4399	cert	4.4399	(3) Same as T1 (since T1 EF still below 5.0 T2 equivalent	na		varies by tech type	cert
>16 to 25	8.5	OFFROAD	4.4399	cert	4.4399	(3) Same as T1 (since T1 EF still below 5.0 T2 equivalent	na		varies by tech type	cert
>25 to 50	6.9	OFFROAD	4.7279	cert	4.7279	(3) Same as T1 (since T1 EF still below 5.0 T2 equivalent	na		varies by tech type	cert
>50 to 75	8.30	EF data	5.5988	cert	4.7	(5) 10% default margin from 5.2 T2 equiv std	3.0	(5) 10% margin from 3.3 eqv std	varies by tech type	cert
>75 to 100	8.30	EF data	5.5988	cert	4.7	(5) 10% default margin from 5.2 T2 equiv std	3.0	(5) 10% margin from 3.3 eqv std	varies by tech type	cert
>100 to 175	8.38	EF data	5.6523	cert	4.1	(5) 10% default margin from 4.5 T2 equiv std	2.5	(5) 10% margin from 2.8 eqv std	varies by tech type	cert
>175 to 300	8.38	EF data	5.5772	cert	4.0	(4) 10.5% hwy margin from 4.5 T2 equivalent std	2.5	(4) 10.5% hwy margin from 2.8	varies by tech type	cert
>300 to 600	8.38	EF data	6.0153	cert	4.3351	cert (real data preferred even though margin from 4.5 eqv T2 std <10%)	2.5	(5) 10% margin from 2.8 eqv std	varies by tech type	cert
>600 to 750	8.38	EF data	5.8215	cert	4.1	(5) 10% default margin from 4.5 T2 equiv std	2.5	(5) 10% margin from 2.8 eqv std	varies by tech type	cert
>750 except gen sets	8.38	EF data	6.1525	cert	4.1	(5) 10% default margin from 4.5 T2 equiv std	na		varies by tech type	cert
Gen sets >750 to 1200	8.38	EF data	6.1525	cert	4.1	(5) 10% default margin from 4.5 T2 equiv std	na		varies by tech type	cert
Gen sets >1200	8.38	EF data	6.1525	cert	4.1	(5) 10% default margin from 4.5 T2 equiv std	na		varies by tech type	cert

[a] Tier 0 represents 1988+ MY engines for MYs prior to Tier 1. Separate EFs are also provided for Base (pre-1988 MY) engines. For ≤Tier 0 represents 1988+ MY engines for MYs prior to Tier 1. Separate EFs are also provided for Base (pre-1988 MY) engines.
[b] The Tier 2 and Tier 3 standards are expressed as a combined NMHC + NO_x standard. The NO_x assumed fractions of these combined standards are taken from the RIA.

The resulting NO_x portion of the combined standard is referred to here as the "equivalent" standard.
[c] Numbers in brackets correspond to the option selected, which is briefly described here. For more details regarding the options, consult the text. The derivation of the highway-based compliance margins is discussed in Appendix E.
[d] Tier 4 emission factors are considered to be transient, rather than steady-state.

Table 4-5. Summary of the Basis for the PM10 Zero-Hour Steady-State Nonroad CI Emission Factors in MOVES2014b

HP	PM_{10} g/hp-hr									
	Tier 0[a]	**T0 Basis**	**Tier 1**	**T1 Basis**	**Tier 2**	**T2 Basis[b]**	**Tier 3**	**T3 Basis[b]**	**Tier 4[d]**	**T4 Basis**
>0 to 11	1	OFFROAD	0.4474	cert	0.50	(1) The NOx T1 EF exceeds the T2 std. To meet NOx T2, changes are likely to increase PM. The T2 PM EF is therefore expected to be greater than 0.44 (T1 EF) and less than 0.60 (T2 std); 0.50 chosen as a reasonable value.	na		varies by tech type	cert
>11 to 16	0.9	OFFROAD	0.2665	cert	0.2665	(3) Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>16 to 25	0.9	OFFROAD	0.2665	cert	0.2665	(3) Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>25 to 50	0.8	OFFROAD	0.3389	cert	0.3389	(3) Same as T1 (since T1 EF still below T2 std)	na		varies by tech type	cert
>50 to 75	0.722	EF data	0.4730		0.24	(4) 20% highway-based margin from std (since T1 EF exceeds T2 std, cannot be used)	0.30	(1) T3 std	varies by tech type	cert
>75 to 100	0.722	EF data	0.4730		0.24	(4) 20% highway-based margin from std (since T1 EF exceeds T2 std, cannot be used)	0.30	(1) T3 std	varies by tech type	cert
>100 to 175	0.402	EF data	0.2799		0.18	(4) 20% highway-based margin from std (since T1 EF exceeds T2 std, cannot be used)	0.22	(1) T3 std	varies by tech type	cert
>175 to 300	0.402	EF data	0.2521	cert	0.1316	(2) T2 EF for >300 to 600hp category applied to these hp categories. Rationale: All four hp categories meet same PM std. Also, T2 EF of 0.1316 based on actual certification data.	0.15	(1) T3 std	varies by tech type	cert
>300 to 600	0.402	EF data	0.2008	cert	0.1316		0.15	(1) T3 std	varies by tech type	cert
>600 to 750	0.402	EF data	0.2201	cert	0.1316		0.15	(1) T3 std	varies by tech type	cert

HP	PM_{10} g/hp-hr									
	Tier 0[a]	**T0 Basis**	**Tier 1**	**T1 Basis**	**Tier 2**	**T2 Basis[b]**	**Tier 3**	**T3 Basis[b]**	**Tier 4[d]**	**T4 Basis**
>750 except gen sets	0.402	EF data	0.1934	cert	0.1316		na		varies by tech type	cert
Gen sets >750 to 1200	0.402	EF data	0.1934	cert	0.1316		na		varies by tech type	cert
Gen sets >1200	0.402	EF data	0.1934	cert	0.1316		na		varies by tech type	cert

[a] Tier 0 represents 1988+ MY engines for MYs prior to Tier 1. Separate EFs are also provided for Base (pre-1988 MY) engines. For □50hp engines, Base EF = Tier 0 EF. For >50hp engines, the Base EFs vary by application, so are not provided in this table.
[b] Numbers in brackets correspond to the option selected, which is briefly described here. For more details regarding the options, consult the text. The derivation of the highway-based compliance margins is discussed in Appendix E.
[c] For >25 to 75 hp engines, there is also a transitional Tier 4 PM standard of 0.22 g/hp-hr in 2008-2012. The corresponding PM EF in NONROAD is 0.20 g/hp-hr.
[d] Tier 4 emission factors are considered to be transient, rather than steady-state.

Base (Pre-1988), Engines > 50 hp:
For pre-1988 CI engines of greater than 50 hp, MOVES-Nonroad's steady-state emission factors are based on the emission factors used in the Nonroad Engine and Vehicle Emission Study (NEVES)[14]. The sources of the emission factors used in NEVES are described in Appendix B. The emission factors vary by application. However, NEVES includes an adjustment for in-use operation. Since MOVES-Nonroad uses a different in-use adjustment factor than NEVES (see Appendix F), the NEVES adjustment is removed to determine pre-1988 average steady-state emissions.

Because the testing fuel is generally unknown, we assume that the NEVES PM factors are appropriate for the default certification fuel sulfur content of 0.33 wt. percent sulfur used in MOVES-Nonroad.

A conversion from gram per gallon to gram per horsepower-hr was made to NEVES emission rates for the greater than 50 horsepower engines for the diesel recreational marine categories; inboard, outboard, and sailboat auxiliary. Outboard and sailboat auxiliary engines above 50 hp were converted from the NEVES gram per gallon to gram per horsepower using the higher fuel consumption of 0.408 lbs/hp-hr and 7.1 lbs/gallon fuel density because these engines are primarily less than 100 hp. The NEVES emission rate for inboard engines was converted using the lower fuel consumption rate of 0.367 lbs/hp-hr because these engines are primarily above 100 horsepower.

Tier 0 (1988 to Tier 1), Engines ≤50 hp
For 1988-and-later pre-control engines less than or equal to 50 hp, we used the emission factors described in the documentation for ARB's OFF-ROAD model[17]. We have combined the direct injection and indirect injection factors using the technology fractions listed in the Regulatory Impact Analysis (RIA) for the emission standards[18]. Again, because the sulfur content of fuels used in generating these emission factors is unknown, we have assumed that the PM emission factors are appropriate for the default certification fuel sulfur level of 0.33 weight percent.

Tier 0 (1988 to Tier 1), Engines >50 hp
Studies have indicated that, in general, emission rates from Tier 0 engines greater than 50 hp are lower than for Tier 0 engines less than or equal to 50 hp. For these engines, we will use emission factors calculated from recent studies. A summary of the emission data from these studies is provided in Appendix C. As explained in Appendix C, a correction for fuel sulfur content is applied.

Tier 1 Engines, all hp categories
The MOVES-Nonroad model's emission factors for Tier 1 engines are based on EPA certification data. The certification data are described in Appendix D.

Tier 2 Engines, >300 to 600 hp
Since EPA certification data are available for this hp category, the emission factors are based on analysis of the certification data, as described in Appendix D.

Tier 2 Engines ≤300 hp and > 600 hp and Tier 3 Engines
The emission factors for these engines were developed for NONROAD2005, when certification data were not available. As a result, we developed five alternative options for calculating zero mile, steady-state emission factors for these engines. These options were considered in the order they are presented here.

1. *Examine likely impacts of expected technology changes*. In this option, we consider offsetting changes to PM and HC with implementation of stricter emission standards for NO_x. This includes assigning the applicable standard as the PM emission factor without applying a compliance margin. The compliance margin is the percent difference between a standard and average emissions at certification for engines manufactured under that standard.

2. *Assign an emission factor from another hp category*. In this option, we assume that an emission factor based on certification data is applicable to another hp category and is preferable to applying a compliance margin to the applicable nonroad standard.

3. *Continue to use the Tier 1 or Tier 2 emission factors derived from the nonroad certification data*. In this option, we assume that manufacturers will maintain current emission levels, e.g., design technologies, if they appear adequate to achieve compliance while maintaining some margin of safety. Under this option, we would assume that emission factors remain at the same levels used for Tier 1 or Tier 2 engines.

   This option was only considered if the compliance margin (percent difference) between the proposed emission factor and the applicable nonroad standard was at least 10 percent. We based this lower bound (10 percent) on average highway-certification compliance margins for NO_x, assuming that it represents progressive highway certification experience for a "controlling pollutant," i.e., a pollutant for which the necessity to achieve compliance drives innovation in engine design or control technology.

4. *Reduce the applicable nonroad standard by a compliance margin derived from certification test results for analogous highway engines*. We expect that the control of emissions from nonroad engines will follow a course similar to that experienced for highway engines, since we believe that as standards for nonroad engines become more stringent, manufacturers will adopt technologies similar to those already introduced in highway engines. Based on this expectation, we calculated compliance margins using highway standards and corresponding highway certification test results. In this discussion, we will refer to compliance margins calculated for

highway engines as "highway-certification compliance margins" (HCCM). The derivation of the HCCMs is discussed in detail in Appendix E. An HCCM is only considered for use if it is greater than or equal to 10 percent and less than 75 percent.

5. *Apply a default compliance margin of 10 percent*. In this option, we assume that on average, manufacturers will maintain a minimum compliance margin. This margin is based on average highway certification compliance margins for NO_x, the pollutant appearing to drive measures to achieve compliance in highway diesel engines. A default compliance margin was considered when the highway-based compliance margins were outside the acceptable range. With this option, the applicable nonroad standard is simply reduced by 10 percent.

The EPA regulates HC and NO_x under a combined standard for all Tier 2 and Tier 3 engines. Thus, in order to apply compliance margins for these pollutants, where applicable, we split the combined standard into pollutant-specific components for HC and NO_x. These are presented in Table 4-6.

For each pollutant in Tiers 2 and 3, we evaluated one or more of these five options for each horsepower category. The specific options selected for each pollutant and Tier are presented in Table 4-2 thru Table 4-5 and summarized below:

HC: *Tier 2*: For categories less than 300 hp, we continued to use the Tier 1 nonroad certification results (option 3) or applied the default compliance margin (option 5) on an individual basis by horsepower category to give nonroad compliance margins of at least 10 percent. We did not use the highway-certification compliance margins because the highway HC standards have not driven technology development; as a result, the HC standards are unrelated to the certification values.

For the two hp categories greater than 600 hp, we assigned the emission factor for the 300-600 hp category. The rationale, which applies options 1 and 2, is threefold: 1) all three hp categories meet the same HC equivalent standard, 2) the use of certification data is preferable to applying a compliance margin, and 3) changes necessary to meet the Tier 2 NO_x standard for the 600-750 hp category are likely to increase HC, so a slight increase in HC emissions from Tier 1 to Tier 2 for this hp category is not unexpected.

Tier 3: We continued to use the Tier 2 nonroad certification results (option 3) or applied the default compliance margin (option 5) to give nonroad compliance margins of at least 10 percent. We ruled out use of highway-certification compliance margins (option 4) for the same reason as for Tier 2.

CO: *Tiers 2 and 3*: We continued to use the Tier 1 nonroad certification results (option 2) for all horsepower categories in Tiers 2 and 3. Highway-certification compliance margins (option 4) were very large (>90 percent), and as with HC, give implausibly low emission factors in Tiers 2 and 3.

Table 4-6. Tier 2 and Tier 3 Combined and Estimated Pollutant-Specific Emissions Standards for Nonroad Diesel Engines[1]

Power Range (hp)	Combined Standard $HC+NO_x$ (g/hp-hr)		Estimated Pollutant-Specific HC (g/hp-hr)		Estimated Pollutant-Specific NO_x (g/hp-hr)	
	Tier 2	Tier 3	Tier 2	Tier 3	Tier 2	Tier 3
< 11	5.6		0.6		5.0	
≥11 to <25	5.6		0.6		5.0	
≥25 to <50	5.6		0.6		5.0	
≥50 to <100	5.6	3.5	0.4	0.2	5.2	3.3
≥100 to <175	4.9	3.0	0.4	0.2	4.5	2.8
≥175 to <300	4.9	3.0	0.4	0.2	4.5	2.8
≥300 to <600	4.8	3.0	0.3	0.2	4.5	2.8
≥600 to <750	4.8	3.0	0.3	0.2	4.5	2.8
≥750	4.8		0.3		4.5	

[1] Pollutant-specific components have no regulatory significance and are derived to facilitate modeling analyses.

Basis for Pollutant-Specific HC and NO_x Emission Standards:

Tier 2 <50 hp: As in the RIA[18], EPA assumes minimum HC emissions of 0.6 g/hp-hr based on ARB data on indirect injection (IDI) engines under 25 hp. This rate is then subtracted from the combined $HC+NO_x$ standard to split the standard into single pollutant emission factors.

Tier 2 ≥50 hp: As in the RIA[18], the proposed European NO_x standard is used to split the combined $HC+NO_x$ standard into single pollutant emission factors.

Tier 3: MOVES-Nonroad follows the RIA[18] in using engineering judgment to assume minimum HC emissions of 0.2 g/hp-hr. This rate is then subtracted from the combined $HC+NO_x$ standard to split the standard into single pollutant emission factors.

NO_x: *Tier 2*: We applied highway-certification compliance margins (option 4), continued to use the Tier 1 nonroad certification results (option 3) or applied the default compliance margin (option 5) on an individual basis by horsepower category to give compliance margins of at least 10

percent.

Tier 3: We applied the highway certification compliance margin (option 4) or the default compliance margin (option 5) for all horsepower categories. Nonroad certification results (option 3) did not provide adequate compliance margins.

PM: *Tier 2*: We applied the first four options on an individual basis by horsepower category to give compliance margins of at least 10 percent. The highway-certification compliance margin used for the 50-100 hp and 100-175 hp categories was 20 percent.

Tier 3: Tier 3 PM emission factors were set equal to the appropriate nonroad standards. To meet the NO_x Tier 3 standards, technological changes are likely to increase PM; therefore, compliance margins were not applied to PM (option 1).

4.4 HC, CO, NO_x, PM Emission Factors for Tier 4 Engines

In NONROAD2008a, an eight percent compliance margin was applied to the standards. This compliance margin was derived from data for highway diesel vehicles and used in the HD2007 rulemaking. This simple approach was needed due to the absence of Tier 4 certification data at the time of the model release.

In MOVES2014b the modeling approach was changed to utilize the available certification dataset extracted from EPA VERIFY database[3] for model years from 2011[*] thru 2017. This data set is described earlier in this document under the Emission Standards section. The HC, CO, NOx, and PM emission factors reported by the manufacturers for each certified engine family were weighted with projected sale volumes in order to come up with averaged emission factors for each Tier 4 tech type by horsepower category. The VERIFY database has its own horsepower category definition, which has a few additional horsepower bins that aggregate several individual horsepower categories defined in the Tier 4 standards. For instance, VERIFY has a category for 75<hp≤175 in addition to the two standard 75<hp≤100 and 100<hp≤175 categories. In such a case, we used the ratio of the sales volumes reported for the two smaller categories respectively in order to divide up the volume reported for the larger category for the purpose of weighted average calculation.

The new MOVES2014b emission factors for both transitional and final Tier 4 engine technology are shown along with certificated engine family record counts in Figure 2 in Appendix A, where the emission factor levels from previous NONROAD2008a (in MOVES2014a) version are also plotted for comparison. It is worthwhile to note that Tier 4 regulations also have provisions for averaging, banking and trading (ABT) program[19], similar to previous Tier regulations. Therefore, some engine families certified as Tier 4 may have emission factors higher than the applicable standards.

[*] Only partial data set was available for 2011 model year. For analysis purpose, a combined data set for model years 2011 and 2012 was used.

The resulting zero-hour, steady-state emission factors for all Tiers and pollutants are summarized in Table A4 in Appendix A.

5 Recreational Marine and Underground Mining Emission Factors

Recreational marine CI engines under 50 hp are subject to the Tier 1 and Tier 2 CI engine standards in the October 1998 rule[6]. Tier 2 standards for recreational marine CI engines over 50 hp were established by the November 2002 rule[7]. In 2008, Tier 3 standards were promulgated for all recreational marine engines[9], so the emission factor inputs used for these engines do not exactly follow those presented in Table 4-2 thru Table 4-5. The emission standards for this category are provided in Table 5-1. Table 5-2 shows the base and controlled recreational marine emission factors in MOVES2014b, which was carried over from NONROAD2008a. The technology type names have also been revised to differentiate marine CI from other CI engines.

Although underground mining equipment emissions are not controlled by EPA, there have been controls imposed by the Mine Safety and Health Administration (MHSA). The MHSA standards do not directly follow the form used for the MOVES-Nonroad model, but they are considered approximately equivalent to the EPA Tier 2 standards for land-based CI equipment. Therefore, the MOVES-Nonroad model simply uses the NEVES uncontrolled emission factors for Base, Tier 0, and Tier 1 underground mining inputs, and then applies the Tier 2 emission factors from Table 4-2 thru Table 4-5 for all newer engines.

Table 5-1. Emission Standards for Recreational Marine Diesel Engines

Engine Power (hp)	Engine Displacement (L/cyl)	Model Year Start	Regulation	Emission Standards (g/hp-hr) NMHC +NOx	HC +NOx	CO	PM	Nonroad Tech Types
<11	<0.9	2000	Tier 1	7.8		6.0	0.75	T1M
		2005	Tier 2	5.6		6.0	0.60	T2M
		2009	Tier 3		5.6	6.0	0.30	T3M
≥11 to <25	<0.9	2000	Tier 1	7.1		4.9	0.60	T1M
		2005	Tier 2	5.6		4.9	0.60	T2M
		2009	Tier 3		5.6	4.9	0.30	T3M
≥25 to <50	<0.9	1999	Tier 1	7.1		4.1	0.60	T1M
		2004	Tier 2	5.6		4.1	0.45	T2M
		2009	Tier 3		5.6	4.1	0.22	T3M
		2014	Tier 3		3.5	4.1	0.15	T4M[a]
≥50 to <100	<0.9	2007	Tier 2		5.6	4.1	0.30	T2M
		2009	Tier 3		5.6	4.1	0.22	T3M
		2014	Tier 3		3.5	4.1	0.22	T4M[a]
≥100	<0.9	2007	Tier 2		5.6	4.1	0.30	T2M
		2012	Tier 3		4.3	4.1	0.11	T3M
	0.9≤ disp <1.2	2006	Tier 2		5.4	4.1	0.22	T2M
		2013	Tier 3		4.3	4.1	0.10	T3M
	1.2≤ disp <2.5	2006	Tier 2		5.4	4.1	0.15	T2M
		2014	Tier 3		4.3	4.1	0.10	T2M
	2.5≤ disp <3.5	2009	Tier 2		5.4	4.1	0.15	T2M
		2013	Tier 3		4.3	4.1	0.09	T3M
	≥3.5	2009	Tier 2		5.4	4.1	0.15	T2M
		2012	Tier 3		4.3	4.1	0.08	T3M

[a] Although, the full phase-in of the Tier 3 standard for this engine size is labeled as T4M nonroad engineTech these engines are subject to Tier 3 standards, not Tier 4 emission standards.

Table 5-2. MOVES-Nonroad Model EF Inputs for Recreational Marine Diesel Engines

Engine Power (hp)	Model Year Start	Tech Type	Emission Factor Modeling Inputs (g/hp-hr)				BSFC (lb/hp-hr)
			HC	CO	NOx	PM	
hp ≤ 11	Pre-2000	BaseM	1.50	5.00	10.00	1.00	0.408
	2000	T1M	0.76	4.11	5.23	0.45	
	2005	T2M	0.68	4.11	4.39	0.38	
	2009	T3M	0.43	4.11	4.39	0.24	
11 < hp ≤ 25	Pre-2000	BaseM	1.70	5.00	8.50	0.90	0.408
	2000	T1M	0.44	2.16	4.44	0.27	
	2005	T2M	0.21	2.16	3.63	0.19	
	2009	T3M	0.21	2.16	3.63	0.19	
25 < hp ≤ 50	Pre-1999	BaseM	1.80	5.00	6.90	0.80	0.408
	1999	T1M	0.28	1.53	4.73	0.34	
	2004	T2M	0.54	1.53	3.71	0.23	
	2009	T3M	0.41	1.53	3.71	0.18	
	2014	T4M[a]	0.41	1.53	2.32	0.18	
50 < hp ≤ 100	Pre-2007	BaseM	0.22	0.95	6.67	0.16	0.408
	2007	T2M	0.20	0.95	3.82	0.13	
	2009	T3M	0.20	0.95	3.82	0.13	
	2014	T4M[a]	0.20	0.95	2.39	0.13	
100 < hp ≤ 175	Pre-2006	BaseM	0.22	0.95	6.67	0.16	0.367
	2006	T2M	0.20	0.95	3.82	0.13	
	2012	T3M	0.13	0.95	3.34	0.088	
175 < hp ≤ 300	Pre-2006	BaseM	0.22	0.95	6.67	0.16	0.367
	2006	T2M	0.25	0.95	4.46	0.090	
	2013	T3M	0.22	0.95	3.90	0.080	
300 < hp ≤ 750	Pre-2006	BaseM	0.22	0.95	6.67	0.16	0.367
	2006	T2M	0.33	0.95	4.42	0.082	
	2014	T3M	0.29	0.95	3.98	0.072	
750 < hp ≤1200	Pre-2006	BaseM	0.22	0.95	6.67	0.16	0.367
	2006	T2M	0.33	0.95	4.42	0.082	
	2013	T3M	0.29	0.95	3.98	0.072	
>1200	Pre-2009	BaseM	0.22	0.95	6.67	0.16	0.367
	2009	T2M	0.33	0.95	4.42	0.082	
	2012	T3M	0.29	0.95	3.98	0.064	

[a] Although, the full phase-in of the Tier 3 standard for this engine size is labeled as T4M nonroad engineTech these engines are subject to Tier 3 standards, not Tier 4 emission standards.

6 Transient Adjustment Factors – HC, CO, NO_x, PM, and BSFC

Nonroad engines are primarily tested with steady-state tests. However, the steady-state operation typically used for emission testing is not always representative of the operation of engines in many nonroad applications. Some of the differences can be due to load or engine speed, and other differences can be due to transient demands. We will apply "transient adjustment factors" ("TAFs") to the steady-state emission factors previously described. TAFs are applied to the Base, Tier 0, Tier 1, Tier 2, and Tier 3 emission factors. Transient emission control is expected to be an integral part of all Tier 4 engine design considerations. The Tier 4 standards required that engines be certified on a transient cycle, with the exception of constant-speed engines, and engines below 50 HP and larger than 750 HP[20]. As a result, TAFs are not applied to the emission factors for Tier 4 engines (i.e., the model applies a TAF of 1.0).

We calculate the TAF as the ratio of the transient emission factor (EF_{trans}) to the corresponding steady-state (ISO-C1) emission factor (EF_{ss}):

$$TAF = \frac{EF_{trans}}{EF_{ss}}$$ **Equation 4**

Transient adjustment factors may be greater than or less than 1.0.

The derivation and application of the TAFs, including the test data used, are described in more detail in Appendix F.

Table A5 presents the resulting TAFs assigned to each equipment application. The steady-state emission factors given in Table A4 were then multiplied by the appropriate TAFs to create MOVES-Nonroad's emission factor input files for CI engines.

7 Deterioration Factors – HC, CO, NO_x, and PM

The MOVES-Nonroad model addresses the effects of deterioration in the inventory calculation by multiplying a zero hour emission factor for each category of engine by a deterioration factor, DF (see equation 1 above). DF varies as a function of engine age. The following equation is used to calculate DF as a function of engine age:

$$DF = 1 + A * (\text{Age Factor})^b \quad \text{for Age Factor} \leq 1$$

$$DF = 1 + A \quad \text{for Age Factor} > 1$$

Equation 5

Where:

Age Factor = fraction of median life expended = $\frac{\text{(cumulative hours * load factor)}}{\text{median life at full load, in hours}}$

A, b = constants for a given pollutant/technology type; b≤ 1.

Deterioration is capped at the end of an engine's median life (age factor =1), under the assumption that an engine deteriorates to a point where any increased deterioration is offset by maintenance.

The constants A and b can be varied to approximate a wide range of deterioration patterns. "A" can be varied to reflect differences in maximum deterioration. For example, setting A equal to 2.0 would result in emissions at the engine's median life being three times the emissions when new (DF = 1 + 2). The shape of the deterioration function is determined by the second constant, "b." This constant can be set at any level between zero and 1.0. For compression-ignition engines, b is always equal to 1.0. This results in a linear deterioration pattern, in which the rate of deterioration is constant throughout the median life of an engine.

Due to lack of deterioration data for nonroad compression-ignition engines, the deterioration factors are based on data derived from highway engines. The derivation of the constant "A" for compression-ignition engines is described in Appendix G and the resulting deterioration factors (i.e., the constants "A") are given in Table A6.

8 Sulfur Adjustment for PM Emissions

MOVES-Nonroad adjusts PM emissions according to the sulfur content of the fuel using an additive factor. This is different than many of the other fuel effects in MOVES which are multiplicative factors. $S_{PM\ adj}$ corrects PM emissions from the certification fuel sulfur level to the fuel sulfur level provided in the MOVES fuel supply[15]. $S_{PM\ adj}$ is calculated using the following equation:

$$S_{PM\ adj} = BSFC * 453.6 * 7.0 * soxcnv * 0.01 * (soxbas - soxdsl) \qquad \textbf{Equation 6}$$

Where:

$S_{PM\ adj}$ = PM sulfur adjustment (g/hp-hr)
BSFC = in-use adjusted brake-specific fuel consumption (lb fuel/hp-hr)
453.6 = conversion from lb to grams
7.0 = grams PM sulfate/grams PM sulfur
soxcnv = grams PM sulfur/grams fuel sulfur consumed
0.01= conversion from percent to fraction
soxbas =certification fuel sulfur weight percent
soxdsl = fuel sulfur weight percent (provided in NRfuel supply)

The soxcnv term represents the fraction of diesel fuel sulfur converted to PM. This varies by technology type. Soxcnv is equal to 0.02247 for the Base, T0, T1, T2, T3, T3B, T4A, T4B technology types. For Tier 4 engines meeting stringent PM standards below 0.1 g/hp-hr, soxcnv is equal to 0.30. This applies to the T4I and T4F technology types. If the soxcnv value for a technology type is not

provided in the MOVES input database, the default value used in the model is 0.02247. Derivation of the soxcnv term is described in Appendix C.

Values for the soxbas term vary by technology type and were discussed previously. If the soxbas value for a technology type is not provided in the MOVES input database the default value used in the model is 0.33 weight percent for diesel engines.

In general, the sulfur adjustment is subtracted from the base PM emission rates. However, if the input sulfur level (soxdsl) is higher than the certification fuel sulfur percent (soxbas) than the sulfur adjustment is added to the base PM emission factors.

Sample Calculation--EF_{adj}

The following example illustrates how emission factors are calculated in MOVES-Nonroad.

Example: Calculate the PM emission factor for a three-year-old 100-175 hp diesel excavator in 2003. The diesel fuel sulfur level in the nonroad fuel supply is 2284 ppm. (In MOVES-Nonroad, three-year-old equipment in 2003 translates to equipment made in model year 2001, since the calendar year of interest is assigned age =1 year).

Needed inputs: For 100-175 hp, MY2001 = Tier 1 (from Table 2-1)
100-175 hp, Tier 1 PM EF_{ss} = 0.2799 g/hp-hr (from Table A4)
Excavator, Tier 1 PM TAF = 1.23 (from Table A5)

Tier 1 PM Deterioration "A" = 0.473 (from Table A6)

The deterioration factor, DF, is calculated as:

$$DF = 1 + A*\frac{\text{(cumulative hours * load factor)}}{\text{median life at full load, in hours}} \qquad \textbf{Equation 7}$$

Where:
Diesel excavator activity = 1092 hours/year (from *nrsourceusetype* MOVES input DB file)
Diesel excavator load factor = 0.59 (from *nrsourceusetype* MOVES input DB file)
Diesel excavator median life = 4667 hours (from *nrsourceusetype* MOVES input DB file)
Cumulative hours = age * activity = 3*1092 = 3276 hours

Substituting the above values into the equation yields:

$$DF = 1 + 0.473*\frac{(3276 * 0.59)}{4667} = 1 + 0.473 * 0.414 = 1.196$$

The sulfur adjustment factor, $S_{PM\ adj}$, is calculated as:

$S_{PM\ adj}$ = BSFC * 453.6 * 7.0 * soxcnv * 0.01 * (soxbas - soxdsl) **Equation 8**

Where:

BSFC = 100-175 hp $BSFC_{ss}$ * Excavator BSFC TAF = 0.367*1.01 = 0.371
($BSFC_{ss}$ from Table A2 and BSFC TAF from Table A5)
soxcnv = 0.02247
soxbas = 0.3300
soxdsl = 0.2284

Substituting the values into the equation yields:

$S_{PM\ adj}$ = 0.371* 453.6 * 7.0 * 0.02247 * 0.01 * (0.33 - 0.2284) = 0.0269g/hp-hr

The resulting adjusted emission factor is calculated as follows:

$EF_{adj(PM)}$ = EF_{ss} * TAF * DF - S_{PMadj}
= (0.2799 * 1.23 * 1.196) - 0.0269
= 0.385 g/hp-hr

9 Emission Factors – CO_2 and SO_2

Emission factors for CO_2 and SO_2 are calculated based on brake-specific fuel consumption (BSFC).

The MOVES-Nonroad model uses in-use adjusted brake-specific fuel consumption (BSFC) to compute CO_2 emissions directly, as shown in the equation below. The carbon that goes to exhaust HC emissions is subtracted as the correction for unburned fuel. This does not require a CO_2 emission factors input file.

CO_2 = (BSFC * 453.6 - HC) * 0.87 * (44/12) **Equation 9**

Where:

CO_2 is in g/hp-hr
BSFC is the in-use adjusted brake-specific fuel consumption in lb/hp-hr
453.6 is the conversion factor from pounds to grams
HC is the in-use adjusted hydrocarbon emissions in g/hp-hr
0.87 is the carbon mass fraction of diesel
44/12 is the ratio of CO_2 mass to carbon mass

The model does not require an SO_2 emission factors input file either. EPA will calculate SO_2 emission factors as shown in the equation below.

SO_2 = (BSFC * 453.6* (1 - soxcnv) - HC) * 0.01 * soxdsl * 2 **Equation 10**

Where:

SO_2 is in g/hp-hr
BSFC is the in-use adjusted fuel consumption in lb/hp-hr
453.6 is the conversion factor from pounds to grams
soxcnv is the fraction of fuel sulfur converted to direct PM
HC is the in-use adjusted hydrocarbon emissions in g/hp-hr
0.01 is the conversion factor from weight percent to weight fraction
soxdsl is the episodic weight percent of sulfur in nonroad diesel fuel
2 is the grams of SO_2 formed from a gram of sulfur

This equation includes corrections for the fraction of sulfur that is converted to direct PM and for the fraction of sulfur remaining in unburned fuel. This equation assumes that the unburned fuel, as indicated by HC emissions, has the same sulfur level as the base fuel.

Note that BSFC for the pre-control (Tier 0) engines is used for all engines in the model. As a result, related emissions of CO_2 and SO_2 will change very little with the advent of new emission reduction technologies. Minor changes will result as HC emissions are changed, since the carbon that goes to exhaust HC is subtracted in the CO_2 and SO_2 equations. For diesel engines, this adjustment is insubstantial.

10 Crankcase HC Emission Factors

Crankcase emissions are those emissions that escape from the combustion chamber past the piston rings into the crankcase. For diesel engines with open crankcases, MOVES-Nonroad assumes the crankcase HC emission factor is equal to 2.0 percent of the exhaust HC emission factor. This applies for all Tier 3 and prior engines. This estimate was obtained from NEVES [14], and is based on data from on-highway engines. These percentages are applied to the final calculated exhaust emission factors, so the resulting crankcase emission factors include the same percentage deterioration as used for exhaust HC. For Tier 4 engines, zero crankcase emissions are assumed. The Tier 4 rule requires that crankcase emissions be controlled (through the use of closed crankcase systems), or if the engines discharge crankcase emissions, the crankcase emissions must be added to the exhaust emissions for emissions testing[21]. Because the Tier 4 emission rates are based on certification tests as discussed in Section 4, we assume that crankcase emissions from Tier 4 engines with open crankcase are included in the tailpipe emission factors. Thus, we are including the crankcase HC emissions from Tier 4 engines, while modeling a HC crankcase factor of 0 percent.

11 $PM_{2.5}$ Fraction of PM_{10}

For diesel engines, all exhaust PM emissions are assumed to be smaller than 10 microns, and reported as PM_{10}. MOVES allows the user to report results for PM_{10} and $PM_{2.5}$ (smaller than 2.5 microns). If $PM_{2.5}$ is selected, an adjustment of 0.97 is applied to the PM_{10} output based on an analysis of size distribution data of particulate matter emissions from diesel engines[22].

12 Peer Review of Draft Report

This section contains comments on the draft report of *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b* from two peer reviewers and EPA's responses to those comments. The reviewers were selected by a third-party contractor, ICF International, facilitating a peer review of MOVES technical reports. The submitted peer review comments are publicly available on the EPA Science Inventory database[23].

12.1 Overview of the Peer-Review

The two experts who reviewed the draft report of *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b* were:

Robert F. Sawyer, Ph.D. Partner Sawyer Associates	Phil Lewis, Ph.D. Associate Professor Department of Construction Science College of Architecture Texas A&M University

The peer-reviewers were charged with reviewing only the updated material in this report, which included the following sections:

- Section 1 and 2, with a focus on the proposed updates made for MOVES related to Tier 4 nonroad engines.
- Section 4.4, HC, CO, NOx, PM Emission Factors for Tier 4 Engines: Evaluate updates to the Tier 4 Engine emission rates
- Table A1: Evaluate the updated nonroad CI technology distributions for 2011+ model years among certification levels and aftertreatment configurations
- Table A4 & Figure 2: Evaluate updates to the Tier 4 Engine emission rates

In conducting the peer-review, the peer-reviewers were given the following charge:

We are submitting this material for you to review selected methods and underlying assumptions, their consistency with the current science as you understand it, and the clarity and completeness of the presentation. For this review, no independent data analysis is required. Rather, we ask that you assess whether the information provided is representative of the state of current understanding, and whether incorporating the information into EPA's MOVES model will result in appropriate predictions and conclusions.
We request you provide us comments on substantive content sequentially. These will be listed as an appendix to the final published report, along with EPA's responses. Comments on organization, formatting, and other minor issues are welcome, but should be provided separately.

Below are questions to define the scope of the review. We are not expecting individual responses to the questions, but would like them to help guide your response.

General Questions to Consider:

1. *Does the presentation describe the selected data sources sufficiently to allow the reader to form a general view of the quantity, quality and representativeness of data used in the analysis? Are you able to recommend alternate data sources that might better allow the model to estimate national or regional default values?*

2. *Is the description of analytic methods and procedures clear and detailed enough to allow the reader to develop an adequate understanding of the steps taken and assumptions made by EPA while developing the model inputs? Are examples selected for tables and figures well-chosen and effective in improving the reader's understanding of approaches and methods?*

3. *Are the methods and procedures employed technically appropriate and reasonable, with respect to the relevant disciplines, including physics, chemistry, engineering, mathematics and statistics? Are you able to suggest or recommend alternate approaches that might better achieve the goal of developing accurate and representative model inputs? In making recommendations, please distinguish between instances involving reasonable disagreement in adoption of methods as opposed to instances where you conclude that current methods involve specific technical errors.*

4. *Where EPA has concluded that applicable data is meager or unavailable, and consequently has made assumptions to frame approaches and arrive at solutions, do you agree that the assumptions are appropriate and reasonable? If not, and you are able to do so, please suggest alternative assumptions that might lead to more reasonable or accurate model inputs.*

5. *Are the resulting model inputs appropriate and, to the best of your knowledge and experience, reasonably consistent with physical and chemical processes involved in mobile source emissions, formation and control? Are the resulting model inputs empirically consistent with the body of data and literature with which you are familiar?*

Specific Questions:

In addition to the general review, we request specific responses to the following question:

1. *Due to limited resources and data, we have not updated the transient adjustment factors, deterioration factors, sulfur adjustments, and crankcase emission factors for Tier 4 nonroad engines [Sections 6, 7, 8, and 10]. For example, for Tier 4 engines, we assume a transient adjustment factor =1. The current deterioration factors for Tier 4 engines are unchanged from Tier 3 engines. We are currently assuming a crankcase emission factor = 0% for Tier 4 engines. How appropriate are the current assumptions for these adjustments and factors for Tier 4 engines? Are there data available for informing updates to these adjustment and factors?*

12.2 General Comments from Robert F. Sawyer

General Comments:
The EPA MOVES emissions inventory model was designed to make use of data rich information on vehicle emissions. Data on in-use offroad emissions is woefully lacking for both Tier 4 and pre Tier 4 technology. Estimating in-use emissions from Tier 4 certification data combined with pre Tier 4 correction factors is inherently unreliable.

> ***RESPONSE:*** *See our comments below in the Introduction section with regard to using Tier 4 certification data. With regard to pre Tier 4 adjustment factors, we address this comment further below in the section labeled* Section 4.4: HC, CO, NOx, PM Emission Factors for Tier 4 Engines.

Presentation of data sources, details, and descriptions is clear and easy to follow. Reliance on engine certification data, independent of application, is a deficiency as it the dependence on old correction factors for transient operation and deterioration. The California Air Resources Board has additional California specific offroad emissions data.
Methods and procedures descriptions are straightforward. The accompanying tables and figures assist in the clarity of the presentation and assist reader understanding.

> ***RESPONSE:*** *In 2017 the California Air Resources Board (CARB) updated the off-road diesel engine NOx and PM emission factors used for their mobile source emissions inventory[24]. According to the CARB's documentation[25], they used the EPA nonroad compression ignition certification data[26] as a basis to update the emission factors for 1996-2016 model year engines. EPA is continuing dialogue with CARB staff to expand the datasets available for future modeling updates.*

The technical methodology is sound.

The assumptions made by the EPA to make up for the basic lack of test data are reasonable.

The model inputs are consistent with processes impacting emissions, but they are incomplete in that they do not adequately treat such factors as deterioration, transient operation, ambient temperature, altitude, or fuel. The lack of in-use data prevents assessment of the uncertainty in the model output.

Considering the constrains of very limited Tier 4 offroad measurements, the EPA has made reasonable approximations and extrapolations to make up for this basic deficiency. A portable emissions measurements systems (PEMS) in-use measurement program to provide reliable emissions and activity data for the offroad sector should be a high priority.

Specific Comments:

Section 1: Introduction

Reliance of certification data to estimate emissions is a major problem. The statement "…updating Tier 4 emission rates will have a larger impact on future inventories than updating the Tier 2 and Tier 3 emission rates" while eventually true is not obvious because of deterioration and low turnover rates.

> ***RESPONSE:*** *We agree that a modeling approach based on certification data has its limitations. And in-use emission data − if available and amenable for modeling purpose − can be valuable for further improvement in the future. Tier 4 update was given a priority over others this time in order to enhance the model predictions by accounting for the actual implementation of Tier 4 emission standards that occurred since the last nonroad model update. According to our analysis, the newer engines certified for Tier-4 standards tend to have significantly lower emission rates (especially when equipped with a modern aftertreatment system) than previously estimated. In addition, EPA also updated the nonroad equipment population growth rate for MOVES2014b to capture the effect of the population changes on the future inventories. Due to a combined effect of those updates, the national NOx and PM2.5 emissions from nonroad diesel engines that MOVES2014b estimates for calendar year 2023 are reduced by 15.2 and 14.8 percent respectively, compared to MOVES2014a estimates. For calendar year 2028, the reductions are 21.4 and 21.2 percent respectively.*

Section 2: Emission Standards and Technology Type

The presentation of emissions standards in Table 2.1 is comprehensive and clear. Is there any evidence that manufacturers actually took full advantage of phase-in allowances? TPEM data suggest otherwise.

> ***RESPONSE:*** *The level of voluntary participation in the flexibility program varies significantly by manufacturer, engine power category, model year and the types of allowances (percent of production, small volume: single family or multiple families) applied. For modeling purpose, we used the available information reported by manufacturers to obtain reasonable estimates of certified vs. TPEM engine volume ratios in an aggregated way as shown in Table 2-5.*

Section 4.4: HC, CO, NOx, PM Emission Factors for Tier 4 Engines

Reliance on certification data provides an extensive amount of data, but may not be consistent with in-use emissions due to the failure of test cycles to match actual use and the chance of defeat strategies. Other than the lack of data, there is no reason to assume that deterioration factors and transient adjustment factors have not changed for Tier 4 engine applications.

> ***RESPONSE:*** *We agree that a modeling approach relying on certification data has its limitations. For future versions of MOVES, EPA is interested in collecting real-world nonroad emission data as well as in leveraging other data sources[27] to further improve the nonroad model.*
> *With regard to deterioration factors, we are using the same deterioration factors for Tier 4 engines as we used for Tier 3 engines as discussed in Section 7.*
> *For transient adjustment factors, we are using different transient adjustment factors for Tier 4 engines compared to Tier 3 engines as discussed in Section 6. As discussed in Appendix F, the*

Tier 3 engines transient adjustment factors were based on engineering judgment, considering the engine technologies (including EGR) and the steady-state certification cycles required under the Tier 3 regulation. We used a transient adjustment factor =1 for Tier 4 engines, because Tier 4 engines are required to be certified on transient cycles as documented in Section 6.

Table A1: Nonroad CI Technology Distributions by HP Category and Model Year

The populations are based on projected sales. Has this been checked? (Perhaps any differences are not significant?)

RESPONSE: *A rigorous verification of the projected sales data was not possible because sufficient information about actual engine production volumes was not available for our analysis. However, it should be noted that the projected sales data was only used to estimate the engine population fractions (distributions) among different engine technologies, not the populations themselves. (Regarding the actual populations of non-road equipment that MOVES uses, refer to "Nonroad Engine Population Growth Estimates in MOVES2014b" technical report.) For that limited use, the projected volumes provide a reasonable approximation.*

Table A4: Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines

The assignment of only two brake specific fuel consumption values cannot be correct. While this will not affect HC, CO, NO_x, or PM emissions, it may be a problem with CO_2 estimates and relating fuel consumption to engine populations.

RESPONSE: *The revision of the fuel consumption values was not within the scope of the nonroad model update this time. Fuel consumption rates are certainly important for CO_2 estimates and will be one of the candidates for future updates.*

Figure 2: Record Counts and Emission Factors for Tier 4 Based on Certification Data in MOVES2014b

I do not detect anything that is questionable in these figures.

12.3 General Comments from Phil Lewis

General Comments:

In my opinion, the reports include an adequate presentation of the methods used to update the Nonroad model. As a user of previous versions of Nonroad, I frequently referred to the documents and reports to gain better insight to the application of the model. I believe these reports provide a sufficient explanation of the assumptions and data used in the updated Nonroad model. As a potential user of

Nonroad in the future, I am satisfied with the explanations given for the assumptions and data sources provided in the reports. Furthermore, I have no recommendations for alternate data sources.

Description of the analytical methods are thorough enough for the reader to gain an understanding of the general approaches used to update the Nonroad model; however, it would be somewhat difficult to duplicate the methodologies in their entirety. In order to duplicate the methodologies, I believe more detail is needed, perhaps in the form of sample calculations. I do not believe, however, that duplication is the primary objective of the reports; therefore, I do not recommend adding unnecessary details. I also found the examples provided for tables and figures to be appropriate for their intended use.

I believe the methods and procedures are technically and scientifically sound. This is a reasonable approach to predict the future of nonroad equipment on a grand scale. I have no suggestions or recommendations for improving the approach.

When trying to predict the future, no one has a High Definition crystal ball; therefore, we are left with assumptions. I believe the assumptions chosen to fill in the gaps in data are sufficient enough to provide reasonable model outputs.

Unfortunately, I have limited expertise with the physical and chemical processes associated with the formation and speciation of emissions. I believe the model inputs are empirically consistent and adequate based on my limited knowledge.

Specific Comments:

I have no objections to TAF = 1.0 or crankcase emission factor = 0% for Tier 4 engines. I feel this is a reasonable assumption given the lack of empirical data. I am not convinced that additional study or investigation aimed at improving estimates of these two variables would yield significant results in the model outputs. I am not aware of other data sources that could be used to verify or disclaim these assumptions.

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14 Appendix A: Nonroad CI Inputs for MOVES2014b: Technology Distributions, Zero-Hour, Steady-State Emission Factors, Transient Adjustment Factors, and Deterioration Factors

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year[a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA[d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
≤25	Pre-1988	1												
	1988-1999		1											
	2000-2001		0.2	0.8										
	2002-2004		0.1	0.9										
	2005		0.1		0.9									
	2006-2007				1									
	2008-2010						1							
	2011				0.010		0.064				0.926			
	2012				0.010		0.064				0.926			
	2013				0.138						0.862			
	2014				0.048						0.952			
	2015										1.000			
	2016										1.000			
	2017+										1.000			
>25 to 50	Pre-1988	1												
	1988-1998		1											
	1999-2000		0.2	0.8										

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2001-2003		0.1	0.9										
	2004		0.1		0.9									
	2005-2007				1									
	2008-2010						1							
	2011						1							
	2012						1							
	2013				0.648						0.105		0.247	
	2014				0.242						0.361		0.397	
	2015				0.091						0.444		0.465	
	2016				0.048						0.535		0.417	
	2017+										0.574		0.426	
>50 to 75	Pre-1988	1												
	1988-1997		1											
	1998-2003			1										
	2004-2005			0.2	0.8									
	2006-2007			0.1	0.9									
	2008-2009			0.1			0.9							
	2010						1							

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2011						1.000							
	2012						1.000							
	2013				0.648						0.081		0.271	
	2014				0.242						0.248		0.509	
	2015				0.091						0.383		0.526	
	2016				0.048						0.456		0.496	
	2017+										0.552		0.448	
>75 to 100	Pre-1988	1												
	1988-1997		1											
	1998-2003			1										
	2004-2005			0.2	0.8									
	2006-2007			0.1	0.9									
	2008-2009			0.1		0.9								
	2010					1								
	2011					0.151	0.592		0.257					
	2012					0.482	0.361		0.157					
	2013					0.187	0.399		0.414					
	2014					0.107	0.224		0.669					
	2015					0.401					0.066	0.497	0.036	

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2016					0.206						0.274	0.429	0.091
	2017+											0.451	0.375	0.174
>100 to 175	Pre-1988	1												
	1988-1996		1											
	1997-2002			1										
	2003-2004			0.2	0.8									
	2005-2006			0.1	0.9									
	2007-2008			0.1		0.9								
	2009-2010					1								
	2011					0.102	0.146	0.173	0.579					
	2012					0.453	0.089	0.105	0.353					
	2013					0.187	0.093	0.070	0.650					
	2014					0.107	0.108	0.081	0.687	0.005		0.011		
	2015					0.401						0.441	0.034	0.124
	2016					0.206						0.654	0.001	0.138
	2017+											0.767	0.020	0.213
>175 to 300	Pre-1988	1												
	1988-1995		1											

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	1996-2002			1										
	2003-2004			0.2	0.8									
	2005			0.1	0.9									
	2006-2008			0.1		0.9								
	2009-2010					1								
	2011					0.286	0.016	0.158	0.541					
	2012					0.167	0.018	0.184	0.631					
	2013					0.130	0.017	0.220	0.624	0.009				
	2014					0.306						0.417	0.023	0.254
	2015					0.145						0.501	0.008	0.346
	2016					0.099						0.447	0.002	0.452
	2017					0.048						0.423	0.002	0.527
	2018+											0.445	0.001	0.554
>300 to 600	Pre-1988	1												
	1988-1995		1											
	1996-2000			1										
	2001-2002			0.2	0.8									
	2003-2005			0.1	0.9									

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2006			0.1		0.9								
	2007-2010					1								
	2011					0.286	0.016	0.158	0.541					
	2012					0.167	0.018	0.184	0.631					
	2013					0.130	0.017	0.214	0.631	0.009				
	2014					0.306						0.417	0.023	0.254
	2015					0.145						0.501	0.008	0.346
	2016					0.099						0.447	0.002	0.452
	2017					0.048						0.423	0.002	0.527
	2018+											0.445	0.001	0.554
>600 to 750	Pre-1988	1												
	1988-1995		1											
	1996-2001			1										
	2002-2003			0.2	0.8									
	2004-2005			0.1	0.9									
	2006-2007			0.1		0.9								
	2008-2010					1								
	2011					0.286	0.016	0.158	0.541					

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2012					0.167	0.018	0.184	0.631					
	2013					0.130	0.017	0.214	0.631	0.009				
	2014					0.306						0.417	0.023	0.254
	2015					0.145						0.501	0.008	0.346
	2016					0.099						0.447	0.002	0.452
	2017					0.048						0.423	0.002	0.527
	2018+											0.445	0.001	0.554
>750 Non-Generators	Pre-1988	1												
	1988-1999		1											
	2000-2005			1										
	2006-2007			0.3	0.7									
	2008			0.2	0.8									
	2009-2010				1									
	2011				0.242		0.449				0.308			
	2012				0.237		0.453				0.311			
	2013				0.412		0.331				0.255	0.003		
	2014				0.219		0.193	0.162			0.420	0.007		
	2015				0.301						0.451	0.249		
	2016				0.265						0.330	0.402	0.003	
	2017				0.225						0.443	0.329	0.003	

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2018+										0.571	0.425	0.004	
750-1200 Generators	Pre-1988	1												
	1988-1999		1											
	2000-2005			1										
	2006-2007			0.3	0.7									
	2008			0.2	0.8									
	2009-2010				1									
	2011				0.242		0.294	0.464						
	2012				0.237		0.296	0.468						
	2013				0.412		0.234	0.354						
	2014				0.219		0.225	0.556						
	2015				0.301							0.634		0.065
	2016				0.265							0.593		0.142
	2017				0.225							0.720		0.055
	2018+											0.929		0.071
>1200 Generators	Pre-1988	1												
	1988-1999		1											
	2000-2005			1										

Table A1. Nonroad CI Technology Distributions by HP Category and Model Year (cont.) [a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type[b]												
		Base	Tier 0	Tier 1	Tier 2	Tier 3[c]	Tier 4IA [d]	Tier 4IB	Tier 4IC	Tier 4ID	Tier 4FA[e]	Tier 4FB	Tier 4FC	Tier 4FD
	2006-2007			0.3	0.7									
	2008			0.2	0.8									
	2009-2010				1									
	2011				0.242			0.758						
	2012				0.237			0.763						
	2013				0.412			0.298		0.290				
	2014				0.219			0.495		0.286				
	2015				0.301							0.374		0.325
	2016				0.265							0.368		0.368
	2017				0.225							0.775		
	2018+											1.0		

[a] Used in MOVES2014b for all nonroad diesel equipment with the exception of recreational marine engines and underground mining equipment; these are presented in separate tables. The technology fractions are contained in the nrengtechfraction MOVES input DB file. Blank cells have a technology fraction of 0.000. For model years 2011-2017, population fractions are calculated using VERIFY data weighted by projected sales volumes for engine families.

[b] Base = pre-control, pre-1988 MY engines. Tier 0 = pre-control 1988+ MY engines prior to Tier 1.
Tier 4I = Tier 4 interim (transitional). Tier 4F = Tier 4 final. Tier 4 subcategories: A = Without diesel particulate filter (DPF) and without selective catalytic reduction (SCR). B = Without DPF and with SCR. C = With DPF and without SCR. D = With DPF and with SCR.

[c] For hp >75 to 100 category only, tech type is T3B. For all the other hp categories, tech type is T3.

[d] For engine power categories where hp ≤ 75, tech type T4A instead of T4IA is used.

[e] For hp ≤ 25 category only, tech type T4B instead of T4FA is used.

Table A2. Recreational Marine CI Technology Distributions by HP Category and Model Year[a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type					
		Base[b]	Tier 0[b]	Tier 1	Tier 2	Tier 3	Tier 4[c]
≤25	Pre-1988	1.000					
	1988-1999		1.000				
	2000		0.200	0.800			
	2001-2004		0.100	0.900			
	2005-2006		0.100		0.900		
	2007-2008				1.000		
	2009+					1.000	
>25 to 50	Pre-1988	1.000					
	1988-1998		1.000				
	1999		0.200	0.800			
	2000-2003		0.100	0.900			
	2004-2005		0.100		0.900		
	2006-2008				1.000		
	2009-2013					1.000	
	2014+						1.000
>50 to 100	Pre-2007	1.000					
	2007-2008				1.000		
	2009-2013					1.000	
	2014+						1.000
>100 to 175	Pre-2006	1.000					
	2006-2011				1.000		
	2012+					1.000	
>175 to 300	Pre-2006	1.000					
	2006-2012				1.000		
	2013+					1.000	
>300 to 750	Pre-2006	1.000					

Table A2. Recreational Marine CI Technology Distributions by HP Category and Model Year (cont.)[a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type					
		Base[b]	Tier 0[b]	Tier 1	Tier 2	Tier 3	Tier 4[c]
	2006-2013				1.000		
	2014+					1.000	
>750 to 1200	Pre-2006	1.000					
	2006-2012				1.000		
	2013+					1.000	
>1200	Pre-2009	1.000					
	2009-2011				1.000		
	2012+					1.000	

[a] The technology fractions are contained in the nrengtechfraction MOVES input DB file. Blank cells have a technology fraction of 0.000.
[b] Base = pre-control, pre-1988 MY engines. Tier 0 = pre-control 1988+ MY engines prior to Tier 1.
[c] This source category is not subject to Tier 4 standards. Some horsepower categories are subject to two phases of the Tier 3 standard; the second phase is referred to as Tier 4.

Table A3. Underground Mining Equipment Technology Distributions by HP Category and Model Year[a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type			
		Base[b]	Tier 0[b]	Tier 1	Tier 2
≤25	Pre-1988		1.000		
	1988-1999		1.000		
	2000-2001		1.000		
	2002-2004		1.000		
	2005		0.100		0.900
	2006+				1.000
>25 to 50	Pre-1988		1.000		
	1988-1998		1.000		
	1999-2000		1.000		
	2001-2003		1.000		
	2004		0.100		0.900
	2005+				1.000
>50 to 100	Pre-1988	1.000			
	1988-1997		1.000		
	1998-2003		1.000		
	2004-2005		0.200		0.800
	2006-2007		0.100		0.900
	2008-2009		0.100		0.900
	2010+				1.000
>100 to 175	Pre-1988	1.000			
	1988-1996		1.000		
	1997-2002		1.000		
	2003-2004		0.200		0.800
	2005-2006		0.100		0.900
	2007-2008		0.100		0.900

Table A3. Underground Mining Equipment Technology Distributions by HP Category and Model Year (cont.)[a]

Engine Power (hp)	Model Year	Fraction of Population in Each Technology Type			
		Base[b]	Tier 0[b]	Tier 1	Tier 2
	2009+				1.000
>175 to 300	Pre-1988	1.000			
	1988-1995		1.000		
	1996-2002		1.000		
	2003-2004		0.200		0.800
	2005		0.100		0.900
	2006-2008		0.100		0.900
	2009+				1.000
>300 to 600	Pre-1988	1.000			
	1988-1995		1.000		
	1996-2000		1.000		
	2001-2002		0.200		0.800
	2003-2005		0.100		0.900
	2006		0.100		0.900
	2007+				1.000
>600 to 750	Pre-1988	1.000			
	1988-1995		1.000		
	1996-2001		1.000		
	2002-2003		0.200		0.800
	2004-2005		0.100		0.900
	2006-2007		0.100		0.900
	2008+				1.000
>750	Pre-1988	1.000			
	1988-1999		1.000		
	2000-2005		1.000		
	2006-2007		0.300		0.700
	2008		0.200		0.800
	2009+				1.000

[a] The technology fractions are contained in the nrengtechfraction MOVES input DB file. Blank cells have a technology fraction of 0.000.

[b] Base = pre-control, pre-1988 MY engines. Tier 0 = pre-control 1988+ MY engines prior to Tier 1.

Table A4. Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines[a]

Engine Power (hp)	Technology Type	BSFC (lb/hp-hr)	Emission Factors (g/hp-hr)			
			HC	CO	NO_x	PM
>0 to 11	Base	0.408[b]	1.500	5.000	10.000	1.000
	Tier 0		1.500	5.000	10.000	1.000
	Tier 1		0.763	4.113	5.230	0.447
	Tier 2		0.551	4.113	4.300	0.500
	Tier 4A		0.540	2.084	4.037	0.213
	Tier 4B		0.741	2.251	4.163	0.185
>11 to 16	Base	0.408	1.7000	5.0000	8.5000	0.9000
	Tier 0		1.7000	5.0000	8.5000	0.9000
	Tier 1		0.4380	2.1610	4.4399	0.2665
	Tier 2		0.4380	2.1610	4.4399	0.2665
	Tier 4A		0.540	2.084	4.037	0.213
	Tier 4B		0.311	1.362	3.744	0.132
>16 to 25	Base	0.408	1.7000	5.0000	8.5000	0.9000
	Tier 0		1.7000	5.0000	8.5000	0.9000
	Tier 1		0.4380	2.1610	4.4399	0.2665
	Tier 2		0.4380	2.1610	4.4399	0.2665
	Tier 4A		0.540	2.084	4.037	0.213
	Tier 4B		0.311	1.362	3.744	0.132
>25 to 50	Base	0.408	1.8000	5.0000	6.9000	0.8000
	Tier 0		1.8000	5.0000	6.9000	0.8000
	Tier 1		0.2789	1.5323	4.7279	0.3389
	Tier 2		0.2789	1.5323	4.7279	0.3389
	Tier 4A		0.420	1.373	3.905	0.161
	Tier 4FA		0.136	0.408	2.762	0.027
	Tier 4FC		0.018	0.047	2.184	0.001
>50 to 75	Base	0.408	Vary by application, see NEVES			
	Tier 0		0.990	3.490	6.900	0.722
	Tier 1		0.521	2.366	5.599	0.473
	Tier 2		0.367	2.366	4.700	0.240
	Tier 4A		0.177	0.978	3.030	0.149
	Tier 4FA		0.074	0.267	2.787	0.024

Table A4. Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines (cont.)[a]

Engine Power (hp)	Technology Type	BSFC (lb/hp-hr)	Emission Factors (g/hp-hr)			
			HC	CO	NO_x	PM
	Tier 4FC		0.018	0.055	2.218	0.001
>75 to 100	Base	0.408	Vary by application, see NEVES			
	Tier 0		0.990	3.490	6.900	0.722
	Tier 1		0.521	2.366	5.599	0.473
	Tier 2		0.367	2.366	4.700	0.240
	Tier 3B		0.184	2.366	3.000	0.200
	Tier 4IA		0.087	0.392	2.521	0.115
	Tier 4IC		0.007	0.027	1.955	0.007
	Tier 4FA		0.075	1.342	3.274	0.186
	Tier 4FB		0.012	0.101	0.136	0.015
	Tier 4FC		0.000	0.000	2.064	0.007
	Tier 4FD		0.008	0.000	0.091	0.000
>100 to 175	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.338	0.867	5.652	0.280
	Tier 2		0.338	0.867	4.100	0.180
	Tier 3		0.184	0.867	2.500	0.220
	Tier 4IA		0.035	0.200	1.976	0.033
	Tier 4IB		0.017	0.262	2.029	0.011
	Tier 4IC		0.003	0.009	1.888	0.004
	Tier 4ID		0.007	0.075	0.224	0.000
	Tier 4FB		0.007	0.052	0.144	0.011
	Tier 4FC		0.003	0.004	1.828	0.002
	Tier 4FD		0.010	0.023	0.096	0.001
>175 to 300	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.309	0.748	5.577	0.252
	Tier 2		0.309	0.748	4.000	0.132
	Tier 3		0.184	0.748	2.500	0.150
	Tier 4IA		0.114	1.642	2.467	0.108
	Tier 4IB		0.008	0.247	1.100	0.011
	Tier 4IC		0.011	0.052	1.116	0.001

Table A4. Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines (cont.)[a]

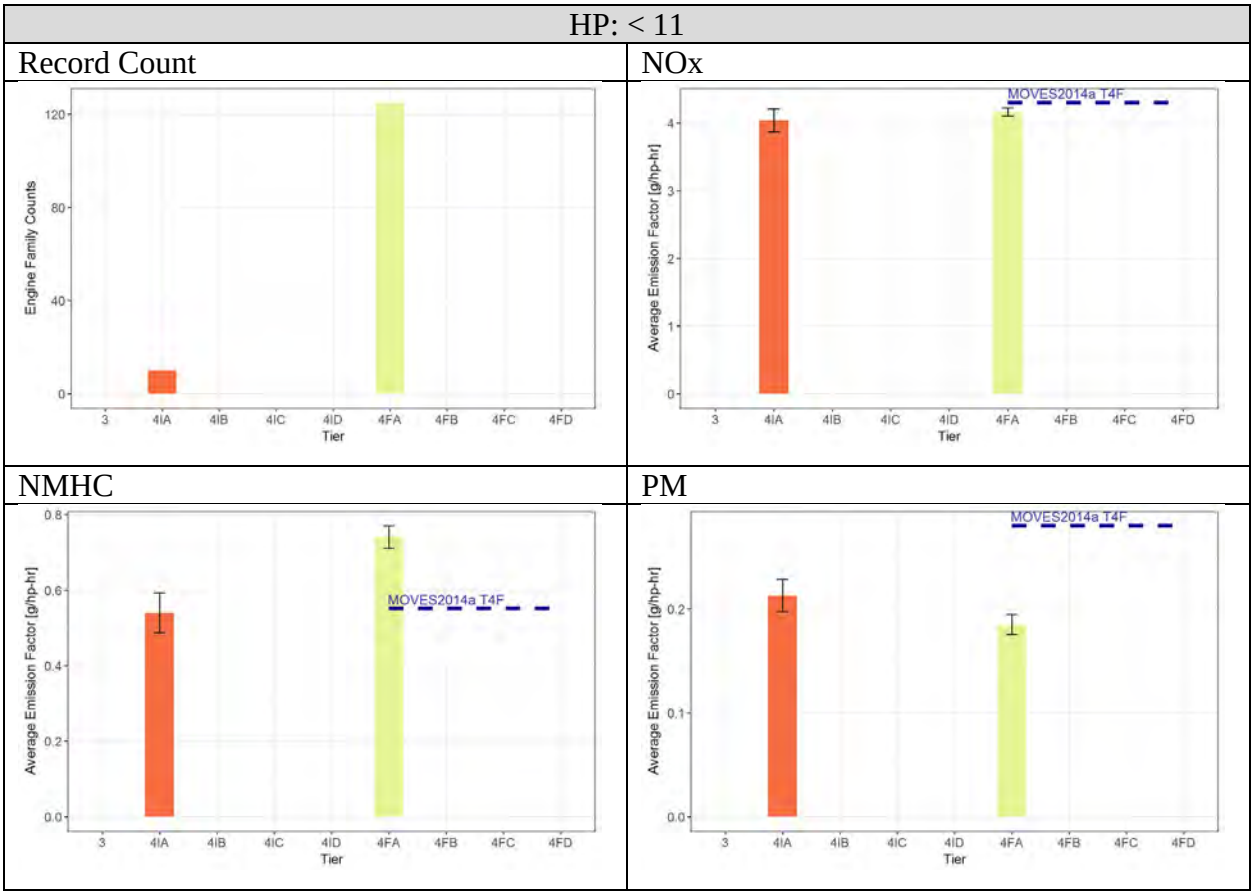
Engine Power (hp)	Technology Type	BSFC (lb/hp-hr)	Emission Factors (g/hp-hr)			
			HC	CO	NO_x	PM
	Tier 4ID		0.028	0.000	0.110	0.007
	Tier 4FB		0.008	0.020	0.148	0.009
	Tier 4FC		0.011	0.214	1.153	0.000
	Tier 4FD		0.010	0.015	0.079	0.002
>300 to 600	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.203	1.306	6.015	0.201
	Tier 2		0.167	0.843	4.335	0.132
	Tier 3		0.167	0.843	2.500	0.150
	Tier 4IA		0.114	1.642	2.467	0.108
	Tier 4IB		0.008	0.247	1.100	0.011
	Tier 4IC		0.012	0.053	1.115	0.001
	Tier 4ID		0.028	0.000	0.110	0.007
	Tier 4FB		0.008	0.020	0.148	0.009
	Tier 4FC		0.011	0.214	1.153	0.000
	Tier 4FD		0.010	0.015	0.079	0.002
>600 to 750	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.147	1.327	5.822	0.220
	Tier 2		0.167	1.327	4.100	0.132
	Tier 3		0.167	1.327	2.500	0.150
	Tier 4IA		0.114	1.642	2.467	0.108
	Tier 4IB		0.008	0.247	1.100	0.011
	Tier 4IC		0.012	0.053	1.115	0.001
	Tier 4ID		0.028	0.000	0.110	0.007
	Tier 4FB		0.008	0.020	0.148	0.009
	Tier 4FC		0.011	0.214	1.153	0.000
	Tier 4FD		0.010	0.015	0.079	0.002
>750 except generator sets	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.286	0.764	6.153	0.193
	Tier 2		0.167	0.764	4.100	0.132

Table A4. Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines (cont.)[a]

Engine Power (hp)	Technology Type	BSFC (lb/hp-hr)	Emission Factors (g/hp-hr)			
			HC	CO	NO_x	PM
	Tier 4IA		0.100	0.369	2.208	0.044
	Tier 4IB		0.066	0.149	2.218	0.014
	Tier 4FA		0.035	0.019	2.278	0.021
	Tier 4FB		0.026	0.131	2.083	0.015
	Tier 4FC		0.007	0.000	2.088	0.000
Gen sets >750 to 1200	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.286	0.764	6.153	0.193
	Tier 2		0.167	0.764	4.100	0.132
	Tier 4IA		0.084	0.691	2.239	0.051
	Tier 4IB		0.030	0.224	2.386	0.030
	Tier 4FB		0.000	0.075	0.231	0.015
	Tier 4FD		0.015	0.000	0.068	0.007
Gen sets >1200	Base	0.367	Vary by application, see NEVES			
	Tier 0		0.680	2.700	8.380	0.402
	Tier 1		0.286	0.764	6.153	0.193
	Tier 2		0.167	0.764	4.100	0.132
	Tier 4IB		0.008	0.567	0.399	0.056
	Tier 4ID		0.015	1.044	0.403	0.000
	Tier 4FB		0.004	0.571	0.379	0.052
	Tier 4FD		0.015	1.044	0.403	0.000

[a]Prior to listing in MOVES-Nonroad input files, these ISO-C1 emission factors are adjusted for in-use operation as explained in Appendix F. The emission factors in the input files are rounded to two decimal places. The emission factors for recreational marine CI engines are provided in Table 5-2. Underground mining equipment inputs are just the Base (NEVES) and Tier 2 values from this table.
[b]BSFC for engines <50 hp is assumed to be the same as 50-100 hp engines

Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b



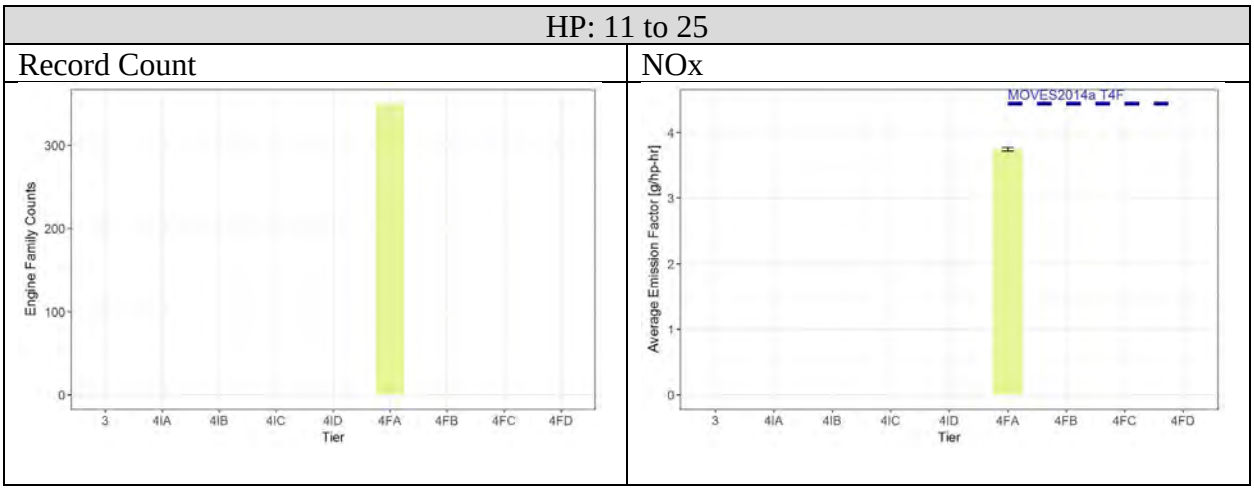
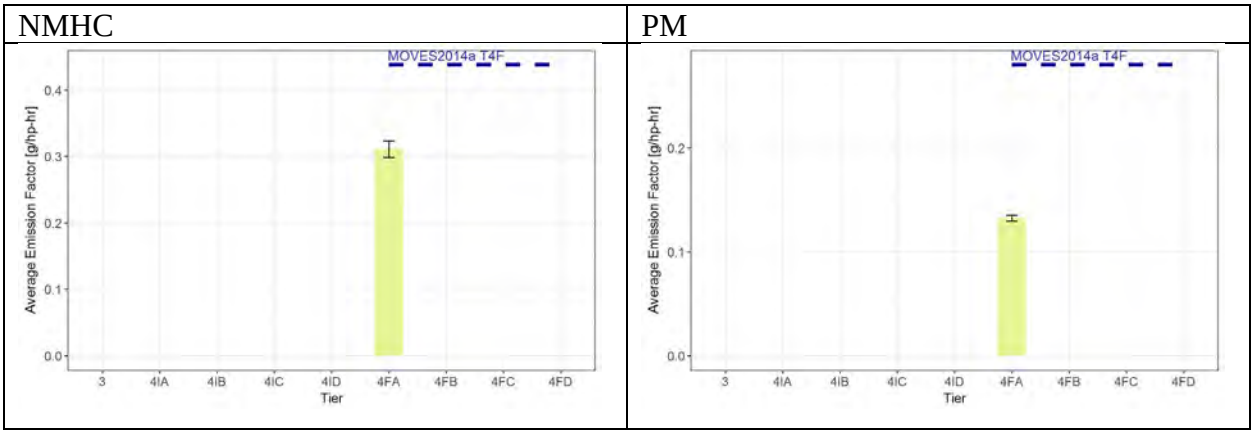


Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)



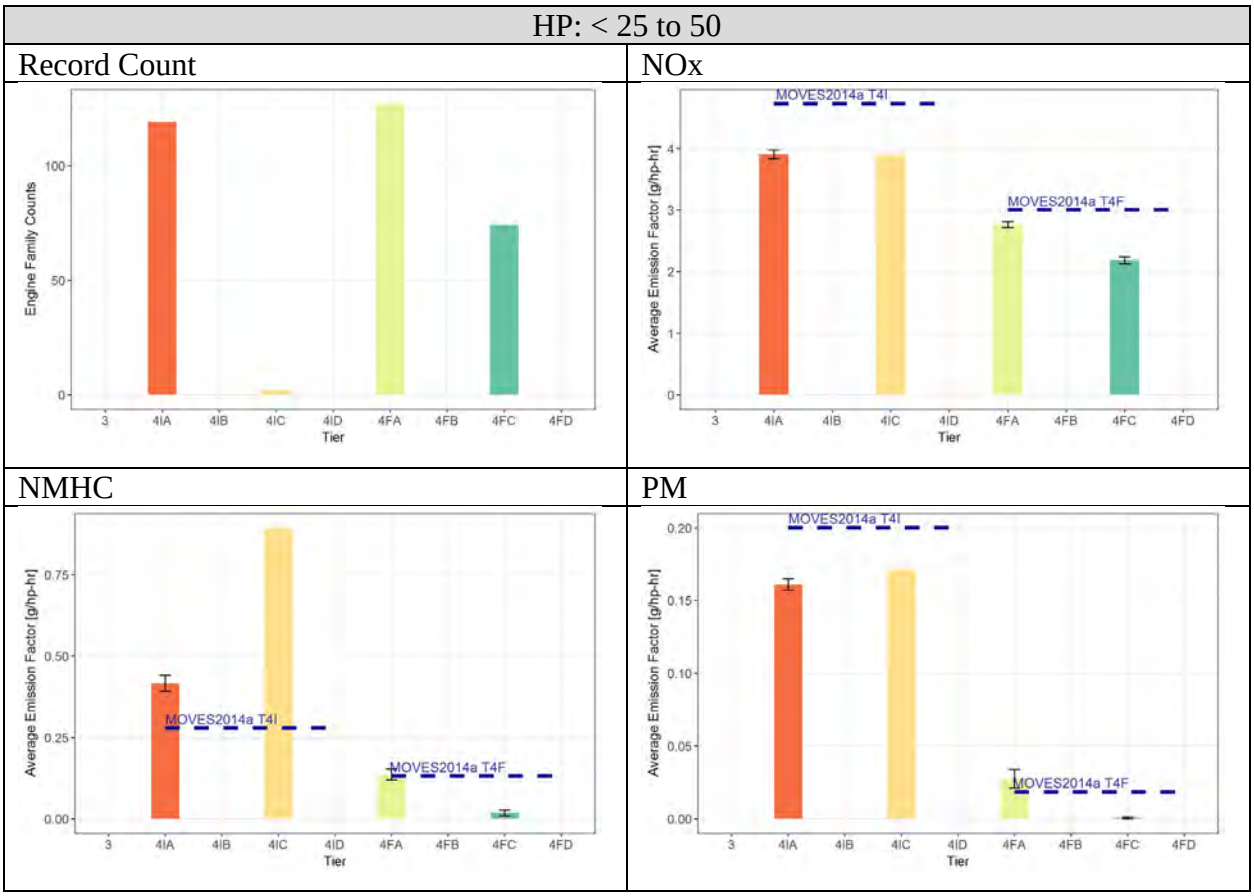
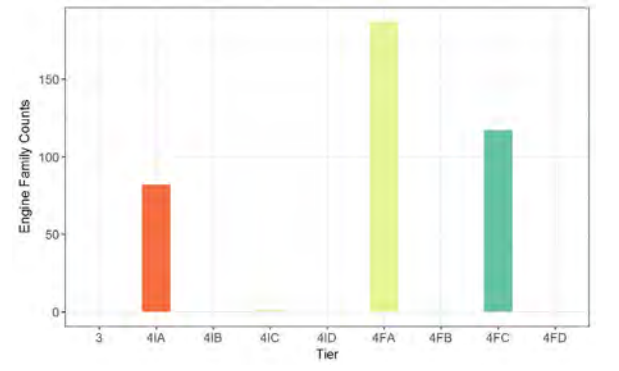


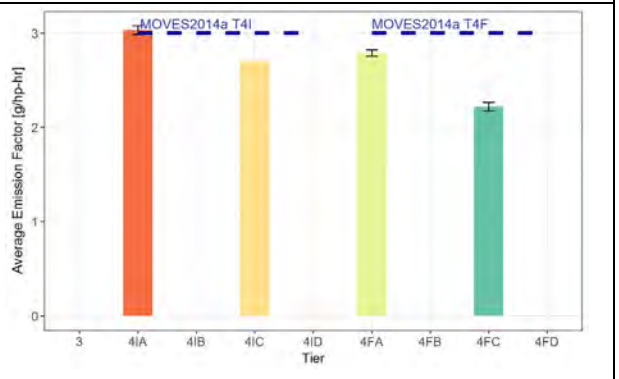
Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

HP: 50 to 75

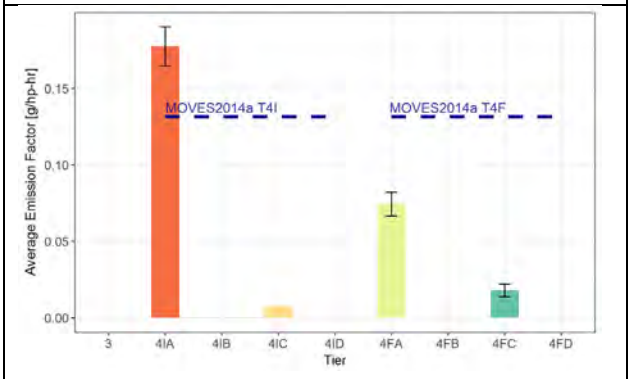
Record Count



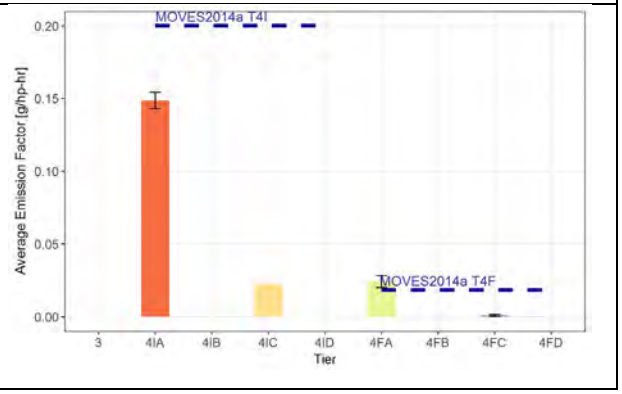
NOx



NMHC

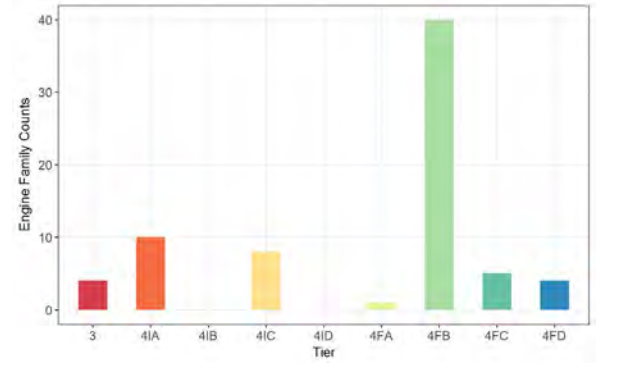


PM



HP: 75 to 100

Record Count



NOx

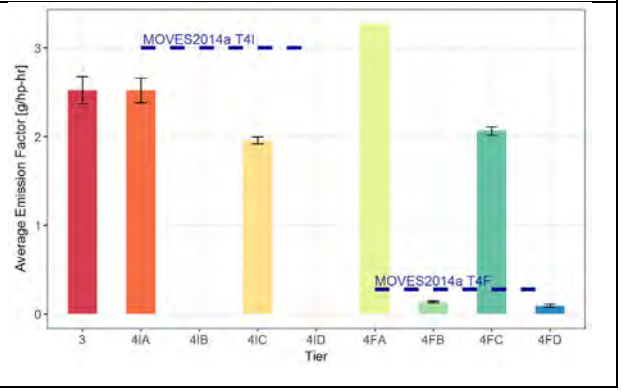
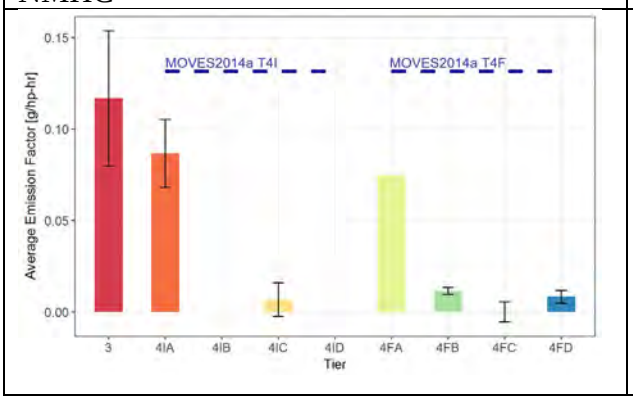
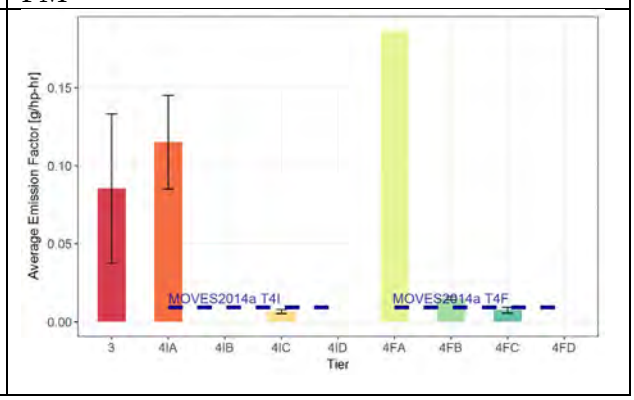


Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

NMHC

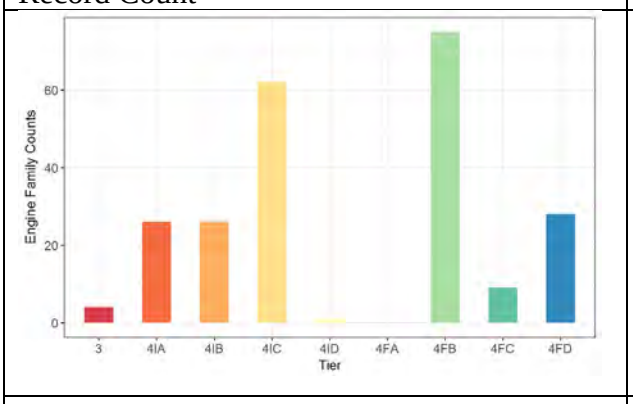


PM



HP: 100 to 175

Record Count



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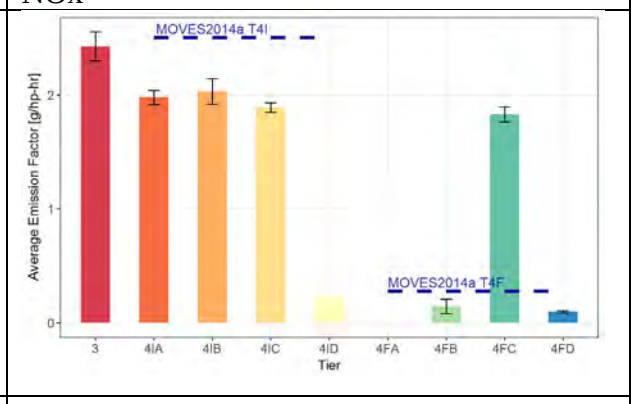

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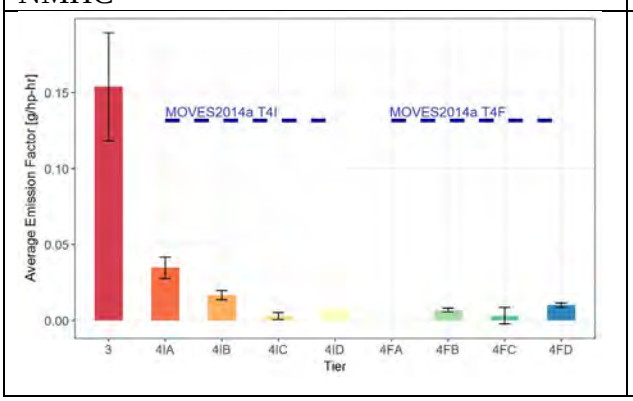


PM

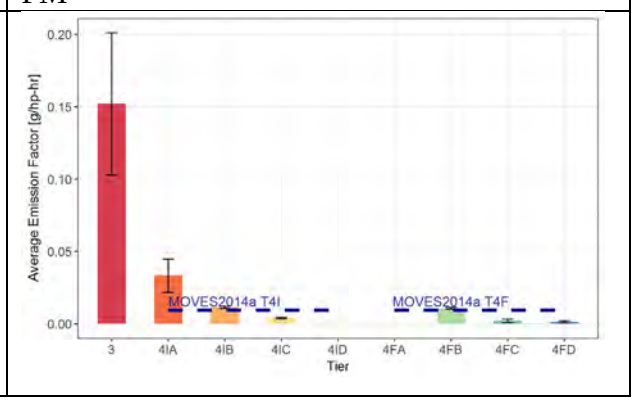
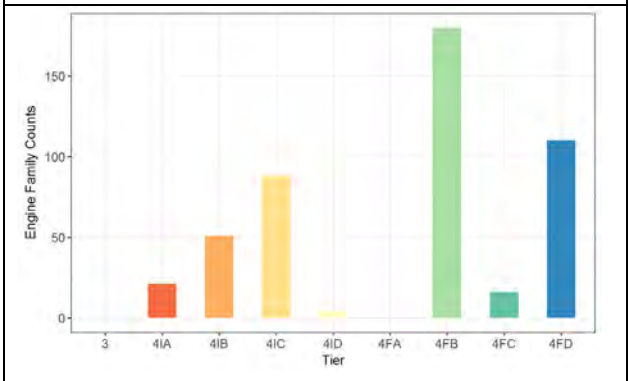


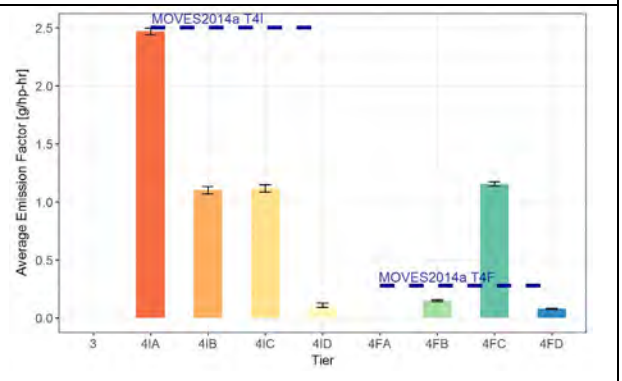
Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

HP: 175 to 300

Record Count



NOx



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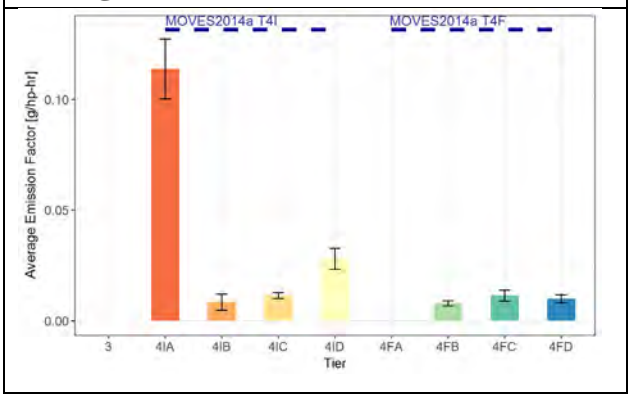
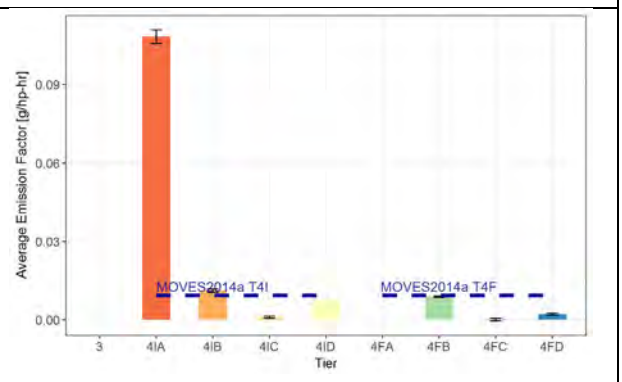
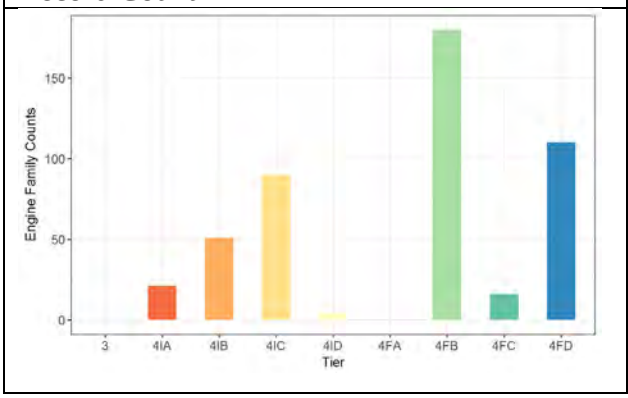


PM



HP: 300 to 600

Record Count



NOx

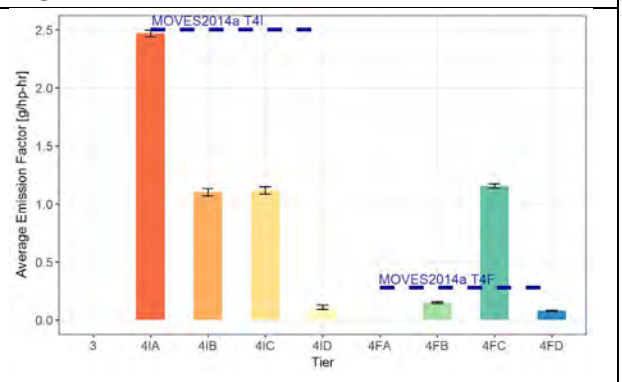
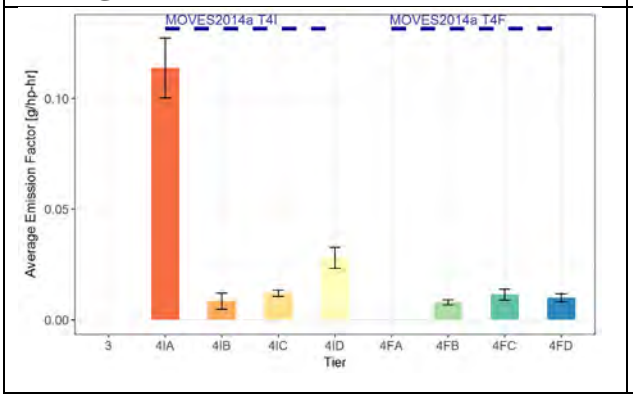
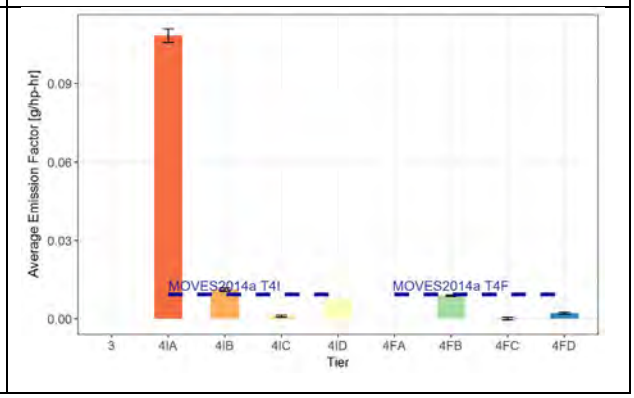


Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

NMHC

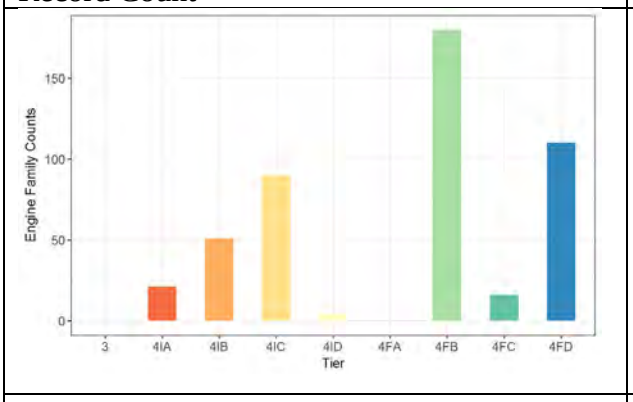


PM

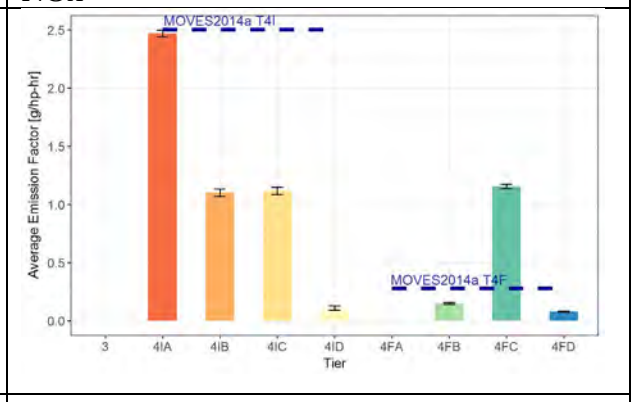


HP: 600 to 750

Record Count



NOx



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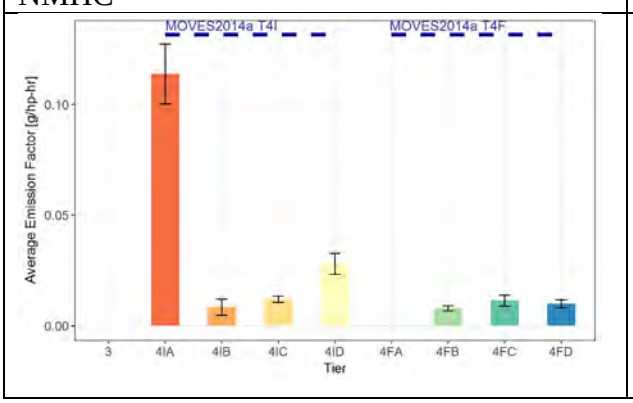


PM

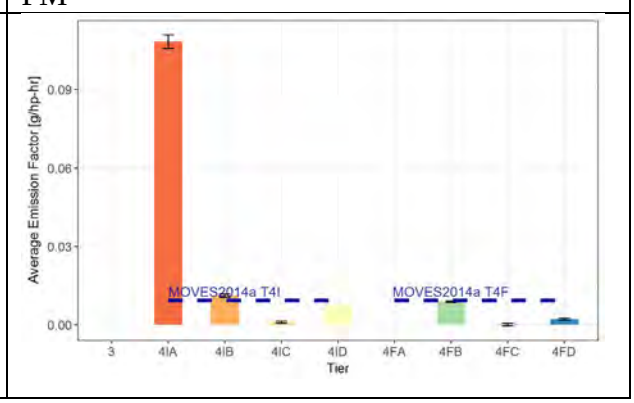
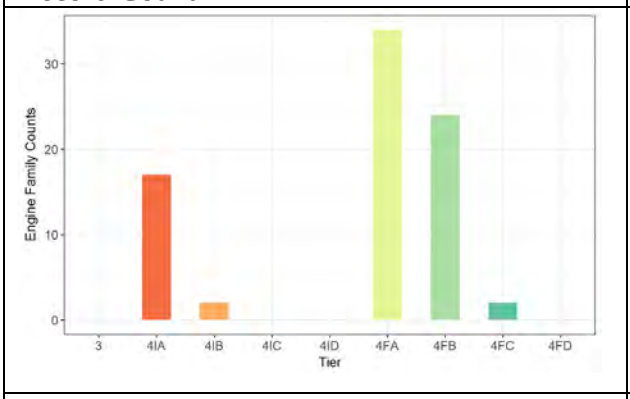


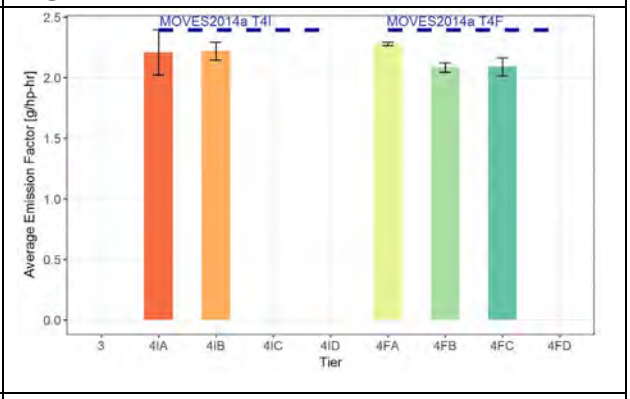
Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

HP: >750 – non generator

Record Count



NOx



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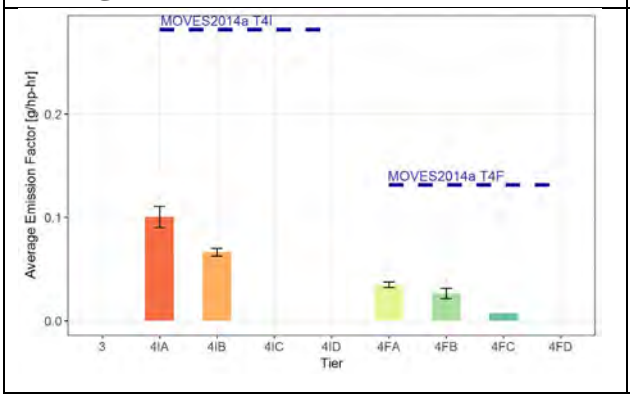

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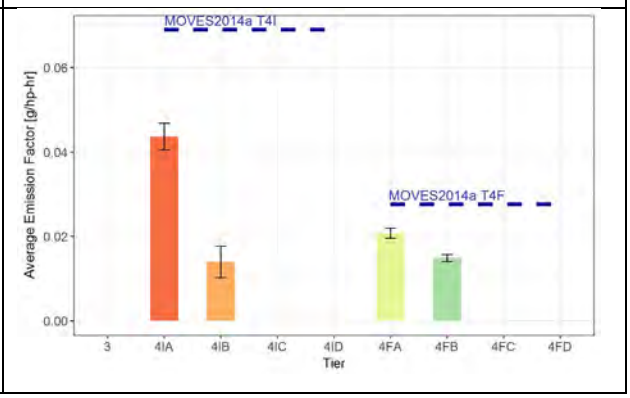
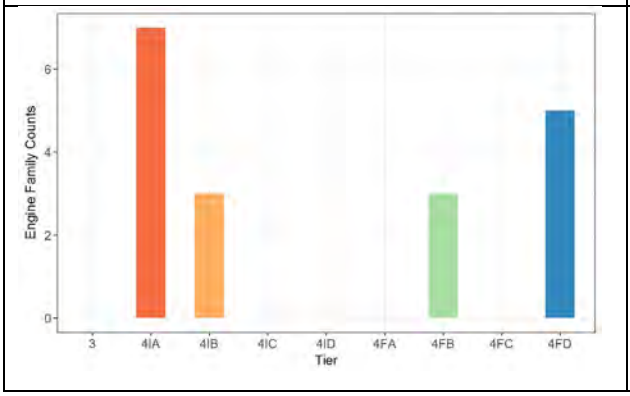


HP: 750 to 1200 – generator

Record Count



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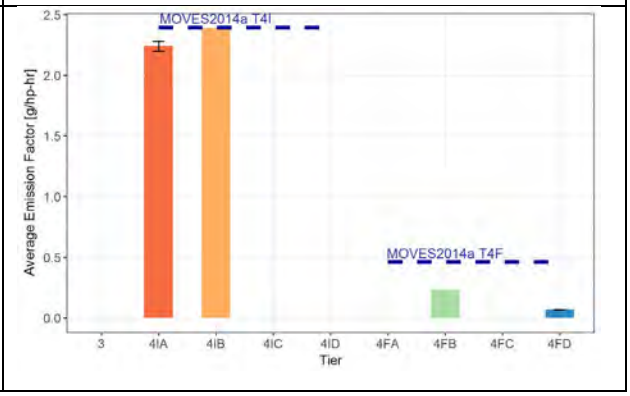
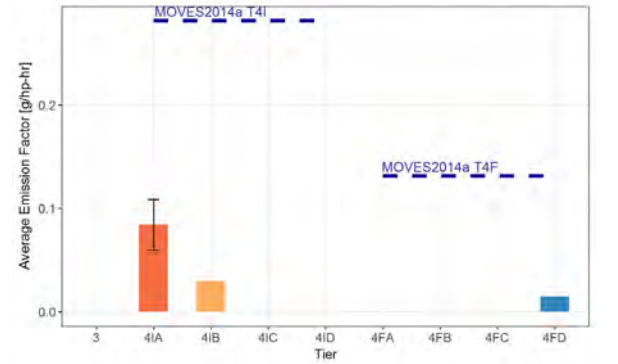
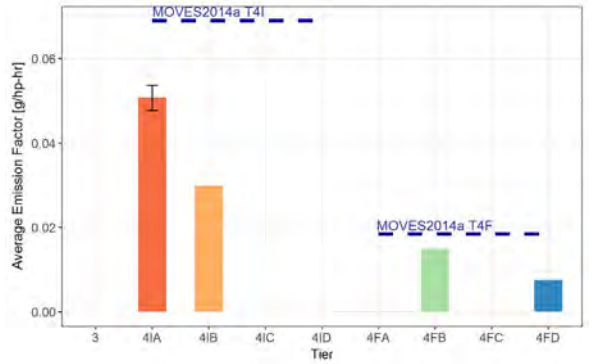


Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)

NMHC	PM
	

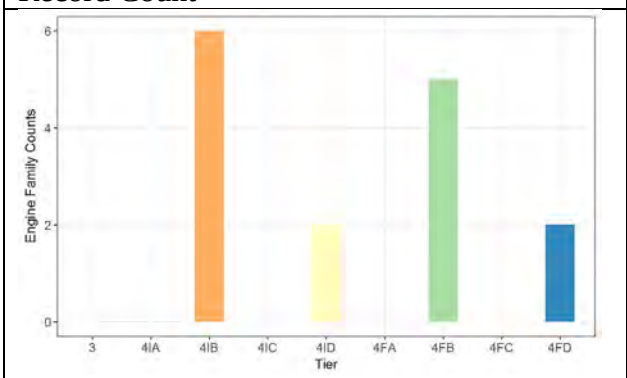
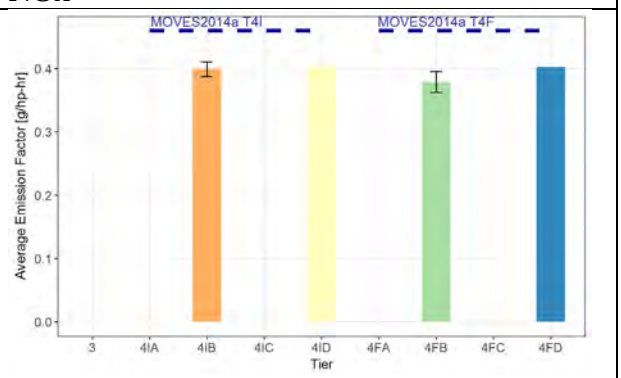
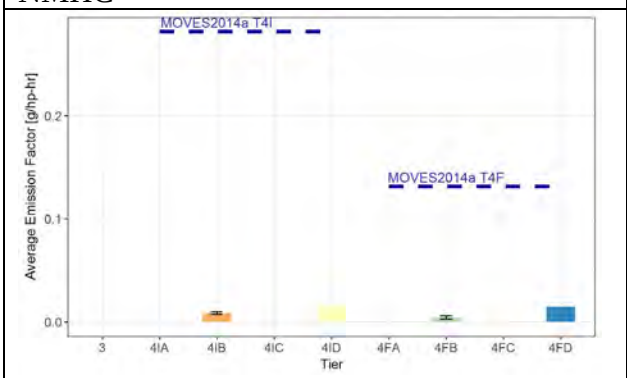
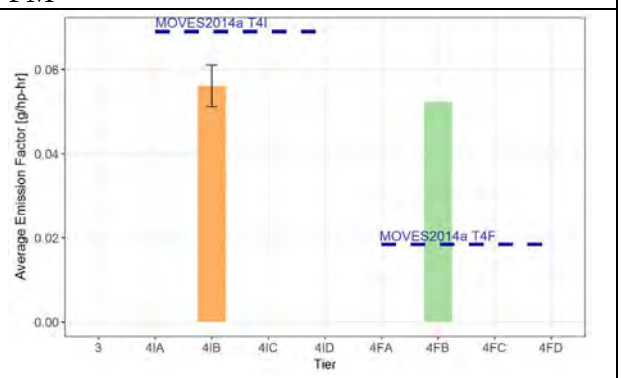
HP: >1200 – generator	
Record Count	NOx
	
NMHC	PM
	

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270001000	Recreational Vehicles All	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270001020	Recreational Vehicles Snowmobiles	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270001030	Recreational Vehicles All-Terrain Vehicles	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270001040	Recreational Vehicles Minibikes	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270001050	Recreational Vehicles Golf Carts	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270001060	Recreational Vehicles Specialty Vehicle Carts	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270002003	Construction Equipment Pavers	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002006	Construction Equipment Tampers/Rammers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002009	Construction Equipment Plate Compactors	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002015	Construction Equipment Rollers	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002018	Construction Equipment Scrapers	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002021	Construction Equipment Paving Equipment	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002024	Construction Equipment Surfacing Equipment	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270002027	Construction Equipment Signal Boards	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002030	Construction Equipment Trenchers	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002033	Construction Equipment Bore/Drill Rigs	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002036	Construction Equipment Excavators	Excavator	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002039	Construction Equipment Concrete/Industrial Saws	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002042	Construction Equipment Cement & Mortar Mixers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002045	Construction Equipment Cranes	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002048	Construction Equipment Graders	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002051	Construction Equipment Off-highway Trucks	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002054	Construction Equipment Crushing/Proc. Equipment	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270002057	Construction Equipment Rough Terrain Forklifts	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]

SCC	Equipment Type	Cycle	TAF Assignment	HC	CO	NO_x		PM		BSFC
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270002060	Construction Equipment Rubber Tire Loaders	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002063	Construction Equipment Rubber Tire Dozers	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002066	Construction Equipment Tractors/Loaders/Backhoes	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270002069	Construction Equipment Crawler Dozer	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002072	Construction Equipment Skid Steer Loaders	SSLoader	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270002075	Construction Equipment Off-Highway Tractors	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270002078	Construction Equipment Dumpers/Tenders	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270002081	Construction Equipment Other Construction Equipment	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270003010	Industrial Equipment Aerial Lifts	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270003020	Industrial Equipment Forklifts	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270003030	Industrial Equipment Sweepers/Scrubbers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270003040		None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
	Industrial Equipment Other General Industrial Equipment									
2270003050	Industrial Equipment Other Material Handling Equipment	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270003060	Industrial Equipment AC\Refrigeration	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270003070	Terminal Tractors	Crawler	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270004000	Lawn & Garden Equipment ALL	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004010	Lawn & Garden Equipment Lawn mowers (Residential)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004011	Lawn & Garden Equipment Lawn mowers (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004015	Lawn & Garden Equipment Rotary Tillers < 6 HP	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004016	Lawn & Garden Equipment Rotary Tillers < 6 HP (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004020	Lawn & Garden Equipment Chain Saws < 6 HP	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004021		None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
	Lawn & Garden Equipment Chain Saws < 6 HP (Commercial)									
2270004025	Lawn & Garden Equipment Trimmers/Edgers/Brush Cutters	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004026	Lawn & Garden Equipment Trimmers/Edgers/Brush Cutters (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004030	Lawn & Garden Equipment Leafblowers/Vacuums	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004031	Lawn & Garden Equipment Leafblowers/Vacuums (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004035	Lawn & Garden Equipment Snowblowers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004036	Lawn & Garden Equipment Snowblowers (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004040	Lawn & Garden Equipment Rear Engine Riding Mowers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004041	Lawn & Garden Equipment Rear Engine Riding Mowers (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004045	Lawn & Garden Equipment Front Mowers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270004046	Lawn & Garden Equipment Front Mowers (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004050	Lawn & Garden Equipment Shredders < 6 HP	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004051	Lawn & Garden Equipment Shredders < 6 HP (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004055	Lawn & Garden Equipment Lawn & Garden Tractors	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004056	Lawn & Garden Equipment Lawn & Garden Tractors (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004060	Lawn & Garden Equipment Wood Splitters	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004061	Lawn & Garden Equipment Wood Splitters (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004065	Lawn & Garden Equipment Chippers/Stump Grinders	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004066	Lawn & Garden Equipment Chippers/Stump Grinders (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004071	Lawn & Garden Equipment Commercial Turf Equipment (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270004075	Lawn & Garden Equipment Other Lawn & Garden Equipment	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270004076	Lawn & Garden Equipment Other Lawn & Garden Equipment (Commercial)	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270005010	Farm Equipment 2-Wheel Tractors	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005015	Farm Equipment Agricultural Tractors	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005020	Farm Equipment Combines	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005025	Farm Equipment Balers	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005030	Farm Equipment Agricultural Mowers	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005035	Farm Equipment Sprayers	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005040	Farm Equipment Tillers > 6 HP	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005045	Farm Equipment Swathers	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270005050	Farm Equipment Hydro Power Units	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270005055	Farm Equipment Other Agricultural Equipment	AgTractor	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2270005060	Farm Equipment Irrigation Sets	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006000	Light Commercial ALL	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006005	Light Commercial Generator Sets	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006010	Light Commercial Pumps	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006015	Light Commercial Air Compressors	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006020	Light Commercial Gas Compressors	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270006025	Light Commercial Welders	ArcWelder	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270006030	Light Commercial Pressure Washers	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2270007005	Logging Equipment Chain Saws > 6 HP	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270007010	Logging Equipment Shredders > 6 HP	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270007015	Logging Equipment Forest Equipment	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270008005	Airport Service Equipment Airport Support Equipment	RTLoader	Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
2270009010	Other Underground Mining Equipment	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
2270010010	Other Oil Field Equipment	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment [a]										
SCC	**Equipment Type**	**Cycle**	**TAF Assignment**	**HC**	**CO**	**NO_x**		**PM**		**BSFC**
				Base-T3	Base-T3	Base, T0-T2	Tier 3	Base, T0-T2	Tier 3	Base-T3
2282020005	Recreational Pleasure Craft, Inboards	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2282020010	Recreational Pleasure Craft, Outboards	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2282020015	Recreational Pleasure Craft, Personal Water Craft	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2282020025	Recreational Pleasure Craft, Sailboat Aux. Outboard	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2285002015	Railway Maintenance	Backhoe	Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18

a TAFs are not applied to the emission factors for Tier 4 engines (i.e., the model applies a TAF of 1.0). "Base-T3" in this table refers to Tier 3 and prior engines.

Table A6. Deterioration Factors for Nonroad Diesel Engines

Pollutant	Relative Deterioration Factor (*A*) (% increase/%useful life)			
	Base/Tier 0	Tier 1	Tier 2	Tier 3+
HC	0.047	0.036	0.034	0.027
CO	0.185	0.101	0.101	0.151
NO_x	0.024	0.024	0.009	0.008
PM	0.473	0.473	0.473	0.473

DF =1+A*(fraction of useful life expended)^b
b = 1 for diesel nonroad engines

15 Appendix B: Sources of Previous Emission Factors for Nonroad Compression Ignition Engines

There is little test data available on nonroad engines. Table B1 lists the data sources used for EPA's Nonroad Engine and Vehicle Study's (NEVES) diesel emission factors. Published in November, 1991, NEVES was mandated by Congress to determine whether nonroad sources made a significant contribution to urban air pollution. It covers HC, CO, NO_x, PM, SO_x and other pollutants. It provides inventories for 19 ozone and 16 CO nonattainment areas.

Table B1. Data sources for NEVES Diesel Emission Factors

Application	Emissions Test Data Source	Notes
Lawn and Garden and Light Commercial	None	NEVES emission factors were based on factors for "continuous service diesel < 50 hp" SwRI, 1991, which are based on Radian, 1988 factors for truck/container refrigeration units.
Agriculture	Cal/ERT, 1982	
Construction	EMA SwRI, 1973 Cal/ERT, 1982	NEVES emission factors were based on EMA when possible. For PM and for applications not available from EMA, factors were taken from AP-42, which relies on Cal/ERT for most emission factors and on SwRI, 1973 for PM and SOx.
Logging (skidders)	EMA	
Industrial and Airport Service Equipment	SwRI, 1973	
Recreational Marine (Inboard)	NMMA	

Table B2 lists the data sources used for California's Air Resources Board (ARB) OFFROAD diesel emission factors. OFFROAD is designed to estimate nonroad emissions for the state of California only. A version of this model was released in late summer 1997. It covers HC, CO, NO_x, PM, SO_2, and CO_2. The studies listed in the tables are described below.

Table B2. Data sources for ARB OFFROAD Diesel Emission Factors

Horsepower Class	Emissions Test Data Source	Notes
0-15 hp	Manufacturers' data-- 2 Yanmar engines 1 Deutz engine	
15-25 hp	Manufacturers (ARB Off-Road Equipment Study, 1990)	
25-50 hp	Manufacturers Submissions (ARB Off-Road Equipment Study, 1990)	
50-125 hp	Manufacturers (CA HD Construction Study, 1988)	
125-250 250+	Manufacturers (CA HD Construction Study, 1988)	ARB factors on all engines from 125 hp and above are based on the same data, but the weighting between turbo-charged and naturally aspirated engines is different in the two horsepower categories listed here.

Description and Citations of Sources used for Previous Emission Factors

Radian, 1988. Radian's estimates of HC, CO, NO_x and PM for truck/container refrigeration units are not based on testing, but on Radian's estimates for "typical small direct injection and indirect injection diesel engines." (Weaver, C.S., "Feasibility and Cost Effectiveness of Controlling Emissions from Diesel Engines in Rail, Marine, Construction, Farm and Other Mobile Off-Highway Equipment." Final Report by Radian Corporation for U.S. EPA, Office of Policy Analysis, under contract 68-01-7288, February, 1988.)

SwRI, 1973. Southwest Research Institute tested 8 diesel engines for HC, CO, NO_x and PM. Emissions of SOx were calculated for no. 2 diesel fuel assuming sulfur content of 0.22 percent. BSFC is not stated. The emissions tests were given different weightings to

estimate industrial, construction and farm equipment emission factors. (Hare, C.T and K.J. Springer. Exhaust Emission from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines, Final Report, Part 5, Heavy Duty Farm, Construction and Agricultural Engines. San Antonio TX: Southwest Research Institute, October 1973.)

EMA. Emission factors for 17 applications based on unknown number of tests, unknown horsepower engines. Engine vintage unknown, but data was submitted by the Engine Manufacturers Association to EPA prior to NEVES (1991). (Listed in NEVES table I-06.)

Cal/ERT, 1982. Data from 13 engine manufacturers representing 391 models of construction equipment. Raw data was aggregated by an accounting firm prior to analysis and reporting. (Environmental Research and Technology, Inc. "Feasibility, Cost and Air Quality Impact of Potential Emission Control Requirements on Farm, Construction and Industrial Equipment in California", Document PA841, sponsored by the Farm and Industrial Equipment Institute, Engine Manufacturers Association, and Construction Industry Manufacturers Association, May 1982.)

NMMA. The National Marine Manufacturers Association submitted data to EPA on HC, CO, NO_x and BSFC for 3 diesel inboard motors. Engine vintage unknown, but data was submitted to EPA prior to NEVES (1991). (NEVES, Table I-11(e).)

ARB Off-Road Study, 1990. A study of lawn and garden and utility emissions. (Manufacturer Submissions to ARB on Exhaust Emission Standards for Utility and Lawn and Garden Equipment Engines. California ARB, October 1990. EPA requests assistance in locating this study)

ARB Heavy Duty Construction Study, 1988.[28] Reports HC, NO_x and PM emission factors based on emission information from four manufacturers. Does not include information on test programs. It is not clear how data collected in the study was used to create the inputs for the ARB model. (Energy and Environment Analysis, Inc. " Feasibility of Controlling Emissions from Off-Road, Heavy-Duty Construction Equipment." Final Report to the California Air Resources Board. Arlington, VA, December 1988.)

16 Appendix C: 1988-1995 (Tier 0) Zero-Hour, Steady-State Emission Factors and Fuel Sulfur Adjustment for Nonroad Compression Ignition Engines

Introduction

EPA's 1991 Nonroad Engine and Vehicle Emission Study (NEVES) (1) used emission factors for diesel engines based primarily on tests of older engines. All the NEVES particulate matter (PM) emission factors are from tests conducted in 1972 and many of the other emissions factors in NEVES are based on data from tests prior to 1982.

To better characterize emissions from more recent, pre-control engines, EPA analyzed available emission test data on 1988-1995 nonroad diesel engines. This analysis provides the basis for MOVES-Nonroad pre-control emission factors for 1988-and-later engines greater than 50 hp, as described in the main body of this report. The analysis indicated a significant difference in emissions based on engine power. Engines between 50 and 100 horsepower in general had higher emissions and fuel consumption than engines larger than 100 horsepower. Table C1 summarizes these results.

Table C1. Average Emission Test Results for 1988 to 1995 Model Year Engines

Engine (Reference)	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
Average (50 to 100 hp)	0.99	3.49	8.30	0.722	0.408
Average (>=100 hp)	0.68	2.70	8.38	0.402	0.367

A summary of test results for individual engines is presented in Table C2. Note that testing was conducted using the current certification test procedure, also known as ISO-C1. The procedure uses eight steady-state modes weighted by time to produce one number in units such as grams per horsepower-hour. EPA adjusted this test data to account for differences between the test fuel and typical in-use fuel sulfur levels of 0.33 wt. percent as explained below.

Table C2. Summary of ISO-C1 Emission Results for 1988 through 1995 Engines

Engine (Reference)	Model Year	Age (Hrs)	Fuel Sulfur (wt. %)	Power Level (hp)	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
Ford New Holland (2)	1991	0	0.26	127	1.02	7.70	7.48	1.10	0.358
John Deere 7068T (2)	1990	0	0.26	139	0.45	2.98	11.74	0.41	0.349
Volvo TD 71G (avg. of 2) (3)	1984	0	0.046	144	0.47	1.64	12.68	0.149	0.373
Volvo TD73 KBE (avg. of 2) (3)	1992	0	0.046	139	0.64	0.85	4.52	0.12	0.386
Weterbeke 32BEDA (4)	1995	0	0.033	95	1.95	7.43	7.99	1.50	0.484
Caterpillar 3176B (4)	1995	0	0.033	451	0.09	2.94	6.37	0.213	0.358
Cummins KTA19-M3 (4)	1995	0	0.033	599	0.68	3.26	8.78	0.257	0.359
Caterpillar 3306 (Nonroad) (5)	1990	0	0.26	285	1.1	1.4	6.5	0.18	0.354
Cummins 4BT (Nonroad) (5)	1990	0	0.26	100	0.8	2.1	11	0.39	0.365
John Deere 4039D (6)	1991	0	0.25	72	0.6	3.5	7.2	0.59	0.385
Caterpillar 3116 (7)	1991	2,511	0.28	201	0.07	2.51	9.38	0.406	0.352
			0.035					0.350	
Caterpillar 3054 (7)	1991	1,964	0.28	85	0.66	1.00	7.53	0.387	0.393
			0.035					0.340	
	1994	2,265	0.28	86	0.41	2.17	11.22	0.384	0.389

Engine (Reference)	Model Year	Age (Hrs)	Fuel Sulfur (wt. %)	Power Level (hp)	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
John Deere 4039 (7)			0.035					0.256	
John Deere 7076 (7)	1993	3,300	0.28	174	0.53	2.05	10.22	0.250	0.385
			0.035					0.205	
Consolidated Diesel 6TA-830 (7)	1990	4,370	0.28	226	0.86	1.50	6.53	0.397	0.365
			0.035					0.338	
John Deere 6619 (7)	1993	4,970	0.28	275	0.82	4.69	7.29	0.662	0.397
			0.035					0.556	
Consolidated Diesel 4039 (7)	1988	3,570	0.28	71	1.32	3.37	7.57	0.581	0.389
			0.035					0.484	
Caterpillar 3306 (7)	1990	6,700	0.28	278	1.27	1.46	6.52	0.248	0.373
			0.035					0.245	
Average (50 to 100 hp)			**0.33**		**0.99**	**3.49**	**8.30**	**0.722***	**0.408**
Average (>=100 hp)			**0.33**		**0.68**	**2.70**	**8.38**	**0.402***	**0.367**

* Adjusted to the national average fuel sulfur level of 0.33 weight percent

Fuel Sulfur Adjustment

PM emissions from diesel engines are highly dependent on the sulfur content of the fuel the engine is burning. PM emissions from diesel engines are generally comprised of unburned or partially burned fuel, engine oil, and sulfur compounds. When the engine burns fuel, the fuel sulfur is oxidized to both sulfur dioxide and sulfur trioxide. The sulfur trioxide rapidly absorbs water to form hydrated sulfuric acid which condenses and is collected on filters as particulate matter (PM) during emission testing.

Because historically the sulfur content of diesel fuel could vary considerably, it is important to account for fuel sulfur in establishing emission factors for PM. To adjust emission test data to the default sulfur level used in MOVES-Nonroad for Tier 1 and pre-

control emissions (0.33 wt. percent), EPA followed the approach described below**.**

EPA measured particulate emissions from nine nonroad diesel engines using fuel with two different sulfur levels, a typical highway diesel fuel at a sulfur level of 0.035 weight percent and a typical nonroad diesel fuel doped to a sulfur level of 0.28 weight percent to simulate more closely the average nonroad diesel fuel sulfur level of 0.33 weight percent. (8) Data from eight of the engines is listed in Table C2, above. In addition, the study included a 1997 John Deere nonroad engine. This engine is not shown in Table C2 because it is certified for the Tier 1 emission regulations and should not be used to determine an overall emission factor for pre-control engines. Test results from this study (including all 9 engines tested) were used to determine the emission adjustment associated with fuel sulfur level. Other fuel parameter differences such as cetane and fuel distillation that might also have affected particulate emissions were ignored for this analysis.

The study found that emissions of all pollutants were reduced by using highway fuel as compared to the nonroad fuel; however, only the average PM reduction was statistically significant at the 90 percent confidence level.

The particulate sulfur emission rate should be proportional to the fuel consumption and the fuel sulfur level. By dividing the difference in particulate emissions by the difference in fuel sulfur consumption, EPA calculated the average effect of fuel sulfur levels on PM emissions for the nine engines, as shown in Table C3 below.

Table C3. Effects of Fuel Sulfur on PM Emissions

Engine	**MY**	**Fuel Sulfur** (wt percent)	**PM** (g/hp-hr)	**BSFC** (lb/hp-hr)	**Delta PM** (g/hp-hr)	**Delta Fuel Sulfur Consumed*** (g/hp-hr)	**Delta PM / Delta Sulfur**
Cat 3116	1991	0.280	0.406	0.352	0.056	0.391	0.143
Cat 3116	1991	0.035	0.350	0.352			
Cat 3054	1991	0.280	0.387	0.393	0.047	0.437	0.107
Cat 3054	1991	0.035	0.340	0.393			
Deere 4039	1994	0.280	0.384	0.389	0.128	0.432	0.296
Deere 4039	1994	0.035	0.256	0.389			
Deere 7076	1993	0.280	0.250	0.385	0.045	0.428	0.105
Deere 7076	1993	0.035	0.205	0.385			
ConDsl 6TA-830	1990	0.280	0.397	0.365	0.059	0.405	0.146
ConDsl 6TA-830	1990	0.035	0.338	0.365			
Deere 6619	1993	0.280	0.662	0.397	0.106	0.441	0.240
Deere 6619	1993	0.035	0.556	0.397			
Con Dsl 4039	1988	0.280	0.581	0.389	0.097	0.432	0.225

Con Dsl 4039	1988	0.035	0.484	0.389			
Cat 3306	1990	0.280	0.248	0.373	0.003	0.415	0.007
Cat 3306	1990	0.035	0.245	0.373			
Deere 6101	1997	0.280	0.186	0.350	0.057	0.389	0.147
Deere 6101	1997	0.035	0.129	0.350			
				Average:			**0.1573**

* Delta fuel sulfur consumed (g S/hp-hr) = 0.01*(0.280-0.035)*BSFC*453.6 g/lb.

The value of 0.1573 is the average change in PM emissions per change in grams of fuel sulfur consumed. The change in PM emissions would be due to PM sulfate, so this can also be expressed as the change in PM sulfate emissions per change in grams of fuel sulfur consumed. We assume that PM sulfate is H2SO4:7H20 (sulfuric acid hydrated seven times). For PM sulfate, there is 7.0 grams sulfate per gram sulfur. Therefore, 0.1573 ÷7 = 0.02247 grams PM sulfur per gram fuel sulfur consumed, which is the fraction of fuel sulfur converted to PM. In the MOVES-Nonroad model, the change in PM emissions per change in grams of fuel sulfur consumed is expressed as the term, "soxcnv * 7," where soxcnv is the fraction of fuel sulfur converted to PM and 7 is the grams sulfate PM per gram sulfur. Soxcnv is equal to 0.02247 and soxcnv * 7 is equal to 0.157 for diesel equipment not equipped with advanced oxidation catalyst technologies. This applies to the Base, Tier 0, Tier 1, Tier 2, Tier 3, Tier 3B, Tier 4A, and Tier 4B technology types in MOVES-Nonroad.

Consistent with our analysis in the Heavy-Duty (HD) 2007 highway rule, we have assumed that the conversion of fuel sulfur to sulfate emissions for engines equipped with advanced oxidation catalyst technologies (e.g., catalyzed diesel particulate filters) will be 30 percent. As a result, soxcnv is equal to 0.30 for the Tier 4 and Tier 4N technology types in MOVES-Nonroad. The balance (70 percent) of the fuel sulfur is assumed to be emitted as SO_2. The memo to EPA Air Docket A-99-06 Item II-B-32 documents the analysis from the HD 2007 rulemaking. Extensive discussion of diesel fuel sulfur oxidation to sulfate PM can be found in Chapter 3 of the HD 2007 Final Regulatory Impact Analysis (RIA) and in Chapter 4 of the nonroad Tier 4 RIA. The 30 percent conversion of fuel sulfur to sulfate represents an assumed average rate; sulfur conversion rates can vary widely depending upon operating conditions and catalyst technology.

The above analysis of engine test data provided the constant "A" in the equation below, which describes the adjustment made to correct PM emissions from the test fuel sulfur level to the default sulfur level of 0.33 weight percent.

$$PMBase = PM + BSFC * A * (0.0033 - Fuel\ Sulfur)$$

Where:

PMBase = PM emissions with default fuel, in g/hp-hr
PM = PM emissions with test fuel, in g/hp-hr
BSFC = Brake Specific Fuel Consumption in g/hp-hr
A = 0.157 g PM/hp-hr/Weight Fraction sulfur/BSFC
0.0033= the default weight fraction of fuel sulfur for nonroad diesel
Fuel Sulfur = Weight Fraction of sulfur in test fuel

EPA then used this equation for all tests listed in Table C2 to correct PM emissions from the test-fuel sulfur level to a fuel sulfur level of 0.33 wt. percent before computing the averages listed in Table C1 and at the bottom of Table C2. Since the engines tested are pre-Tier 4 technologies, the constant "A" value of 0.157 was used in the equation.

References

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(5) Fritz, S. G., "Dynamometer Testing of Heavy-Duty Diesel Engines to Support Non-Road Regulations," SwRI Report No. 08-3426-010, Work Assignment 0-10 of EPA Contract No. 68-C0-0014 (September 1991).

(6) Smith, Michael. "Dynamometer Testing of Nonroad Diesel Engines to Support Nonroad Regulations." Southwest Research Institute, 08-4855-150, EPA Docket A-91-24, June 1992.

(7) Fritz, S. G. and M.E. Starr, "Emission Factors for Compression Ignition Nonroad Engines Operated on Number 2 Highway and Nonroad Diesel Fuel," Southwest Research Institute. EPA contract # 68-C5-0077, SwRI 08-7601-822, March 1998.

(8) Korotney, David. "Estimates for In-Use Nonroad Diesel Fuel Levels," Memorandum to Docket A-96-40. July 1, 1997.

17 Appendix D: Certification Data for Tier 1 and Selected Tier 2 Nonroad Compression Ignition Engines

Certification data were available and therefore used to develop zero-hour, steady-state emission factors for Tier 1 engines in all hp categories and Tier 2 engines in the >300 to 600 hp category. Certification data were extracted from the database as of October, 2001. Official test results (OTR values) obtained with the nonroad 8-mode test procedure were used. Note that emissions for some engines exceed the applicable standards if the engine families are part of the Average Banking and Trading (ABT) program.

Tests were conducted with fuel meeting either diesel nonroad or diesel on-highway specifications. For tests conducted on the Tier 1 engines with diesel on-highway fuel, the PM emissions were adjusted from 350 ppm to 3300 ppm sulfur (the default diesel sulfur level used in MOVES-Nonroad), using the equation described in Appendix C. For tests conducted on the Tier 2 engines with diesel on-highway fuel, the PM emissions were adjusted from 350 ppm to 2000 ppm. An estimate of brake-specific fuel consumption is required to calculate the adjustment. If the fuel rate for a certification test was reported, the engine-specific BSFC was calculated and used directly. If the fuel rate was not reported, the default BSFC values in MOVES-Nonroad were used to calculate the adjustment.

The certification data were grouped by model year and by hp category. Sales-weighted emission averages were calculated for each model year/hp category. Then, for each hp category, a straight average of the applicable model year data was used.

For categories less than 50 hp, the Tier 1 standard for HC and NO_x is expressed as a combination of HC and NO_x (HC+NO_x, refer to Table 1). As a result, most of the certification data for these engines is provided as the sum of HC and NO_x, although there are some data reported for HC and NO_x separately. To obtain separate HC and NO_x emission factors for categories less than 50 hp, HC fractions of HC+NO_x emissions were calculated for those tests which reported both HC and HC+NO_x emission factors. The average HC fraction was then calculated and multiplied by the sales-weighted average HC+NO_x emission factor to obtain an HC emission factor (referred to as HC calc in the tables). The remaining fraction of the HC+NO_x emission factor was assigned as the NO_x emission factor (referred to as NO_x calc in the tables). This was done for each model year and for each of the hp categories less than 50 hp (i.e., 0-11 hp, 11-25 hp, 25-50 hp).

Table D1 presents a summary of the results, as well as the sample sizes for each pollutant/model year/hp category. The numbers in bold are those used in the model. Tables D2-D7 present the individual engine emissions data and sales weightings for each model year and hp category. The engine identification and specific sales information have been removed. For categories less than 50 hp, the HC fractions, HC calc emission

factors, and NO_x calc emission factors are also provided. The HC calc and NOx calc emission factors are used in the model.

Table D1. Summary of Certification Data for Nonroad Compression Ignition Engines*

>0 to 11 hp								
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**	**HC frac**	**HC calc**	**NOx calc**
2000	0.692103	5.170337	5.966223	4.051366	0.452858	0.113196	0.675351	5.290871
2001	0.828378	5.073763	6.018891	4.174066	0.44201	0.141247	0.850153	5.168738
average	0.760241	5.12205	5.992557	**4.1127**	**0.4474**		**0.7628**	**5.2298**
sample size	HC	NOx	HC+NOx	CO	PM			
2000	4	6	20	20	20			
2001	5	5	19	19	19			
total	9	11	39	39	39			
>11 to 25 hp								
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**	**HC frac**	**HC calc**	**NOx calc**
2000	0.489983	3.749647	4.9489	2.207041	0.289982	0.081156	0.401631	4.547269
2001	0.447831	4.109521	4.80692	2.114884	0.242992	0.09869	0.474395	4.332525
average	0.468907	3.929584	4.87791	**2.1610**	**0.2665**		**0.4380**	**4.4399**
sample size	HC	NOx	HC+NOx	CO	PM			
2000	9	10	40	39	40			
2001	16	16	43	43	43			
total	25	26	83	82	83			
>25 to 50 hp								
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**	**HC frac**	**HC calc**	**NOx calc**
1999	0.496458	4.558405	4.983359	1.54213	0.35614	0.047095	0.23469	4.748669
2000	0.452946	4.893606	5.083919	1.522782	0.331337	0.056039	0.284899	4.79902
2001	0.472917	4.469647	4.952901	1.532028	0.329222	0.064006	0.317014	4.635887
average	0.474107	4.640553	5.006726	**1.5323**	**0.3389**		**0.2789**	**4.7279**
sample size	HC	NOx	HC+NOx	CO	PM			
1999	11	15	72	72	72			
2000	14	22	95	96	96			
2001	25	35	103	104	104			
total	50	72	270	272	272			

Table D1. Summary of Certification Data for Nonroad Compression Ignition Engines (cont.)*

>50 to 100 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
1998	0.528845	5.682411	4.235576	2.753546	0.472055
1999	0.517642	5.613376	6.569501	2.34687	0.452553
2000	0.46289	5.494892	4.235576	2.047055	0.460428
2001	0.575867	5.604515	5.976957	2.314372	0.506824
average	**0.5213**	**5.5988**	5.254402	**2.3655**	**0.4730**
sample size	HC	NOx	HC+NOx	CO	PM
1998	18	71	1	21	19
1999	27	91	3	33	31
2000	35	104	1	38	36
2001	40	127	3	47	43
total	120	393	8	139	129
>100 to 175 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
1997	0.297479	5.599201		0.745072	0.281314
1998	0.355336	5.743938		0.961288	0.276378
1999	0.35159	5.749792		0.93731	0.270345
2000	0.33246	5.593736		0.68581	0.282059
2001	0.355107	5.574714		1.003922	0.28934
average	**0.3384**	**5.6523**		**0.8667**	**0.2799**
sample size	HC	NOx	HC+NOx	CO	PM
1997	29	43	0	29	25
1998	25	52	0	27	24
1999	25	59	0	27	25
2000	27	61	0	29	28
2001	34	69	0	37	36
total	140	284	0	149	138
>175 to 300 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
1996	0.331633	5.667602		0.834876	0.239994
1997	0.307044	5.723983		0.819777	0.24542
1998	0.316321	5.574079		0.722968	0.262486
1999	0.314974	5.549376		0.695869	0.257528
2000	0.26631	5.441729	4.54	0.666725	0.240685
2001	0.314765	5.506545	4.203295	0.744633	0.266622
average	**0.3085**	**5.5772**	4.371648	**0.7475**	**0.2521**
sample size	HC	NOx	HC+NOx	CO	PM
1996	44	44	0	44	44
1997	43	43	0	43	43
1998	72	72	0	72	72
1999	71	71	0	71	71
2000	64	64	2	64	64
2001	86	86	6	88	88

total	380	380	8	382	382

Table D1. Summary of Certification Data for Nonroad Compression Ignition Engines (cont.)*

>300 to 600 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
1996	0.260521	6.264393		1.353145	0.195978
1997	0.1553	5.865363		1.431343	0.213156
1998	0.209071	6.126551		1.289223	0.198893
1999	0.201521	6.04976		1.201752	0.192703
2000	0.186024	5.77026	5.24	1.254546	0.203148
average	**0.2025**	**6.0153**	5.24	**1.3060**	**0.2008**
2001Tier 2	**0.1669**	**4.3351**	4.345348	**0.8425**	**0.1316**
sample size	HC	NOx	HC+NOx	CO	PM
1996	40	40	0	40	40
1997	35	35	0	35	35
1998	48	48	0	48	48
1999	55	55	0	55	55
2000	51	51	1	51	51
2001	14	14	35	35	35
total	243	243	36	264	264
>600 to 750 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
1996	0.174804	6.063537		1.502117	0.242149
1997	0.135125	5.872338		1.571034	0.236991
1998	0.190719	5.866023		1.277422	0.205116
1999	0.118392	5.723896		1.361031	0.227162
2000	0.126821	5.790567		1.368105	0.225632
2001	0.138065	5.612418	3.975047	0.883305	0.183773
average	**0.1473**	**5.8215**	3.975047	**1.3272**	**0.2201**
sample size	HC	NOx	HC+NOx	CO	PM
1996	11	11	0	11	11
1997	10	10	0	10	10
1998	12	12	0	12	12
1999	13	13	0	13	13
2000	15	15	0	15	15
2001	16	16	3	17	17
total	77	77	3	78	78

Table D1. Summary of Certification Data for Nonroad Compression Ignition Engines (cont.)*

>750 hp					
g/hp-hr	**HC**	**NOx**	**HC+NOx**	**CO**	**PM**
2000	0.25906	6.252638		0.727419	0.183308
2001	0.313093	6.052394		0.800887	0.203589
average	**0.2861**	**6.1525**		**0.7642**	**0.1934**
sample size	HC	NOx	HC+NOx	CO	PM
2000	16	16	0	16	16
2001	18	18	0	18	18
total	34	34	0	34	34

* Values in bold are used in MOVES-Nonroad. All are Tier 1 emission factors, with the exception that both Tier 1 and Tier 2 emission factors are provided for the >300 to 600 hp category.

Table D2. 1996 MY Certification Data

175 to 300 hp	Emission Factors (g/hp-hr)				
Rated HP	HC	NOx	CO	PM	Sales wgt
261	0.47	6.06	0.89	0.27	0.0005
248	0.34	5.31	1.04	0.35	0.0005
215	0.32	5.51	0.55	0.33	0.0628
260	0.44	5.81	0.70	0.27	0.0398
240	0.29	5.38	0.49	0.27	0.0545
260	0.37	5.73	1.30	0.31	0.0177
225	0.41	5.70	0.84	0.15	0.0862
275	0.11	4.56	1.25	0.18	0.0174
258	0.05	6.34	0.89	0.22	0.0064
275	0.08	4.93	1.80	0.25	0.0034
220	0.11	6.16	0.89	0.20	0.0563
200	0.26	5.12	0.60	0.22	0.0910
215	0.32	5.51	0.55	0.33	0.1054
260	0.44	5.80	0.70	0.27	0.0652
240	0.29	5.38	0.49	0.27	0.0362
255	0.46	6.11	0.52	0.20	0.0014
296	0.31	6.41	0.96	0.18	0.0005
196	0.28	5.44	0.65	0.21	0.0074
287	0.33	5.94	1.16	0.21	0.1080
263	0.43	6.13	2.68	0.24	0.0322
275	0.46	6.51	1.19	0.15	0.0273
216	0.59	6.20	1.55	0.20	0.0262
293	0.09	6.20	0.46	0.12	0.0018
261	0.30	4.38	0.69	0.23	0.0050
194	0.30	6.26	0.80	0.17	0.0024
280	0.25	4.03	0.56	0.18	0.0005
241	0.41	6.44	1.11	0.26	0.0036
193	0.60	6.69	0.85	0.28	0.0025
215	0.32	5.51	0.55	0.33	0.0136
240	0.29	5.38	0.49	0.27	0.0362
189	0.31	5.40	0.92	0.16	0.0020
252	0.22	6.23	0.30	0.17	0.0058
273	0.31	4.46	0.48	0.08	0.0009
248	0.34	5.31	1.04	0.35	0.0005
275	0.10	4.14	0.78	0.13	0.0028
210	0.16	6.85	1.47	0.17	0.0043
225	0.11	6.63	0.57	0.06	0.0014
228	0.36	5.45	0.59	0.21	0.0504
182	0.42	6.43	0.87	0.32	0.0072
207	0.44	6.59	1.15	0.36	0.0045
188	0.37	5.51	0.63	0.18	0.0018
235	0.31	6.18	0.52	0.13	0.0018
201	0.42	5.38	0.63	0.16	0.0018
255	0.43	6.43	0.76	0.20	0.0027
Sales-wgt EF	**0.331633**	**5.667602**	**0.834876**	**0.239994**	1.0000

Sample Size	44	44	44	44	

Table D2. 1996 MY Certification Data (cont.)

300 to 600 hp	Emission Factors (g/hp-hr)				
Rated HP	HC	NOx	CO	PM	Sales wgt
335	0.27	5.51	0.74	0.28	0.0013
543	2.24	5.66	0.54	0.24	0.0010
300	0.28	6.13	0.81	0.28	0.0249
330	0.34	5.27	1.07	0.28	0.0075
362	0.16	5.49	1.57	0.13	0.3220
425	0.09	6.38	2.18	0.08	0.0155
500	0.17	8.19	2.24	0.13	0.0078
455	0.12	5.48	0.82	0.17	0.0039
542	0.07	6.05	1.43	0.31	0.0959
300	0.08	5.78	0.43	0.05	0.0093
397	0.19	4.65	1.35	0.19	0.0216
535	0.08	5.79	2.10	0.34	0.0186
515	0.05	6.05	1.44	0.21	0.0180
300	0.31	5.50	0.41	0.22	0.0052
480	0.17	6.85	1.16	0.17	0.0833
525	0.25	6.36	0.45	0.15	0.0104
375	0.40	6.03	1.51	0.20	0.0339
337	0.41	5.99	1.31	0.22	0.0170
300	0.51	8.03	1.28	0.21	0.1823
313	0.10	6.55	0.49	0.14	0.0039
440	0.39	6.55	0.43	0.18	0.0052
568	0.37	6.46	2.17	0.37	0.0124
350	0.78	6.32	1.30	0.37	0.0357
400	0.10	6.28	0.49	0.14	0.0129
412	0.35	6.51	1.76	0.30	0.0039
322	0.23	5.00	0.87	0.23	0.0026
563	0.18	4.56	0.48	0.18	0.0078
305	0.24	6.29	0.72	0.29	0.0044
335	0.19	5.78	0.41	0.10	0.0003
349	0.20	5.41	0.34	0.15	0.0016
526	0.17	6.06	0.60	0.16	0.0003
493	0.16	5.89	0.95	0.20	0.0005
573	0.14	5.86	0.62	0.17	0.0005
571	0.31	3.98	0.48	0.11	0.0026
308	0.28	5.68	0.45	0.18	0.0021
335	0.27	5.51	0.74	0.28	0.0023
543	0.22	5.66	0.54	0.25	0.0037
300	0.07	4.54	0.51	0.15	0.0052
300	0.07	6.35	0.52	0.04	0.0078
369	0.24	5.43	0.51	0.14	0.0052
Sales-wgt EF	**0.260521**	**6.264393**	**1.353145**	**0.195978**	1.0000
Sample Size	40	40	40	40	

Table D2. 1996 MY Certification Data (cont.)

600 to 750 hp	Emission Factors (g/hp-hr)				
Rated HP	HC	NOx	CO	PM	Sales wgt
750	0.07	5.90	1.29	0.22	0.1010
750	0.07	5.84	0.90	0.16	0.0056
750	0.08	6.01	1.92	0.30	0.1330
750	0.35	5.80	1.48	0.29	0.0859
660	0.05	6.24	0.83	0.14	0.1627
740	0.10	5.53	1.63	0.33	0.1324
640	0.10	5.62	0.83	0.19	0.0056
730	0.05	5.04	0.99	0.18	0.0960
600	0.46	6.86	1.46	0.23	0.1403
710	0.25	6.64	2.42	0.27	0.1347
740	0.24	5.85	1.37	0.21	0.0028
Sales-wgt EF	**0.174804**	**6.063537**	**1.502117**	**0.242149**	1.0000
Sample Size	11	11	11	11	

Table D3. 1997 MY Certification Data

100 to 175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
100	0.35	6.08	0.70	0.28	0.0015	0.0011	0.0015	0.0015
125	0.23	6.21	0.47	0.16	0.0087	0.0069	0.0087	0.0090
165	0.36	4.95	0.75	0.31	0.1552	0.1226	0.1552	0.1597
110		6.06			0.0000	0.0174	0.0000	0.0000
165		6.24			0.0000	0.0915	0.0000	0.0000
166		4.95			0.0000	0.0022	0.0000	0.0000
100	0.35	6.08	0.70	0.30	0.0102	0.0080	0.0102	0.0104
125	0.23	6.21	0.47	0.16	0.1001	0.0790	0.1001	0.1030
165	0.36	4.95	0.75	0.31	0.2320	0.1833	0.2320	0.2388
114	0.39	4.88	0.88		0.0038	0.0030	0.0038	0.0000
141	0.39	4.97	2.30		0.0057	0.0045	0.0057	0.0000
134	0.33	6.59	1.15	0.17	0.0218	0.0172	0.0218	0.0224
168	0.43	6.52	1.25	0.17	0.0044	0.0034	0.0044	0.0045
110	0.75	6.18	2.60	0.41	0.0058	0.0046	0.0058	0.0060
158	0.51	6.26	1.28	0.38	0.0247	0.0195	0.0247	0.0254
153		5.65			0.0000	0.0206	0.0000	0.0000
134		6.51			0.0000	0.0041	0.0000	0.0000
103		6.26			0.0000	0.0069	0.0000	0.0000
106		6.01			0.0000	0.0018	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0022	0.0017	0.0022	0.0022
125	0.23	6.21	0.47	0.16	0.0015	0.0011	0.0015	0.0015
165	0.36	4.95	0.75	0.31	0.0537	0.0424	0.0537	0.0552
162	0.62	6.11	0.90	0.29	0.0035	0.0028	0.0035	0.0036
130		5.58			0.0000	0.0115	0.0000	0.0000
134		6.08			0.0000	0.0183	0.0000	0.0000
131		5.18			0.0000	0.0115	0.0000	0.0000
157	0.12	6.55	1.15	0.13	0.0125	0.0099	0.0125	0.0128
168	0.11	6.63	0.57	0.06	0.0091	0.0072	0.0091	0.0094
108	0.17	5.99	0.37	0.17	0.0242	0.0191	0.0242	0.0249
166	0.38	6.21	0.56	0.22	0.0182	0.0143	0.0182	0.0187
121	0.68	6.11	1.22	0.18	0.0085	0.0067	0.0085	0.0087
108	0.20	5.63	0.70	0.32	0.2393	0.1890	0.2393	0.2463
103		6.19			0.0000	0.0128	0.0000	0.0000
172	0.13	5.31	0.45	0.25	0.0258	0.0204	0.0258	0.0266
130	0.64	6.70	1.23	0.36	0.0004	0.0003	0.0004	0.0004
102		6.68			0.0000	0.0023	0.0000	0.0000
172		6.23			0.0000	0.0069	0.0000	0.0000
117		6.23			0.0000	0.0023	0.0000	0.0000
173	0.54	6.57	1.83	0.42	0.0029	0.0023	0.0029	0.0030
122	0.07	5.75	1.06	0.34	0.0029	0.0023	0.0029	0.0030
122	0.12	4.12	0.64		0.0030	0.0024	0.0030	0.0000
161	0.23	5.96	0.83		0.0160	0.0126	0.0160	0.0000
161	0.34	5.26	1.05	0.19	0.0029	0.0023	0.0029	0.0030
Sales-wgt EF	**0.297479**	**5.599201**	**0.745072**	**0.281314**	1.0000	1.0000	1.0000	1.0000
Sample Size	**29**	**43**	**29**	**25**				

Table D3. 1997 MY Certification Data (cont.)

175 to 300 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
261	0.47	6.06	0.89	0.27	0.0048	0.0048	0.0048	0.0048
248	0.34	5.31	1.04	0.35	0.0060	0.0060	0.0060	0.0060
280	0.47	5.47	0.52	0.23	0.1439	0.1439	0.1439	0.1439
260	0.37	5.73	1.30	0.39	0.0282	0.0282	0.0282	0.0282
246	0.34	5.27	1.07	0.36	0.0056	0.0056	0.0056	0.0056
225	0.41	5.70	0.84	0.22	0.1444	0.1444	0.1444	0.1444
220	0.11	6.16	0.89	0.27	0.1523	0.1523	0.1523	0.1523
275	0.11	4.56	1.25	0.26	0.0489	0.0489	0.0489	0.0489
205	0.19	5.96	1.73	0.25	0.0060	0.0060	0.0060	0.0060
260	0.08	6.48	0.82	0.29	0.0854	0.0854	0.0854	0.0854
275	0.08	4.93	1.80	0.32	0.0116	0.0116	0.0116	0.0116
280	0.47	5.47	0.52	0.23	0.0059	0.0059	0.0059	0.0059
260	0.46	6.11	0.52	0.27	0.0104	0.0104	0.0104	0.0104
188	0.50	5.29	1.31	0.37	0.0045	0.0045	0.0045	0.0045
296	0.23	4.78	0.72	0.21	0.0013	0.0013	0.0013	0.0013
264	0.64	6.38	2.37	0.41	0.0085	0.0085	0.0085	0.0085
250	0.10	6.41	0.54	0.12	0.0040	0.0040	0.0040	0.0040
189	0.43	6.65	1.04	0.34	0.0053	0.0053	0.0053	0.0053
261	0.30	4.38	0.69	0.23	0.0240	0.0240	0.0240	0.0240
194	0.30	6.26	0.80	0.17	0.0133	0.0133	0.0133	0.0133
189	0.37	5.87	0.76	0.28	0.0069	0.0069	0.0069	0.0069
241	0.41	6.44	1.11	0.26	0.0115	0.0115	0.0115	0.0115
227	0.51	6.72	1.07	0.31	0.0101	0.0101	0.0101	0.0101
193	0.60	6.69	0.85	0.28	0.0051	0.0051	0.0051	0.0051
296	0.42	5.77	0.82	0.25	0.0008	0.0008	0.0008	0.0008
234	0.31	4.22	0.51	0.08	0.0027	0.0027	0.0027	0.0027
248	0.34	5.31	1.04	0.35	0.0044	0.0044	0.0044	0.0044
247	0.57	6.13	0.69	0.17	0.0011	0.0011	0.0011	0.0011
240	0.35	5.36	0.54	0.23	0.0053	0.0053	0.0053	0.0053
225	0.14	6.73	0.64	0.16	0.0008	0.0008	0.0008	0.0008
228	0.36	5.45	0.59	0.21	0.1289	0.1289	0.1289	0.1289
253	0.55	4.64	1.10	0.29	0.0133	0.0133	0.0133	0.0133
182	0.42	6.43	0.87	0.29	0.0027	0.0027	0.0027	0.0027
207	0.44	6.59	1.15	0.36	0.0027	0.0027	0.0027	0.0027
183	0.54	6.63	0.81	0.34	0.0016	0.0016	0.0016	0.0016
227	0.35	0.63	0.51	0.27	0.0016	0.0016	0.0016	0.0016
272	0.35	6.44	1.09	0.23	0.0027	0.0027	0.0027	0.0027
255	0.25	5.85	0.40	0.13	0.0373	0.0373	0.0373	0.0373
255	0.25	6.22	1.10	0.14	0.0250	0.0250	0.0250	0.0250
188	0.37	5.51	0.60	0.18	0.0053	0.0053	0.0053	0.0053
235	0.31	6.41	0.54	0.13	0.0053	0.0053	0.0053	0.0053
201	0.42	5.38	0.63	0.16	0.0053	0.0053	0.0053	0.0053
255	0.43	6.43	0.76	0.20	0.0053	0.0053	0.0053	0.0053
Sales-wgt EF	**0.307044**	**5.723983**	**0.819777**	**0.245420**	1.0000	1.0000	1.0000	1.0000
Sample Size	**43**	**43**	**43**	**43**				

Table D3. 1997 MY Certification Data (cont.)

300 to 600 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
335	0.27	5.51	0.74	0.28	0.0004	0.0004	0.0004	0.0004
543	0.22	5.66	0.54	0.24	0.0035	0.0035	0.0035	0.0035
425	0.09	6.38	2.18	0.16	0.0282	0.0282	0.0282	0.0282
300	0.28	6.13	0.81	0.36	0.0339	0.0339	0.0339	0.0339
397	0.19	4.65	1.35	0.19	0.0261	0.0261	0.0261	0.0261
362	0.16	5.49	1.57	0.21	0.4232	0.4232	0.4232	0.4232
373	0.17	8.19	2.24	0.21	0.0141	0.0141	0.0141	0.0141
455	0.12	5.48	0.82	0.17	0.0023	0.0023	0.0023	0.0023
599	0.04	6.59	2.67	0.33	0.1521	0.1521	0.1521	0.1521
492	0.05	6.24	0.83	0.14	0.0052	0.0052	0.0052	0.0052
535	0.08	5.79	2.10	0.34	0.0065	0.0065	0.0065	0.0065
559	0.07	5.84	0.90	0.16	0.0004	0.0004	0.0004	0.0004
300	0.08	5.78	0.43	0.13	0.0173	0.0173	0.0173	0.0173
307	0.10	6.52	0.51	0.14	0.0069	0.0069	0.0069	0.0069
430	0.38	6.58	0.43	0.18	0.0177	0.0177	0.0177	0.0177
425	0.08	6.44	0.76	0.16	0.0355	0.0355	0.0355	0.0355
413	0.35	6.51	1.76	0.29	0.0140	0.0140	0.0140	0.0140
590	0.34	6.40	0.72	0.23	0.0002	0.0002	0.0002	0.0002
313	0.18	4.56	0.48	0.18	0.0121	0.0121	0.0121	0.0121
305	0.24	6.29	0.72	0.29	0.0089	0.0089	0.0089	0.0089
493	0.16	4.26	1.04	0.30	0.0024	0.0024	0.0024	0.0024
426	0.31	3.98	0.48	0.11	0.0040	0.0040	0.0040	0.0040
308	0.28	5.68	0.45	0.20	0.0019	0.0019	0.0019	0.0019
335	0.27	5.51	0.74	0.28	0.0115	0.0115	0.0115	0.0115
543	0.22	5.66	0.54	0.16	0.0275	0.0275	0.0275	0.0275
308	0.38	5.70	0.39	0.18	0.0002	0.0002	0.0002	0.0002
330	0.07	5.07	0.44	0.12	0.0270	0.0270	0.0270	0.0270
320	0.12	7.41	0.51	0.08	0.0008	0.0008	0.0008	0.0008
300	0.08	5.62	0.45	0.12	0.0121	0.0121	0.0121	0.0121
381	0.21	6.55	0.61	0.08	0.0403	0.0403	0.0403	0.0403
496	0.13	6.12	0.28	0.07	0.0379	0.0379	0.0379	0.0379
369	0.24	6.50	0.51	0.14	0.0081	0.0081	0.0081	0.0081
526	0.45	5.59	0.67	0.11	0.0081	0.0081	0.0081	0.0081
315	0.34	5.48	0.79	0.13	0.0081	0.0081	0.0081	0.0081
362	0.37	5.29	0.82	0.12	0.0016	0.0016	0.0016	0.0016
Sales-wgt EF	**0.155300**	**5.865363**	**1.431343**	**0.213156**	1.0000	1.0000	1.0000	1.0000
Sample Size	**35**	**35**	**35**	**35**				

Table D3. 1997 MY Certification Data (cont.)

600 to 750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
740	0.04	5.67	1.57	0.25	0.3355	0.3355	0.3355	0.3355
750	0.08	6.01	1.92	0.30	0.0205	0.0205	0.0205	0.0205
740	0.10	5.53	1.63	0.33	0.0169	0.0169	0.0169	0.0169
640	0.10	5.62	0.83	0.19	0.0319	0.0319	0.0319	0.0319
743	0.05	5.04	0.99	0.18	0.1004	0.1004	0.1004	0.1004
750	0.07	5.90	1.29	0.22	0.0771	0.0771	0.0771	0.0771
600	0.26	6.02	1.78	0.24	0.1597	0.1597	0.1597	0.1597
710	0.25	6.64	2.42	0.27	0.1643	0.1643	0.1643	0.1643
750	0.13	5.89	1.07	0.13	0.0479	0.0479	0.0479	0.0479
748	0.30	6.04	0.45	0.24	0.0456	0.0456	0.0456	0.0456
Sales-wgt EF	**0.135125**	**5.872338**	**1.571034**	**0.236991**	1.0000	1.0000	1.0000	1.0000
Sample Size	**10**	**10**	**10**	**10**				

Table D4. 1998 MY Certification Data

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings			
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
67		6.40				0.0000	0.0071	0.0000	0.0000
79		5.74				0.0000	0.0024	0.0000	0.0000
96		5.81				0.0000	0.0006	0.0000	0.0000
80	0.48	7.61		4.32	0.56	0.2600	0.0914	0.2581	0.0000
67	0.75	6.35		1.96	0.34	0.1418	0.0499	0.1408	0.0000
80	0.72	5.78		3.26	0.51	0.2786	0.0979	0.2765	0.0000
98	0.71	6.30		1.68	0.21	0.0009	0.0003	0.0009	0.0000
62		6.23				0.0000	0.0012	0.0000	0.0000
57		6.20				0.0000	0.0012	0.0000	0.0000
59		6.56				0.0000	0.0310	0.0000	0.0000
84		5.74				0.0000	0.0413	0.0000	0.0000
64		5.92				0.0000	0.0049	0.0000	0.0000
82		5.23				0.0000	0.0605	0.0000	0.0000
53		6.32				0.0000	0.0175	0.0000	0.0000
72		6.30				0.0000	0.0006	0.0000	0.0000
78		6.22				0.0000	0.0001	0.0000	0.0000
52		4.59				0.0000	0.0208	0.0000	0.0000
50		4.14				0.0000	0.0036	0.0000	0.0000
51	0.60	6.68		3.04	0.63	0.0004	0.0001	0.0004	0.0000
55	0.39	6.16		0.98	0.28	0.0118	0.0042	0.0117	0.0000
64	0.43	5.62		2.17	0.60	0.0254	0.0089	0.0252	0.0000
73	0.29	5.35		1.08	0.52	0.0118	0.0042	0.0117	0.0000
56	0.48	4.88		0.46	0.27	0.0016	0.0006	0.0016	0.0000
79	0.55	5.25		2.47	0.55	0.0258	0.0091	0.0256	0.0000
91	0.42	6.63		1.32	0.54	0.0133	0.0047	0.0132	0.0000
59		6.65				0.0000	0.0170	0.0000	0.0000
62		6.23				0.0000	0.0012	0.0000	0.0000
80	0.72	5.78		3.26	0.51	0.0051	0.0018	0.0050	0.0000
98	0.71	6.30		1.68	0.21	0.0009	0.0003	0.0009	0.0000
59		4.37				0.0000	0.0042	0.0000	0.0000
56		4.18				0.0000	0.0148	0.0000	0.0000
86		5.42				0.0000	0.0047	0.0000	0.0000
93		4.71				0.0000	0.0030	0.0000	0.0000
72		4.31				0.0000	0.0059	0.0000	0.0000
54	0.55	6.31		2.42		0.0077	0.0027	0.0076	0.0000
65	0.05	4.18	4.24	0.90		0.0010	0.0003	0.0010	1.0000
54		2.62				0.0000	0.0057	0.0000	0.0000
50		4.38				0.0000	0.0190	0.0000	0.0000
89		5.98				0.0000	0.0066	0.0000	0.0000
72		4.63				0.0000	0.0145	0.0000	0.0000
78		6.05				0.0000	0.0101	0.0000	0.0000
52		6.32				0.0000	0.0060	0.0000	0.0000
67	0.14	4.94		1.07	0.45	0.1213	0.0426	0.1204	0.0000
92	0.27	5.62		0.99	0.27	0.0834	0.0293	0.0828	0.0000
55		2.62				0.0000	0.0015	0.0000	0.0000

Table D4. 1998 MY Certification Data

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings			
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
85		2.18				0.0000	0.0018	0.0000	0.0000
59		5.90				0.0000	0.0006	0.0000	0.0000
58		3.23				0.0000	0.0297	0.0000	0.0000
52		6.62				0.0000	0.0125	0.0000	0.0000
64		5.13				0.0000	0.0064	0.0000	0.0000
60		6.06				0.0000	0.0297	0.0000	0.0000
96		5.09				0.0000	0.0861	0.0000	0.0000
72		6.30				0.0000	0.0025	0.0000	0.0000
68		5.85				0.0000	0.0772	0.0000	0.0000
68		6.44				0.0000	0.0504	0.0000	0.0000
80	0.86	5.40		4.00	0.64	0.0091	0.0032	0.0091	0.0000
59		4.33				0.0000	0.0036	0.0000	0.0000
84		6.14				0.0000	0.0012	0.0000	0.0000
94		5.75				0.0000	0.0003	0.0000	0.0000
82		4.84		1.22	0.44	0.0000	0.0011	0.0032	0.0000
60		5.87		3.96	0.39	0.0000	0.0006	0.0017	0.0000
62		6.19		1.69	0.30	0.0000	0.0009	0.0026	0.0000
75		3.87				0.0000	0.0046	0.0000	0.0000
58		3.91				0.0000	0.0069	0.0000	0.0000
54		5.40				0.0000	0.0003	0.0000	0.0000
67		4.89				0.0000	0.0148	0.0000	0.0000
80		4.80				0.0000	0.0006	0.0000	0.0000
60		4.12				0.0000	0.0042	0.0000	0.0000
70		5.59				0.0000	0.0006	0.0000	0.0000
56		5.23				0.0000	0.0018	0.0000	0.0000
58		5.12				0.0000	0.0033	0.0000	0.0000
Sales-wgt EF	**0.528845**	**5.682411**	**4.235576**	**2.753546**	**0.472055**	1.0000	1.0000	1.0000	1.0000
Sample Size	**18**	**71**	**1**	**21**	**19**				

Table D4. 1998 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
167	0.34	5.26	1.05	0.18	0.0003	0.0003	0.0003	0.0003
108		6.47			0.0000	0.0009	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.1104	0.0940	0.1101	0.1112
125	0.23	6.21	0.47	0.16	0.0041	0.0035	0.0041	0.0042
165	0.36	4.95	0.75	0.31	0.0647	0.0551	0.0645	0.0652
110		6.06			0.0000	0.0062	0.0000	0.0000
165		6.24			0.0000	0.0336	0.0000	0.0000
166		4.95			0.0000	0.0029	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.1765	0.1504	0.1760	0.1779
125	0.23	6.21	0.47	0.16	0.0537	0.0457	0.0535	0.0541
165	0.36	4.95	0.75	0.31	0.1891	0.1611	0.1886	0.1906
158		6.53			0.0000	0.0018	0.0000	0.0000
109		6.41			0.0000	0.0018	0.0000	0.0000
133		6.44			0.0000	0.0018	0.0000	0.0000
172		6.48			0.0000	0.0018	0.0000	0.0000
114	0.52	6.54	1.18		0.0014	0.0012	0.0014	0.0000
141		3.71			0.0000	0.0018	0.0000	0.0000
135	0.40	5.70	1.75	0.29	0.2535	0.2160	0.2528	0.2555
155		6.39			0.0000	0.0021	0.0000	0.0000
124		6.60			0.0000	0.0068	0.0000	0.0000
103		6.22			0.0000	0.0310	0.0000	0.0000
158		6.26			0.0000	0.0077	0.0000	0.0000
103	0.57	6.26	1.58	0.39	0.0033	0.0028	0.0033	0.0033
153	0.51	5.65	0.49	0.26	0.0126	0.0108	0.0126	0.0127
106		6.01			0.0000	0.0095	0.0000	0.0000
144		6.61			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0085	0.0072	0.0085	0.0086
125	0.23	6.21	0.47	0.16	0.0012	0.0010	0.0012	0.0012
165	0.36	4.95	0.75	0.31	0.0140	0.0119	0.0140	0.0141
114		5.87			0.0000	0.0049	0.0000	0.0000
148	0.16	6.58	0.70	0.13	0.0003	0.0003	0.0003	0.0003
168	0.34	6.17	0.63	0.13	0.0002	0.0002	0.0002	0.0002
162	0.62	6.11	0.90	0.28	0.0006	0.0005	0.0006	0.0006
108		6.11			0.0000	0.0137	0.0000	0.0000
113		4.41			0.0000	0.0020	0.0000	0.0000
108	0.17	5.99	0.37	0.17	0.0555	0.0473	0.0553	0.0559
121	0.68	6.11	1.22	0.18	0.0117	0.0100	0.0117	0.0118
166	0.38	6.21	0.56	0.22	0.0196	0.0167	0.0195	0.0197
118		6.30			0.0000	0.0006	0.0000	0.0000
103		6.19			0.0000	0.0070	0.0000	0.0000
103	0.53	5.30	1.24	0.51	0.0018	0.0015	0.0018	0.0018
100	0.57	5.50	1.35	0.47	0.0024	0.0020	0.0023	0.0024
102		6.68			0.0000	0.0027	0.0000	0.0000
127		5.38			0.0000	0.0009	0.0000	0.0000
117		6.23			0.0000	0.0009	0.0000	0.0000

Table D4. 1998 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
172		6.23			0.0000	0.0027	0.0000	0.0000
173	0.54	6.57	1.83	0.42	0.0032	0.0027	0.0032	0.0032
123		4.12	0.64		0.0000	0.0015	0.0018	0.0018
122	0.07	5.75	1.06	0.44	0.0021	0.0018	0.0021	0.0022
142		5.92	1.33	0.31	0.0000	0.0010	0.0011	0.0011
138		6.68			0.0000	0.0004	0.0000	0.0000
161	0.23	5.96	0.83		0.0092	0.0078	0.0092	0.0000
Sales-wgt EF	**0.355336**	**5.743938**	**0.961288**	**0.276378**	1.0000	1.0000	1.0000	1.0000
Sample Size	**25**	**52**	**27**	**24**				

Table D4. 1998 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
257	0.43	6.43	0.76	0.20	0.0002	0.0002	0.0002	0.0002
261	0.47	6.06	0.89	0.27	0.0013	0.0013	0.0013	0.0013
248	0.34	5.31	1.04	0.35	0.0011	0.0011	0.0011	0.0011
200	0.26	5.13	0.60	0.22	0.0124	0.0124	0.0124	0.0124
215	0.32	5.51	0.55	0.32	0.0184	0.0184	0.0184	0.0184
260	0.44	5.82	0.70	0.27	0.0222	0.0222	0.0222	0.0222
240	0.29	5.38	0.49	0.27	0.0222	0.0222	0.0222	0.0222
278	0.13	4.70	0.51	0.15	0.0061	0.0061	0.0061	0.0061
280	0.47	5.47	0.52	0.23	0.0160	0.0160	0.0160	0.0160
275	0.11	4.56	1.26	0.26	0.0049	0.0049	0.0049	0.0049
205	0.19	5.96	1.73	0.25	0.0056	0.0056	0.0056	0.0056
260	0.17	6.48	0.82	0.29	0.0108	0.0108	0.0108	0.0108
290	0.10	5.60	2.19	0.32	0.0030	0.0030	0.0030	0.0030
260	0.42	6.16	1.30	0.39	0.0018	0.0018	0.0018	0.0018
225	0.41	5.70	0.84	0.22	0.0253	0.0253	0.0253	0.0253
275	0.04	4.76	0.31	0.14	0.0013	0.0013	0.0013	0.0013
200	0.26	5.13	0.60	0.22	0.0726	0.0726	0.0726	0.0726
215	0.32	5.51	0.55	0.32	0.0749	0.0749	0.0749	0.0749
260	0.44	5.82	0.70	0.27	0.0616	0.0616	0.0616	0.0616
240	0.29	5.38	0.49	0.27	0.0738	0.0738	0.0738	0.0738
284	0.41	5.76	0.52	0.22	0.0042	0.0042	0.0042	0.0042
200	0.19	4.05	0.92	0.28	0.0016	0.0016	0.0016	0.0016
253	0.34	6.58	0.57	0.21	0.0016	0.0016	0.0016	0.0016
188	0.50	5.29	1.31	0.37	0.0007	0.0007	0.0007	0.0007
256	0.46	6.11	0.52	0.27	0.0016	0.0016	0.0016	0.0016
296	0.23	4.78	0.72	0.21	0.0002	0.0002	0.0002	0.0002
261	0.47	6.06	0.89	0.27	0.0002	0.0002	0.0002	0.0002
220	0.20	5.87	0.72	0.27	0.0050	0.0050	0.0050	0.0050
234	0.19	5.45	0.62	0.25	0.0104	0.0104	0.0104	0.0104
196	0.28	5.44	0.65	0.28	0.3023	0.3023	0.3023	0.3023
197	0.23	5.52	0.75	0.29	0.0074	0.0074	0.0074	0.0074
263	0.43	6.13	2.68	0.31	0.0040	0.0040	0.0040	0.0040
294	0.38	5.99	0.95	0.23	0.1154	0.1154	0.1154	0.1154
280	0.49	6.14	2.52	0.31	0.0157	0.0157	0.0157	0.0157
294	0.64	6.38	2.37	0.40	0.0007	0.0007	0.0007	0.0007
283	0.09	6.38	0.51	0.12	0.0020	0.0020	0.0020	0.0020
196	0.35	6.52	0.95	0.36	0.0006	0.0006	0.0006	0.0006
240	0.29	4.88	0.73	0.23	0.0056	0.0056	0.0056	0.0056
187	0.26	5.99	0.73	0.15	0.0026	0.0026	0.0026	0.0026
189	0.37	5.87	0.76	0.35	0.0016	0.0016	0.0016	0.0016
241	0.41	6.44	1.11	0.34	0.0028	0.0028	0.0028	0.0028
227	0.51	6.72	1.07	0.33	0.0006	0.0006	0.0006	0.0006
193	0.60	6.69	0.85	0.28	0.0010	0.0010	0.0010	0.0010
296	0.38	6.19	0.54	0.22	0.0002	0.0002	0.0002	0.0002
255	0.42	5.77	0.82	0.26	0.0006	0.0006	0.0006	0.0006

Table D4. 1998 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
200	0.26	5.13	0.60	0.22	0.0036	0.0036	0.0036	0.0036
215	0.32	5.51	0.55	0.32	0.0049	0.0049	0.0049	0.0049
240	0.29	5.38	0.49	0.27	0.0052	0.0052	0.0052	0.0052
189	0.31	5.40	0.92	0.21	0.0010	0.0010	0.0010	0.0010
252	0.22	6.23	0.30	0.23	0.0027	0.0027	0.0027	0.0027
211	0.37	5.42	0.57	0.22	0.0004	0.0004	0.0004	0.0004
253	0.23	5.28	0.47	0.27	0.0002	0.0002	0.0002	0.0002
231	0.32	4.69	0.46	0.15	0.0005	0.0005	0.0005	0.0005
260	0.18	6.35	0.73	0.15	0.0016	0.0016	0.0016	0.0016
275	0.14	5.38	0.48	0.14	0.0002	0.0002	0.0002	0.0002
248	0.34	5.31	1.04	0.35	0.0001	0.0001	0.0001	0.0001
247	0.57	6.13	0.69	0.17	0.0004	0.0004	0.0004	0.0004
225	0.11	6.63	0.57	0.13	0.0028	0.0028	0.0028	0.0028
210	0.12	6.55	1.15	0.20	0.0048	0.0048	0.0048	0.0048
225	0.14	6.73	0.64	0.16	0.0018	0.0018	0.0018	0.0018
228	0.37	5.46	0.60	0.21	0.0294	0.0294	0.0294	0.0294
190	0.66	6.08	1.56	0.40	0.0005	0.0005	0.0005	0.0005
268	0.44	6.50	0.50	0.30	0.0024	0.0024	0.0024	0.0024
182	0.42	6.43	0.87	0.30	0.0004	0.0004	0.0004	0.0004
207	0.44	6.59	1.15	0.36	0.0004	0.0004	0.0004	0.0004
217	0.36	5.49	1.00	0.22	0.0004	0.0004	0.0004	0.0004
183	0.54	6.63	0.81	0.34	0.0002	0.0002	0.0002	0.0002
227	0.35	0.63	0.51	0.27	0.0002	0.0002	0.0002	0.0002
244	0.19	6.30	1.66	0.36	0.0016	0.0016	0.0016	0.0016
272	0.35	6.44	1.09	0.23	0.0016	0.0016	0.0016	0.0016
255	0.25	5.89	0.40	0.13	0.0056	0.0056	0.0056	0.0056
255	0.25	6.22	1.10	0.14	0.0033	0.0033	0.0033	0.0033
Sales-wgt EF	**0.316321**	**5.574079**	**0.722968**	**0.262486**	1.0000	1.0000	1.0000	1.0000
Sample Size	**72**	**72**	**72**	**72**				

Table D4. 1998 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
310	0.34	5.48	0.79	0.13	0.0011	0.0011	0.0011	0.0011
373	0.24	6.50	0.51	0.14	0.0011	0.0011	0.0011	0.0011
335	0.27	5.51	0.74	0.28	0.0002	0.0002	0.0002	0.0002
543	0.22	5.66	0.54	0.24	0.0016	0.0016	0.0016	0.0016
300	0.08	5.78	0.43	0.13	0.0036	0.0036	0.0036	0.0036
425	0.90	6.38	2.17	0.16	0.0514	0.0514	0.0514	0.0514
300	0.28	6.13	0.81	0.36	0.0118	0.0118	0.0118	0.0118
330	0.33	5.28	1.07	0.36	0.0111	0.0111	0.0111	0.0111
397	0.19	5.24	1.35	0.29	0.0040	0.0040	0.0040	0.0040
362	0.16	5.49	1.57	0.21	0.2369	0.2369	0.2369	0.2369
500	0.13	6.10	1.67	0.17	0.0257	0.0257	0.0257	0.0257
455	0.12	5.48	0.82	0.17	0.0029	0.0029	0.0029	0.0029
599	0.04	6.59	2.67	0.33	0.0715	0.0715	0.0715	0.0715
350	0.22	6.52	1.17	0.20	0.1676	0.1676	0.1676	0.1676
525	0.25	6.36	0.45	0.15	0.0032	0.0032	0.0032	0.0032
480	0.17	6.85	1.16	0.18	0.1718	0.1718	0.1718	0.1718
336	0.14	5.48	0.45	0.15	0.0070	0.0070	0.0070	0.0070
375	0.40	6.03	2.02	0.28	0.0012	0.0012	0.0012	0.0012
336	0.41	5.99	1.31	0.30	0.0084	0.0084	0.0084	0.0084
399	0.18	5.33	0.91	0.14	0.0285	0.0285	0.0285	0.0285
339	0.21	5.72	0.92	0.15	0.0020	0.0020	0.0020	0.0020
517	0.17	5.74	0.37	0.13	0.0630	0.0630	0.0630	0.0630
401	0.23	6.02	0.50	0.14	0.0090	0.0090	0.0090	0.0090
313	0.13	6.38	0.59	0.15	0.0077	0.0077	0.0077	0.0077
420	0.36	6.65	0.47	0.18	0.0118	0.0118	0.0118	0.0118
425	0.08	6.44	0.76	0.15	0.0193	0.0193	0.0193	0.0193
567	0.28	5.65	2.26	0.33	0.0010	0.0010	0.0010	0.0010
586	0.20	4.64	0.45	0.18	0.0029	0.0029	0.0029	0.0029
329	0.26	6.38	0.61	0.19	0.0018	0.0018	0.0018	0.0018
590	0.34	6.40	0.72	0.23	0.0001	0.0001	0.0001	0.0001
306	0.24	6.29	0.72	0.37	0.0086	0.0086	0.0086	0.0086
493	0.16	4.26	1.04	0.30	0.0037	0.0037	0.0037	0.0037
335	0.19	5.78	0.41	0.18	0.0002	0.0002	0.0002	0.0002
375	0.22	5.72	0.32	0.20	0.0014	0.0014	0.0014	0.0014
525	0.17	6.06	0.60	0.23	0.0002	0.0002	0.0002	0.0002
493	0.16	5.89	0.95	0.28	0.0004	0.0004	0.0004	0.0004
572	0.14	5.86	0.62	0.24	0.0004	0.0004	0.0004	0.0004
571	0.31	3.98	0.48	0.17	0.0021	0.0021	0.0021	0.0021
531	0.36	5.01	0.40	0.16	0.0021	0.0021	0.0021	0.0021
327	0.22	6.39	0.46	0.14	0.0021	0.0021	0.0021	0.0021
327	0.24	6.11	0.48	0.13	0.0021	0.0021	0.0021	0.0021
308	0.30	5.67	0.45	0.18	0.0018	0.0018	0.0018	0.0018
335	0.27	5.51	0.74	0.28	0.0027	0.0027	0.0027	0.0027
543	0.02	5.66	0.54	0.24	0.0064	0.0064	0.0064	0.0064
330	0.07	5.07	0.44	0.10	0.0068	0.0068	0.0068	0.0068

Table D4. 1998 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
330	0.04	5.64	0.40	0.16	0.0114	0.0114	0.0114	0.0114
381	0.21	6.55	0.61	0.08	0.0167	0.0167	0.0167	0.0167
496	0.13	6.12	0.28	0.07	0.0021	0.0021	0.0021	0.0021
Sales-wgt EF	**0.209071**	**6.126551**	**1.289223**	**0.198893**	1.0000	1.0000	1.0000	1.0000
Sample Size	**48**	**48**	**48**	**48**				

Table D4. 1998 MY Certification Data (cont.)

600-750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
660	0.10	6.03	0.54	0.13	0.0630	0.0630	0.0630	0.0630
640	0.11	5.62	0.83	0.19	0.0132	0.0132	0.0132	0.0132
740	0.10	5.53	1.62	0.33	0.0350	0.0350	0.0350	0.0350
600	0.26	6.02	1.78	0.24	0.2955	0.2955	0.2955	0.2955
606	0.16	6.01	0.58	0.12	0.1128	0.1128	0.1128	0.1128
725	0.16	5.88	0.84	0.12	0.0855	0.0855	0.0855	0.0855
750	0.07	5.84	0.90	0.16	0.0210	0.0210	0.0210	0.0210
750	0.07	5.90	1.29	0.22	0.1089	0.1089	0.1089	0.1089
750	0.06	4.48	1.43	0.24	0.0389	0.0389	0.0389	0.0389
750	0.35	5.80	1.48	0.30	0.1322	0.1322	0.1322	0.1322
750	0.13	5.89	1.06	0.13	0.0855	0.0855	0.0855	0.0855
740	0.24	5.85	1.37	0.28	0.0086	0.0086	0.0086	0.0086
Sales-wgt EF	**0.190719**	**5.866023**	**1.277422**	**0.205116**	1.0000	1.0000	1.0000	1.0000
Sample Size	**12**	**12**	**12**	**12**				

Table D5. 1999 MY Certification Data

25-50 hp	Emission Factors (g/hp-hr)						Sales Weighting				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
34			5.21	1.44	0.38		0.0000	0.0000	0.0107	0.0107	0.0107
36			3.12	1.31	0.40		0.0000	0.0000	0.0011	0.0011	0.0011
45			5.95	0.48	0.26		0.0000	0.0000	0.0011	0.0011	0.0011
50		6.14					0.0000	0.1061	0.0000	0.0000	0.0000
38			6.69	1.92	0.32		0.0000	0.0000	0.0113	0.0113	0.0113
35			5.68	1.74	0.21		0.0000	0.0000	0.0282	0.0282	0.0282
39			6.58	1.84	0.11		0.0000	0.0000	0.0068	0.0068	0.0068
47			5.84	1.35	0.09		0.0000	0.0000	0.0056	0.0056	0.0056
28			3.76	1.24	0.20		0.0000	0.0000	0.0025	0.0025	0.0025
33			3.65	0.87	0.17		0.0000	0.0000	0.0033	0.0033	0.0033
40			4.50	0.62	0.20		0.0000	0.0000	0.0013	0.0013	0.0013
47			3.38	0.87	0.27		0.0000	0.0000	0.0007	0.0007	0.0007
27			5.66	1.62	0.56		0.0000	0.0000	0.0008	0.0008	0.0008
29			4.11	1.16	0.35		0.0000	0.0000	0.0310	0.0310	0.0310
40			2.78	1.62	0.42		0.0000	0.0000	0.0507	0.0507	0.0507
45			4.04	0.87	0.38		0.0000	0.0000	0.0158	0.0158	0.0158
28			3.57	2.65	0.43		0.0000	0.0000	0.0017	0.0017	0.0017
27	0.17	4.29	4.46	1.25	0.52	0.038763	0.0019	0.0014	0.0003	0.0003	0.0003
37	0.16	3.56	3.72	2.30	0.60	0.043011	0.0027	0.0020	0.0004	0.0004	0.0004
32	0.26	4.22	4.49	1.61	0.54	0.058036	0.0360	0.0262	0.0048	0.0048	0.0048
27	0.09	3.95	4.04	0.82	0.42	0.022277	0.0046	0.0034	0.0006	0.0006	0.0006
39	0.14	4.59	4.74	0.90	0.45	0.029598	0.0115	0.0084	0.0016	0.0016	0.0016
34	0.16	3.30	3.46	0.68	0.30	0.046243	0.0028	0.0020	0.0004	0.0004	0.0004
35	0.56	4.54	5.10	1.52	0.48	0.109804	0.8386	0.6112	0.1127	0.1127	0.1127
34	0.08	4.56	4.64	0.90	0.40	0.017241	0.0616	0.0449	0.0083	0.0083	0.0083
40	0.69	6.18	6.88	1.62	0.25	0.100868	0.0046	0.0034	0.0006	0.0006	0.0006
34			4.59	0.92	0.42		0.0000	0.0000	0.0001	0.0001	0.0001
46			3.79	0.68	0.33		0.0000	0.0000	0.0008	0.0008	0.0008
34			3.80	0.98	0.54		0.0000	0.0000	0.0058	0.0058	0.0058
47	0.12	6.71	6.83	0.74	0.30	0.01757	0.0042	0.0031	0.0006	0.0006	0.0006
38			6.16	1.66	0.41		0.0000	0.0000	0.0451	0.0451	0.0451
26			4.64	1.30	0.28		0.0000	0.0000	0.0011	0.0011	0.0011
31			3.80	1.16	0.36		0.0000	0.0000	0.0163	0.0163	0.0163
42			3.84	0.77	0.24		0.0000	0.0000	0.0047	0.0047	0.0047
26			4.46	0.96	0.35		0.0000	0.0000	0.0417	0.0417	0.0417
41			4.81	0.75	0.25		0.0000	0.0000	0.0008	0.0008	0.0008
31			5.27	0.74	0.19		0.0000	0.0000	0.0118	0.0118	0.0118
31			5.11	0.80	0.26		0.0000	0.0000	0.0662	0.0662	0.0662
37			4.47	0.80	0.29		0.0000	0.0000	0.1936	0.1936	0.1936
40	0.18	4.99	5.17	0.94	0.48	0.034632	0.0315	0.0230	0.0042	0.0042	0.0042
30			2.79	3.06	0.46		0.0000	0.0000	0.0013	0.0013	0.0013
38			3.62	2.13	0.51		0.0000	0.0000	0.0025	0.0025	0.0025
25			5.78	3.66	0.43		0.0000	0.0000	0.0045	0.0045	0.0045
33			2.37	1.58	0.53		0.0000	0.0000	0.0017	0.0017	0.0017

Table D5. 1999 MY Certification Data

25-50 hp	Emission Factors (g/hp-hr)						Sales Weighting				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
30			5.29	1.50	0.33		0.0000	0.0000	0.0008	0.0008	0.0008
35			5.48	1.61	0.36		0.0000	0.0000	0.0025	0.0025	0.0025
40			5.53	2.57	0.22		0.0000	0.0000	0.0025	0.0025	0.0025
44			5.56	1.69	0.34		0.0000	0.0000	0.0017	0.0017	0.0017
44			5.96	2.39	0.19		0.0000	0.0000	0.0017	0.0017	0.0017
38			6.00	1.25	0.36		0.0000	0.0000	0.0001	0.0001	0.0001
30			6.51	3.22	0.50		0.0000	0.0000	0.0034	0.0034	0.0034
39			4.73	1.01	0.34		0.0000	0.0000	0.0021	0.0021	0.0021
35			6.27	2.35	0.48		0.0000	0.0000	0.0118	0.0118	0.0118
44			6.19	1.09	0.53		0.0000	0.0000	0.0225	0.0225	0.0225
34		3.53	3.55	1.22	0.54		0.0000	0.0458	0.0085	0.0085	0.0085
49		3.20	3.31	1.29	0.40		0.0000	0.0917	0.0169	0.0169	0.0169
49		4.85					0.0000	0.0275	0.0000	0.0000	0.0000
28			5.78	3.61	0.40		0.0000	0.0000	0.0152	0.0152	0.0152
30			5.82	2.93	0.35		0.0000	0.0000	0.0026	0.0026	0.0026
33			5.76	2.74	0.28		0.0000	0.0000	0.0596	0.0596	0.0596
41			5.97	1.35	0.49		0.0000	0.0000	0.0006	0.0006	0.0006
29			5.82	2.82	0.25		0.0000	0.0000	0.0070	0.0070	0.0070
37			6.76	1.71	0.40		0.0000	0.0000	0.0007	0.0007	0.0007
37			6.03	2.59	0.35		0.0000	0.0000	0.0098	0.0098	0.0098
30			6.07	3.01	0.38		0.0000	0.0000	0.0169	0.0169	0.0169
45			5.85	3.21	0.45		0.0000	0.0000	0.0423	0.0423	0.0423
38			5.79	3.23	0.39		0.0000	0.0000	0.0011	0.0011	0.0011
48			6.00	1.56	0.44		0.0000	0.0000	0.0001	0.0001	0.0001
34			5.94	1.87	0.34		0.0000	0.0000	0.0507	0.0507	0.0507
46			6.01	2.54	0.20		0.0000	0.0000	0.0039	0.0039	0.0039
41			5.76	2.79	0.33		0.0000	0.0000	0.0041	0.0041	0.0041
48			6.25	1.59	0.28		0.0000	0.0000	0.0002	0.0002	0.0002
27			3.04	0.98	0.40		0.0000	0.0000	0.0036	0.0036	0.0036
39			5.53	1.96	0.26		0.0000	0.0000	0.0015	0.0015	0.0015
Sales-wgt EF	**0.4965**	**4.5584**	**4.9834**	**1.5421**	**0.3561**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**11**	**15**	**72**	**72**	**72**	**0.047095**					
Calc HC*	**0.2347**										
Calc NOx*		**4.7487**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D5. 1999 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx	CO wgt	PM wgt
67		6.40				0.0000	0.0035	0.0000	0.0000	0.0000
79		5.74				0.0000	0.0007	0.0000	0.0000	0.0000
96		5.81				0.0000	0.0005	0.0000	0.0000	0.0000
80	0.48	7.61		4.32	0.56	0.1942	0.0652	0.0000	0.1802	0.1814
67	0.75	6.35		1.96	0.34	0.1177	0.0395	0.0000	0.1092	0.1100
75	0.70	5.68		2.28	0.49	0.1618	0.0544	0.0000	0.1502	0.1512
80	0.72	5.78		3.26	0.51	0.0647	0.0217	0.0000	0.0601	0.0605
56	0.46	5.71		2.19	0.29	0.0309	0.0104	0.0000	0.0287	0.0289
75	0.70	5.68		2.28	0.49	0.0486	0.0163	0.0000	0.0451	0.0454
98	0.71	6.30		1.68	0.21	0.0008	0.0003	0.0000	0.0008	0.0008
62		6.23				0.0000	0.0010	0.0000	0.0000	0.0000
57		6.20				0.0000	0.0010	0.0000	0.0000	0.0000
55		5.80				0.0000	0.0010	0.0000	0.0000	0.0000
59		6.56				0.0000	0.0216	0.0000	0.0000	0.0000
84		5.74				0.0000	0.0306	0.0000	0.0000	0.0000
59	0.89	8.82		3.55	0.84	0.0099	0.0033	0.0000	0.0092	0.0092
74		5.82				0.0000	0.0045	0.0000	0.0000	0.0000
82		5.23				0.0000	0.0552	0.0000	0.0000	0.0000
53		6.32				0.0000	0.0280	0.0000	0.0000	0.0000
56			6.70	2.22	0.34	0.0000	0.0000	0.9552	0.0655	0.0660
60		6.16				0.0000	0.0173	0.0000	0.0000	0.0000
72		6.30				0.0000	0.0018	0.0000	0.0000	0.0000
56		5.21				0.0000	0.0040	0.0000	0.0000	0.0000
70		5.02				0.0000	0.0005	0.0000	0.0000	0.0000
96		6.32				0.0000	0.0006	0.0000	0.0000	0.0000
74		3.22				0.0000	0.0049	0.0000	0.0000	0.0000
78		6.22				0.0000	0.0000	0.0000	0.0000	0.0000
52		4.59				0.0000	0.0148	0.0000	0.0000	0.0000
50		4.14				0.0000	0.0030	0.0000	0.0000	0.0000
52	0.17	5.22		1.18	0.45	0.0049	0.0016	0.0000	0.0045	0.0045
54	0.69	4.15		1.45	0.36	0.0183	0.0062	0.0000	0.0170	0.0171
51	0.60	6.68		3.04	0.63	0.0003	0.0001	0.0000	0.0003	0.0003
61	0.46	6.07		1.33	0.32	0.0121	0.0041	0.0000	0.0112	0.0113
64	0.43	5.62		2.17	0.60	0.0056	0.0019	0.0000	0.0052	0.0052
73	0.24	4.79		0.87	0.52	0.0110	0.0037	0.0000	0.0102	0.0103
56	0.48	4.88		0.46	0.27	0.0003	0.0001	0.0000	0.0003	0.0003
63	0.52	6.27		1.67	0.57	0.0118	0.0040	0.0000	0.0109	0.0110
71	0.55	5.27		2.17	0.57	0.0236	0.0079	0.0000	0.0219	0.0221
91	0.42	6.63		1.32	0.54	0.0287	0.0096	0.0000	0.0266	0.0268
59		6.65				0.0000	0.0230	0.0000	0.0000	0.0000
80	0.72	5.78		3.26	0.51	0.0044	0.0015	0.0000	0.0041	0.0041
98	0.71	6.30		1.68	0.21	0.0008	0.0003	0.0000	0.0008	0.0008
56	0.46	5.71		2.19	0.29	0.0002	0.0001	0.0000	0.0002	0.0002
59		4.37				0.0000	0.0022	0.0000	0.0000	0.0000
56		4.18				0.0000	0.0148	0.0000	0.0000	0.0000

Table D5. 1999 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx	CO wgt	PM wgt
86		5.42				0.0000	0.0089	0.0000	0.0000	0.0000
93		4.71				0.0000	0.0074	0.0000	0.0000	0.0000
72		4.31				0.0000	0.0119	0.0000	0.0000	0.0000
54	0.55	6.31		2.42		0.0060	0.0020	0.0000	0.0056	0.0000
58	0.08	3.32	3.41	0.89		0.0011	0.0004	0.0149	0.0010	0.0000
59		3.34				0.0000	0.0002	0.0000	0.0000	0.0000
54		2.62				0.0000	0.0047	0.0000	0.0000	0.0000
79		5.06				0.0000	0.0002	0.0000	0.0000	0.0000
50			4.09	0.80	0.25	0.0000	0.0000	0.0299	0.0020	0.0021
57		4.46				0.0000	0.0061	0.0000	0.0000	0.0000
55		2.91				0.0000	0.0014	0.0000	0.0000	0.0000
51		5.35				0.0000	0.0083	0.0000	0.0000	0.0000
87		5.92				0.0000	0.0058	0.0000	0.0000	0.0000
52		6.32				0.0000	0.0050	0.0000	0.0000	0.0000
89		6.40				0.0000	0.0005	0.0000	0.0000	0.0000
67	0.14	4.94		1.07	0.45	0.1378	0.0463	0.0000	0.1279	0.1288
92	0.27	5.62		0.99	0.27	0.0902	0.0303	0.0000	0.0837	0.0842
58		3.00				0.0000	0.0012	0.0000	0.0000	0.0000
85		2.18				0.0000	0.0013	0.0000	0.0000	0.0000
59		5.90				0.0000	0.0010	0.0000	0.0000	0.0000
58		3.23				0.0000	0.0247	0.0000	0.0000	0.0000
81		5.43				0.0000	0.0059	0.0000	0.0000	0.0000
52		6.62				0.0000	0.0104	0.0000	0.0000	0.0000
64		5.13				0.0000	0.0049	0.0000	0.0000	0.0000
60		6.06				0.0000	0.0247	0.0000	0.0000	0.0000
96		5.09				0.0000	0.1503	0.0000	0.0000	0.0000
68		5.85				0.0000	0.0652	0.0000	0.0000	0.0000
68		6.34				0.0000	0.0420	0.0000	0.0000	0.0000
80	0.83	6.00		3.19	0.63	0.0063	0.0021	0.0000	0.0059	0.0059
80	0.86	5.40		4.00	0.64	0.0079	0.0027	0.0000	0.0074	0.0074
59		4.33				0.0000	0.0030	0.0000	0.0000	0.0000
84		6.14				0.0000	0.0010	0.0000	0.0000	0.0000
94		5.75				0.0000	0.0003	0.0000	0.0000	0.0000
82		4.84		1.22	0.44	0.0000	0.0010	0.0000	0.0029	0.0029
62		6.06		3.96	0.39	0.0000	0.0000	0.0000	0.0001	0.0001
100		6.27		0.87	0.41	0.0000	0.0003	0.0000	0.0007	0.0007
62		6.19		1.69	0.30	0.0000	0.0003	0.0000	0.0007	0.0007
75		3.87				0.0000	0.0020	0.0000	0.0000	0.0000
58		3.91				0.0000	0.0022	0.0000	0.0000	0.0000
54		5.40				0.0000	0.0001	0.0000	0.0000	0.0000
67		4.89				0.0000	0.0163	0.0000	0.0000	0.0000
80		4.80				0.0000	0.0005	0.0000	0.0000	0.0000
56		5.23				0.0000	0.0020	0.0000	0.0000	0.0000
58		5.12				0.0000	0.0004	0.0000	0.0000	0.0000
60		4.12				0.0000	0.0025	0.0000	0.0000	0.0000

Table D5. 1999 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx	CO wgt	PM wgt
70		5.59				0.0000	0.0049	0.0000	0.0000	0.0000
93		5.35				0.0000	0.0005	0.0000	0.0000	0.0000
100		5.73				0.0000	0.0002	0.0000	0.0000	0.0000
Sales-wgt EF	**0.517642**	**5.613376**	**6.569501**	**2.34687**	**0.452553**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**27**	**91**	**3**	**33**	**31**					

Table D5. 1999 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
167	0.34	5.26	1.05	0.18	0.0004	0.0003	0.0004	0.0004
108		6.47			0.0000	0.0005	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.1343	0.1074	0.1342	0.1355
125	0.23	6.21	0.47	0.16	0.0048	0.0039	0.0048	0.0049
155	0.38	4.23	0.75	0.35	0.1246	0.0996	0.1245	0.1257
110		6.06			0.0000	0.0014	0.0000	0.0000
165		6.24			0.0000	0.0373	0.0000	0.0000
166		4.95			0.0000	0.0030	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.2077	0.1660	0.2075	0.2095
125	0.23	6.21	0.47	0.16	0.1179	0.0942	0.1178	0.1189
158		6.53			0.0000	0.0020	0.0000	0.0000
109		6.41			0.0000	0.0020	0.0000	0.0000
133		6.50			0.0000	0.0020	0.0000	0.0000
141		4.97			0.0000	0.0020	0.0000	0.0000
172		4.83			0.0000	0.0020	0.0000	0.0000
168	0.11	6.17	0.63	0.13	0.0004	0.0003	0.0004	0.0004
162	0.62	6.11	0.90	0.29	0.0004	0.0003	0.0004	0.0004
135	0.40	5.70	1.75	0.29	0.2486	0.1987	0.2483	0.2507
155		6.39			0.0000	0.0022	0.0000	0.0000
108		6.55			0.0000	0.0102	0.0000	0.0000
157		6.65			0.0000	0.0074	0.0000	0.0000
103	0.57	6.26	1.58	0.39	0.0071	0.0056	0.0070	0.0071
144	0.53	6.08	0.55	0.28	0.0187	0.0150	0.0187	0.0189
144		6.61			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0100	0.0080	0.0100	0.0101
125	0.23	6.21	0.47	0.16	0.0014	0.0011	0.0014	0.0014
155	0.38	4.23	0.75	0.35	0.0165	0.0132	0.0165	0.0166
114		5.87			0.0000	0.0010	0.0000	0.0000
103		5.94			0.0000	0.0001	0.0000	0.0000
151		5.60			0.0000	0.0002	0.0000	0.0000
120		5.50			0.0000	0.0200	0.0000	0.0000
144		5.80			0.0000	0.0121	0.0000	0.0000
118		5.52			0.0000	0.0007	0.0000	0.0000
113		4.41			0.0000	0.0050	0.0000	0.0000
173		5.79			0.0000	0.0005	0.0000	0.0000
108	0.17	5.99	0.37	0.17	0.0515	0.0411	0.0514	0.0519
116	0.62	5.36	1.39	0.18	0.0101	0.0081	0.0101	0.0102
168	0.37	5.68	0.54	0.17	0.0257	0.0206	0.0257	0.0260
118		6.30			0.0000	0.0006	0.0000	0.0000
164		5.92			0.0000	0.0161	0.0000	0.0000
103		6.19			0.0000	0.0125	0.0000	0.0000
120		5.55			0.0000	0.0453	0.0000	0.0000
173		6.05			0.0000	0.0050	0.0000	0.0000
115		5.77			0.0000	0.0002	0.0000	0.0000
135	0.45	6.68	0.92	0.24	0.0009	0.0007	0.0009	0.0009

Table D5. 1999 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
150	0.50	5.74	1.06	0.49	0.0009	0.0007	0.0009	0.0009
103	0.53	5.30	1.24	0.51	0.0021	0.0017	0.0021	0.0022
130	0.63	6.61	1.21	0.36	0.0015	0.0012	0.0015	0.0015
100	0.57	5.50	1.35	0.47	0.0028	0.0022	0.0028	0.0028
114		6.39			0.0000	0.0030	0.0000	0.0000
127		5.38			0.0000	0.0010	0.0000	0.0000
117		6.23			0.0000	0.0010	0.0000	0.0000
172		6.23			0.0000	0.0030	0.0000	0.0000
173	0.54	6.57	1.83	0.42	0.0013	0.0010	0.0013	0.0013
123		4.12	0.64		0.0000	0.0003	0.0003	0.0000
122	0.07	5.75	1.06	0.43	0.0010	0.0008	0.0010	0.0010
142		5.92	1.33	0.31	0.0000	0.0005	0.0007	0.0007
138		6.68			0.0000	0.0005	0.0000	0.0000
161	0.23	5.96	0.83		0.0094	0.0075	0.0093	0.0000
Sales-wgt EF	**0.351590**	**5.749792**	**0.937310**	**0.270345**	1.0000	1.0000	1.0000	1.0000
Sample Size	**25**	**59**	**27**	**25**				

Table D5. 1999 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
257	0.43	6.43	0.76	0.20	0.0002	0.0002	0.0002	0.0002
200	0.26	5.13	0.60	0.22	0.0290	0.0290	0.0290	0.0290
215	0.32	5.51	0.55	0.32	0.0136	0.0136	0.0136	0.0136
260	0.44	5.82	0.70	0.27	0.0091	0.0091	0.0091	0.0091
240	0.29	5.38	0.49	0.27	0.0091	0.0091	0.0091	0.0091
280	0.47	5.47	0.52	0.23	0.0207	0.0207	0.0207	0.0207
275	0.11	4.56	1.26	0.26	0.0012	0.0012	0.0012	0.0012
205	0.19	5.96	1.73	0.25	0.0041	0.0041	0.0041	0.0041
255	0.08	6.20	0.96	0.27	0.0108	0.0108	0.0108	0.0108
294	0.09	5.45	2.19	0.34	0.0041	0.0041	0.0041	0.0041
260	0.36	5.73	1.30	0.39	0.0009	0.0009	0.0009	0.0009
225	0.41	5.70	0.84	0.22	0.0252	0.0252	0.0252	0.0252
240	0.10	5.06	0.38	0.15	0.0414	0.0414	0.0414	0.0414
200	0.26	5.13	0.60	0.22	0.0746	0.0746	0.0746	0.0746
215	0.32	5.51	0.55	0.32	0.0787	0.0787	0.0787	0.0787
260	0.44	5.82	0.70	0.27	0.0575	0.0575	0.0575	0.0575
240	0.29	5.38	0.49	0.27	0.0828	0.0828	0.0828	0.0828
280	0.47	5.47	0.52	0.23	0.0083	0.0083	0.0083	0.0083
200	0.25	5.43	1.23	0.35	0.0015	0.0015	0.0015	0.0015
253	0.34	6.58	0.57	0.20	0.0015	0.0015	0.0015	0.0015
296	0.31	6.41	0.96	0.25	0.0015	0.0015	0.0015	0.0015
261	0.47	6.06	0.89	0.27	0.0002	0.0002	0.0002	0.0002
248	0.34	5.31	1.04	0.35	0.0002	0.0002	0.0002	0.0002
275	0.14	5.38	0.48	0.14	0.0002	0.0002	0.0002	0.0002
220	0.20	5.87	0.72	0.27	0.0043	0.0043	0.0043	0.0043
234	0.19	5.45	0.62	0.25	0.0108	0.0108	0.0108	0.0108
196	0.28	5.44	0.65	0.28	0.2781	0.2781	0.2781	0.2781
197	0.23	5.52	0.75	0.29	0.0097	0.0097	0.0097	0.0097
294	0.38	5.99	0.95	0.23	0.0988	0.0988	0.0988	0.0988
285	0.46	6.51	1.19	0.22	0.0146	0.0146	0.0146	0.0146
216	0.59	6.20	1.55	0.28	0.0260	0.0260	0.0260	0.0260
285	0.47	4.59	0.73	0.26	0.0040	0.0040	0.0040	0.0040
237	0.78	6.32	1.31	0.38	0.0002	0.0002	0.0002	0.0002
196	0.35	6.52	0.95	0.36	0.0017	0.0017	0.0017	0.0017
187	0.26	5.99	0.73	0.15	0.0039	0.0039	0.0039	0.0039
186	0.34	6.28	0.69	0.23	0.0017	0.0017	0.0017	0.0017
189	0.37	5.87	0.76	0.35	0.0011	0.0011	0.0011	0.0011
249	0.48	6.37	1.08	0.24	0.0002	0.0002	0.0002	0.0002
243	0.40	5.88	1.67	0.37	0.0001	0.0001	0.0001	0.0001
241	0.41	6.44	1.11	0.34	0.0008	0.0008	0.0008	0.0008
227	0.51	6.72	1.07	0.33	0.0034	0.0034	0.0034	0.0034
193	0.60	6.69	0.85	0.21	0.0004	0.0004	0.0004	0.0004
200	0.26	5.13	0.60	0.22	0.0034	0.0034	0.0034	0.0034
215	0.32	5.51	0.55	0.32	0.0046	0.0046	0.0046	0.0046
240	0.29	5.38	0.49	0.27	0.0049	0.0049	0.0049	0.0049

Table D5. 1999 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
280	0.47	5.47	0.52	0.23	0.0005	0.0005	0.0005	0.0005
189	0.31	5.40	0.92	0.21	0.0009	0.0009	0.0009	0.0009
252	0.22	6.23	0.30	0.23	0.0026	0.0026	0.0026	0.0026
211	0.37	5.42	0.57	0.22	0.0003	0.0003	0.0003	0.0003
253	0.23	5.28	0.47	0.27	0.0002	0.0002	0.0002	0.0002
244	0.39	6.24	0.74	0.18	0.0005	0.0005	0.0005	0.0005
247	0.57	6.13	0.69	0.17	0.0003	0.0003	0.0003	0.0003
184	0.30	6.70	0.61	0.18	0.0010	0.0010	0.0010	0.0010
280	0.19	5.68	0.51	0.18	0.0017	0.0017	0.0017	0.0017
298	0.37	6.32	1.16	0.30	0.0012	0.0012	0.0012	0.0012
225	0.11	6.63	0.57	0.13	0.0001	0.0001	0.0001	0.0001
210	0.13	6.73	1.77	0.21	0.0019	0.0019	0.0019	0.0019
210	0.12	6.55	1.15	0.20	0.0017	0.0017	0.0017	0.0017
225	0.14	6.73	0.64	0.16	0.0017	0.0017	0.0017	0.0017
286	0.39	5.07	0.50	0.20	0.0246	0.0246	0.0246	0.0246
190	0.66	6.08	1.56	0.40	0.0005	0.0005	0.0005	0.0005
268	0.44	6.50	0.50	0.22	0.0013	0.0013	0.0013	0.0013
177	0.34	6.20	0.89	0.28	0.0004	0.0004	0.0004	0.0004
182	0.42	6.43	0.87	0.30	0.0004	0.0004	0.0004	0.0004
207	0.44	6.59	1.15	0.36	0.0004	0.0004	0.0004	0.0004
217	0.36	5.49	1.00	0.22	0.0004	0.0004	0.0004	0.0004
183	0.54	6.63	0.81	0.34	0.0002	0.0002	0.0002	0.0002
227	0.35	6.34	0.51	0.27	0.0002	0.0002	0.0002	0.0002
244	0.19	6.30	1.66	0.36	0.0015	0.0015	0.0015	0.0015
272	0.35	6.44	1.09	0.23	0.0015	0.0015	0.0015	0.0015
255	0.25	5.89	0.40	0.13	0.0055	0.0055	0.0055	0.0055
Sales-wgt EF	**0.314974**	**5.549376**	**0.695869**	**0.257528**	1.0000	1.0000	1.0000	1.0000
Sample Size	**71**	**71**	**71**	**71**				

Table D5. 1999 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
310	0.34	5.48	0.79	0.13	0.0011	0.0011	0.0011	0.0011
415	0.10	4.65	0.40	0.08	0.0036	0.0036	0.0036	0.0036
340	0.12	3.91	0.56	0.17	0.0271	0.0271	0.0271	0.0271
300	0.08	5.78	0.43	0.13	0.0036	0.0036	0.0036	0.0036
425	0.90	6.38	2.17	0.16	0.0522	0.0522	0.0522	0.0522
300	0.28	6.13	0.81	0.36	0.0049	0.0049	0.0049	0.0049
330	0.33	5.28	1.07	0.36	0.0060	0.0060	0.0060	0.0060
397	0.19	4.65	1.35	0.19	0.0027	0.0027	0.0027	0.0027
362	0.16	5.49	1.57	0.21	0.1859	0.1859	0.1859	0.1859
500	0.13	6.10	1.67	0.17	0.0260	0.0260	0.0260	0.0260
455	0.12	5.48	0.82	0.17	0.0036	0.0036	0.0036	0.0036
599	0.04	6.59	2.67	0.33	0.0763	0.0763	0.0763	0.0763
535	0.08	5.79	2.10	0.34	0.0060	0.0060	0.0060	0.0060
350	0.22	6.52	1.17	0.20	0.0597	0.0597	0.0597	0.0597
430	0.14	6.29	0.34	0.13	0.0199	0.0199	0.0199	0.0199
480	0.17	6.85	1.16	0.18	0.1809	0.1809	0.1809	0.1809
525	0.16	6.52	0.65	0.16	0.0109	0.0109	0.0109	0.0109
336	0.14	5.48	0.45	0.15	0.0071	0.0071	0.0071	0.0071
422	0.15	4.97	0.40	0.11	0.0007	0.0007	0.0007	0.0007
563	0.14	5.11	0.40	0.11	0.0004	0.0004	0.0004	0.0004
308	0.28	5.68	0.45	0.20	0.0016	0.0016	0.0016	0.0016
335	0.27	5.51	0.74	0.28	0.0027	0.0027	0.0027	0.0027
543	0.22	5.66	0.54	0.25	0.0099	0.0099	0.0099	0.0099
336	0.37	4.65	0.68	0.25	0.0282	0.0282	0.0282	0.0282
336	0.41	5.99	1.31	0.30	0.0072	0.0072	0.0072	0.0072
339	0.21	5.72	0.92	0.15	0.0035	0.0035	0.0035	0.0035
399	0.18	5.33	0.91	0.15	0.0047	0.0047	0.0047	0.0047
517	0.17	5.74	0.37	0.13	0.0575	0.0575	0.0575	0.0575
401	0.23	6.02	0.50	0.14	0.0158	0.0158	0.0158	0.0158
431	0.17	5.59	0.43	0.15	0.0071	0.0071	0.0071	0.0071
361	0.20	5.77	0.62	0.16	0.0061	0.0061	0.0061	0.0061
350	0.08	5.74	2.10	0.15	0.0089	0.0089	0.0089	0.0089
313	0.13	6.38	0.59	0.14	0.0116	0.0116	0.0116	0.0116
430	0.35	6.64	0.56	0.19	0.0022	0.0022	0.0022	0.0022
425	0.08	6.44	0.76	0.16	0.0689	0.0689	0.0689	0.0689
586	0.20	4.64	0.45	0.18	0.0043	0.0043	0.0043	0.0043
329	0.26	6.38	0.61	0.19	0.0025	0.0025	0.0025	0.0025
590	0.34	6.40	0.72	0.24	0.0001	0.0001	0.0001	0.0001
335	0.26	6.17	1.05	0.32	0.0004	0.0004	0.0004	0.0004
306	0.24	6.29	0.72	0.37	0.0137	0.0137	0.0137	0.0137
326	0.50	4.04	0.43	0.14	0.0010	0.0010	0.0010	0.0010
493	0.16	4.26	1.04	0.22	0.0014	0.0014	0.0014	0.0014
493	0.16	5.89	0.95	0.28	0.0004	0.0004	0.0004	0.0004
335	0.19	5.78	0.41	0.18	0.0002	0.0002	0.0002	0.0002
375	0.22	5.72	0.32	0.20	0.0038	0.0038	0.0038	0.0038

Table D5. 1999 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
525	0.17	6.06	0.60	0.23	0.0002	0.0002	0.0002	0.0002
571	0.31	3.98	0.48	0.17	0.0022	0.0022	0.0022	0.0022
475	0.28	4.09	0.46	0.15	0.0022	0.0022	0.0022	0.0022
327	0.22	6.39	0.46	0.14	0.0022	0.0022	0.0022	0.0022
327	0.24	6.11	0.48	0.13	0.0022	0.0022	0.0022	0.0022
330	0.07	5.07	0.44	0.10	0.0036	0.0036	0.0036	0.0036
330	0.04	5.64	0.40	0.16	0.0116	0.0116	0.0116	0.0116
313	0.27	6.26	0.31	0.06	0.0134	0.0134	0.0134	0.0134
381	0.21	6.55	0.61	0.08	0.0186	0.0186	0.0186	0.0186
496	0.13	6.12	0.28	0.07	0.0016	0.0016	0.0016	0.0016
Sales-wgt EF	**0.201521**	**6.049760**	**1.201752**	**0.192703**	1.0000	1.0000	1.0000	1.0000
Sample Size	**55**	**55**	**55**	**55**				

Table D5. 1999 MY Certification Data (cont.)

600-750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
660	0.05	6.24	0.83	0.14	0.1765	0.1765	0.1765	0.1765
740	0.05	5.68	1.57	0.25	0.2857	0.2857	0.2857	0.2857
640	0.11	5.62	0.83	0.19	0.0071	0.0071	0.0071	0.0071
730	0.06	5.04	0.99	0.19	0.0903	0.0903	0.0903	0.0903
740	0.10	5.53	1.62	0.33	0.0429	0.0429	0.0429	0.0429
600	0.26	6.02	1.78	0.24	0.1618	0.1618	0.1618	0.1618
686	0.20	5.70	0.65	0.30	0.0139	0.0139	0.0139	0.0139
750	0.07	5.84	0.90	0.16	0.0113	0.0113	0.0113	0.0113
750	0.07	5.90	1.29	0.22	0.0588	0.0588	0.0588	0.0588
750	0.06	4.48	1.43	0.24	0.0597	0.0597	0.0597	0.0597
750	0.35	5.80	1.48	0.30	0.0828	0.0828	0.0828	0.0828
641	0.26	5.84	0.83	0.18	0.0046	0.0046	0.0046	0.0046
740	0.24	5.85	1.37	0.28	0.0046	0.0046	0.0046	0.0046
Sales-wgt EF	**0.118392**	**5.723896**	**1.361031**	**0.227162**	1.0000	1.0000	1.0000	1.0000
Sample Size	**13**	**13**	**13**	**13**				

Table D6. 2000 MY Certification Data

0-11 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
6		6.57	7.33	4.20	0.07		0.0000	0.1007	0.0289	0.0289	0.0289
6		5.28	7.78	3.16	0.12		0.0000	0.0280	0.0080	0.0080	0.0080
10			3.36	1.04	0.28		0.0000	0.0000	0.0088	0.0088	0.0088
7			3.82	2.11	0.35		0.0000	0.0000	0.0096	0.0096	0.0096
7			3.77	2.95	0.33		0.0000	0.0000	0.0225	0.0225	0.0225
11			5.45	4.10	0.24		0.0000	0.0000	0.0096	0.0096	0.0096
10			5.23	1.68	0.21		0.0000	0.0000	0.0193	0.0193	0.0193
7			6.54	3.81	0.43		0.0000	0.0000	0.0123	0.0123	0.0123
8			5.76	4.50	0.52		0.0000	0.0000	0.0006	0.0006	0.0006
10			5.03	4.21	0.42		0.0000	0.0000	0.0006	0.0006	0.0006
4	0.78	5.18	5.96	3.93	0.66	0.131414	0.1309	0.1141	0.0328	0.0328	0.0328
7	0.71	4.82	5.53	3.83	0.57	0.128205	0.6675	0.5817	0.1672	0.1672	0.1672
8	0.58	5.74	6.32	3.29	0.45	0.091981	0.1309	0.1141	0.0328	0.0328	0.0328
11	0.57	5.10	5.67	3.18	0.54	0.101183	0.0706	0.0615	0.0177	0.0177	0.0177
4			6.61	5.00	0.50		0.0000	0.0000	0.2089	0.2089	0.2089
7			6.25	5.03	0.49		0.0000	0.0000	0.1607	0.1607	0.1607
10			6.30	3.84	0.39		0.0000	0.0000	0.1832	0.1832	0.1832
7			6.57	3.61	0.48		0.0000	0.0000	0.0164	0.0164	0.0164
10			3.72	1.91	0.35		0.0000	0.0000	0.0501	0.0501	0.0501
9			3.88	3.84	0.33		0.0000	0.0000	0.0096	0.0096	0.0096
Sales-wgt EF	0.692103	5.170337	5.966223	**4.051366**	**0.452858**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**4**	**6**	**20**	**20**	**20**	**0.113196**					
Calc HC*	**0.675351**										
Calc NOx*		**5.290871**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D6. 2000 MY Certification Data

11-25 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
19			5.02	1.36	0.45		0.0000	0.0000	0.0030	0.0032	0.0030
17	0.58	3.79	4.37	3.82	0.57	0.131868	0.0373	0.0289	0.0051	0.0053	0.0051
25	0.45	4.07	4.52	3.09	0.38	0.099558	0.1493	0.1156	0.0203	0.0211	0.0203
21			4.30	1.74	0.24		0.0000	0.0000	0.0005	0.0005	0.0005
17			5.26	1.69	0.39		0.0000	0.0000	0.0012	0.0012	0.0012
18			5.15	0.77	0.23		0.0000	0.0000	0.0013	0.0014	0.0013
23			3.98	1.08	0.26		0.0000	0.0000	0.0034	0.0035	0.0034
11			4.88	1.88	0.50		0.0000	0.0000	0.0026	0.0027	0.0026
17			4.38	2.36	0.52		0.0000	0.0000	0.0140	0.0146	0.0140
12			5.54	2.57	0.33		0.0000	0.0000	0.0081	0.0084	0.0081
18		1.10	4.96		0.56		0.0000	0.2254	0.0395	0.0000	0.0395
21			3.68	1.34	0.57		0.0000	0.0000	0.0130	0.0135	0.0130
24			3.54	1.06	0.30		0.0000	0.0000	0.0020	0.0021	0.0020
24			5.67	1.66	0.56		0.0000	0.0000	0.0022	0.0023	0.0022
25			6.45	1.20	0.41		0.0000	0.0000	0.0022	0.0023	0.0022
19			3.40	0.99	0.37		0.0000	0.0000	0.0028	0.0029	0.0028
18	0.17	5.59	5.76	0.97	0.54	0.028849	0.0033	0.0025	0.0004	0.0005	0.0004
17	0.10	3.48	3.58	0.56	0.33	0.027933	0.1866	0.1445	0.0253	0.0264	0.0253
25	0.11	3.38	3.49	0.56	0.30	0.030399	0.0974	0.0754	0.0132	0.0138	0.0132
12			5.53	2.77	0.22		0.0000	0.0000	0.3139	0.3268	0.3139
23			4.30	1.73	0.14		0.0000	0.0000	0.0810	0.0843	0.0810
22			4.66	1.50	0.12		0.0000	0.0000	0.0253	0.0264	0.0253
20			5.66	2.23	0.21		0.0000	0.0000	0.0041	0.0042	0.0041
16			4.02	3.13	0.19		0.0000	0.0000	0.0003	0.0003	0.0003
19			6.24	4.15	0.43		0.0000	0.0000	0.0223	0.0232	0.0223
21			4.30	1.74	0.24		0.0000	0.0000	0.0046	0.0047	0.0046
18			5.97	2.73	0.50		0.0000	0.0000	0.0152	0.0158	0.0152
21			4.10	2.24	0.35		0.0000	0.0000	0.0101	0.0105	0.0101
15	0.72	5.29	6.02	3.70	0.43	0.120198	0.0410	0.0318	0.0056	0.0058	0.0056
15	0.43	5.70	6.12	2.41	0.39	0.069428	0.0784	0.0607	0.0106	0.0111	0.0106
16	0.57	5.62	6.19	3.00	0.37	0.092771	0.0187	0.0145	0.0025	0.0026	0.0025
22	0.77	5.17	5.94	3.04	0.45	0.129397	0.3881	0.3006	0.0527	0.0548	0.0527
12			5.03	2.95	0.26		0.0000	0.0000	0.0010	0.0011	0.0010
16			4.46	2.98	0.35		0.0000	0.0000	0.0450	0.0468	0.0450
12			3.17	1.47	0.30		0.0000	0.0000	0.0505	0.0526	0.0505
19			4.29	1.28	0.08		0.0000	0.0000	0.0284	0.0295	0.0284
22			3.47	2.27	0.19		0.0000	0.0000	0.0374	0.0390	0.0374
24			5.63	0.90	0.25		0.0000	0.0000	0.0837	0.0872	0.0837
17			4.88	1.55	0.42		0.0000	0.0000	0.0398	0.0414	0.0398
18			3.24	1.91	0.32		0.0000	0.0000	0.0061	0.0063	0.0061
Sales-wgt EF	0.489983	3.749647	4.948900	**2.207041**	**0.289982**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**9**	**10**	**40**	**39**	**40**	**0.081156**					
Calc HC*	**0.401631**										

Table D6. 2000 MY Certification Data

11-25 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
Calc NOx*		**4.547269**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D6. 2000 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
42			6.52	3.35	0.42		0.0000	0.0000	0.0025	0.0025	0.0025
25			5.31	1.49	0.50		0.0000	0.0000	0.0005	0.0005	0.0005
28			4.92	1.56	0.54		0.0000	0.0000	0.0022	0.0022	0.0022
34			5.21	1.44	0.38		0.0000	0.0000	0.0069	0.0069	0.0069
45			5.95	0.48	0.26		0.0000	0.0000	0.0007	0.0007	0.0007
36			3.12	1.31	0.39		0.0000	0.0000	0.0007	0.0007	0.0007
38			3.62	2.13	0.51		0.0000	0.0000	0.0033	0.0033	0.0033
30			2.79	3.06	0.46		0.0000	0.0000	0.0004	0.0004	0.0004
50		6.14					0.0000	0.1584	0.0000	0.0000	0.0000
30			6.94	1.64	0.27		0.0000	0.0000	0.0390	0.0390	0.0390
38			6.69	1.92	0.32		0.0000	0.0000	0.0133	0.0133	0.0133
46			6.65	2.29	0.35		0.0000	0.0000	0.0123	0.0123	0.0123
35			5.68	1.74	0.21		0.0000	0.0000	0.0036	0.0036	0.0036
39			6.58	1.84	0.11		0.0000	0.0000	0.0051	0.0051	0.0051
47			5.84	1.35	0.09		0.0000	0.0000	0.0044	0.0044	0.0044
25			4.35	0.64	0.13		0.0000	0.0000	0.0004	0.0004	0.0004
28			3.76	1.24	0.20		0.0000	0.0000	0.0022	0.0022	0.0022
30			3.86	0.83	0.17		0.0000	0.0000	0.0030	0.0030	0.0030
40			4.50	0.62	0.20		0.0000	0.0000	0.0013	0.0013	0.0013
47			3.38	0.87	0.27		0.0000	0.0000	0.0005	0.0005	0.0005
26			3.18	0.98	0.37		0.0000	0.0000	0.0004	0.0004	0.0004
27			5.66	1.62	0.56		0.0000	0.0000	0.0001	0.0001	0.0001
29			4.11	1.16	0.35		0.0000	0.0000	0.0160	0.0159	0.0159
40			2.78	1.62	0.42		0.0000	0.0000	0.0379	0.0379	0.0379
45			4.04	0.87	0.38		0.0000	0.0000	0.0147	0.0147	0.0147
28			3.57	2.65	0.43		0.0000	0.0000	0.0010	0.0010	0.0010
39			4.35	1.89	0.45		0.0000	0.0000	0.0004	0.0004	0.0004
28	0.13	4.23	4.36	1.33	0.54	0.029817	0.0267	0.0167	0.0019	0.0019	0.0019
37	0.16	3.56	3.72	2.30	0.58	0.041678	0.0595	0.0372	0.0043	0.0043	0.0043
37	0.67	6.00	6.67	3.55	0.42	0.10051	0.0017	0.0010	0.0001	0.0001	0.0001
27	0.11	4.52	4.63	0.57	0.31	0.023758	0.0017	0.0010	0.0001	0.0001	0.0001
27	0.09	3.95	4.04	0.82	0.46	0.021308	0.0278	0.0173	0.0020	0.0020	0.0020
37	0.85	4.85	5.56	2.55	0.38	0.149123	0.0076	0.0047	0.0005	0.0005	0.0005
35	0.08	4.56	4.64	0.90	0.40	0.017234	0.0216	0.0135	0.0016	0.0016	0.0016
40	0.69	6.19	6.88	1.62	0.25	0.100291	0.0056	0.0035	0.0004	0.0004	0.0004
35	0.56	4.54	5.10	1.52	0.48	0.109804	0.7065	0.4409	0.0509	0.0509	0.0509
46	0.04	3.75	3.79	0.68	0.33	0.010554	0.0014	0.0009	0.0001	0.0001	0.0001
34	0.14	3.66	3.80	0.98	0.50	0.036842	0.0734	0.0458	0.0053	0.0053	0.0053
47	0.12	6.71	6.83	0.74	0.30	0.01757	0.0050	0.0031	0.0004	0.0004	0.0004
48	0.64	6.36	7.00	1.46	0.31	0.091429	0.0151	0.0094	0.0011	0.0011	0.0011
38			6.16	1.66	0.41		0.0000	0.0000	0.0363	0.0363	0.0363
26			4.64	1.30	0.28		0.0000	0.0000	0.0076	0.0076	0.0076
31			3.80	1.16	0.36		0.0000	0.0000	0.0400	0.0400	0.0400
42			3.84	0.77	0.24		0.0000	0.0000	0.0073	0.0073	0.0073

Table D6. 2000 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
26			4.46	0.96	0.35		0.0000	0.0000	0.0545	0.0545	0.0545
41			4.81	0.75	0.25		0.0000	0.0000	0.0009	0.0009	0.0009
31			5.27	0.74	0.19		0.0000	0.0000	0.0309	0.0309	0.0309
31			5.11	0.80	0.26		0.0000	0.0000	0.0582	0.0581	0.0581
37			4.47	0.80	0.29		0.0000	0.0000	0.2108	0.2107	0.2107
49			5.95	1.93	0.43		0.0000	0.0000	0.0018	0.0018	0.0018
38			5.99	1.58	0.36		0.0000	0.0000	0.0018	0.0018	0.0018
48			4.63	0.93	0.23		0.0000	0.0000	0.0031	0.0031	0.0031
40	0.18	4.99	5.17	0.94	0.48	0.034632	0.0465	0.0290	0.0033	0.0033	0.0033
30			2.79	3.06	0.46		0.0000	0.0000	0.0011	0.0011	0.0011
38			3.62	2.13	0.51		0.0000	0.0000	0.0003	0.0003	0.0003
26			2.62	1.83	0.25		0.0000	0.0000	0.0001	0.0001	0.0001
25			5.78	3.66	0.43		0.0000	0.0000	0.0029	0.0029	0.0029
33			2.37	1.58	0.53		0.0000	0.0000	0.0013	0.0013	0.0013
36		5.73	6.06	1.07	0.33		0.0000	0.0441	0.0051	0.0051	0.0051
30			5.29	1.50	0.33		0.0000	0.0000	0.0002	0.0002	0.0002
35		5.15	5.48	1.61	0.36		0.0000	0.0157	0.0018	0.0018	0.0018
40		4.62	5.53	2.57	0.22		0.0000	0.0236	0.0027	0.0027	0.0027
42			6.35	1.01	0.13		0.0000	0.0000	0.0001	0.0001	0.0001
44		4.82	5.56	1.69	0.34		0.0000	0.0157	0.0018	0.0018	0.0018
40			6.36	1.33	0.33		0.0000	0.0000	0.0015	0.0015	0.0015
38			6.00	1.25	0.36		0.0000	0.0000	0.0004	0.0004	0.0004
30			6.51	3.22	0.50		0.0000	0.0000	0.0038	0.0038	0.0038
42			6.07	0.70	0.31		0.0000	0.0000	0.0004	0.0004	0.0004
39			4.73	1.01	0.34		0.0000	0.0000	0.0138	0.0138	0.0138
45			5.62	1.30	0.38		0.0000	0.0000	0.0016	0.0016	0.0016
49			4.09	0.80	0.25		0.0000	0.0000	0.0038	0.0038	0.0038
44			6.19	1.09	0.53		0.0000	0.0000	0.0016	0.0016	0.0016
47		5.32	5.81	2.45	0.44		0.0000	0.0693	0.0080	0.0080	0.0080
43			6.35	2.33	0.26		0.0000	0.0000	0.0004	0.0004	0.0004
41		6.35		0.95	0.32		0.0000	0.0055	0.0000	0.0006	0.0006
48			6.25	1.59	0.28		0.0000	0.0000	0.0002	0.0002	0.0002
26			5.45	2.00	0.15		0.0000	0.0000	0.0236	0.0236	0.0236
28			5.78	3.61	0.40		0.0000	0.0000	0.0096	0.0096	0.0096
25			5.53	2.91	0.37		0.0000	0.0000	0.0129	0.0129	0.0129
30			5.82	2.93	0.35		0.0000	0.0000	0.0012	0.0012	0.0012
25			5.91	3.45	0.24		0.0000	0.0000	0.0006	0.0006	0.0006
33			5.76	2.74	0.28		0.0000	0.0000	0.0230	0.0230	0.0230
41			5.97	1.35	0.49		0.0000	0.0000	0.0009	0.0009	0.0009
29			5.82	2.82	0.25		0.0000	0.0000	0.0070	0.0070	0.0070
37			6.76	1.71	0.40		0.0000	0.0000	0.0007	0.0007	0.0007
25			6.01	3.03	0.32		0.0000	0.0000	0.0222	0.0222	0.0222
37			6.03	2.59	0.35		0.0000	0.0000	0.0181	0.0181	0.0181
25			6.09	3.03	0.20		0.0000	0.0000	0.0000	0.0000	0.0000

Table D6. 2000 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
30			6.07	3.01	0.38		0.0000	0.0000	0.0117	0.0117	0.0117
45			5.85	3.21	0.45		0.0000	0.0000	0.0291	0.0291	0.0291
38			5.79	3.23	0.39		0.0000	0.0000	0.0027	0.0027	0.0027
48			6.00	1.56	0.44		0.0000	0.0000	0.0000	0.0000	0.0000
34			5.94	1.87	0.34		0.0000	0.0000	0.0715	0.0715	0.0715
50		4.85					0.0000	0.0435	0.0000	0.0000	0.0000
46			6.01	2.54	0.20		0.0000	0.0000	0.0064	0.0064	0.0064
41			5.76	2.79	0.33		0.0000	0.0000	0.0042	0.0042	0.0042
27			3.04	0.98	0.40		0.0000	0.0000	0.0023	0.0023	0.0023
39			5.53	1.96	0.26		0.0000	0.0000	0.0010	0.0010	0.0010
Sales-wgt EF	0.452946	4.893606	5.083919	**1.522782**	**0.331337**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**14**	**22**	**95**	**96**	**96**	**0.056039**					
Calc HC*	**0.284899**										
Calc NOx*		**4.799020**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D6. 2000 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
67		6.40				0.0000	0.0035	0.0000	0.0000	0.0000
79		5.74				0.0000	0.0015	0.0000	0.0000	0.0000
96		5.81				0.0000	0.0005	0.0000	0.0000	0.0000
80	0.48	7.61		4.32	0.56	0.1534	0.0381	0.0000	0.1520	0.1572
67	0.75	6.35		1.96	0.34	0.0219	0.0054	0.0000	0.0217	0.0225
75	0.70	5.68		2.28	0.49	0.1315	0.0327	0.0000	0.1303	0.1348
85	0.48	6.14		1.03	0.35	0.0418	0.0104	0.0000	0.0415	0.0429
56	0.46	5.71		2.19	0.29	0.0418	0.0104	0.0000	0.0415	0.0429
75	0.70	5.68		2.28	0.49	0.0279	0.0069	0.0000	0.0276	0.0286
98	0.71	6.30		1.68	0.21	0.0005	0.0001	0.0000	0.0005	0.0005
62		6.23				0.0000	0.0010	0.0000	0.0000	0.0000
57		6.20				0.0000	0.0010	0.0000	0.0000	0.0000
55		5.80				0.0000	0.0010	0.0000	0.0000	0.0000
64		5.92				0.0000	0.0049	0.0000	0.0000	0.0000
82		5.23				0.0000	0.0802	0.0000	0.0000	0.0000
53		6.32				0.0000	0.0217	0.0000	0.0000	0.0000
83		6.47				0.0000	0.0029	0.0000	0.0000	0.0000
65		6.20				0.0000	0.0174	0.0000	0.0000	0.0000
84		6.79				0.0000	0.0000	0.0000	0.0000	0.0000
68		6.70				0.0000	0.0030	0.0000	0.0000	0.0000
51		5.38				0.0000	0.0015	0.0000	0.0000	0.0000
56		5.21				0.0000	0.0042	0.0000	0.0000	0.0000
78		6.22				0.0000	0.0001	0.0000	0.0000	0.0000
52		4.59				0.0000	0.0188	0.0000	0.0000	0.0000
50		3.43				0.0000	0.0079	0.0000	0.0000	0.0000
52	0.17	5.22		1.18	0.45	0.0094	0.0023	0.0000	0.0093	0.0096
51	1.44	5.79		3.90	0.38	0.0110	0.0027	0.0000	0.0109	0.0112
54	0.69	4.15		1.45	0.36	0.0240	0.0060	0.0000	0.0238	0.0246
51	0.60	6.68		3.04	0.63	0.0011	0.0003	0.0000	0.0011	0.0011
55	0.39	6.16		0.98	0.28	0.0163	0.0041	0.0000	0.0162	0.0167
64	0.43	5.62		2.17	0.60	0.0076	0.0019	0.0000	0.0075	0.0078
76	0.29	5.35		1.08	0.51	0.0149	0.0037	0.0000	0.0148	0.0153
51	0.41	5.34		2.22	0.64	0.0087	0.0022	0.0000	0.0086	0.0089
56	0.48	4.88		0.46	0.27	0.0014	0.0003	0.0000	0.0014	0.0014
83	0.49	4.80		0.76	0.34	0.0099	0.0025	0.0000	0.0098	0.0101
91	0.42	6.63		1.32	0.54	0.0378	0.0094	0.0000	0.0375	0.0388
79	0.55	5.25		2.47	0.55	0.0335	0.0083	0.0000	0.0332	0.0344
86	0.46	4.98		0.83	0.38	0.0013	0.0003	0.0000	0.0013	0.0013
86	0.35	5.09		0.67	0.21	0.0013	0.0003	0.0000	0.0013	0.0014
53		6.56				0.0000	0.0478	0.0000	0.0000	0.0000
51	0.05	3.56		0.75	0.20	0.0159	0.0040	0.0000	0.0158	0.0163
78	0.49	3.77		3.00	0.52	0.0159	0.0040	0.0000	0.0158	0.0163
74	0.76	4.70		2.06	0.32	0.0199	0.0050	0.0000	0.0197	0.0204
80	0.72	5.78		3.26	0.51	0.0060	0.0015	0.0000	0.0059	0.0061

Table D6. 2000 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
98	0.71	6.30		1.68	0.21	0.0050	0.0012	0.0000	0.0049	0.0051
56	0.46	5.71		2.19	0.29	0.0002	0.0001	0.0000	0.0002	0.0002
85	0.48	6.14		1.03	0.35	0.0002	0.0001	0.0000	0.0002	0.0002
59		4.37				0.0000	0.0119	0.0000	0.0000	0.0000
51		5.12				0.0000	0.0005	0.0000	0.0000	0.0000
56		4.18				0.0000	0.0114	0.0000	0.0000	0.0000
89		3.57				0.0000	0.0178	0.0000	0.0000	0.0000
73		3.68				0.0000	0.0124	0.0000	0.0000	0.0000
86		5.42				0.0000	0.0104	0.0000	0.0000	0.0000
93		4.71				0.0000	0.0114	0.0000	0.0000	0.0000
72		4.31				0.0000	0.0054	0.0000	0.0000	0.0000
54	0.54	6.31		2.42		0.0157	0.0039	0.0000	0.0156	0.0000
65	0.05	4.18	4.24	0.90		0.0178	0.0044	1.0000	0.0177	0.0000
59		3.34				0.0000	0.0003	0.0000	0.0000	0.0000
53		4.60				0.0000	0.0015	0.0000	0.0000	0.0000
56		5.95				0.0000	0.0005	0.0000	0.0000	0.0000
54		2.62				0.0000	0.0048	0.0000	0.0000	0.0000
63		5.06				0.0000	0.0006	0.0000	0.0000	0.0000
57		4.46				0.0000	0.0052	0.0000	0.0000	0.0000
55		2.91				0.0000	0.0014	0.0000	0.0000	0.0000
51		5.35				0.0000	0.0154	0.0000	0.0000	0.0000
87		5.92				0.0000	0.0154	0.0000	0.0000	0.0000
52		6.32				0.0000	0.0050	0.0000	0.0000	0.0000
89		6.40				0.0000	0.0025	0.0000	0.0000	0.0000
67	0.22	5.71		1.01	0.54	0.1915	0.0476	0.0000	0.1898	0.1963
92	0.35	6.16		1.22	0.29	0.0992	0.0247	0.0000	0.0983	0.1017
55		2.62				0.0000	0.0012	0.0000	0.0000	0.0000
59		5.90				0.0000	0.0012	0.0000	0.0000	0.0000
85		2.18				0.0000	0.0013	0.0000	0.0000	0.0000
64		5.58				0.0000	0.0124	0.0000	0.0000	0.0000
79		6.16				0.0000	0.0067	0.0000	0.0000	0.0000
58		3.23				0.0000	0.0109	0.0000	0.0000	0.0000
52		6.62				0.0000	0.0097	0.0000	0.0000	0.0000
64		5.13				0.0000	0.0045	0.0000	0.0000	0.0000
60		6.06				0.0000	0.0258	0.0000	0.0000	0.0000
96		5.09				0.0000	0.1312	0.0000	0.0000	0.0000
68		5.85				0.0000	0.0669	0.0000	0.0000	0.0000
52		5.97				0.0000	0.0421	0.0000	0.0000	0.0000
68		6.11				0.0000	0.0099	0.0000	0.0000	0.0000
80	0.83	6.00		3.19	0.63	0.0060	0.0015	0.0000	0.0059	0.0061
80	0.86	5.40		4.00	0.64	0.0075	0.0019	0.0000	0.0074	0.0077
59		3.58				0.0000	0.0030	0.0000	0.0000	0.0000
84		6.14				0.0000	0.0010	0.0000	0.0000	0.0000
94		5.75				0.0000	0.0003	0.0000	0.0000	0.0000

Table D6. 2000 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
50		5.80		1.78	0.38	0.0000	0.0008	0.0000	0.0034	0.0035
77	0.03	3.55		0.15	0.18	0.0021	0.0005	0.0000	0.0021	0.0021
59		5.59		0.96	0.45	0.0000	0.0010	0.0000	0.0040	0.0042
100		6.27		0.87	0.33	0.0000	0.0004	0.0000	0.0015	0.0015
75		3.87				0.0000	0.0015	0.0000	0.0000	0.0000
58		3.91				0.0000	0.0020	0.0000	0.0000	0.0000
54		5.40				0.0000	0.0001	0.0000	0.0000	0.0000
67		4.89				0.0000	0.0163	0.0000	0.0000	0.0000
80		4.80				0.0000	0.0005	0.0000	0.0000	0.0000
56		5.23				0.0000	0.0016	0.0000	0.0000	0.0000
58		5.12				0.0000	0.0157	0.0000	0.0000	0.0000
60		4.12				0.0000	0.0025	0.0000	0.0000	0.0000
70		5.59				0.0000	0.0138	0.0000	0.0000	0.0000
58		5.72				0.0000	0.0002	0.0000	0.0000	0.0000
95		5.10				0.0000	0.0030	0.0000	0.0000	0.0000
100		5.73				0.0000	0.0114	0.0000	0.0000	0.0000
Sales-wgt	**0.46289**									
EF		**5.494892**	4.235576	**2.04706**	**0.46043**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**35**	**104**	**1**	**38**	**36**					

Table D6. 2000 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
173	0.33	6.37	0.78	0.11	0.0006	0.0004	0.0006	0.0006
108		6.47			0.0000	0.0007	0.0000	0.0000
143		6.09			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.2138	0.1425	0.2133	0.2164
125	0.23	6.21	0.47	0.16	0.0077	0.0051	0.0077	0.0078
118	0.25	4.53	0.54	0.22	0.0165	0.0110	0.0165	0.0167
155	0.38	4.23	0.75	0.35	0.1983	0.1322	0.1979	0.2008
110		6.06			0.0000	0.0019	0.0000	0.0000
165		6.24			0.0000	0.0495	0.0000	0.0000
166		4.95			0.0000	0.0040	0.0000	0.0000
125	0.23	6.21	0.47	0.16	0.1202	0.0801	0.1200	0.1217
118	0.25	4.53	0.54	0.22	0.0165	0.0110	0.0165	0.0167
144		4.97			0.0000	0.0026	0.0000	0.0000
109		6.41			0.0000	0.0026	0.0000	0.0000
133		6.50			0.0000	0.0026	0.0000	0.0000
168	0.11	6.17	0.63	0.13	0.0009	0.0006	0.0009	0.0009
155		6.39			0.0000	0.0170	0.0000	0.0000
109		6.32	0.53	0.13	0.0000	0.0000	0.0000	0.0000
157		6.65			0.0000	0.0116	0.0000	0.0000
121	0.49	4.30	1.23	0.28	0.0013	0.0009	0.0013	0.0013
134	0.34	4.30	1.00	0.24	0.0007	0.0004	0.0007	0.0007
103	0.57	6.26	1.58	0.39	0.0127	0.0085	0.0127	0.0129
153	0.51	5.65	0.49	0.26	0.0145	0.0097	0.0145	0.0147
164	0.47	4.67	1.06	0.23	0.0033	0.0022	0.0033	0.0033
139	0.52	4.30	1.25	0.19	0.0012	0.0008	0.0012	0.0012
144		6.61			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0881	0.0588	0.0880	0.0892
125	0.23	6.21	0.47	0.16	0.0220	0.0147	0.0220	0.0223
155	0.38	4.23	0.75	0.35	0.1102	0.0735	0.1100	0.1115
125		5.74			0.0000	0.0134	0.0000	0.0000
103		5.94			0.0000	0.0005	0.0000	0.0000
151		5.60			0.0000	0.0005	0.0000	0.0000
120		5.50			0.0000	0.0414	0.0000	0.0000
144		5.80			0.0000	0.0494	0.0000	0.0000
118		5.52			0.0000	0.0009	0.0000	0.0000
113		4.41			0.0000	0.0060	0.0000	0.0000
132		6.05			0.0000	0.0067	0.0000	0.0000
173		5.79			0.0000	0.0027	0.0000	0.0000
108	0.16	6.25	0.43	0.26	0.0759	0.0506	0.0757	0.0768
116	0.57	6.43	1.45	0.33	0.0150	0.0100	0.0150	0.0152
168	0.42	5.85	0.76	0.27	0.0382	0.0255	0.0381	0.0387
118		6.30			0.0000	0.0008	0.0000	0.0000
120		5.55			0.0000	0.0287	0.0000	0.0000
103		6.19			0.0000	0.0089	0.0000	0.0000
172	0.13	5.31	0.45	0.25	0.0180	0.0120	0.0180	0.0183

Table D6. 2000 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
115		5.77			0.0000	0.0067	0.0000	0.0000
152		5.82			0.0000	0.0601	0.0000	0.0000
103	0.53	5.30	1.24	0.51	0.0023	0.0015	0.0023	0.0023
135	0.45	6.68	0.92	0.24	0.0010	0.0007	0.0010	0.0010
130	0.63	6.61	1.21	0.36	0.0017	0.0011	0.0017	0.0017
100	0.57	5.50	1.35	0.47	0.0031	0.0021	0.0031	0.0031
114		6.39			0.0000	0.0040	0.0000	0.0000
127		5.38			0.0000	0.0013	0.0000	0.0000
117		6.23			0.0000	0.0013	0.0000	0.0000
172		6.23			0.0000	0.0040	0.0000	0.0000
173	0.54	6.57	1.83	0.42	0.0020	0.0013	0.0020	0.0020
142		5.92	1.33	0.23	0.0000	0.0013	0.0020	0.0020
138		6.68			0.0000	0.0014	0.0000	0.0000
161	0.23	5.96	0.83		0.0141	0.0094	0.0141	0.0000
130		5.05			0.0000	0.0002	0.0000	0.0000
116		5.82			0.0000	0.0003	0.0000	0.0000
Sales-wgt EF	**0.332460**	**5.593736**	**0.685810**	**0.282059**	1.0000	1.0000	1.0000	1.0000
Sample Size	**27**	**61**	**29**	**28**				

Table D6. 2000 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
257	0.43	6.43		0.76	0.20	0.0005	0.0005	0.0000	0.0005	0.0005
200	0.26	5.13		0.60	0.22	0.0678	0.0678	0.0000	0.0678	0.0678
240	0.10	5.06		0.38	0.15	0.0136	0.0136	0.0000	0.0136	0.0136
215	0.32	5.51		0.55	0.32	0.0329	0.0329	0.0000	0.0329	0.0329
260	0.44	5.82		0.70	0.27	0.0213	0.0213	0.0000	0.0213	0.0213
240	0.29	5.38		0.49	0.27	0.0213	0.0213	0.0000	0.0213	0.0213
280	0.47	5.47		0.52	0.23	0.0484	0.0484	0.0000	0.0484	0.0484
210	0.20	5.89		1.49	0.33	0.0362	0.0362	0.0000	0.0362	0.0362
275	0.11	4.56		1.26	0.26	0.0027	0.0027	0.0000	0.0027	0.0027
205	0.19	5.96		1.73	0.25	0.0096	0.0096	0.0000	0.0096	0.0096
255	0.08	6.20		0.96	0.29	0.0252	0.0252	0.0000	0.0252	0.0252
290	0.09	5.46		2.19	0.35	0.0097	0.0097	0.0000	0.0097	0.0097
260	0.36	5.73		1.30	0.39	0.0022	0.0022	0.0000	0.0022	0.0022
225	0.41	5.70		0.84	0.22	0.0588	0.0588	0.0000	0.0588	0.0588
240	0.10	5.06		0.38	0.15	0.0968	0.0968	0.0000	0.0968	0.0968
200	0.26	5.13		0.60	0.22	0.1355	0.1355	0.0000	0.1355	0.1355
189	0.33	3.95		0.54	0.20	0.0039	0.0039	0.0000	0.0039	0.0039
240	0.29	5.38		0.49	0.27	0.1936	0.1936	0.0000	0.1936	0.1936
200	0.25	5.43		1.23	0.35	0.0034	0.0034	0.0000	0.0034	0.0034
296	0.31	6.41		0.96	0.25	0.0034	0.0034	0.0000	0.0034	0.0034
261	0.47	6.06		0.89	0.27	0.0002	0.0002	0.0000	0.0002	0.0002
248	0.34	5.31		1.04	0.35	0.0002	0.0002	0.0000	0.0002	0.0002
275	0.14	5.38		0.48	0.14	0.0014	0.0014	0.0000	0.0014	0.0014
196	0.35	6.52		0.95	0.36	0.0037	0.0037	0.0000	0.0037	0.0037
184	0.24	5.84		0.69	0.15	0.0215	0.0215	0.0000	0.0215	0.0215
186	0.34	6.28		0.69	0.23	0.0017	0.0017	0.0000	0.0017	0.0017
249	0.48	6.37		1.08	0.24	0.0001	0.0001	0.0000	0.0001	0.0001
243	0.40	5.88		1.67	0.37	0.0002	0.0002	0.0000	0.0002	0.0002
185	0.54	4.19	4.73	0.93	0.20	0.0004	0.0004	0.5000	0.0004	0.0004
241	0.21	4.14	4.35	0.67	0.17	0.0004	0.0004	0.5000	0.0004	0.0004
241	0.41	6.44		1.11	0.34	0.0024	0.0024	0.0000	0.0024	0.0024
227	0.51	6.72		1.07	0.33	0.0055	0.0055	0.0000	0.0055	0.0055
193	0.60	6.69		0.85	0.21	0.0010	0.0010	0.0000	0.0010	0.0010
200	0.26	5.13		0.60	0.22	0.0194	0.0194	0.0000	0.0194	0.0194
189	0.33	3.95		0.54	0.20	0.0039	0.0039	0.0000	0.0039	0.0039
215	0.32	5.51		0.55	0.32	0.0194	0.0194	0.0000	0.0194	0.0194
240	0.29	5.38		0.49	0.27	0.0116	0.0116	0.0000	0.0116	0.0116
280	0.47	5.47		0.52	0.23	0.0020	0.0020	0.0000	0.0020	0.0020
189	0.31	5.40		0.92	0.21	0.0014	0.0014	0.0000	0.0014	0.0014
252	0.22	6.23		0.30	0.23	0.0092	0.0092	0.0000	0.0092	0.0092
238	0.21	5.95		0.51	0.19	0.0006	0.0006	0.0000	0.0006	0.0006
244	0.39	6.24		0.74	0.18	0.0011	0.0011	0.0000	0.0011	0.0011
285	0.06	5.93		0.60	0.09	0.0009	0.0009	0.0000	0.0009	0.0009
197	0.33	5.07		0.76	0.18	0.0044	0.0044	0.0000	0.0044	0.0044

Table D6. 2000 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
251	0.23	5.59		0.42	0.11	0.0072	0.0072	0.0000	0.0072	0.0072
184	0.30	6.70		0.61	0.18	0.0023	0.0023	0.0000	0.0023	0.0023
280	0.19	5.68		0.51	0.18	0.0039	0.0039	0.0000	0.0039	0.0039
298	0.37	6.32		1.16	0.30	0.0029	0.0029	0.0000	0.0029	0.0029
212	0.29	6.41		0.40	0.14	0.0035	0.0035	0.0000	0.0035	0.0035
210	0.09	5.16		0.90	0.18	0.0070	0.0070	0.0000	0.0070	0.0070
225	0.09	6.78		0.40	0.16	0.0058	0.0058	0.0000	0.0058	0.0058
286	0.22	5.35		1.24	0.38	0.0304	0.0304	0.0000	0.0304	0.0304
181	0.15	5.69		0.44	0.27	0.0127	0.0127	0.0000	0.0127	0.0127
202	0.38	8.06		1.42	0.42	0.0009	0.0009	0.0000	0.0009	0.0009
190	0.66	6.08		1.56	0.40	0.0007	0.0007	0.0000	0.0007	0.0007
177	0.34	6.20		0.89	0.28	0.0026	0.0026	0.0000	0.0026	0.0026
182	0.42	6.43		0.87	0.30	0.0009	0.0009	0.0000	0.0009	0.0009
207	0.44	6.59		1.15	0.37	0.0009	0.0009	0.0000	0.0009	0.0009
217	0.36	5.49		1.00	0.22	0.0018	0.0018	0.0000	0.0018	0.0018
183	0.54	6.63		0.81	0.34	0.0009	0.0009	0.0000	0.0009	0.0009
227	0.35	6.34		0.51	0.27	0.0009	0.0009	0.0000	0.0009	0.0009
244	0.19	6.30		1.66	0.36	0.0035	0.0035	0.0000	0.0035	0.0035
272	0.35	6.44		1.09	0.23	0.0035	0.0035	0.0000	0.0035	0.0035
255	0.25	5.89		0.40	0.13	0.0087	0.0087	0.0000	0.0087	0.0087
Sales-wgt EF	**0.266310**	**5.441729**	4.540000	**0.666725**	**0.240685**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**64**	**64**	**2**	**64**	**64**					

Table D6. 2000 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
310	0.34	5.48		0.79	0.13	0.0016	0.0029	0.0016	0.0015	0.0000
415	0.10	4.65		0.40	0.08	0.0053	0.0030	0.0053	0.0042	0.0000
496	0.13	6.12		0.28	0.07	0.0011	0.0008	0.0011	0.0011	0.0000
340	0.12	3.91		0.56	0.17	0.0395	0.0253	0.0395	0.0267	0.0000
300	0.08	5.78		0.43	0.13	0.0053	0.0023	0.0053	0.0053	0.0000
395	0.51	6.48		2.14	0.16	0.0759	0.2081	0.0759	0.0852	0.0000
300	0.28	6.13		0.81	0.36	0.0071	0.0107	0.0071	0.0075	0.0000
330	0.33	5.28		1.07	0.36	0.0087	0.0154	0.0087	0.0079	0.0000
397	0.19	4.65		1.35	0.19	0.0039	0.0040	0.0039	0.0032	0.0000
362	0.16	5.49		1.57	0.21	0.2706	0.2327	0.2706	0.2574	0.0000
322	0.15	3.98		0.75	0.19	0.0379	0.0306	0.0379	0.0261	0.0000
455	0.12	5.48		0.82	0.17	0.0053	0.0034	0.0053	0.0050	0.0000
599	0.04	6.59		2.67	0.33	0.1111	0.0239	0.1111	0.1268	0.0000
535	0.08	5.79		2.10	0.34	0.0087	0.0037	0.0087	0.0087	0.0000
350	0.22	6.52		1.17	0.20	0.0869	0.1010	0.0869	0.0982	0.0000
430	0.14	6.29		0.34	0.13	0.0290	0.0221	0.0290	0.0316	0.0000
525	0.16	6.52		0.65	0.16	0.0158	0.0139	0.0158	0.0179	0.0000
440	0.11	6.38		0.35	0.13	0.0200	0.0117	0.0200	0.0221	0.0000
336	0.14	5.48		0.45	0.15	0.0103	0.0077	0.0103	0.0097	0.0000
422	0.15	4.97		0.40	0.11	0.0003	0.0002	0.0003	0.0002	0.0000
449	0.14	5.10	5.24	0.50	0.15	0.0005	0.0004	0.0005	0.0005	1.0000
308	0.28	5.68		0.45	0.20	0.0021	0.0031	0.0021	0.0021	0.0000
335	0.27	5.51		0.74	0.28	0.0006	0.0009	0.0006	0.0006	0.0000
563	0.14	5.11		0.40	0.11	0.0016	0.0012	0.0016	0.0014	0.0000
543	0.22	5.66		0.54	0.25	0.0116	0.0139	0.0116	0.0114	0.0000
305	0.09	6.00		0.99	0.13	0.0104	0.0052	0.0104	0.0108	0.0000
325	0.10	6.51		0.51	0.13	0.0235	0.0130	0.0235	0.0265	0.0000
315	0.28	5.20		0.70	0.17	0.0358	0.0545	0.0358	0.0322	0.0000
329	0.24	6.60		0.84	0.17	0.0037	0.0048	0.0037	0.0042	0.0000
590	0.34	6.40		0.72	0.23	0.0001	0.0002	0.0001	0.0001	0.0000
335	0.26	6.17		1.05	0.32	0.0003	0.0004	0.0003	0.0003	0.0000
306	0.24	6.29		0.72	0.37	0.0145	0.0187	0.0145	0.0158	0.0000
326	0.50	4.04		0.43	0.14	0.0048	0.0130	0.0048	0.0034	0.0000
493	0.16	4.26		1.04	0.22	0.0029	0.0025	0.0029	0.0021	0.0000
493	0.16	5.89		0.95	0.28	0.0006	0.0005	0.0006	0.0006	0.0000
334	0.25	5.58		0.31	0.18	0.0284	0.0387	0.0284	0.0275	0.0000
322	0.23	3.99		0.41	0.20	0.0009	0.0011	0.0009	0.0006	0.0000
375	0.22	5.72		0.32	0.20	0.0055	0.0066	0.0055	0.0055	0.0000
525	0.17	6.06		0.60	0.23	0.0047	0.0044	0.0047	0.0050	0.0000
330	0.21	6.39		0.44	0.20	0.0003	0.0004	0.0003	0.0004	0.0000
571	0.31	3.98		0.48	0.17	0.0032	0.0052	0.0032	0.0022	0.0000
475	0.28	4.09		0.46	0.15	0.0032	0.0048	0.0032	0.0022	0.0000
542	0.32	3.80		0.56	0.19	0.0032	0.0054	0.0032	0.0021	0.0000
327	0.22	6.39		0.46	0.14	0.0032	0.0038	0.0032	0.0035	0.0000

Table D6. 2000 MY Certification Data (cont.)

300-600 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
327	0.24	6.11		0.48	0.13	0.0032	0.0041	0.0032	0.0033	0.0000
460	0.19	3.35		0.33	0.05	0.0003	0.0003	0.0003	0.0002	0.0000
335	0.43	4.29		0.81	0.12	0.0013	0.0029	0.0013	0.0009	0.0000
330	0.05	5.33		0.43	0.21	0.0405	0.0115	0.0405	0.0374	0.0000
313	0.27	6.26		0.31	0.06	0.0148	0.0214	0.0148	0.0161	0.0000
381	0.21	6.55		0.61	0.08	0.0289	0.0324	0.0289	0.0328	0.0000
496	0.13	6.12		0.28	0.07	0.0016	0.0011	0.0016	0.0017	0.0000
Sales-wgt EF	**0.186024**	**5.770260**	5.240000	**1.254546**	**0.203148**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**51**	**51**	**1**	**51**	**51**					

Table D6. 2000 MY Certification Data (cont.)

600-750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
660	0.05	6.24	0.83	0.14	0.1743	0.1743	0.1743	0.1743
740	0.05	5.68	1.57	0.25	0.2823	0.2823	0.2823	0.2823
730	0.06	5.04	0.99	0.19	0.0892	0.0892	0.0892	0.0892
740	0.10	5.53	1.62	0.33	0.0423	0.0423	0.0423	0.0423
600	0.26	6.02	1.78	0.24	0.1598	0.1598	0.1598	0.1598
630	0.16	4.46	0.66	0.18	0.0249	0.0249	0.0249	0.0249
641	0.19	5.98	1.05	0.23	0.0137	0.0137	0.0137	0.0137
740	0.24	5.85	1.37	0.28	0.0066	0.0066	0.0066	0.0066
740	0.24	5.85	1.37	0.28	0.0066	0.0066	0.0066	0.0066
750	0.07	5.84	0.90	0.16	0.0112	0.0112	0.0112	0.0112
750	0.08	6.01	1.92	0.30	0.0589	0.0589	0.0589	0.0589
750	0.35	5.80	1.48	0.30	0.0818	0.0818	0.0818	0.0818
750	0.13	5.89	1.06	0.13	0.0357	0.0357	0.0357	0.0357
684	0.19	5.98	0.68	0.22	0.0062	0.0062	0.0062	0.0062
671	0.48	6.63	0.52	0.16	0.0062	0.0062	0.0062	0.0062
Sales-wgt EF	**0.126821**	**5.790567**	**1.368105**	**0.225632**	1.0000	1.0000	1.0000	1.0000
Sample Size	**15**	**15**	**15**	**15**				

Table D6. 2000 MY Certification Data (cont.)

>750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
800	0.03	6.19	0.36	0.10	0.0321	0.0321	0.0321	0.0321
758	0.07	5.26	1.07	0.16	0.0067	0.0067	0.0067	0.0067
1082	0.04	5.96	0.70	0.15	0.0555	0.0555	0.0555	0.0555
1850	0.16	5.89	1.10	0.31	0.0658	0.0658	0.0658	0.0658
2750	0.14	6.18	1.31	0.17	0.0515	0.0515	0.0515	0.0515
1200	0.17	5.17	0.34	0.16	0.0044	0.0044	0.0044	0.0044
2000	0.31	5.91	1.49	0.25	0.0297	0.0297	0.0297	0.0297
1250	0.20	6.51	0.51	0.13	0.4683	0.4683	0.4683	0.4683
1500	0.54	6.24	0.87	0.27	0.2120	0.2120	0.2120	0.2120
1200	0.17	5.17	0.34	0.16	0.0297	0.0297	0.0297	0.0297
899	0.21	6.02	0.53	0.15	0.0044	0.0044	0.0044	0.0044
1230	0.12	6.03	0.67	0.26	0.0024	0.0024	0.0024	0.0024
1874	0.38	6.15	1.36	0.15	0.0059	0.0059	0.0059	0.0059
1207	0.23	5.45	1.26	0.24	0.0059	0.0059	0.0059	0.0059
1026	0.26	5.07	0.70	0.18	0.0059	0.0059	0.0059	0.0059
2346	0.40	6.04	1.39	0.26	0.0198	0.0198	0.0198	0.0198
Sales-wgt EF	**0.259060**	**6.252638**	**0.727419**	**0.183308**	1.0000	1.0000	1.0000	1.0000
Sample Size	**16**	**16**	**16**	**16**				

Table D7. 2001 MY Certification Data

0-11 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOxwgt	CO wgt	PM wgt
9			6.70	4.70	0.57		0.0000	0.0000	0.0426	0.0426	0.0426
10			3.36	1.04	0.28		0.0000	0.0000	0.0059	0.0059	0.0059
7			3.82	2.11	0.35		0.0000	0.0000	0.0106	0.0106	0.0106
7			3.77	2.95	0.33		0.0000	0.0000	0.0355	0.0355	0.0355
11			5.45	4.10	0.24		0.0000	0.0000	0.0284	0.0284	0.0284
10			5.23	1.68	0.21		0.0000	0.0000	0.0248	0.0248	0.0248
7	1.59	4.67	6.26	3.81	0.44	0.253454	0.2013	0.2013	0.0106	0.0106	0.0106
8			4.09	1.09	0.44		0.0000	0.0000	0.0004	0.0004	0.0004
4	0.78	5.18	5.96	3.93	0.66	0.131414	0.1409	0.1409	0.0075	0.0075	0.0075
7	0.71	4.82	5.53	3.83	0.57	0.128205	0.1477	0.1477	0.0078	0.0078	0.0078
8	0.58	5.74	6.32	3.29	0.45	0.091981	0.1409	0.1409	0.0075	0.0075	0.0075
10			5.49	3.86	0.51		0.0000	0.0000	0.0075	0.0075	0.0075
11	0.57	5.10	5.67	3.18	0.54	0.101183	0.3691	0.3691	0.0195	0.0195	0.0195
4			6.61	5.00	0.50		0.0000	0.0000	0.2768	0.2768	0.2768
7			6.25	5.03	0.49		0.0000	0.0000	0.1821	0.1821	0.1821
10			6.30	3.84	0.39		0.0000	0.0000	0.2425	0.2425	0.2425
7			6.57	3.61	0.48		0.0000	0.0000	0.0234	0.0234	0.0234
10			3.72	1.91	0.35		0.0000	0.0000	0.0554	0.0554	0.0554
9			3.88	3.84	0.33		0.0000	0.0000	0.0114	0.0114	0.0114
Sales-wgt EF	0.828378	5.073763	6.018891	**4.174066**	**0.442010**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**5**	**5**	**19**	**19**	**19**	**0.141247**					
Calc HC*	**0.850153**										
Calc NOx*		**5.168738**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D7. 2001 MY Certification Data (cont.)

11-25 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
19			5.02	1.36	0.45		0.0000	0.0000	0.0029	0.0029	0.0029
17	0.58	3.79	4.37	3.82	0.57	0.131868	0.0312	0.0312	0.0036	0.0036	0.0036
25	0.45	4.07	4.52	3.09	0.38	0.099558	0.1248	0.1248	0.0143	0.0143	0.0143
16	0.60	3.61	4.21	2.31	0.10	0.141844	0.0062	0.0062	0.0007	0.0007	0.0007
21	0.30	3.77	4.07	1.72	0.20	0.073394	0.0312	0.0312	0.0036	0.0036	0.0036
17			5.26	1.69	0.39		0.0000	0.0000	0.0004	0.0004	0.0004
18			5.15	0.77	0.23		0.0000	0.0000	0.0005	0.0005	0.0005
23			3.98	1.08	0.26		0.0000	0.0000	0.0024	0.0024	0.0024
11			4.88	1.88	0.50		0.0000	0.0000	0.0027	0.0027	0.0027
17			4.38	2.36	0.52		0.0000	0.0000	0.0037	0.0037	0.0037
12			5.54	2.57	0.33		0.0000	0.0000	0.0021	0.0021	0.0021
18			4.96	1.10	0.56		0.0000	0.0000	0.0301	0.0301	0.0301
21			3.68	1.34	0.57		0.0000	0.0000	0.0064	0.0064	0.0064
24			3.54	1.06	0.30		0.0000	0.0000	0.0014	0.0014	0.0014
24			5.67	1.66	0.56		0.0000	0.0000	0.0020	0.0020	0.0020
19			3.40	0.99	0.37		0.0000	0.0000	0.0031	0.0031	0.0031
18	0.17	5.59	5.76	0.97	0.54	0.028849	0.0027	0.0027	0.0003	0.0003	0.0003
17	0.10	3.48	3.58	0.56	0.33	0.027933	0.2702	0.2702	0.0309	0.0309	0.0309
25	0.11	3.38	3.49	0.56	0.30	0.030399	0.1179	0.1179	0.0135	0.0135	0.0135
12			5.53	2.77	0.22		0.0000	0.0000	0.3563	0.3563	0.3563
20			5.66	2.23	0.21		0.0000	0.0000	0.0107	0.0107	0.0107
23			4.30	1.73	0.14		0.0000	0.0000	0.2138	0.2138	0.2138
22			4.66	1.50	0.12		0.0000	0.0000	0.0356	0.0356	0.0356
16	0.60	3.61	4.21	2.31	0.10	0.142113	0.0031	0.0031	0.0004	0.0004	0.0004
19	0.98	4.38	5.36	3.78	0.25	0.182132	0.1373	0.1373	0.0157	0.0157	0.0157
18	1.03	5.04	6.05	3.50	0.41	0.169964	0.0811	0.0811	0.0093	0.0093	0.0093
21	0.30	3.77	4.07	1.72	0.20	0.073154	0.0343	0.0343	0.0039	0.0039	0.0039
21			4.10	2.24	0.35		0.0000	0.0000	0.0071	0.0071	0.0071
17			3.62	1.57	0.30		0.0000	0.0000	0.0170	0.0170	0.0170
23			5.34	0.68	0.22		0.0000	0.0000	0.0020	0.0020	0.0020
15	0.72	5.29	6.02	3.70	0.43	0.120198	0.0137	0.0137	0.0016	0.0016	0.0016
15	0.43	5.70	6.12	2.41	0.39	0.069428	0.0137	0.0137	0.0016	0.0016	0.0016
16	0.57	5.62	6.19	3.00	0.37	0.092771	0.0069	0.0069	0.0008	0.0008	0.0008
22	0.77	5.17	5.94	3.04	0.45	0.129397	0.0630	0.0630	0.0072	0.0072	0.0072
22	0.37	5.17	5.53	1.58	0.32	0.066038	0.0624	0.0624	0.0071	0.0071	0.0071
12			5.03	2.95	0.26		0.0000	0.0000	0.0011	0.0011	0.0011
16			4.46	2.98	0.35		0.0000	0.0000	0.0323	0.0323	0.0323
12			3.17	1.47	0.30		0.0000	0.0000	0.0355	0.0355	0.0355
19			4.29	1.28	0.08		0.0000	0.0000	0.0217	0.0217	0.0217
22			3.47	2.27	0.19		0.0000	0.0000	0.0276	0.0276	0.0276
24			5.63	0.90	0.25		0.0000	0.0000	0.0351	0.0351	0.0351
17			4.88	1.55	0.42		0.0000	0.0000	0.0280	0.0280	0.0280
18			3.24	1.91	0.32		0.0000	0.0000	0.0043	0.0043	0.0043

Table D7. 2001 MY Certification Data (cont.)

11-25 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
Sales-wgt EF	0.447831	4.109521	4.806920	**2.114884**	**0.242992**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**16**	**16**	**43**	**43**	**43**	**0.09869**					
Calc HC*	**0.474395**										
Calc NOx*		**4.332525**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D7. 2001 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
42			6.52	3.35	0.42		0.0000	0.0000	0.0016	0.0016	0.0016
25			5.31	1.49	0.50		0.0000	0.0000	0.0013	0.0013	0.0013
28			4.92	1.56	0.54		0.0000	0.0000	0.0016	0.0016	0.0016
49			4.93	0.92	0.34		0.0000	0.0000	0.0011	0.0011	0.0011
34			5.21	1.44	0.38		0.0000	0.0000	0.0041	0.0041	0.0041
33	0.11	4.65	4.77	0.98	0.25	0.023474	0.0149	0.0116	0.0016	0.0016	0.0016
38	0.26	3.59	3.85	0.92	0.19	0.067829	0.0030	0.0023	0.0003	0.0003	0.0003
30	0.16	4.00	4.17	1.17	0.26	0.039356	0.0030	0.0023	0.0003	0.0003	0.0003
26	0.29	3.02	3.31	1.33	0.15	0.087838	0.0030	0.0023	0.0003	0.0003	0.0003
28		0.00	7.02	1.48	0.24		0.0000	0.0000	0.0350	0.0349	0.0349
43		0.00	6.89	2.10	0.34		0.0000	0.0000	0.0119	0.0119	0.0119
48		0.00	6.82	1.99	0.44		0.0000	0.0000	0.0110	0.0110	0.0110
35			5.68	1.74	0.21		0.0000	0.0000	0.0013	0.0013	0.0013
39			6.39	1.87	0.16		0.0000	0.0000	0.0024	0.0024	0.0024
47			6.37	1.24	0.12		0.0000	0.0000	0.0024	0.0024	0.0024
25			4.35	0.64	0.13		0.0000	0.0000	0.0001	0.0001	0.0001
28			3.76	1.24	0.20		0.0000	0.0000	0.0047	0.0047	0.0047
30			3.86	0.83	0.17		0.0000	0.0000	0.0033	0.0033	0.0033
40			4.50	0.62	0.20		0.0000	0.0000	0.0025	0.0025	0.0025
47			3.38	0.87	0.27		0.0000	0.0000	0.0006	0.0006	0.0006
29			4.11	1.54	0.50		0.0000	0.0000	0.0008	0.0008	0.0008
29			4.11	1.16	0.35		0.0000	0.0000	0.0156	0.0156	0.0156
33			3.13	1.00	0.34		0.0000	0.0000	0.0495	0.0495	0.0495
35			4.21	0.85	0.37		0.0000	0.0000	0.0204	0.0204	0.0204
28			3.57	2.65	0.43		0.0000	0.0000	0.0029	0.0029	0.0029
39			4.35	1.89	0.45		0.0000	0.0000	0.0009	0.0009	0.0009
28	0.13	4.23	4.36	1.33	0.54	0.029817	0.0417	0.0324	0.0046	0.0046	0.0046
33	0.55	4.81	5.36	2.62	0.47	0.102612	0.1204	0.0935	0.0132	0.0131	0.0131
37	0.16	3.56	3.72	2.30	0.58	0.041678	0.0459	0.0356	0.0050	0.0050	0.0050
37	0.67	6.00	6.67	3.55	0.42	0.10051	0.0361	0.0280	0.0039	0.0039	0.0039
27	0.11	4.52	4.63	0.57	0.31	0.023758	0.0002	0.0001	0.0000	0.0000	0.0000
37	0.82	4.27	5.09	3.10	0.37	0.1611	0.0387	0.0301	0.0042	0.0042	0.0042
27	0.09	3.95	4.04	0.82	0.46	0.021308	0.0051	0.0039	0.0006	0.0006	0.0006
49	0.51	4.59	5.10	2.85	0.50	0.1	0.0605	0.0470	0.0066	0.0066	0.0066
35	0.08	4.56	4.64	0.90	0.40	0.017234	0.0566	0.0440	0.0062	0.0062	0.0062
45	0.75	5.33	6.08	2.40	0.29	0.123355	0.0548	0.0426	0.0060	0.0060	0.0060
35	0.56	4.54	5.10	1.52	0.48	0.109804	0.4172	0.3240	0.0456	0.0456	0.0456
46	0.04	3.75	3.79	0.68	0.33	0.010554	0.0038	0.0029	0.0004	0.0004	0.0004
34	0.14	3.66	3.80	0.98	0.50	0.036842	0.0459	0.0356	0.0050	0.0050	0.0050
47	0.12	6.71	6.83	0.74	0.30	0.01757	0.0015	0.0012	0.0002	0.0002	0.0002
48	0.64	6.36	7.00	1.46	0.31	0.091429	0.0042	0.0032	0.0005	0.0005	0.0005
30			1.41	0.62	0.26		0.0000	0.0000	0.0326	0.0325	0.0325
26			4.64	1.30	0.28		0.0000	0.0000	0.0065	0.0065	0.0065
31			3.80	1.16	0.36		0.0000	0.0000	0.0195	0.0195	0.0195

Table D7. 2001 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
42			3.84	0.78	0.24		0.0000	0.0000	0.0163	0.0163	0.0163
26			4.46	0.95	0.35		0.0000	0.0000	0.0651	0.0651	0.0651
44			5.37	1.10	0.38		0.0000	0.0000	0.0000	0.0000	0.0000
33			5.52	1.71	0.36		0.0000	0.0000	0.0000	0.0000	0.0000
41			4.81	0.75	0.25		0.0000	0.0000	0.0003	0.0003	0.0003
31			5.27	0.74	0.19		0.0000	0.0000	0.0326	0.0325	0.0325
31			5.11	0.80	0.26		0.0000	0.0000	0.0391	0.0390	0.0390
38			6.16	1.66	0.41		0.0000	0.0000	0.0260	0.0260	0.0260
37			4.47	0.80	0.29		0.0000	0.0000	0.1628	0.1627	0.1627
49			5.95	1.93	0.43		0.0000	0.0000	0.0003	0.0003	0.0003
38			5.99	1.58	0.36		0.0000	0.0000	0.0003	0.0003	0.0003
48			4.63	0.93	0.23		0.0000	0.0000	0.0020	0.0020	0.0020
35		3.69	3.83	1.40	0.29		0.0000	0.0231	0.0033	0.0033	0.0033
40		3.36	3.54	0.95	0.21		0.0000	0.0231	0.0033	0.0033	0.0033
40	0.18	4.99	5.17	0.94	0.48	0.034632	0.0136	0.0105	0.0015	0.0015	0.0015
38	0.26	3.59	3.85	0.93	0.19	0.068327	0.0006	0.0005	0.0001	0.0001	0.0001
26	0.29	3.02	3.31	1.33	0.15	0.088659	0.0012	0.0009	0.0001	0.0001	0.0001
25	0.59	4.87	5.47	1.88	0.29	0.108272	0.0143	0.0111	0.0016	0.0016	0.0016
33	0.23	4.10	4.33	0.74	0.23	0.054045	0.0104	0.0081	0.0011	0.0011	0.0011
36		5.26	5.58	1.87	0.28		0.0000	0.0116	0.0016	0.0016	0.0016
35			6.03	2.07	0.21		0.0000	0.0000	0.0015	0.0015	0.0015
31			4.68	1.10	0.16		0.0000	0.0000	0.0015	0.0015	0.0015
41			5.65	2.45	0.24		0.0000	0.0000	0.0024	0.0024	0.0024
42			6.35	1.01	0.13		0.0000	0.0000	0.0020	0.0020	0.0020
30			5.12	1.98	0.43		0.0000	0.0000	0.0035	0.0035	0.0035
42			3.24	0.94	0.33		0.0000	0.0000	0.0003	0.0003	0.0003
39			4.73	1.01	0.34		0.0000	0.0000	0.0026	0.0026	0.0026
45			5.62	1.30	0.38		0.0000	0.0000	0.0009	0.0009	0.0009
49			4.00	0.64	0.24		0.0000	0.0000	0.0001	0.0001	0.0001
43			5.12	1.98	0.43		0.0000	0.0000	0.0001	0.0001	0.0001
35			6.27	2.35	0.48		0.0000	0.0000	0.0033	0.0033	0.0033
44			6.19	1.09	0.45		0.0000	0.0000	0.0015	0.0015	0.0015
34		3.53	3.55	1.22	0.53		0.0000	0.0127	0.0018	0.0018	0.0018
49		3.20	3.31	1.29	0.40		0.0000	0.0694	0.0098	0.0098	0.0098
47		5.44	5.83	1.86	0.44		0.0000	0.0509	0.0072	0.0072	0.0072
43			6.35	2.33	0.34		0.0000	0.0000	0.0006	0.0006	0.0006
30			6.09	1.99	0.46		0.0000	0.0000	0.0003	0.0003	0.0003
26			5.45	2.00	0.15		0.0000	0.0000	0.0280	0.0280	0.0280
28			5.78	3.61	0.40		0.0000	0.0000	0.0097	0.0097	0.0097
25			5.53	2.91	0.37		0.0000	0.0000	0.0137	0.0137	0.0137
30			5.82	2.93	0.35		0.0000	0.0000	0.0009	0.0009	0.0009
25			5.91	3.45	0.24		0.0000	0.0000	0.0018	0.0018	0.0018
33			5.76	2.74	0.28		0.0000	0.0000	0.0476	0.0476	0.0476
41			5.97	1.35	0.49		0.0000	0.0000	0.0009	0.0009	0.0009

Table D7. 2001 MY Certification Data (cont.)

25-50 hp	Emission Factors (g/hp-hr)						Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC frac of HC+NOx*	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
29			5.82	2.82	0.25		0.0000	0.0000	0.0030	0.0030	0.0030
37			5.40	1.73	0.50		0.0000	0.0000	0.0009	0.0009	0.0009
25			6.01	3.03	0.32		0.0000	0.0000	0.0004	0.0004	0.0004
37			6.03	2.59	0.35		0.0000	0.0000	0.0272	0.0272	0.0272
25			6.09	3.03	0.20		0.0000	0.0000	0.0000	0.0000	0.0000
30			6.07	3.01	0.38		0.0000	0.0000	0.0110	0.0110	0.0110
45			5.85	3.21	0.45		0.0000	0.0000	0.0367	0.0367	0.0367
38			5.79	3.23	0.39		0.0000	0.0000	0.0017	0.0017	0.0017
48			6.00	1.56	0.44		0.0000	0.0000	0.0000	0.0000	0.0000
34			5.94	1.87	0.34		0.0000	0.0000	0.0689	0.0689	0.0689
46			6.01	2.54	0.20		0.0000	0.0000	0.0063	0.0062	0.0062
41			5.76	2.79	0.33		0.0000	0.0000	0.0030	0.0030	0.0030
48			6.25	1.59	0.28		0.0000	0.0000	0.0002	0.0002	0.0002
27			3.04	0.98	0.40		0.0000	0.0000	0.0021	0.0021	0.0021
39			5.53	1.96	0.26		0.0000	0.0000	0.0010	0.0010	0.0010
30	0.17	4.01		1.17	0.26	0.040139	0.0036	0.0028	0.0000	0.0004	0.0004
50		4.85					0.0000	0.0325	0.0000	0.0000	0.0000
Sales-wgt EF	0.472917	4.469647	4.952901	**1.532028**	**0.329222**		1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**25**	**35**	**103**	**104**	**104**	**0.064006**					
Calc HC*	**0.317014**										
Calc NOx*		**4.635887**									

* HC fraction of HC+NOx = HC ÷ (HC+NOx). The average HC fraction is not a sales-weighted average.
Calculated HC = (avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).
Calculated NOx = (1- avg HC fraction of HC+NOx) * (sales-wgt avg HC+NOx).

Table D7. 2001 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
67		6.40				0.0000	0.0016		0.0000	0.0000
79		5.74				0.0000	0.0004		0.0000	0.0000
96		5.81				0.0000	0.0002		0.0000	0.0000
80	0.48	7.61		4.32	0.56	0.0621	0.0157		0.0591	0.0608
67	0.75	6.35		1.96	0.34	0.0036	0.0009		0.0034	0.0035
75	0.70	5.68		2.28	0.46	0.0888	0.0224		0.0844	0.0869
80	0.72	5.78		3.26	0.51	0.0855	0.0216		0.0813	0.0837
56	0.62	5.83		1.63	0.41	0.0339	0.0086		0.0322	0.0332
75	0.70	5.68		2.28	0.49	0.0586	0.0148		0.0557	0.0573
98	0.71	6.30		1.68	0.21	0.0004	0.0001		0.0004	0.0004
62		6.23				0.0000	0.0008		0.0000	0.0000
57		6.20				0.0000	0.0008		0.0000	0.0000
55		5.80				0.0000	0.0008		0.0000	0.0000
59		6.56				0.0000	0.0045		0.0000	0.0000
84		5.74				0.0000	0.0478		0.0000	0.0000
59	0.89	8.82		3.55	0.84	0.1563	0.0395		0.1486	0.1530
78	0.48	5.36		1.92	0.35	0.0858	0.0217		0.0816	0.0840
81	0.33	6.35		2.33	0.38	0.0154	0.0039		0.0147	0.0151
74		5.90				0.0000	0.0040		0.0000	0.0000
59		5.90				0.0000	0.0205		0.0000	0.0000
82		5.44				0.0000	0.0661		0.0000	0.0000
65		5.80				0.0000	0.0179		0.0000	0.0000
58		6.39				0.0000	0.0002		0.0000	0.0000
87		6.39				0.0000	0.0002		0.0000	0.0000
83		6.56				0.0000	0.0024		0.0000	0.0000
65		6.20				0.0000	0.0143		0.0000	0.0000
84		6.79				0.0000	0.0000		0.0000	0.0000
79		6.32				0.0000	0.0025		0.0000	0.0000
94		6.09				0.0000	0.0004		0.0000	0.0000
94		6.09				0.0000	0.0004		0.0000	0.0000
94		6.09				0.0000	0.0004		0.0000	0.0000
51		5.38				0.0000	0.0024		0.0000	0.0000
56		4.98				0.0000	0.0011		0.0000	0.0000
78		6.22				0.0000	0.0000		0.0000	0.0000
51		4.86		1.51		0.0000	0.0022		0.0084	0.0000
60		4.06		1.73		0.0000	0.0022		0.0084	0.0000
52		4.59				0.0000	0.0163		0.0000	0.0000
50		3.43				0.0000	0.0094		0.0000	0.0000
52	0.17	5.22		1.18	0.45	0.0107	0.0027		0.0101	0.0104
51	1.44	5.79		3.90	0.38	0.0179	0.0045		0.0170	0.0175
54	0.69	4.15		1.45	0.36	0.0100	0.0025		0.0095	0.0098
51	0.60	6.68		3.04	0.63	0.0008	0.0002		0.0008	0.0008
55	0.39	6.16		0.98	0.28	0.0134	0.0034		0.0127	0.0131
64	0.43	5.62		2.17	0.60	0.0042	0.0011		0.0040	0.0041

Table D7. 2001 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
76	0.29	5.35		1.08	0.51	0.0092	0.0023		0.0087	0.0090
51	0.41	5.34		2.22	0.64	0.0386	0.0098		0.0367	0.0378
56	0.48	4.88		0.46	0.27	0.0048	0.0012		0.0046	0.0047
83	0.49	4.80		0.76	0.34	0.0065	0.0016		0.0061	0.0063
91	0.42	6.63		1.32	0.54	0.0172	0.0043		0.0163	0.0168
79	0.55	5.25		2.47	0.55	0.0248	0.0063		0.0236	0.0243
86	0.46	4.98		0.83	0.38	0.0012	0.0003		0.0011	0.0012
86	0.35	5.09		0.67	0.21	0.0002	0.0001		0.0002	0.0002
59		6.65				0.0000	0.0333		0.0000	0.0000
51	0.05	3.56		0.75	0.20	0.0097	0.0024		0.0092	0.0095
74	0.49	3.77		3.00	0.52	0.0008	0.0002		0.0008	0.0008
74	0.76	4.70		2.06	0.32	0.0161	0.0041		0.0153	0.0158
80	0.72	5.78		3.26	0.51	0.0018	0.0004		0.0017	0.0017
99	0.28	4.15		0.76	0.25	0.0133	0.0034		0.0127	0.0130
98	0.71	6.30		1.68	0.21	0.0040	0.0010		0.0038	0.0039
56	0.62	5.83		1.63	0.41	0.0019	0.0005		0.0018	0.0018
59		4.37				0.0000	0.0367		0.0000	0.0000
51		5.12				0.0000	0.0004		0.0000	0.0000
51		4.72				0.0000	0.0004		0.0000	0.0000
56		4.18				0.0000	0.0245		0.0000	0.0000
89		4.79				0.0000	0.0020		0.0000	0.0000
73		4.93				0.0000	0.0020		0.0000	0.0000
86		5.42				0.0000	0.0082		0.0000	0.0000
93		4.71				0.0000	0.0082		0.0000	0.0000
72		4.31				0.0000	0.0151		0.0000	0.0000
54	0.54	6.31		2.42		0.0085	0.0021		0.0081	0.0000
59		3.34				0.0000	0.0002		0.0000	0.0000
51		4.78				0.0000	0.0029		0.0000	0.0000
56		5.95				0.0000	0.0029		0.0000	0.0000
51		3.91				0.0000	0.0031		0.0000	0.0000
54		2.62				0.0000	0.0039		0.0000	0.0000
63		5.06				0.0000	0.0006		0.0000	0.0000
95		5.58				0.0000	0.0002		0.0000	0.0000
57		4.46				0.0000	0.0046		0.0000	0.0000
51		5.35				0.0000	0.0042		0.0000	0.0000
87		5.92				0.0000	0.0056		0.0000	0.0000
55		2.91				0.0000	0.0013		0.0000	0.0000
81		5.87				0.0000	0.0001		0.0000	0.0000
92		5.10				0.0000	0.0002		0.0000	0.0000
52		6.32				0.0000	0.0041		0.0000	0.0000
72		5.14				0.0000	0.0008		0.0000	0.0000
89		6.40				0.0000	0.0020		0.0000	0.0000
67	0.22	5.71		1.01	0.54	0.0934	0.0236		0.0888	0.0914
92	0.35	6.16		1.22	0.29	0.0638	0.0161		0.0606	0.0624

Table D7. 2001 MY Certification Data (cont.)

50-100 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
55		2.62				0.0000	0.0010		0.0000	0.0000
85		2.18				0.0000	0.0011		0.0000	0.0000
59		5.90				0.0000	0.0002		0.0000	0.0000
64		5.58				0.0000	0.0102		0.0000	0.0000
79		6.16				0.0000	0.0055		0.0000	0.0000
55		3.22				0.0000	0.0090		0.0000	0.0000
52		6.62				0.0000	0.0080		0.0000	0.0000
64		5.13				0.0000	0.0037		0.0000	0.0000
60		6.06				0.0000	0.0212		0.0000	0.0000
96		5.09				0.0000	0.1081		0.0000	0.0000
68		5.85				0.0000	0.0551		0.0000	0.0000
52		5.97				0.0000	0.0347		0.0000	0.0000
68		6.34				0.0000	0.0347		0.0000	0.0000
80	0.83	6.00		3.19	0.63	0.0043	0.0011		0.0041	0.0042
80	0.86	5.40		4.00	0.64	0.0051	0.0013		0.0048	0.0050
59		3.58				0.0000	0.0025		0.0000	0.0000
89		5.10				0.0000	0.0008		0.0000	0.0000
94		5.75				0.0000	0.0002		0.0000	0.0000
50		5.80		1.78	0.46	0.0000	0.0002		0.0008	0.0009
74	0.05	4.00		0.25	0.20	0.0002	0.0000		0.0002	0.0002
82	0.07	4.84		1.22	0.44	0.0113	0.0029		0.0107	0.0111
60		5.87		3.96	0.31	0.0000	0.0004		0.0015	0.0016
58		6.27		1.32	0.27	0.0000	0.0015		0.0058	0.0059
59		5.59		0.96	0.45	0.0000	0.0003		0.0013	0.0013
75		3.87				0.0000	0.0013		0.0000	0.0000
58		3.91				0.0000	0.0017		0.0000	0.0000
54		5.40				0.0000	0.0001		0.0000	0.0000
67		4.89				0.0000	0.0135		0.0000	0.0000
80		4.80				0.0000	0.0004		0.0000	0.0000
56		5.23				0.0000	0.0015		0.0000	0.0000
58		5.12				0.0000	0.0037		0.0000	0.0000
60		4.12				0.0000	0.0032		0.0000	0.0000
70		5.59				0.0000	0.0117		0.0000	0.0000
57		5.72				0.0000	0.0002		0.0000	0.0000
95		5.10				0.0000	0.0032		0.0000	0.0000
100		5.73				0.0000	0.0144		0.0000	0.0000
50	0.52	4.77	5.28	1.94	0.33	0.0121	0.0031	0.3000	0.0115	0.0118
65	0.05	4.18	4.24	0.90		0.0040	0.0010	0.1000	0.0038	0.0000
79		5.98	6.61	1.71	0.37	0.0000	0.0061	0.6000	0.0230	0.0237
Sales-wgt	**0.575867**	**5.604515**		**2.314372**	**0.506824**					
EF			**5.976957**			1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**40**	**127**	**3**	**47**	**43**					

Table D7. 2001 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
173	0.33	6.37	0.78	0.11	0.0003	0.0002	0.0003	0.0003
108		6.47			0.0000	0.0002	0.0000	0.0000
143		6.09			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0857	0.0682	0.0856	0.0863
125	0.23	6.21	0.47	0.16	0.0057	0.0045	0.0057	0.0058
118	0.25	4.53	0.54	0.22	0.0021	0.0017	0.0021	0.0021
155	0.38	4.23	0.75	0.35	0.1029	0.0819	0.1027	0.1035
110		6.06			0.0000	0.0039	0.0000	0.0000
165		6.24			0.0000	0.0303	0.0000	0.0000
166		4.95			0.0000	0.0003	0.0000	0.0000
155	0.15	4.25	1.91	0.22	0.0072	0.0057	0.0072	0.0072
100	0.35	6.08	0.70	0.28	0.1247	0.0992	0.1244	0.1255
125	0.23	6.21	0.47	0.16	0.0623	0.0496	0.0622	0.0627
118	0.25	4.53	0.54	0.22	0.0023	0.0018	0.0023	0.0023
155	0.38	4.23	0.75	0.35	0.0935	0.0744	0.0933	0.0941
158		6.53			0.0000	0.0016	0.0000	0.0000
109		6.41			0.0000	0.0016	0.0000	0.0000
144		4.97			0.0000	0.0016	0.0000	0.0000
168	0.11	6.17	0.63	0.13	0.0007	0.0006	0.0007	0.0007
135	0.40	5.70	1.75	0.29	0.2824	0.2248	0.2819	0.2842
168		6.26			0.0000	0.0105	0.0000	0.0000
109		6.32	0.53	0.13	0.0000	0.0001	0.0001	0.0001
158		6.70			0.0000	0.0072	0.0000	0.0000
119	0.58	6.20	0.63	0.17	0.0010	0.0008	0.0010	0.0010
121	0.49	4.30	1.23	0.28	0.0011	0.0009	0.0011	0.0011
134	0.34	4.30	1.00	0.24	0.0050	0.0040	0.0050	0.0050
103	0.57	6.26	1.58	0.39	0.0059	0.0047	0.0059	0.0059
153	0.51	5.65	0.49	0.26	0.0078	0.0062	0.0078	0.0079
164	0.47	4.67	1.06	0.23	0.0017	0.0014	0.0017	0.0017
139	0.52	4.30	1.25	0.19	0.0006	0.0005	0.0006	0.0006
106		6.01			0.0000	0.0426	0.0000	0.0000
144		6.61			0.0000	0.0001	0.0000	0.0000
100	0.35	6.08	0.70	0.28	0.0457	0.0364	0.0456	0.0460
125	0.23	6.21	0.47	0.16	0.0114	0.0091	0.0114	0.0115
155	0.38	4.23	0.75	0.35	0.0571	0.0455	0.0570	0.0575
125		5.74			0.0000	0.0041	0.0000	0.0000
114		5.42			0.0000	0.0002	0.0000	0.0000
151		5.60			0.0000	0.0000	0.0000	0.0000
120		5.50			0.0000	0.0009	0.0000	0.0000
144		5.80			0.0000	0.0001	0.0000	0.0000
114		6.35			0.0000	0.0113	0.0000	0.0000
113		4.41			0.0000	0.0060	0.0000	0.0000
132		6.05			0.0000	0.0041	0.0000	0.0000
173		5.79			0.0000	0.0017	0.0000	0.0000
108	0.16	6.25	0.43	0.26	0.0407	0.0324	0.0406	0.0410

Table D7. 2001 MY Certification Data (cont.)

100-175 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
116	0.57	6.43	1.45	0.33	0.0050	0.0040	0.0050	0.0051
168	0.42	5.85	0.76	0.27	0.0199	0.0159	0.0199	0.0200
118		6.30			0.0000	0.0005	0.0000	0.0000
120		5.55			0.0000	0.0178	0.0000	0.0000
103		6.19			0.0000	0.0055	0.0000	0.0000
172	0.13	5.31	0.45	0.17	0.0094	0.0074	0.0093	0.0094
115		5.77			0.0000	0.0041	0.0000	0.0000
152		5.82			0.0000	0.0372	0.0000	0.0000
103	0.53	5.30	1.24	0.51	0.0010	0.0008	0.0010	0.0010
135	0.45	6.68	0.92	0.24	0.0004	0.0003	0.0004	0.0004
130	0.63	6.61	1.21	0.36	0.0007	0.0006	0.0007	0.0007
100	0.57	5.50	1.35	0.47	0.0015	0.0012	0.0015	0.0015
114		6.39			0.0000	0.0025	0.0000	0.0000
127		5.38			0.0000	0.0008	0.0000	0.0000
117		6.23			0.0000	0.0008	0.0000	0.0000
172		6.23			0.0000	0.0025	0.0000	0.0000
173	0.54	6.57	1.83	0.42	0.0010	0.0008	0.0010	0.0010
122	0.07	3.93	0.42	0.14	0.0001	0.0001	0.0001	0.0001
122	0.07	5.75	1.06	0.34	0.0049	0.0039	0.0049	0.0050
100		6.27	0.87	0.33	0.0000	0.0005	0.0006	0.0006
142		5.92	1.33	0.23	0.0000	0.0008	0.0010	0.0010
138		6.68			0.0000	0.0019	0.0000	0.0000
161	0.23	5.96	0.83		0.0082	0.0065	0.0082	0.0000
116		5.82			0.0000	0.0005	0.0000	0.0000
Sales-wgt EF	**0.355107**	**5.574714**	**1.003922**	**0.289340**	1.0000	1.0000	1.0000	1.0000
Sample Size	**34**	**69**	**37**	**36**				

Table D7. 2001 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
272	0.32	6.24		0.62	0.10	0.0003	0.0003	0.0000	0.0003	0.0003
257	0.43	6.43		0.76	0.20	0.0002	0.0002	0.0000	0.0002	0.0002
200	0.26	5.13		0.60	0.22	0.0045	0.0045	0.0000	0.0045	0.0045
240	0.10	5.06		0.38	0.15	0.0023	0.0023	0.0000	0.0022	0.0022
240	0.07	4.06		0.50	0.16	0.0023	0.0023	0.0000	0.0022	0.0022
215	0.32	5.51		0.55	0.32	0.0038	0.0038	0.0000	0.0037	0.0037
260	0.44	5.82		0.70	0.27	0.0015	0.0015	0.0000	0.0015	0.0015
240	0.29	5.38		0.49	0.27	0.0064	0.0064	0.0000	0.0063	0.0063
280	0.47	5.47		0.52	0.23	0.0151	0.0151	0.0000	0.0149	0.0149
210	0.20	5.89		1.49	0.33	0.0092	0.0092	0.0000	0.0091	0.0091
275	0.11	4.56		1.26	0.26	0.0002	0.0002	0.0000	0.0002	0.0002
205	0.19	5.96		1.73	0.25	0.0024	0.0024	0.0000	0.0024	0.0024
255	0.08	6.20		0.96	0.29	0.0143	0.0143	0.0000	0.0141	0.0141
290	0.09	5.46		2.19	0.35	0.0016	0.0016	0.0000	0.0016	0.0016
205	0.39	5.95		1.19	0.31	0.0008	0.0008	0.0000	0.0007	0.0007
190	0.55	5.64		1.44	0.32	0.0227	0.0227	0.0000	0.0225	0.0225
240	0.10	5.06		0.38	0.15	0.0038	0.0038	0.0000	0.0037	0.0037
200	0.26	5.13		0.60	0.22	0.0753	0.0753	0.0000	0.0745	0.0745
189	0.33	3.95		0.54	0.20	0.0015	0.0015	0.0000	0.0015	0.0015
215	0.32	5.51		0.55	0.32	0.0376	0.0376	0.0000	0.0372	0.0372
260	0.44	5.82		0.70	0.27	0.0205	0.0205	0.0000	0.0203	0.0203
240	0.29	5.38		0.49	0.27	0.0753	0.0753	0.0000	0.0745	0.0745
280	0.47	5.47		0.52	0.23	0.0075	0.0075	0.0000	0.0074	0.0074
240	0.07	4.06		0.50	0.16	0.0038	0.0038	0.0000	0.0037	0.0037
200	0.25	5.43		1.23	0.35	0.0013	0.0013	0.0000	0.0013	0.0013
296	0.31	6.41		0.96	0.25	0.0013	0.0013	0.0000	0.0013	0.0013
255	0.36	6.45		0.72	0.24	0.0000	0.0000	0.0000	0.0000	0.0000
261	0.47	6.06		0.89	0.27	0.0000	0.0000	0.0000	0.0000	0.0000
248	0.34	5.31		1.04	0.35	0.0001	0.0001	0.0000	0.0001	0.0001
275	0.14	5.38		0.48	0.14	0.0008	0.0008	0.0000	0.0008	0.0008
220	0.20	5.87		0.72	0.27	0.0042	0.0042	0.0000	0.0041	0.0041
234	0.19	5.45		0.62	0.25	0.0097	0.0097	0.0000	0.0096	0.0096
196	0.28	5.44		0.65	0.28	0.4205	0.4205	0.0000	0.4161	0.4161
199	0.27	5.70		1.05	0.32	0.0147	0.0147	0.0000	0.0146	0.0146
294	0.38	5.99		0.95	0.23	0.0640	0.0640	0.0000	0.0633	0.0633
285	0.46	6.51		1.19	0.22	0.0164	0.0164	0.0000	0.0163	0.0163
216	0.59	6.20		1.55	0.28	0.0458	0.0458	0.0000	0.0453	0.0453
285	0.47	4.59		0.73	0.26	0.0287	0.0287	0.0000	0.0284	0.0284
237	0.78	6.32		1.30	0.38	0.0000	0.0000	0.0000	0.0000	0.0000
189	0.43	6.65		1.04	0.34	0.0014	0.0014	0.0000	0.0014	0.0014
194	0.31	6.28		0.81	0.17	0.0083	0.0083	0.0000	0.0083	0.0083
288	0.62	6.62		1.69	0.36	0.0005	0.0005	0.0000	0.0005	0.0005
186	0.34	6.28		0.69	0.23	0.0004	0.0004	0.0000	0.0004	0.0004
249	0.48	6.37		1.08	0.24	0.0001	0.0001	0.0000	0.0001	0.0001

Table D7. 2001 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
243	0.40	5.88		1.67	0.37	0.0000	0.0000	0.0000	0.0000	0.0000
210	0.09	5.16		0.90	0.11	0.0021	0.0021	0.0000	0.0020	0.0020
250	0.09	5.29		0.44	0.05	0.0001	0.0001	0.0000	0.0001	0.0001
215	0.10	6.30		0.50	0.07	0.0005	0.0005	0.0000	0.0005	0.0005
197	0.33	4.42		0.71	0.20	0.0002	0.0002	0.0000	0.0001	0.0001
241	0.21	4.14		0.67	0.17	0.0002	0.0002	0.0000	0.0001	0.0001
241	0.41	6.44		1.11	0.34	0.0006	0.0006	0.0000	0.0006	0.0006
227	0.51	6.72		1.07	0.33	0.0009	0.0009	0.0000	0.0009	0.0009
193	0.60	6.69		0.85	0.28	0.0004	0.0004	0.0000	0.0004	0.0004
200	0.26	5.13		0.60	0.22	0.0075	0.0075	0.0000	0.0074	0.0074
189	0.33	3.95		0.54	0.20	0.0015	0.0015	0.0000	0.0015	0.0015
215	0.32	5.51		0.55	0.32	0.0075	0.0075	0.0000	0.0074	0.0074
240	0.29	5.38		0.49	0.27	0.0045	0.0045	0.0000	0.0045	0.0045
280	0.47	5.47		0.52	0.23	0.0008	0.0008	0.0000	0.0008	0.0008
189	0.31	5.40		0.92	0.21	0.0001	0.0001	0.0000	0.0001	0.0001
252	0.22	6.23		0.30	0.23	0.0030	0.0030	0.0000	0.0029	0.0029
283	0.14	4.25		0.43	0.17	0.0011	0.0011	0.0000	0.0011	0.0011
262	0.17	5.84		0.57	0.21	0.0002	0.0002	0.0000	0.0002	0.0002
244	0.39	6.24		0.74	0.18	0.0004	0.0004	0.0000	0.0004	0.0004
285	0.06	5.93		0.60	0.09	0.0003	0.0003	0.0000	0.0003	0.0003
215	0.04	4.10		0.51	0.16	0.0034	0.0034	0.0000	0.0034	0.0034
197	0.33	5.07		0.76	0.18	0.0021	0.0021	0.0000	0.0021	0.0021
251	0.23	5.59		0.42	0.11	0.0039	0.0039	0.0000	0.0039	0.0039
184	0.30	6.70		0.61	0.18	0.0010	0.0010	0.0000	0.0010	0.0010
280	0.19	5.68		0.51	0.18	0.0020	0.0020	0.0000	0.0019	0.0019
298	0.37	6.32		1.16	0.30	0.0011	0.0011	0.0000	0.0011	0.0011
212	0.29	6.41		0.40	0.14	0.0014	0.0014	0.0000	0.0014	0.0014
286	0.22	5.35		1.24	0.37	0.0083	0.0083	0.0000	0.0082	0.0082
208	0.15	4.28		0.52	0.26	0.0051	0.0051	0.0000	0.0050	0.0050
202	0.28	6.00		1.05	0.33	0.0003	0.0003	0.0000	0.0003	0.0003
190	0.66	6.08		1.56	0.40	0.0002	0.0002	0.0000	0.0002	0.0002
177	0.34	6.20		0.89	0.28	0.0010	0.0010	0.0000	0.0010	0.0010
182	0.42	6.43		0.87	0.29	0.0003	0.0003	0.0000	0.0003	0.0003
207	0.44	6.59		1.15	0.36	0.0003	0.0003	0.0000	0.0003	0.0003
217	0.36	5.49		1.00	0.22	0.0007	0.0007	0.0000	0.0007	0.0007
244	0.19	6.30		1.66	0.37	0.0014	0.0014	0.0000	0.0014	0.0014
272	0.35	6.44		1.09	0.22	0.0014	0.0014	0.0000	0.0014	0.0014
255	0.25	5.89		0.40	0.13	0.0026	0.0026	0.0000	0.0026	0.0026
279			4.18	0.73	0.20	0.0000	0.0000	0.8977	0.0102	0.0102
275	0.11	4.02	4.13	0.80	0.16	0.0002	0.0002	0.0209	0.0002	0.0002
185	0.54	4.19	4.73	0.93	0.20	0.0002	0.0002	0.0132	0.0001	0.0001
245			4.55	0.45	0.15	0.0000	0.0000	0.0359	0.0004	0.0004
295	0.22	4.08	4.29	0.60	0.13	0.0003	0.0003	0.0299	0.0003	0.0003
268	0.30	4.00	4.47	0.66	0.19	0.0000	0.0000	0.0024	0.0000	0.0000

Table D7. 2001 MY Certification Data (cont.)

175-300 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
Sales-wgt EF	**0.314765**	**5.506545**	4.203295	**0.744633**	**0.266622**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**86**	**86**	**6**	**88**	**88**					

Table D7. 2001 MY Certification Data (cont.) (Tier 2 for this hp category)

300-600 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
325			4.56	1.52	0.17	0.0000	0.0000	0.0516	0.0516	0.0516
439			3.75	1.19	0.16	0.0000	0.0000	0.0589	0.0589	0.0589
515			3.58	1.14	0.17	0.0000	0.0000	0.0521	0.0521	0.0521
593			4.08	0.58	0.10	0.0000	0.0000	0.2080	0.2080	0.2080
475			4.14	0.99	0.14	0.0000	0.0000	0.0460	0.0460	0.0460
325			4.56	1.52	0.17	0.0000	0.0000	0.0516	0.0516	0.0516
449	0.10	3.80	3.91	0.37	0.10	0.0036	0.0036	0.0011	0.0011	0.0011
422	0.14	4.09	4.24	0.35	0.10	0.0279	0.0279	0.0082	0.0082	0.0082
322	0.13	4.37	4.50	0.44	0.11	0.0110	0.0110	0.0032	0.0032	0.0032
333	0.15	4.38	4.53	0.53	0.14	0.6951	0.6951	0.2042	0.2042	0.2042
300			4.53	0.82	0.14	0.0000	0.0000	0.0038	0.0038	0.0038
350			4.71	0.77	0.11	0.0000	0.0000	0.0038	0.0038	0.0038
500			4.75	1.30	0.12	0.0000	0.0000	0.1467	0.1467	0.1467
500			4.61	0.48	0.12	0.0000	0.0000	0.0258	0.0258	0.0258
300	0.06	4.02	4.08	0.59	0.13	0.0239	0.0239	0.0070	0.0070	0.0070
317	0.39	4.19	4.58	0.80	0.15	0.0150	0.0150	0.0044	0.0044	0.0044
321	0.17	4.22	4.39	0.52	0.14	0.0389	0.0389	0.0114	0.0114	0.0114
483	0.16	4.23	4.39	0.46	0.13	0.0235	0.0235	0.0069	0.0069	0.0069
360	0.12	4.47	4.59	0.63	0.09	0.0030	0.0030	0.0009	0.0009	0.0009
326	0.50	4.04	4.54	0.43	0.14	0.0022	0.0022	0.0006	0.0006	0.0006
456	0.15	4.37	4.52	0.57	0.10	0.0070	0.0070	0.0021	0.0021	0.0021
481	0.10	4.44	4.53	0.43	0.08	0.0036	0.0036	0.0011	0.0011	0.0011
322			4.34	0.65	0.15	0.0000	0.0000	0.0066	0.0066	0.0066
410			4.40	0.30	0.11	0.0000	0.0000	0.0264	0.0264	0.0264
508			4.20	0.30	0.12	0.0000	0.0000	0.0016	0.0016	0.0016
572			4.53	0.86	0.19	0.0000	0.0000	0.0019	0.0019	0.0019
503			4.50	0.93	0.15	0.0000	0.0000	0.0064	0.0064	0.0064
571			4.29	0.48	0.14	0.0000	0.0000	0.0035	0.0035	0.0035
475			4.38	0.46	0.11	0.0000	0.0000	0.0035	0.0035	0.0035
595			4.20	0.63	0.16	0.0000	0.0000	0.0035	0.0035	0.0035
367			4.55	0.45	0.15	0.0000	0.0000	0.0035	0.0035	0.0035
493			4.49	0.71	0.13	0.0000	0.0000	0.0006	0.0006	0.0006
493			4.49	0.71	0.13	0.0000	0.0000	0.0006	0.0006	0.0006
324	0.22	4.30	4.53	0.47	0.08	0.0100	0.0100	0.0029	0.0029	0.0029
375	0.25	4.29	4.54	0.48	0.08	0.1354	0.1354	0.0398	0.0398	0.0398
Sales-wgt EF	**0.166924**	**4.335113**	4.345348	**0.842460**	**0.131581**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**14**	**14**	**35**	**35**	**35**					

Table D7. 2001 MY Certification Data (cont.)

600-750 hp	Emission Factors (g/hp-hr)					Sales Weightings				
Rated HP	HC	NOx	HC+NOx	CO	PM	HC wgt	NOx wgt	HC+NOx wgt	CO wgt	PM wgt
660	0.05	6.24		0.83	0.14	0.0276	0.0276	0.0000	0.0192	0.0192
742	0.04	6.27		0.52	0.10	0.0408	0.0408	0.0000	0.0284	0.0284
654	0.04	6.21		1.58	0.25	0.1192	0.1192	0.0000	0.0829	0.0829
730	0.06	5.04		0.99	0.19	0.1159	0.1159	0.0000	0.0806	0.0806
740	0.10	5.53		1.62	0.33	0.0850	0.0850	0.0000	0.0591	0.0591
670	0.25	6.53		1.27	0.36	0.0795	0.0795	0.0000	0.0553	0.0553
710	0.27	6.63		2.31	0.30	0.0552	0.0552	0.0000	0.0384	0.0384
641	0.19	5.98		1.05	0.23	0.0353	0.0353	0.0000	0.0246	0.0246
740	0.24	5.85		1.37	0.28	0.0839	0.0839	0.0000	0.0583	0.0583
684	0.19	5.98		0.68	0.22	0.0055	0.0055	0.0000	0.0038	0.0038
671	0.48	6.63		0.52	0.16	0.0221	0.0221	0.0000	0.0153	0.0153
747	0.22	4.50		0.76	0.09	0.0055	0.0055	0.0000	0.0038	0.0038
680			3.89	0.33	0.12	0.0000	0.0000	0.7192	0.3047	0.3047
601	0.13	4.19	4.32	0.22	0.12	0.1049	0.1049	0.1721	0.0729	0.0729
750	0.07	5.84		0.90	0.16	0.0121	0.0121	0.0000	0.0084	0.0084
750	0.13	5.89		1.06	0.13	0.1413	0.1413	0.0000	0.0982	0.0982
630	0.12	3.87	3.99	0.87	0.18	0.0662	0.0662	0.1087	0.0460	0.0460
Sales-wgt EF	**0.138065**	**5.612418**	3.975047	**0.883305**	**0.183773**	1.0000	1.0000	1.0000	1.0000	1.0000
Sample Size	**16**	**16**	**3**	**17**	**17**					

Table D7. 2001 MY Certification Data (cont.)

>750 hp	Emission Factors (g/hp-hr)				Sales Weightings			
Rated HP	HC	NOx	CO	PM	HC wgt	NOx wgt	CO wgt	PM wgt
758	0.07	5.26	1.07	0.16	0.0052	0.0052	0.0052	0.0052
891	0.05	6.22	0.73	0.14	0.0152	0.0152	0.0152	0.0152
1850	0.16	5.89	1.09	0.30	0.0654	0.0654	0.0654	0.0654
2250	0.16	6.43	1.28	0.20	0.0395	0.0395	0.0395	0.0395
755	0.35	5.80	1.48	0.30	0.0599	0.0599	0.0599	0.0599
1200	0.17	5.17	0.34	0.16	0.0033	0.0033	0.0033	0.0033
2000	0.31	5.91	1.49	0.25	0.0228	0.0228	0.0228	0.0228
1110	0.23	6.03	0.55	0.14	0.4402	0.4402	0.4402	0.4402
1500	0.54	6.24	0.87	0.27	0.2677	0.2677	0.2677	0.2677
1200	0.17	5.17	0.34	0.16	0.0228	0.0228	0.0228	0.0228
899	0.21	6.02	0.53	0.15	0.0088	0.0088	0.0088	0.0088
1230	0.12	6.03	0.67	0.26	0.0046	0.0046	0.0046	0.0046
811	0.27	6.24	1.05	0.21	0.0152	0.0152	0.0152	0.0152
1874	0.38	6.15	1.36	0.15	0.0024	0.0024	0.0024	0.0024
878	0.34	5.96	0.89	0.14	0.0152	0.0152	0.0152	0.0152
1207	0.23	5.45	1.26	0.24	0.0030	0.0030	0.0030	0.0030
1026	0.26	5.07	0.70	0.18	0.0009	0.0009	0.0009	0.0009
2346	0.40	6.04	1.39	0.26	0.0076	0.0076	0.0076	0.0076
Sales-wgt EF	**0.313093**	**6.052394**	**0.800887**	**0.203589**	1.0000	1.0000	1.0000	1.0000
Sample Size	**18**	**18**	**18**	**18**				

18 Appendix E: Derivation of Highway-Certification Compliance Margins and Application to Selected Tier 2/3 Nonroad Compression Ignition Engines

As described in Section 4.3, some Tier 2 and Tier 3 nonroad compression ignition emission rates were adjusted to account for expected compliance margins using factors originally calculated for highway vehicles. In this appendix, we describe the derivation of the highway-certification compliance margins (HCCMs) in greater detail. The highway certification results used for this purpose in derivation of Tier 2/3 emission factors (option 4) are summarized in a report updating emission levels for heavy-duty highway diesel engines for use in MOBILE6 (1). The report presents results for light, medium, and heavy vehicle classes in model years 1988-1989 and 1991-1994. For this analysis, we supplemented these certification data with more recent highway certification data from model years 1997-2001.

We used the highway certification results to calculate compliance margins (HCCM) for some highway engines for MY 1988-2001. The procedure followed several steps (refer to Table E1):

1. We assigned highway model-year groups, (e.g., 1991-93) to each nonroad horsepower category (e.g., 50-100 hp). These assignments vary for each pollutant and individual horsepower category. The assignments attempt to associate similar highway and nonroad engine technologies. We averaged results for multiple years within a model-year group.

2. We assigned nonroad engines less than 50 horsepower to the light heavy-duty diesel vehicle weight class (LHDD), engines in the range of 50-250 hp to the medium heavy-duty diesel vehicle weight class (MHDD), and engines greater than 250 hp to the heavy heavy-duty diesel vehicle weight class (HHDD). Within a model-year group, these assignments identified subsets of certification data to represent specific nonroad horsepower categories. Correspondence between highway weight class (light-duty, medium-duty, heavy-duty) and nonroad horsepower categories follows relationships established by the California Air Resources Board (CARB 2000).

3. We used the highway certification data described above and assigned to the appropriate nonroad horsepower categories to calculate compliance margins for highway engines at certification:

$$HCCM_{i,j} = \frac{HS_{i,j} - AHC_{i,j}}{HS_{i,j}}$$

where $HCCM_{i,j}$, $HS_{i,j}$ and $AHC_{i,j}$ are the highway-certification compliance margin, highway standard and average certification emissions level, respectively, for pollutant *i*, and horsepower category *j* (e.g., NO_x, 50-100 hp).

While we calculated the highway-certification compliance margins for all pollutants and horsepower categories, note that Table E1 presents results only for NO_x and PM. We do not present compliance margins for HC and CO because the margins were higher than 80 percent. As a result, we did not use them to estimate HC and CO Tier 2/3 emission factors.

References

(1) EPA, "Update of Heavy-Duty Emission Levels (Model Years 1988-2004+) for Use in MOBILE6," EPA420-R-99-010, April 1999.

Table E1. Highway-Certification Compliance Margins by Horsepower Category

Nonroad Engine Power Categories (hp)	Highway Model-Year Group (MYG)	Corresponding Heavy-Duty Highway Vehicle Weight Class (VWC), Emission Standards (HS), Certification Test Results (AHC) and Compliance Margins (HCCM)			
		NO_x			
		VWC[1]	**HS (g/hp-hr)**	**AHC [2] (g/hp-hr)**	**HCCM (% HS)**
< 11	1991-93	LHDD	5.0	4.28	14
11-25	1991-93	LHDD	5.0	4.28	14
25-50	1991-93	LHDD	5.0	4.28	14
50-100	1991-93	MHDD	5.0	4.54	9.0
100-175	1998-2003	MHDD	4.0	3.78	5.5
175-300	1998-2003	MHDD	4.0	3.58	10.5
300-600	1998-2003	HHDD	4.0	3.92	2.0
600-750	1998-2003	HHDD	4.0	3.84	4.0
>750	1998-2003	HHDD	4.0	3.84	4.0
		PM			
< 11	1988-89	LHDD	0.6	0.44	27
11-25	1988-89	LHDD	0.6	0.44	27
25-50	1988-89	LHDD	0.6	0.44	27
50-100	1991-93	MHDD	0.25	0.20	20
100-175	1991-93	MHDD	0.25	0.20	20
175-300	1994-97	MHDD	0.10	0.08	20
300-600	1994-97	HHDD	0.10	0.08	20
600-750	1994-97	HHDD	0.10	0.08	20
>750	1994-97	HHDD	0.10	0.08	20

[1] LHDD = "light heavy-duty diesel," MHDD = "medium heavy-duty diesel," and HHDD = "heavy heavy-duty diesel."
[2] Source: USEPA (1999), for NO_x, Table 10 or MY 1997-2001 highway certification data; for PM, Table 11 or MY 1997-2001highway certification data.

19 Appendix F: Derivation of Transient Adjustment Factors (TAFs) for Nonroad Compression Ignition Engines

Nonroad engines often operate under conditions unlike that of the steady-state ISO-C1 testing procedure typically used in emissions testing. This alternate operation can cause a change in the emission characteristics of nonroad compression ignition (CI) engines. As in NEVES, the MOVES-Nonroad model accounts for in-use (transient) operation in CI engines by applying an adjustment to emission factors generated using the ISO-C1 (8-mode) steady-state tests. Unlike NEVES, the MOVES-Nonroad model uses transient adjustment factors derived from emission testing designed to represent operational behavior of nonroad equipment. Note that the transient adjustments are not applied by the MOVES-Nonroad model, but are applied by EPA during the creation of the MOVES-Nonroad emission factor input files.

TAFs are applied to the Base, Tier 0, Tier 1, Tier 2, and Tier 3 emission factors. Since transient emission control is expected to be an integral part of all Tier 4 engine design considerations, TAFs are not applied to the emission factors for Tier 4 engines (i.e., the model applies a TAF of 1.0).

Development of Transient Adjustment Factors

In NEVES, EPA adjusted the ISO-C1-derived emission factor data available at the time to account for in-use operation by applying a set of multipliers. These factors were derived from a comparison of only a few engines tested with both the ISO-C1 test procedure and the highway Federal Test Procedure (FTP). (1) These factors shown in Table F1 were applied in NEVES only to engines used in applications judged to be sufficiently transient in nature.

Table F1. NEVES Test Cycle Adjustment from ISO-C1 Emission Factors

	HC	CO	NO_x	PM
NEVES Adjustment	1.4	2.0	1	1.6

MOVES-Nonroad's steady-state emission factors for pre-1988 CI engines of greater than 50 hp are based on the emission factors used in the NEVES. As a result, the NEVES in-use adjustments were removed to determine pre-1988 average steady-state emissions for these engines. The TAFs described below are then applied consistently to all the steady-state emission factors in MOVES-Nonroad, including the NEVES-derived steady-state emission factors.

Since it was recognized that the highway test procedure may not simulate engine behavior when used in nonroad applications, a joint EMA\EPA project was initiated to develop more realistic test cycles for nonroad engine emissions characterization. The project developed cycles to represent typical operation of an agricultural tractor, a crawler dozer, and a backhoe\loader. The cycles were developed from data acquired from instrumenting one

piece of each type of equipment. This data was used to construct appropriate test cycles from statistical criteria developed by EMA and EPA. Southwest Research Institute (SwRI) then tested nine late-model nonroad engines using the steady-state ISO-C1 certification procedure and the three nonroad test cycles. (2) Later testing at SwRI involved three additional engines and four additional cycles (rubber-tire loader, skid-steer loader, arc welder, and excavator cycles). (3) A summary of the cycle specific emission results for each engine is given in Table F2.

For each pollutant and test cycle, we calculate the TAF as the ratio of the transient emission factor (EF_{trans}) to the corresponding steady-state (ISO-C1) emission factor (EF_{ss}):

$$TAF = \frac{EF_{trans}}{EF_{ss}}$$

Transient adjustment factors may be greater than or less than 1.0.

Using the emission data in Table F2, TAFs were calculated for each engine, pollutant, and test cycle. The resulting TAFs for each engine are provided in Table F3. The TAFs for each engine were then averaged to obtain composite TAFs for each of the seven test cycles. These are also shown in Table F3 along with the standard deviations. TAFs for Tier 0 and Tier 1 engines were combined, since they were not statistically different, based on P values obtained from performing the Student's *t*-Test.

For this version of MOVES-Nonroad, the seven average cycle TAFs were further binned into two categories, Hi LF and Lo LF, based on the cycle load factors. We thought this approach would be more defensible, given the limited data available. This approach is also consistent with that used to develop the new load factors in the model. Table F4 shows how the cycle TAFs were binned. When reviewing the cycle load factors, two bins emerged. A high load factor bin consisted of the following cycles: agricultural tractor (LF=0.78), crawler dozer (LF=0.58), rubber-tire loader (LF=0.48), and excavator (LF=0.53). A low load factor bin consisted of the remaining cycles: backhoe/loader (LF=0.21), skid-steer loader (LF=0.23), and arc welder (LF=0.19). The TAFs for the high load factor cycles were averaged to obtain a composite Hi LF TAF. Similarly, the TAFs for the low load factor cycles were averaged to obtain a composite Lo LF TAF. As a result, the cycle TAFs were replaced by either a Hi LF TAF or a Lo LF TAF, depending on the cycle assignment.

Table F5 presents the CI TAFs used in MOVES-Nonroad. The TAFs are carried over from Table F4 with the exception of the Tier 3 TAFs for NO_x and PM. The rationale for the NO_x and PM Tier 3 TAFs is described in detail below.

<u>Transient Emission Control and Implications for Tier 3 NO_x and PM TAFs</u>

The nonroad engine test cycle (for pre-Tier 4 engines) is a weighted 8 mode steady-state emission cycle without a transient test element. This is in contrast to on-highway diesel regulations which are set based on average emissions over a 20 minute transient test and a separate steady-state test. The absence of a transient test allows some additional control

flexibilities for nonroad engines not available, or available at a diminished level, for on-highway diesel engines. The nonroad engine standards are therefore inherently less restrictive than otherwise equivalent on-highway emission standards, as explained in the following paragraphs.

Transient PM emission control is realized for on-highway diesel engines by limiting fuel injection quantities dependent upon the oxygen content available (the air to fuel ratio, A/F) to burn the fuel. When an on-highway diesel engine transitions from a low load steady-state condition to a higher load it does so by increasing the fuel injection rate and the air induction rate through increases in the intake manifold pressure (i.e. higher boost from the turbocharger) in order to maintain an A/F ratio with acceptable PM emissions. While the fueling rate can be changed almost instantaneously on a diesel engine, it takes a longer amount of time for the turbocharger to increase the air flow due to the inertial lag of the turbocharger and the mass of air. During the transient period when the turbocharger is gradually increasing the air flow, the engine control system limits the addition of fuel in order to prevent excess PM emissions. It is only after the air flow has increased to the proper amount, that the engine control system allows the fueling rate to rise to the level needed to deliver the desired engine torque. This control approach limits transient PM emissions so that the engine will pass the highway transient test. Absent a transient PM emissions test, the engine controller could immediately increase the fueling rate, providing rapid attainment of the desired torque level, but this would also dramatically increase PM emissions. The increase in PM emissions under transient conditions due to the lack of oxygen (low A/F) is exacerbated by the use of exhaust gas recirculation (EGR) to limit NO_x emissions. This is because the recirculated gases have a lower oxygen content (the very reason they help to lower NO_x emissions). In order to maintain effective PM emission control with EGR, turbocharger boost levels are increased (more low oxygen content air is forced in to the engine in order to give a total oxygen content similar to without EGR). Because of the higher boost pressure required, transient PM control might be expected to be worse for EGR equipped engines. For highway diesel engines which must meet a transient PM emission standard, these issues are addressed with sophisticated control systems and with the use of advanced turbocharger systems (i.e., variable geometry turbochargers). Absent a transient test procedure, these advanced systems would not necessarily be used.

Similarly, NO_x control for on-highway diesel engines equipped with EGR systems are significantly constrained by the transient emission test procedure. When undergoing a transient event as described in the previous example, an EGR emission control system for on-highway engines would briefly turn off EGR in order to increase the fresh air flow to the system in order to limit PM emissions and increase engine torque response. The control system must, however, restore the EGR relatively quickly in order to control NO_x emissions under the highway transient test procedure. Failure to do so would lead to higher NO_x emissions. Absent a transient NO_x standard, the EGR system could be turned off for a long period under transient operation, leading to substantially higher NO_x emissions than what would be expected based upon a steady state emission test level alone. The extent of this increase in NO_x emissions is dependent upon the degree of transient operation (the relative change in engine load). To the extent that load transient are less severe or not extended, the differences in the resulting NO_x emissions would be less evident.

The lack of a transient emission test procedure for pre-Tier 4 nonroad engines is a concern to the Agency, because we know that PM emissions realized in use can be significantly higher than the steady-state emission level set by the PM standards. Similarly, we have concerns that NO_x emissions under transient conditions may be higher than indicated by the steady state emissions test and the associated standards. We are therefore working to develop a more comprehensive set of emission test requirements for nonroad engines to include a transient test element. In the absence of such a test procedure for Tier 3 engines, we believe that it is prudent to try to characterize these in-use emissions by increasing the TAFs applied for NO_x and PM emissions for Tier 3 engines from the level estimated for Tier 2 engines. Since Tier 3 engines are not available to provide test data to establish the level of adjustment required, we have applied engineering judgement to estimate the level of increase in emissions. For PM we have estimated that the TAF will increase by 20 percent due to the lack of a transient test and the inherent reduction in average A/F ratio values due to the use of EGR. Given the highly transient nature of some nonroad diesel engine applications the actual level of increase could be even higher. In the absence of more definitive data we believe that a 20 percent increase in the TAF is appropriate. We intend to investigate this issue further when Tier 3 engines become available for testing. We also believe that the NO_x TAF should be adjusted in a similar manner. For NO_x we believe that a 10 percent increase in the TAF is appropriate given the characteristics of EGR systems as we understand them today. We believe that nonroad engine manufacturers will choose to modulate EGR rates during high load change transient operation in order to limit PM emissions increases. This will lead to an increase in NO_x emission for the period that the EGR rate is modulated below the steady-state level. For example, a 10 percent increase in NO_x emissions could correspond to an EGR rate of zero for 10 percent of the time (a duty cycle of 90 percent moderate transient and steady-state operation and 10 percent highly transient operation) assuming that NO_x emissions double when the EGR flow is zero. For some applications with extreme transient operations it is conceivable that the increase in emission could be even higher. As with PM, we intend to investigate the actual level of NO_x emissions when Tier 3 engines become available.

Applying In-use Adjustment Factors

To apply the in-use adjustment factors listed in Table F5 to the entire CI equipment population, EPA matched nonroad applications with the test cycle that most closely represents the nonroad activity for the application. Table F6 lists the nonroad applications used in the MOVES-Nonroad model and the in-use adjustment most representative of that application. If steady-state operation is typical of an application no adjustment was made, and the cycle adjustment is listed as 'none'.

Table A3 presents the resulting TAFs assigned to each equipment application. The steady-state emission factors given in Table A2 were then multiplied by the appropriate in-use adjustment factor to create MOVES-Nonroad's emission factor inputs for CI engines.

Comparison with Previous Draft Versions of NONROAD

Table F7 presents a comparison of TAF methodologies used in the various draft versions of NONROAD.

References

(1) EPA, "Nonroad Engine and Vehicle Emission Study" (NEVES), U.S. EPA, Office of Air and Radiation, 21A-2001. November, 1991

(2) Fritz, S. G. and M.E. Starr, "Emission Factors for Compression Ignition Nonroad Engines Operated on Number 2 Highway and Nonroad Diesel Fuel," Southwest Research Institute. EPA contract # 68-C5-0077, SwRI 08-7601-822, March 1998.

(3) Starr, M.E., "Nonroad Engine Emissions Testing," Southwest Research Institute. EPA contract # 68-C5-0076 and 68-C-98-169, September 1999.

Table F2. CI Engine Emissions Data Used to Calculate Transient Adjustment Factors

Engine (reference)	Tier	Test Cycle	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
Caterpillar 3116 (2)	0	ISO-C1 8-mode	0.07	2.51	9.38	0.406	0.352
		Agricultural	0.04	0.75	9.4	0.28	0.357
		Backhoe Loader	0.36	7.47	9.46	0.652	0.411
		Crawler Dozer	0.09	7.3	8.7	0.713	0.362
Caterpillar 3054 (2)	0	ISO-C1 8-mode	0.66	1	7.53	0.387	0.393
		Agricultural	0.46	0.47	9.46	0.263	0.377
		Backhoe Loader	1.22	3.34	5.45	0.759	0.446
		Crawler Dozer	0.51	1.06	8.28	0.384	0.372
John Deere 4039 (2)	0	ISO-C1 8-mode	0.41	2.17	11.22	0.384	0.389
		Agricultural	0.2	0.56	11.7	0.173	0.361
		Backhoe Loader	1	2.62	9.57	0.447	0.471
		Crawler Dozer	0.33	1.42	11.7	0.254	0.372
John Deere 7076 (2)	0	ISO-C1 8-mode	0.53	2.05	10.22	0.25	0.385
		Agricultural	0.54	0.57	9.45	0.168	0.366
		Backhoe Loader	1.13	4.82	14.35	0.522	0.493
		Crawler Dozer	0.52	2.22	10.14	0.303	0.37
Consolidated Diesel 6TA-830 (2)	0	ISO-C1 8-mode	0.86	1.5	6.53	0.397	0.365
		Agricultural	0.9	1.07	5.62	0.304	0.377
		Backhoe Loader	2.08	9.86	6.69	1.698	0.438
		Crawler Dozer	0.83	3.76	6.06	0.805	0.37
John Deere 6619 (2)	0	ISO-C1 8-mode	0.82	4.69	7.29	0.662	0.397
		Agricultural	0.87	1.16	6.77	0.283	0.4
		Backhoe Loader	1.99	6.89	8.29	1.102	0.466
		Crawler Dozer	0.8	3.31	7.01	0.698	0.398
Consolidated Diesel 4039 (2)	0	ISO-C1 8-mode	1.32	3.37	7.57	0.581	0.389
		Agricultural	0.86	2.5	7.28	0.43	0.367

Table F2. CI Engine Emissions Data Used to Calculate Transient Adjustment Factors							
Engine (reference)	Tier	Test Cycle	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
		Backhoe Loader	2.89	3.31	6.52	0.725	0.436
		Crawler Dozer	1.22	2.1	7.4	0.413	0.364
Caterpillar 3306 (2)	0	ISO-C1 8-mode	1.27	1.46	6.52	0.248	0.373
		Agricultural	1.33	0.82	6.46	0.201	0.372
		Backhoe Loader	2.3	5.14	7.22	0.813	0.415
		Crawler Dozer	1.16	2.7	6.54	0.436	0.37
John Deere 6101 (2)	1	ISO-C1 8-mode	0.47	0.86	5.55	0.186	0.350
		Agricultural	0.50	0.32	4.93	0.125	0.362
		Backhoe Loader	1.07	1.92	6.36	0.430	0.434
		Crawler Dozer	0.51	1.17	5.25	0.246	0.362
John Deere 6101(same engine) retested (3)	1	ISO-C1 8-mode	0.50	1.17	5.73	0.219	0.363
		Agricultural	0.46	0.44	5.16	0.130	0.355
		Backhoe Loader	0.93	1.90	6.04	0.430	0.419
		Crawler Tractor	0.47	1.14	5.50	0.250	0.357
John Deere 6101 (same engine) retested	1	ISO-C1 8-mode	0.46	0.95	5.75	0.19	
		Agricultural	0.39	0.39	5.24	0.11	
		Backhoe Loader	0.68	1.58	6.09	0.33	
		Crawler Dozer	0.37	1.33	5.61	0.24	
		Excavator	0.67	0.40	4.92	0.171	
John Deere 6101 (average of three tests)	1	ISO-C1 8-mode	0.48	0.99	5.68	0.20	0.36
		Agricultural	0.45	0.38	5.11	0.12	0.36
		Backhoe Loader	0.89	1.80	6.16	0.40	0.43
		Crawler Dozer	0.45	1.21	5.45	0.24	0.36
		Excavator	0.67	0.40	4.92	0.171	
Caterpillar 3176 (3)	1	ISO-C1 8-mode	0.08	1.78	5.51	0.183	0.333
		Agricultural	0.08	1.47	5.39	0.180	0.330
		Backhoe Loader	0.12	4.12	7.20	0.290	0.367
		Crawler Dozer	0.06	2.67	5.61	0.230	0.334
MX270 (3)	1	ISO-C1 8-mode	0.11	0.40	4.51	0.096	0.340
		Agricultural	0.06	0.30	4.33	0.090	0.332
		Backhoe Loader	0.09	1.30	4.49	0.200	0.382
		Crawler Tractor	0.04	0.78	4.11	0.140	0.341
		Typ Rubber-Tire	0.07	1.32	4.33	0.180	0.350
		Typ Skid-Steer	0.09	0.68	4.15	0.160	0.374
		Typ Arc Welder	0.20	1.28	5.39	0.190	0.442
MX240 (3)	1	ISO-C1 8-mode	0.06	0.51	4.32	0.116	0.351
		Agricultural	0.05	0.26	4.02	0.090	0.340
		Backhoe Loader	0.12	1.06	4.63	0.200	0.380
		Crawler Tractor	0.05	1.04	3.99	0.160	0.342
		Typ Rubber-Tire	0.09	2.07	4.18	0.250	0.368
		Typ Skid-Steer	0.13	1.00	4.25	0.210	0.379

Table F2. CI Engine Emissions Data Used to Calculate Transient Adjustment Factors

Engine (reference)	Tier	Test Cycle	HC (g/hp-hr)	CO (g/hp-hr)	NO_x (g/hp-hr)	PM (g/hp-hr)	BSFC (lb/hp-hr)
		Typ Arc Welder	0.27	1.65	6.15	0.260	0.451

Table F3. CI Transient Adjustment Factors for Various Nonroad Test Cycles

Engine	Tier	Test Cycle	HC	CO	NO_x	PM	BSFC
Caterpillar 3116	0	Agricultural	0.57	0.30	1.00	0.69	1.01
		Backhoe Loader	5.14	2.98	1.01	1.61	1.17
		Crawler Dozer	1.29	2.91	0.93	1.76	1.03
Caterpillar 3054	0	Agricultural	0.70	0.47	1.26	0.68	0.96
		Backhoe Loader	1.85	3.34	0.72	1.96	1.13
		Crawler Dozer	0.77	1.06	1.10	0.99	0.95
John Deere 4039	0	Agricultural	0.49	0.26	1.04	0.45	0.93
		Backhoe Loader	2.44	1.21	0.85	1.16	1.21
		Crawler Dozer	0.80	0.65	1.04	0.66	0.96
John Deere 7076	0	Agricultural	1.02	0.28	0.92	0.67	0.95
		Backhoe Loader	2.13	2.35	1.40	2.09	1.28
		Crawler Dozer	0.98	1.08	0.99	1.21	0.96
Consolidated Diesel 6TA-830	0	Agricultural	1.05	0.71	0.86	0.77	1.03
		Backhoe Loader	2.42	6.57	1.02	4.28	1.20
		Crawler Dozer	0.97	2.51	0.93	2.03	1.01
John Deere 6619	0	Agricultural	1.06	0.25	0.93	0.43	1.01
		Backhoe Loader	2.43	1.47	1.14	1.66	1.17
		Crawler Dozer	0.98	0.71	0.96	1.05	1.00
Consolidated Diesel 4039	0	Agricultural	0.65	0.74	0.96	0.74	0.94
		Backhoe Loader	2.19	0.98	0.86	1.25	1.12
		Crawler Dozer	0.92	0.62	0.98	0.71	0.94
Caterpillar 3306	0	Agricultural	1.05	0.56	0.99	0.81	1.00
		Backhoe Loader	1.81	3.52	1.11	3.28	1.11
		Crawler Dozer	0.91	1.85	1.00	1.76	0.99
John Deere 6101 (average of three tests)	1	Agricultural	0.99	0.37	0.89	0.63	1.01
		Backhoe Loader	2.06	1.88	1.10	2.12	1.20
		Crawler Dozer	1.01	1.14	0.95	1.22	1.01
		Excavator	1.40	0.44	0.87	0.89	1.03
Caterpillar 3176	1	Agricultural	1.00	0.83	0.98	0.98	0.99
		Backhoe Loader	1.50	2.31	1.31	1.58	1.10
		Crawler Dozer	0.75	1.50	1.02	1.26	1.00
MX270	1	Agricultural	0.55	0.75	0.96	0.94	0.98
		Backhoe Loader	0.82	3.25	1.00	2.08	1.12
		Crawler Dozer	0.36	1.95	0.91	1.46	1.00
		Typ Rubber-Tire	0.64	3.30	0.96	1.88	1.03
		Typ Skid-Steer	0.82	1.70	0.92	1.67	1.10
		Typ Arc Welder	1.82	3.20	1.20	1.98	1.30

Table F3. CI Transient Adjustment Factors for Various Nonroad Test Cycles							
Engine	Tier	Test Cycle	HC	CO	NO_x	PM	BSFC
MX240	1	Agricultural	0.83	0.51	0.93	0.78	0.97
		Backhoe Loader	2.00	2.08	1.07	1.72	1.08
		Crawler Dozer	0.83	2.04	0.92	1.38	0.97
		Typ Rubber-Tire	1.50	4.06	0.97	2.16	1.05
		Typ Skid-Steer	2.17	1.96	0.98	1.81	1.08
		Typ Arc Welder	4.50	3.24	1.42	2.24	1.28
Average of Individual TAFs		Agricultural	0.83	0.50	0.98	0.71	0.98
		Backhoe Loader	2.23	2.66	1.05	2.07	1.16
		Crawler Dozer	0.88	1.50	0.98	1.29	0.99
		Typ Rubber-Tire	1.07	3.68	0.96	2.02	1.04
		Typ Skid-Steer	1.49	1.83	0.95	1.74	1.09
		Typ Arc Welder	3.16	3.22	1.31	2.11	1.29
		Excavator	1.40	0.44	0.87	0.89	1.03
Standard Deviation of TAFs		Agricultural	0.22	0.21	0.10	0.17	0.03
		Backhoe Loader	1.02	1.49	0.19	0.88	0.06
		Crawler Dozer	0.22	0.75	0.06	0.42	0.03
		Typ Rubber-Tire	0.61	0.54	0.01	0.20	0.01
		Typ Skid-Steer	0.95	0.18	0.04	0.10	0.01
		Typ Arc Welder	1.90	0.02	0.16	0.19	0.01
Student's *t*-test: P value* T0 vs T1		Agricultural	0.90	0.21	0.40	0.08	0.77
		Backhoe Loader	0.13	0.67	0.40	0.63	0.17
		Crawler Dozer	0.11	0.64	0.26	0.83	0.36

* P value > 0.05 indicates that the difference between the Tier 0 and Tier 1 values is not statistically significant.

Table F4. CI Cycle Transient Adjustment Factors Binned by Load Factor Category

Cycle	Cycle Load Factors*	Assignment	HC		CO		NO_x	
			Cycle TAFs	New TAFs	Cycle TAFs	New TAFs	Cycle TAFs	New TAFs
None (steady-state)	N/A	None	1.00	1.00	1.00	1.00	1.00	1.00
Agricultural Tractor	0.78	Hi LF	0.83	1.05	0.50	1.53	0.98	0.95
Backhoe/Loader	0.21	Lo LF	2.23	2.29	2.66	2.57	1.05	1.10
Crawler Dozer	0.58	Hi LF	0.88	1.05	1.50	1.53	0.98	0.95
Rubber-Tire Loader	0.48	Hi LF	1.07	1.05	3.68	1.53	0.96	0.95
Skid-Steer Loader	0.23	Lo LF	1.49	2.29	1.83	2.57	0.95	1.10
Arc Welder	0.19	Lo LF	3.16	2.29	3.22	2.57	1.31	1.10
Excavator	0.53	Hi LF	1.40	1.05	0.44	1.53	0.87	0.95
		avg Hi LF	1.05		1.53		0.95	
		avg Lo LF	2.29		2.57		1.10	

Cycle	Cycle Load Factors*	Assignment	PM		BSFC	
			Cycle TAFs	New TAFs	Cycle TAFs	New TAFs
None (steady-state)	N/A	None	1.00	1.00	1.00	1.00
Agricultural Tractor	0.78	Hi LF	0.71	1.23	0.98	1.01
Backhoe/Loader	0.21	Lo LF	2.07	1.97	1.16	1.18
Crawler Dozer	0.58	Hi LF	1.29	1.23	0.99	1.01
Rubber-Tire Loader	0.48	Hi LF	2.02	1.23	1.04	1.01
Skid-Steer Loader	0.23	Lo LF	1.74	1.97	1.09	1.18
Arc Welder	0.19	Lo LF	2.11	1.97	1.29	1.18
Excavator	0.53	Hi LF	0.89	1.23	1.03	1.01
		avg Hi LF	1.23		1.01	
		avg Lo LF	1.97		1.18	

* The load factors shown were obtained from engine test data and are not used directly in NONROAD.

Table F5. CI Transient Adjustment Factors in Draft NONROAD2004

Assignment	HC	CO	NO_x		PM		BSFC
	Base-Tier 3	Base-Tier 3	Base, Tiers 0-2	Tier 3*	Base, Tiers 0-2	Tier 3*	Base-Tier 3
avg Hi LF	1.05	1.53	0.95	1.04	1.23	1.47	1.01
avg Lo LF	2.29	2.57	1.10	1.21	1.97	2.37	1.18
None	1.00	1.00	1.00	1.10	1.00	1.20	1.00

* NO_x Tier 3 TAF = 1.1*(NO_x Base, Tiers 0-2 TAF). PM Tier 3 TAF = 1.2*(PM Base, Tiers 0-2 TAF). TAFs are not applied to the emission factors for Tier 4 engines (i.e., the model applies a TAF of 1.0).

Table F6. CI Transient Adjustment Factor Assignments by Equipment Type

SCC	Equipment Type	Representative Cycle	TAF Assignment
2270001000	Recreational Vehicles All	Backhoe	Lo LF
2270001020	Recreational Vehicles Snowmobiles	None	None
2270001030	Recreational Vehicles All Terrain Vehicles	None	None
2270001040	Recreational Vehicles Minibikes	None	None
2270001050	Recreational Vehicles Golf Carts	None	None
2270001060	Recreational Vehicles Specialty Vehicle Carts	Backhoe	Lo LF
2270002003	Construction Equipment Pavers	Crawler	Hi LF
2270002006	Construction Equipment Tampers/Rammers	None	None
2270002009	Construction Equipment Plate Compactors	None	None
2270002015	Construction Equipment Rollers	Crawler	Hi LF
2270002018	Construction Equipment Scrapers	Crawler	Hi LF
2270002021	Construction Equipment Paving Equipment	Crawler	Hi LF
2270002024	Construction Equipment Surfacing Equipment	Crawler	Hi LF
2270002027	Construction Equipment Signal Boards	None	None
2270002030	Construction Equipment Trenchers	Crawler	Hi LF
2270002033	Construction Equipment Bore/Drill Rigs	None	None
2270002036	Construction Equipment Excavators	Excavator	Hi LF
2270002039	Construction Equipment Concrete/Industrial Saws	Crawler	Hi LF
2270002042	Construction Equipment Cement & Mortar Mixers	None	None
2270002045	Construction Equipment Cranes	None	None
2270002048	Construction Equipment Graders	Crawler	Hi LF
2270002051	Construction Equipment Off-highway Trucks	Crawler	Hi LF
2270002054	Construction Equipment Crushing/Proc. Equipment	None	None
2270002057	Construction Equipment Rough Terrain Forklifts	RTLoader	Hi LF
2270002060	Construction Equipment Rubber Tire Loaders	RTLoader	Hi LF
2270002063	Construction Equipment Rubber Tire Dozers	Crawler	Hi LF
2270002066	Construction Equipment Tractors/Loaders/Backhoes	Backhoe	Lo LF
2270002069	Construction Equipment Crawler Dozer	Crawler	Hi LF
2270002072	Construction Equipment Skid Steer Loaders	SSLoader	Lo LF
2270002075	Construction Equipment Off-Highway Tractors	Crawler	Hi LF
2270002078	Construction Equipment Dumpers/Tenders	Backhoe	Lo LF
2270002081	Construction Equipment Other Construction Equipment	Crawler	Hi LF
2270003010	Industrial Equipment Aerial Lifts	Backhoe	Lo LF
2270003020	Industrial Equipment Forklifts	RTLoader	Hi LF
2270003030	Industrial Equipment Sweepers/Scrubbers	None	None

Table F6. CI Transient Adjustment Factor Assignments by Equipment Type

SCC	Equipment Type	Representative Cycle	TAF Assignment
2270003040	Industrial Equipment Other General Industrial Equipment	None	None
2270003050	Industrial Equipment Other Material Handling Equipment	Backhoe	Lo LF
2270003060	Industrial Equipment AC\Refrigeration	None	None
2270003070	Terminal Tractors	Crawler	Hi LF
2270004000	Lawn & Garden Equipment ALL	None	None
2270004010	Lawn & Garden Equipment Lawn mowers (Residential)	None	None
2270004011	Lawn & Garden Equipment Lawn mowers (Commercial)	None	None
2270004015	Lawn & Garden Equipment Rotary Tillers < 6 HP	None	None
2270004016	Lawn & Garden Equipment Rotary Tillers < 6 HP (Commercial)	None	None
2270004020	Lawn & Garden Equipment Chain Saws < 6 HP	None	None
2270004021	Lawn & Garden Equipment Chain Saws < 6 HP (Commercial)	None	None
2270004025	Lawn & Garden Equipment Trimmers/Edgers/Brush Cutters	None	None
2270004026	Lawn & Garden Equipment Trimmers/Edgers/Brush Cutters (Commercial)	None	None
2270004030	Lawn & Garden Equipment Leafblowers/Vacuums	None	None
2270004031	Lawn & Garden Equipment Leafblowers/Vacuums (Commercial)	None	None
2270004035	Lawn & Garden Equipment Snowblowers	None	None
2270004036	Lawn & Garden Equipment Snowblowers (Commercial)	None	None
2270004040	Lawn & Garden Equipment Rear Engine Riding Mowers	None	None
2270004041	Lawn & Garden Equipment Rear Engine Riding Mowers (Commercial)	None	None
2270004045	Lawn & Garden Equipment Front Mowers	None	None
2270004046	Lawn & Garden Equipment Front Mowers (Commercial)	None	None
2270004050	Lawn & Garden Equipment Shredders < 6 HP	None	None
2270004051	Lawn & Garden Equipment Shredders < 6 HP (Commercial)	None	None
2270004055	Lawn & Garden Equipment Lawn & Garden Tractors	None	None
2270004056	Lawn & Garden Equipment Lawn & Garden Tractors (Commercial)	None	None

Table F6. CI Transient Adjustment Factor Assignments by Equipment Type

SCC	Equipment Type	Representative Cycle	TAF Assignment
2270004060	Lawn & Garden Equipment Wood Splitters	None	None
2270004061	Lawn & Garden Equipment Wood Splitters (Commercial)	None	None
2270004065	Lawn & Garden Equipment Chippers/Stump Grinders	None	None
2270004066	Lawn & Garden Equipment Chippers/Stump Grinders (Commercial)	None	None
2270004071	Lawn & Garden Equipment Commercial Turf Equipment (Commercial)	None	None
2270004075	Lawn & Garden Equipment Other Lawn & Garden Equipment	None	None
2270004076	Lawn & Garden Equipment Other Lawn & Garden Equipment (Commercial)	None	None
2270005010	Farm Equipment 2-Wheel Tractors	AgTractor	Hi LF
2270005015	Farm Equipment Agricultural Tractors	AgTractor	Hi LF
2270005020	Farm Equipment Combines	AgTractor	Hi LF
2270005025	Farm Equipment Balers	AgTractor	Hi LF
2270005030	Farm Equipment Agricultural Mowers	AgTractor	Hi LF
2270005035	Farm Equipment Sprayers	AgTractor	Hi LF
2270005040	Farm Equipment Tillers > 6 HP	AgTractor	Hi LF
2270005045	Farm Equipment Swathers	AgTractor	Hi LF
2270005050	Farm Equipment Hydro Power Units	None	None
2270005055	Farm Equipment Other Agricultural Equipment	AgTractor	Hi LF
2270005060	Farm Equipment Irrigation Sets	None	None
2270006000	Light Commercial ALL	None	None
2270006005	Light Commercial Generator Sets	None	None
2270006010	Light Commercial Pumps	None	None
2270006015	Light Commercial Air Compressors	None	None
2270006020	Light Commercial Gas Compressors	None	None
2270006025	Light Commercial Welders	ArcWelder	Lo LF
2270006030	Light Commercial Pressure Washers	None	None
2270007005	Logging Equipment Chain Saws > 6 HP	RTLoader	Hi LF
2270007010	Logging Equipment Shredders > 6 HP	RTLoader	Hi LF
2270007015	Logging Equipment Forest Equipment	RTLoader	Hi LF
2270008005	Airport Service Equipment Airport Support Equipment	RTLoader	Hi LF
2270009010	Other Underground Mining Equipment	Backhoe	Lo LF
2270010010	Other Oil Field Equipment	None	None

Table F6. CI Transient Adjustment Factor Assignments by Equipment Type

SCC	Equipment Type	Representative Cycle	TAF Assignment
2282020005	Recreational Pleasure Craft, Inboards	None	None
2282020010	Recreational Pleasure Craft, Outboards	None	None
2282020015	Recreational Pleasure Craft, Personal Water Craft	None	None
2282020025	Recreational Pleasure Craft, Sailboat Aux. Outboard	None	None
2285002015	Railway Maintenance	Backhoe	Lo LF

Table F7. Comparison of TAF Methodology Used in Draft Versions of NONROAD

Model Date	Model Version Name	Data as Basis (# of engines)	Cycles Used	Treatment of Tier 0 vs Tier 1 Data	Ratio of Averages or Average of Ratios?	TAFs Used and Assignments
June 1998	"Original"	9 engines (8 Tier 0 and 1 Tier 1 engines)	Ag tractor Backhoe Loader Crawler Dozer	Tier 0 and Tier 1 data combined	Ratio of averages	3 cycle TAFs. One assigned to each equipment type
April 1999	"Tier 2"	No TAF-related changes				
June 2000	"2007 HD Rule"	12 engines (8 Tier 0 and 4 Tier 1 engines)	Ag tractor Backhoe Loader Crawler Dozer RT Loader SS Loader Arc Welder	Tier 0 and Tier 1 data separated; separate TAFs for each	Ratio of averages	Revised to accommodate separate T0 and T1 TAFs and 3 additional cycles
Nov 2000	"Final Finding / ANPRM"	No TAF related changes relative to June 2000 version				
Oct 2001	"Pentathlon NPRM"	12 engines (8 Tier 0 and 4 Tier 1 engines)	Ag tractor Backhoe Loader Crawler Dozer RT Loader SS Loader Arc Welder	Tier 0 and Tier 1 data re-combined	Average of ratios	6 cycle TAFs. One assigned to each equipment type
March 2002 April 2004 Dec 2005 July 2009	"NONROAD 2002" and "NONROAD 2004" and "NONROAD 2005" and "NONROAD 2008a"	12 engines (8 Tier 0 and 4 Tier 1 engines)	Ag tractor Backhoe Loader Crawler Dozer RT Loader SS Loader Arc Welder Excavator	Tier 0 and Tier 1 data combined	Average of ratios	7 cycle TAFs binned in two categories: Hi LF and Lo LF. One assigned to each equipment type.

20 Appendix G: Derivation of Deterioration Factors for Nonroad Compression Ignition Engines

Deterioration factors used in emissions models are intended to account for increases in emissions above a new engine or vehicle's base emissions level with time. Emissions can increase with time for a number of reasons including, engine wear, poor maintenance practices, and willful or unwitting tampering with emission control systems. Emissions from conventional (pre-aftertreatment) diesel engines increase with time (deteriorate) at a very slow rate when the engine is properly maintained and operated. In fact for a number of pollutants (primarily NOx), emission levels can actually drop slightly as the engine ages. However, anecdotal and emission test experience suggests that many diesel engines emit at a much higher level in-use (especially PM) than would be anticipated for a well maintained diesel engine.

Diesel engines are extremely robust and can continue to provide adequate performance for a user, even when they have been poorly maintained. Unlike speed and load characterized performance, however, their emissions performance can decrease quite rapidly when the engine receives poor maintenance. Analysis and testing conducted by contractors to EPA and to the California Air Resources Board (CARB) have shown that these maintenance and tampering issues comprise the bulk of the observed increase in PM emissions from diesel engines in-use. (1) When CARB updated the large CI component of its OFFROAD model in 2000, they accounted for this increase in emissions by using deterioration factors developed from real world observations of in-use PM emissions correlated to particular engine technologies. (2) We believe that this is the appropriate approach for PM emission modeling in order to account for all of the possible mechanisms of PM deterioration. We have therefore adopted the PM deterioration factors from CARB's OFFROAD model in this version of NONROAD. We averaged the highway-based LDDT, MHDT, and HHDT PM deterioration factors used in CARB's OFFROAD model (0.31, 0.44, and 0.67, respectively) and applied the average (0.473) to all tiers.

For HC, CO, and NO_x, we have continued our practice of using deterioration factors developed by manufacturers based upon well maintained engines. We have done so because we believe that maintenance and tampering issues do not affect the emission rates of these pollutants as dramatically. As a result, we base the HC, CO, and NO_x deterioration factors adopted for nonroad engines on highway certification data (zero-hour levels and lifetime deterioration) (3). We used the same data to derive highway compliance margins for the steady-state emission factor analysis. Correspondence between highway weight class (light, medium, heavy), highway model-year group, and nonroad horsepower categories is identical to that used for the steady-state emission factor analysis.

We converted the highway engine deterioration estimates into a format applicable to nonroad engines, following these steps:

(1) We calculated absolute deterioration rates DF_{abs} using the zero-hour emission factors and lifetime deterioration estimates presented in reference (3).

(2) We converted the absolute deterioration rates DF_{abs} (g/hp-hr^2) to relative deterioration rates DF_{rel} (percent emissions increase/percent useful life expended).

(3) We calculated a separate DF_{rel} for each combination of pollutant**,** Tier, and horsepower category. Then to derive a single value for each Tier and pollutant, we simply averaged the DF_{rel}.

We discuss these calculations in greater detail below.

To adapt highway-certification deterioration rates for application to nonroad engines, it was necessary to convert them from an absolute basis (emissions increase over engine's useful life (g/hp-hr)) to a relative basis (percent emissions increase/percent useful life expended). This conversion involves relating the emissions increase over the engine's useful life to the zero-hour emission factor, in proportional terms.

We achieved this conversion as follows. To begin, if we assume linear deterioration with the intercept at the zero-hour emission factor, (0 deterioration increase at 0 miles (0 hours useful life)), it is possible to calculate the absolute slope of the line, i.e., the absolute deterioration rate DF_{abs} (g/hp-hr^2) (Figure 1 on next page). The required data are the absolute emissions increase D_T (g/hp-hr) over engine's useful life L (years) and the zero-hour emission factor EF_{zm} (g/hp-hr):

$$DF_{abs} = \frac{\Delta y}{\Delta x} = \frac{(EF_{zm} + D_T) - EF_{zm}}{L - 0} = \frac{D_T}{L}$$

Dividing the numerator and denominator by EF_{zm} and L, respectively, and multiplying each by 100 expresses the deterioration factor in percentage terms with respect to emissions increase and useful life, giving a relative deterioration rate DF_{rel} (percent emissions increase/percent useful life).

Thus, the relative deterioration rate is the quotient of the absolute emissions increase and the zero-hour emission factor. Tables G1-G3 present estimates of DF_{rel} for each combination of pollutant, Tier and horsepower category. To derive individual values of DF_{rel} for each pollutant and Tier, we calculated simple unweighted averages.

The resulting DF_{rel} for each pollutant and Tier are presented in Table G4. For Tier 4 engines, we apply the DF_{rel} developed for Tier 3 engines.

We intend to continue to monitor in-use PM emissions levels, and as the body of data increases (especially for newer engine technologies), we intend to further update the deterioration factors used here. Similarly, if we learn that deterioration rates for other pollutants also increase significantly in-use, we will update those factors as well.

References

(1) Engine, Fuel and Emissions Engineering, Inc., "Modeling Deterioration in Heavy-Duty Diesel Particulate Emissions," report prepared for U.S. Environmental Protection Agency,

1998.

(2) ARB, “Public Meeting to Consider Approval of the Emissions Inventory of Off-Road Large Compression-Ignited (CI) Engines (>25HP),” January 2000.

(3) EPA, “Update of Heavy-Duty Emission Levels (Model Years 1988-2004+) for Use in MOBILE6,” EPA420-R-99-010, April 1999.

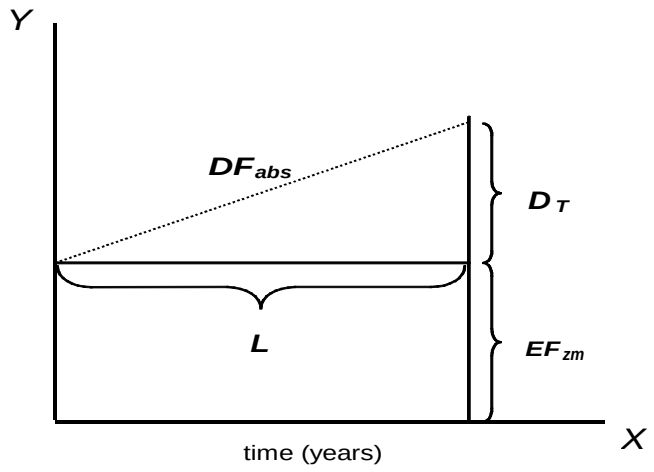

Figure 1. Conceptual representation of absolute linear emissions deterioration over the useful life of a diesel engine.

Table G1. Hydrocarbon (HC) Deterioration Factors by Tier and Horsepower Category					
Nonroad Engine Power Categories (hp)	**Corresponding Highway Vehicle Weight Class[1]**	**Corresponding Highway Model-Year Group**	**Corresponding Highway Certification Test Results and Deterioration Factors**		
			***EF_{ZM}*[2] (g/hp-hr)**	***D_T*[3] (g/hp-hr)**	***DF_{rel}*[4] (%increase/% useful life)**
				Tier 0	
< 11	LHDD	1988-89	0.64	0.02	0.031
11-25	LHDD	1988-89	0.64	0.02	0.031
25-50	LHDD	1988-89	0.64	0.02	0.031
50-100	MHDD	1988-89	0.66	0.05	0.068
100-175	MHDD	1988-89	0.66	0.05	0.068
175-300	MHDD	1988-89	0.66	0.05	0.068
300-600	HHDD	1988-89	0.47	0.02	0.043
600-750	HHDD	1988-89	0.47	0.02	0.043
>750	HHDD	1988-89	0.47	0.02	0.043
				Tiers 1-3	
< 11	LHDD	1994-97	0.26	0.01	0.038
11-25	LHDD	1994-97	0.26	0.01	0.038
25-50	LHDD	1994-97	0.26	0.01	0.038
50-100	MHDD	1994-97	0.31	0.00	0.000
100-175	MHDD	1994-97	0.31	0.00	0.000
175-300	MHDD	1994-97	0.31	0.00	0.000
300-600	HHDD	1994-97	0.22	0.02	0.068
600-750	HHDD	1994-97	0.22	0.02	0.068
>750	HHDD	1994-97	0.22	0.02	0.068

1 LHDD = “light heavy-duty diesel,” MHDD = “medium heavy-duty diesel,” and HHDD = “heavy heavy-duty diesel.”
2 Zero-hour emission factor, Source: USEPA 1999, Table 8.
3 Lifetime Deterioration (cumulative deterioration over vehicle useful life), Source USEPA 1999, Table 8.
4 Relative Deterioration Factor, calculated as DT/EFzm. For discussion, see text.

Table G2. CO Deterioration Factors by Tier and Horsepower Category[1]

Nonroad Engine Power Categories (hp)	Corresponding Highway Vehicle Weight Class[1]	Corresponding Highway Model-Year Group	Corresponding Highway Certification Test Results and Deterioration Factors		
			EF_{ZM}[2] (g/hp-hr)	D_T[3] (g/hp-hr)	EF_{ZM}[2] (g/hp-hr)
				Tier 0	
< 11	LHDD	1988-89	1.22	0.24	0.198
11-25	LHDD	1988-89	1.22	0.24	0.198
25-50	LHDD	1988-89	1.22	0.24	0.198
50-100	MHDD	1988-89	1.70	0.33	0.195
100-175	MHDD	1988-89	1.70	0.33	0.195
175-300	MHDD	1988-89	1.70	0.33	0.195
300-600	HHDD	1988-89	1.36	0.22	0.162
600-750	HHDD	1988-89	1.36	0.22	0.162
>750	HHDD	1988-89	1.36	0.22	0.162
				Tiers 1-3	
< 11	LHDD	1994-97	1.20	0.03	0.021
11-25	LHDD	1994-97	1.20	0.03	0.021
25-50	LHDD	1994-97	1.20	0.03	0.021
50-100	MHDD	1994-97	0.88	0.17	0.189
100-175	MHDD	1994-97	0.88	0.17	0.189
175-300	MHDD	1994-97	0.88	0.17	0.189
300-600	HHDD	1994-97	1.07	0.10	0.093
600-750	HHDD	1994-97	1.07	0.10	0.093
> 750	HHDD	1994-97	1.07	0.10	0.093

1 LHDD = "light heavy-duty diesel," MHDD = "medium heavy-duty diesel," and HHDD = "heavy heavy-duty diesel."
2 Zero-hour emission factor, Source: USEPA 1999, Table 9.
3 Lifetime Deterioration (cumulative deterioration over vehicle useful life), Source USEPA 1999, Table 9.
4 Relative Deterioration Factor, calculated as DT/EFzm. For discussion, see text.

Table G3. NOx Deterioration Factors by Pollutant and Horsepower Category[1]					
Nonroad Engine Power Categories (hp)	**Corresponding Highway Vehicle Weight Class[1]**	**Corresponding Highway Model-Year Group**	**Corresponding Highway Certification Test Results and Deterioration Factors**		
			EF_{ZM}[2] (g/hp-hr)	D_T[3] (g/hp-hr)	EF_{ZM}[2] (g/hp-hr)
				Tier 0-1	
< 11	LHDD	1988-89	4.34	0.02	0.005
11-25	LHDD	1988-89	4.34	0.02	0.005
25-50	LHDD	1988-89	4.34	0.02	0.005
50-100	MHDD	1988-89	6.43	0.16	0.025
100-175	MHDD	1988-89	6.43	0.16	0.025
175-300	MHDD	1988-89	6.43	0.16	0.025
300-600	HHDD	1988-89	6.28	0.28	0.044
600-750	HHDD	1988-89	6.28	0.28	0.044
>750	HHDD	1988-89	6.28	0.28	0.044
				Tier 2	
< 11	LHDD	1991-93	4.28	0.01	0.003
11-25	LHDD	1991-93	4.28	0.01	0.003
25-50	LHDD	1991-93	4.28	0.01	0.003
50-100	MHDD	1998-2003	4.67	0.03	0.006
100-175	MHDD	1998-2003	4.67	0.03	0.006
175-300	MHDD	1998-2003	4.67	0.03	0.006
300-600	HHDD	1998-2003	4.70	0.05	0.011
600-750	HHDD	1998-2003	4.70	0.05	0.011
>750	HHDD	1998-2003	4.70	0.05	0.011
				Tier 3	
50-100	MHDD	1998-2003	4.67	0.03	0.006
100-175	MHDD	1998-2003	4.67	0.03	0.006
175-300	MHDD	1998-2003	4.67	0.03	0.006
300-600	HHDD	1998-2003	4.70	0.05	0.011
600-750	HHDD	1998-2003	4.70	0.05	0.011

1 LHDD = “light heavy-duty diesel,” MHDD = “medium heavy-duty diesel,” and HHDD = “heavy heavy-duty diesel.”
2 Zero-hour emission factor, Source: USEPA 1999, Table 10.
3 Lifetime Deterioration (cumulative deterioration over vehicle useful life), Source USEPA 1999, Table 10.
4 Relative Deterioration Factor, calculated as DT/EFzm. For discussion, see text.

Table G4. Deterioration Factors for Nonroad Diesel Engines

Pollutant	Relative Deterioration Factor (DF_{rel}) (% increase/%useful life)[1]			
	Base/Tier 0	**Tier 1**	**Tier 2**	**Tier 3 &Tier 4**
HC	0.047	0.036	0.034	0.027
CO	0.185	0.101	0.101	0.151
NOx	0.024	0.024	0.009	0.008
PM	0.473	0.473	0.473	0.473

[1]DF_{rel} = A in the equation: DF =1+A*(fraction of useful life expended)^b . Note that the coefficient b = 1.0 for diesel engines, i.e., the deterioration trend is linear.