

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

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

## NOTICE

*This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.*

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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<sub>x</sub>), particulate matter (PM), carbon dioxide (CO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>). 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<sub>x</sub>, 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<sub>2</sub> and SO<sub>2</sub> 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<sub>10</sub> (particulate matter smaller than 10 microns) and PM<sub>2.5</sub> (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<sup>1</sup>. 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<sup>2</sup>.

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<sup>3</sup>. 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<sup>4</sup>, 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)<sup>5</sup>.
- “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<sup>6</sup>.

- “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<sup>7</sup>.
- “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<sup>8</sup>.
- “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<sup>9</sup>.

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<sup>a</sup>**

| Engine Power<br>(hp) | Model Years | Regulation                                        | Emission Standards (g/hp-hr) |                      |     |                 |      | Nonroad Tech Types <sup>g</sup> |
|----------------------|-------------|---------------------------------------------------|------------------------------|----------------------|-----|-----------------|------|---------------------------------|
|                      |             |                                                   | HC <sup>b</sup>              | NMHC+NO <sub>x</sub> | CO  | NO <sub>x</sub> | 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<br>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 <sup>c</sup>                               |                              | 3.5                  | 3.7 |                 | 0.30 | T3                              |
|                      | 2008-2012   | Tier 4<br>transitional<br>(Option 1) <sup>d</sup> |                              | 3.5                  | 3.7 |                 | 0.22 | T4A                             |
|                      | 2012        | Tier 4<br>transitional<br>(option 2) <sup>d</sup> |                              | 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<br>transitional <sup>e</sup>               |                              | 3.5                  | 3.7 |                 | 0.01 | T4IA/T4IB/T4IC/TI4D             |

**Table 2-1. Nonroad CI Engine Emission Standard (cont.)<sup>a</sup>**

| Engine Power<br>(hp) | Model Years | Regulation                          | Emission Standards (g/hp-hr) |                      |     |                 |      | Nonroad Tech Types <sup>g</sup> |
|----------------------|-------------|-------------------------------------|------------------------------|----------------------|-----|-----------------|------|---------------------------------|
|                      |             |                                     | HC <sup>b</sup>              | NMHC+NO <sub>x</sub> | CO  | NO <sub>x</sub> | PM   |                                 |
|                      |             |                                     |                              |                      |     |                 |      |                                 |
|                      | 2014+       | Tier 4 final <sup>f</sup>           | 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<br>transitional <sup>e</sup> |                              | 3.0                  | 3.7 |                 | 0.01 | T4IA/T4IB/T4IC/TI4D             |
|                      | 2014+       | Tier 4 final <sup>f</sup>           | 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<br>transitional <sup>e</sup> |                              | 3.0                  | 2.6 |                 | 0.01 | T4IA/T4IB/T4IC/TI4D             |
|                      | 2014+       | Tier 4 final <sup>f</sup>           | 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<br>transitional <sup>e</sup> |                              | 3.0                  | 2.6 |                 | 0.01 | T4IA/T4IB/T4IC/TI4D             |
|                      | 2014+       | Tier 4 final <sup>f</sup>           | 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<br>transitional <sup>e</sup> |                              | 3.0                  | 2.6 |                 | 0.01 | T4IA/T4IB/T4IC/TI4D             |

**Table 2-1. Nonroad CI Engine Emission Standard (cont.)<sup>a</sup>**

| Engine Power<br>(hp)         | Model Years | Regulation                | Emission Standards (g/hp-hr) |                      |     |                 |       | Nonroad Tech Types <sup>g</sup> |
|------------------------------|-------------|---------------------------|------------------------------|----------------------|-----|-----------------|-------|---------------------------------|
|                              |             |                           | HC <sup>b</sup>              | NMHC+NO <sub>x</sub> | CO  | NO <sub>x</sub> | PM    |                                 |
|                              | 2014+       | Tier 4 final <sup>f</sup> | 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 <sup>f</sup> | 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 <sup>f</sup> | 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 <sup>f</sup> | 0.14                         |                      | 2.6 | 0.5             | 0.02  | T4FA/T4FB/T4FC/TF4D             |

<sup>a</sup> The standards for recreational marine diesel engines are provided in Table 5-1 .

<sup>b</sup> Tier 4 standards are in the form of NMHC.

<sup>c</sup> 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.

<sup>d</sup> 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.

<sup>e</sup> 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.

<sup>f</sup> 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.

<sup>g</sup> 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 particulate 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**

| <b>T4I/T4F Sub-category Index</b> | <b>DPF</b> | <b>SCR</b> |
|-----------------------------------|------------|------------|
| 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<sup>2</sup>.

## 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 – TPME)<sup>10</sup>, 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<sup>11</sup>, as well as engineering or technical hardship relief allowances<sup>12</sup>. 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

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\* For engine power categories where  $hp \leq 75$ , 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 TPPEM, the standard required for the exempted equipment is the Tier 1 standard.

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

| <b>Model Year</b> | <b>Technology Distributions</b> |
|-------------------|---------------------------------|
| 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<sup>3</sup> 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.

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\* 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)**

| <b>Model Year</b> | <b>HP&lt;25</b> | <b>25≤ HP&lt;50</b> | <b>50≤ HP&lt;75</b> | <b>75≤HP&lt;175</b> | <b>175≤HP≤750</b> | <b>750&lt;HP</b> |
|-------------------|-----------------|---------------------|---------------------|---------------------|-------------------|------------------|
| 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<sup>13</sup>.

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<sup>10</sup>) 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.

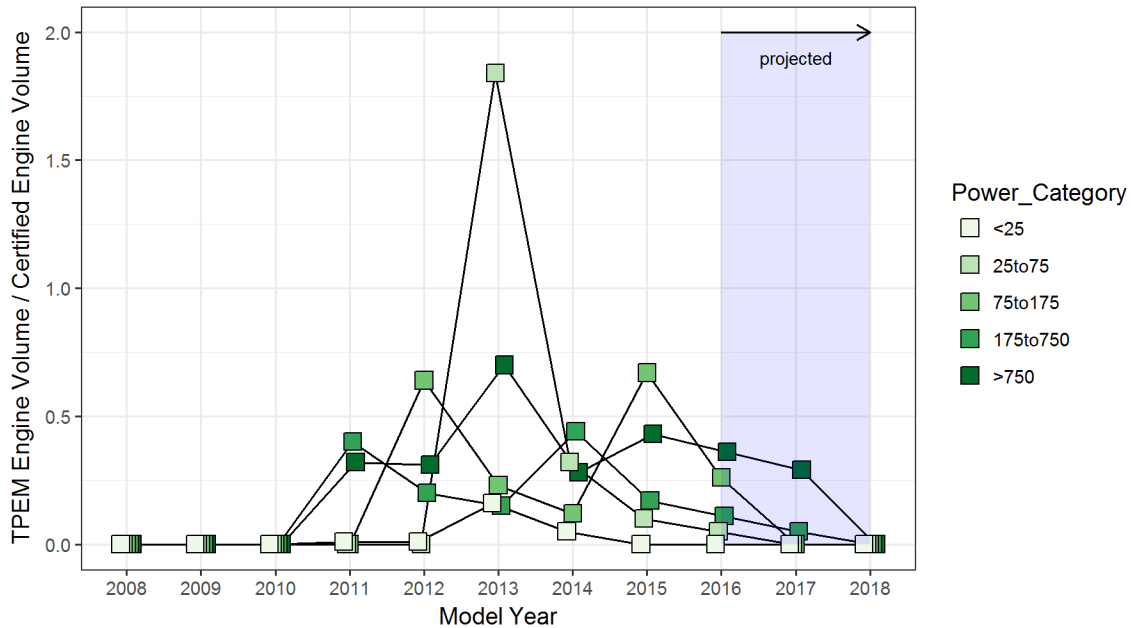
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\* The regular TPEM program ends in 2014 for engines <75HP, in 2018 for engines between 75 and 175 HP, and in 2017 for engines greater than 175 HP.

**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<sub>x</sub>, the exhaust emission factor for a given diesel equipment type in a given model year/age is calculated as follows:

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

Where:

- EF<sub>adj</sub> = final emission factor used in model, after adjustments to account for transient operation and deterioration (g/hp-hr)
- EF<sub>ss</sub> = 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<sub>ss</sub>) 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:

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

Where:

- S<sub>PM adj</sub> = adjustment to PM emission factor to account for variations in fuel sulfur content (g/hp-hr)

PM and SO<sub>2</sub> 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:

$$EF_{adj(BSFC)} = EF_{ss} \times TAF \quad \text{Equation 3}$$

Where:

- EF<sub>adj(BSFC)</sub> = final brake specific fuel consumption used in model, after adjustments to account for transient operation (lb/hp-hr)
- EF<sub>ss</sub> = steady-state brake specific fuel consumption (lb/hp-hr)
- TAF = transient adjustment factor (unitless)

Emission factors for CO<sub>2</sub> and SO<sub>2</sub> are calculated based on brake-specific fuel consumption; therefore, the model does not require CO<sub>2</sub> or SO<sub>2</sub> 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<sup>14</sup>. 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<sub>x</sub>, PM and BSFC**

This section describes the steady-state fuel consumption and emission factors for HC, CO, NO<sub>x</sub>, 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<sup>15</sup>.

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<sup>16</sup>, 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 <sup>a</sup> | 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                                        |

<sup>a</sup> 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<sub>x</sub>, 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.

### Base (Pre-1988), Engines ≤50 hp:

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 <sup>a</sup> | T0 Basis | Tier 1 | T1 Basis | Tier 2 <sup>b</sup> | T2 Basis <sup>c</sup>                                                                          | Tier 3 <sup>b</sup> | T3 Basis <sup>c</sup>           | Tier 4 <sup>c</sup> | T4 Basis |
| >0 to 11    | 1.5                 | OFFROAD  | 0.7628 | cert     | 0.5508 <sup>d</sup> | (5) 10% default margin from 0.6 equivalent std<br>(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<br>(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<br>(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<br>(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 <sup>d</sup> | (5) 10% default margin from 0.4 equivalent std<br>(since T1 EF exceeds T2 std, cannot be used) | 0.1836 <sup>d</sup> | (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 <sup>d</sup> | (5) 10% default margin from 0.4 equivalent std<br>(since T1 EF exceeds T2 std, cannot be used) | 0.1836 <sup>d</sup> | (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<br>(since T1 EF still below 0.4 T2 equivalent std)                              | 0.1836 <sup>d</sup> | (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<br>(since T1 EF still below 0.4 T2 equivalent std)                              | 0.1836 <sup>d</sup> | (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 <sup>a</sup> | T0 Basis | Tier 1 | T1 Basis | Tier 2 <sup>b</sup> | T2 Basis <sup>c</sup>                                                                                           | Tier 3 <sup>b</sup> | T3 Basis <sup>c</sup> | Tier 4 <sup>e</sup> | 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.                                                            | na                  |                       | varies by tech type | cert     |
| Gen sets >750 to 1200 | 0.68                | EF data  | 0.2861 | cert     | 0.1669              | b) The NO <sub>x</sub> T1 EFs exceed the T2 std. To meet NO <sub>x</sub> T2, changes are likely to increase HC. | na                  |                       | varies by tech type | cert     |
| Gen sets >1200        | 0.68                | EF data  | 0.2861 | cert     | 0.1669              | c) EF based on actual cert data.                                                                                | na                  |                       | varies by tech type | cert     |

<sup>a</sup> 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.

<sup>b</sup> The Tier 2 and Tier 3 standards are expressed as a combined NMHC + NO<sub>x</sub> 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.

<sup>c</sup> Numbers in parentheses correspond to the option selected, which is briefly described here. For more details regarding the options, consult the text.

<sup>d</sup> 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.

<sup>e</sup> 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 <sup>a</sup> | T0 Basis | Tier 1 | T1 Basis | Tier 2 | T2 Basis <sup>b</sup>                       | Tier 3 | T3 Basis <sup>b</sup> | Tier 4 <sup>d</sup> | 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 NO<sub>x</sub> Zero-Hour Steady-State Nonroad CI Emission Factors in MOVES2014b**

| HP                    | NO <sub>x</sub> g/hp-hr |          |        |          |                     |                                                                        |                     |                                 |                     |          |
|-----------------------|-------------------------|----------|--------|----------|---------------------|------------------------------------------------------------------------|---------------------|---------------------------------|---------------------|----------|
|                       | Tier 0 <sup>a</sup>     | T0 Basis | Tier 1 | T1 Basis | Tier 2 <sup>b</sup> | T2 Basis <sup>c</sup>                                                  | Tier 3 <sup>b</sup> | T3 Basis <sup>c</sup>           | Tier 4 <sup>d</sup> | 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<br>(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<br>(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<br>(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     |

<sup>a</sup> 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.

<sup>b</sup> The Tier 2 and Tier 3 standards are expressed as a combined NMHC + NO<sub>x</sub> standard. The NO<sub>x</sub> assumed fractions of these combined standards are taken from the RIA.

The resulting NO<sub>x</sub> portion of the combined standard is referred to here as the “equivalent” standard.

<sup>c</sup> 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.

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

**Table 4-5. Summary of the Basis for the PM<sub>10</sub> Zero-Hour Steady-State Nonroad CI Emission Factors in MOVES2014b**

| HP          | PM <sub>10</sub> g/hp-hr |          |        |          |        |                                                                                                                                                                                                                                                     |        |                       |                     |          |
|-------------|--------------------------|----------|--------|----------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------|---------------------|----------|
|             | Tier 0 <sup>a</sup>      | T0 Basis | Tier 1 | T1 Basis | Tier 2 | T2 Basis <sup>b</sup>                                                                                                                                                                                                                               | Tier 3 | T3 Basis <sup>b</sup> | Tier 4 <sup>d</sup> | T4 Basis |
| >0 to 11    | 1                        | OFFROAD  | 0.4474 | cert     | 0.50   | (1) The NO <sub>x</sub> T1 EF exceeds the T2 std. To meet NO <sub>x</sub> 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 <sub>10</sub> g/hp-hr |          |        |          |        |                       |        |                       |                        |          |
|--------------------------|--------------------------|----------|--------|----------|--------|-----------------------|--------|-----------------------|------------------------|----------|
|                          | Tier 0 <sup>a</sup>      | T0 Basis | Tier 1 | T1 Basis | Tier 2 | T2 Basis <sup>b</sup> | Tier 3 | T3 Basis <sup>b</sup> | Tier 4 <sup>d</sup>    | T4 Basis |
| >750 except<br>gen sets  | 0.402                    | EF data  | 0.1934 | cert     | 0.1316 |                       | na     |                       | varies by<br>tech type | cert     |
| Gen sets<br>>750 to 1200 | 0.402                    | EF data  | 0.1934 | cert     | 0.1316 |                       | na     |                       | varies by<br>tech type | cert     |
| Gen sets<br>>1200        | 0.402                    | EF data  | 0.1934 | cert     | 0.1316 |                       | na     |                       | varies by<br>tech type | cert     |

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> 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.

<sup>d</sup> 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)<sup>14</sup>. 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<sup>17</sup>. 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<sup>18</sup>. 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 $\leq 300$ 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<sub>x</sub>. 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<sub>x</sub>, 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<sub>x</sub>, 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<sub>x</sub> 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<sub>x</sub>. 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<sub>x</sub> 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<sup>1</sup>**

| Power Range<br>(hp) | Combined Standard<br>HC+NO <sub>x</sub><br>(g/hp-hr) |        | Estimated<br>Pollutant-Specific<br>HC<br>(g/hp-hr) |        | Estimated<br>Pollutant-Specific<br>NO <sub>x</sub><br>(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                                                             |        |

<sup>1</sup> Pollutant-specific components have no regulatory significance and are derived to facilitate modeling analyses.

#### Basis for Pollutant-Specific HC and NO<sub>x</sub> Emission Standards:

Tier 2 <50 hp: As in the RIA<sup>18</sup>, 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<sub>x</sub> standard to split the standard into single pollutant emission factors.

Tier 2 ≥50 hp: As in the RIA<sup>18</sup>, the proposed European NO<sub>x</sub> standard is used to split the combined HC+NO<sub>x</sub> standard into single pollutant emission factors.

Tier 3: MOVES-Nonroad follows the RIA<sup>18</sup> 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<sub>x</sub> standard to split the standard into single pollutant emission factors.

**NO<sub>x</sub>:** *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<sub>x</sub> 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<sub>x</sub>, 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<sup>3</sup> for model years from 2011\* thru 2017. This data set is described earlier in this document under the Emission Standards section. The HC, CO, NO<sub>x</sub>, 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<sup>19</sup>, similar to previous Tier regulations. Therefore, some engine families certified as Tier 4 may have emission factors higher than the applicable standards.

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\* 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<sup>6</sup>. Tier 2 standards for recreational marine CI engines over 50 hp were established by the November 2002 rule<sup>7</sup>. In 2008, Tier 3 standards were promulgated for all recreational marine engines<sup>9</sup>, 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) |                     |     |      | Nonroad Tech Types |
|-------------------|-----------------------------|------------------|------------|------------------------------|---------------------|-----|------|--------------------|
|                   |                             |                  |            | NMHC +NO <sub>x</sub>        | HC +NO <sub>x</sub> | CO  | PM   |                    |
| <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 <sup>a</sup>   |
| ≥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 <sup>a</sup>   |
| ≥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                |

<sup>a</sup> 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<br>(hp) | Model<br>Year Start | Tech Type        | Emission Factor Modeling Inputs (g/hp-hr) |      |       |       | BSFC<br>(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 <sup>a</sup> | 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 <sup>a</sup> | 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 |                    |

<sup>a</sup> 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<sub>x</sub>, 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<sup>20</sup>. 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 ( $EF_{ss}$ ):

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

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<sub>x</sub>, 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:

$$\begin{aligned} DF &= 1 + A * (\text{Age Factor})^b && \text{for Age Factor} \leq 1 \\ DF &= 1 + A && \text{for Age Factor} > 1 \end{aligned} \quad \text{Equation 5}$$

Where:

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

A, b = constants for a given pollutant/technology type;  $b \leq 1$ .

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<sup>15</sup>.  $S_{PM\ adj}$  is calculated using the following equation:

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

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) then the sulfur adjustment is added to the base PM emission factors.

### **Sample Calculation--EF<sub>adj</sub>**

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<sub>ss</sub> = 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:

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

Where:

Diesel excavator activity = 1092 hours/year (from *nrsourcetype* MOVES input DB file)  
Diesel excavator load factor = 0.59 (from *nrsourcetype* MOVES input DB file )  
Diesel excavator median life = 4667 hours (from *nrsourcetype* 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<sub>PM adj</sub>, is calculated as:

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

Where:

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

Substituting the values into the equation yields:

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

The resulting adjusted emission factor is calculated as follows:

$$\begin{aligned} EF_{adj(PM)} &= EF_{ss} * TAF * DF - S_{PM\ adj} \\ &= (0.2799 * 1.23 * 1.196) - 0.0269 \\ &= 0.385 \text{ g/hp-hr} \end{aligned}$$

## 9 Emission Factors – CO<sub>2</sub> and SO<sub>2</sub>

Emission factors for CO<sub>2</sub> and SO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> emission factors input file.

$$CO_2 = (BSFC * 453.6 - HC) * 0.87 * (44/12) \quad \text{Equation 9}$$

Where:

$$\begin{aligned} CO_2 &\text{ is in g/hp-hr} \\ BSFC &\text{ is the in-use adjusted brake-specific fuel consumption in lb/hp-hr} \\ 453.6 &\text{ is the conversion factor from pounds to grams} \\ HC &\text{ is the in-use adjusted hydrocarbon emissions in g/hp-hr} \\ 0.87 &\text{ is the carbon mass fraction of diesel} \\ 44/12 &\text{ is the ratio of CO}_2 \text{ mass to carbon mass} \end{aligned}$$

The model does not require an SO<sub>2</sub> emission factors input file either. EPA will calculate SO<sub>2</sub> emission factors as shown in the equation below.

$$SO_2 = (BSFC * 453.6 * (1 - soxcnv) - HC) * 0.01 * soxdsl * 2 \quad \text{Equation 10}$$

Where:

SO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> and SO<sub>2</sub> 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<sub>2</sub> and SO<sub>2</sub> 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<sup>14</sup>, 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<sup>21</sup>. 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<sub>2.5</sub> Fraction of PM<sub>10</sub>

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

## 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<sup>23</sup>.

### 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, NO<sub>x</sub>, 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<sup>24</sup>. According to the CARB's documentation<sup>25</sup>, they used the EPA nonroad compression ignition certification data<sup>26</sup> 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 constraints 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<sup>27</sup> 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<sub>x</sub>, or PM emissions, it may be a problem with CO<sub>2</sub> 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<sub>2</sub> 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.

## 13 References

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- <sup>1</sup> USEPA, “Exhaust Emission Factors for Nonroad Engine Modeling – Spark-Ignition, NR-010f,” EPA-420-R-10-019, July 2010 (<https://www.epa.gov/moves/nonroad-technical-reports#2008a>).
- <sup>2</sup> USEPA, “Speciation Profiles and Toxic Emission Factors for Nonroad Engines in MOVES2014b,” EPA-420-R-18-011, July 2018, Ann Arbor, MI, Office of Transportation and Air Quality, US Environmental Protection Agency (<https://www.epa.gov/moves/moves-technical-reports>).
- <sup>3</sup> USEPA, “VERIFY Database” (<https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-engines-and-equipment>).
- <sup>4</sup> USEPA, “Exhaust Emission Factors for Nonroad Engine Modeling – Compression-Ignition, NR-009d,” EPA-420-R-10-018, July 2010 (<https://www.epa.gov/moves/nonroad-technical-reports#2008a>).
- <sup>5</sup> USEPA, “Control of Air Pollution; Determination of Significance for Nonroad Sources and Emission Standards for New Nonroad Compression Ignition Engines At or Above 37 Kilowatts,” 59 FR 31306, June 17, 1994.
- <sup>6</sup> USEPA, “Control of Emissions of Air Pollution From Nonroad Diesel Engines,” 63 FR 56967, October 23, 1998.
- <sup>7</sup> USEPA, “Control of Emissions From Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based); Final Rule,” 67 FR 68241, November 8, 2002.
- <sup>8</sup> USEPA, “Control of Emissions of Air Pollution From Nonroad Diesel Engines and Fuel; Final Rule,” 69 FR 38958, June 29, 2004.
- <sup>9</sup> USEPA, “Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder; Republication,” (Final Rule), 73 FR 37096, June 30, 2008.
- <sup>10</sup> USEPA, “Transition Program for Equipment Manufacturers (TPEM)” (<https://www.epa.gov/vehicle-and-engine-certification/transition-program-equipment-manufacturers-tpem>).
- <sup>11</sup> USEPA, “Regulatory Requirements for Equipment Manufacturers to Participate in the Transition Program for Equipment Manufacturers (TPEM)” (<https://www.epa.gov/vehicle-and-engine-certification/regulatory-requirements-equipment-manufacturers-participate>).
- <sup>12</sup> USEPA, “Regulatory Requirements and Recordkeeping for TPEM Hardship Relief” (<https://www.epa.gov/vehicle-and-engine-certification/regulatory-requirements-and-recordkeeping-tpem-hardship-relief>).
- <sup>13</sup> USEPA, “Nonroad Engine Population Estimate technical report”, EPA-420-R-10-017, July 2010.
- <sup>14</sup> USEPA, “Nonroad Engine and Vehicle Emission Study” (NEVES), U.S. EPA, Office of Air and Radiation, 21A-2001, November 1991.
- <sup>15</sup> USEPA, “Fuel Supply Defaults: Regional Fuels and the Fuel Wizard in MOVES2014b,” EPA-420-R-18-008, July 2018, Ann Arbor, MI, Office of Transportation and Air Quality. US Environmental Protection Agency (<https://www.epa.gov/moves/moves-technical-reports>).
- <sup>16</sup> Korotney, David. “Estimates for In-Use Nonroad Diesel Fuel Levels,” Memorandum to Docket A-96-40, July 1, 1997.
- <sup>17</sup> EEA, “Documentation of Input Factors for the New Off-Road Mobile Source Emissions Inventory Model,” (“Inputs...”) Energy and Environmental Analysis, Inc. for California Air Resources Board. February, 1997.
- <sup>18</sup> USEPA, “Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines,” August 1998.
- <sup>19</sup> USEPA, “Certification for Nonroad Compression-Ignition (NRCI) Engines” (<https://www.epa.gov/vehicle-and-engine-certification/certification-nonroad-compression-ignition-nrci-engines>).
- <sup>20</sup> USEPA, “Nonroad Compression-Ignition Engines: Exhaust Emission Standards,” EPA-420-B-16-022, March 2016, Office of Transportation and Air Quality. US Environmental Protection Agency, (<https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1000A05.pdf>).
- <sup>21</sup> Code of Federal Regulations, 40: Chapter 1, Subchapter U, Part 1039, Subpart B, 1039.115.
- <sup>22</sup> Cantrell, Bruce. “Recommended Revision of the Fraction of Diesel Particulate Emissions Mass Less Than 2.5 Microns in Size,” Memorandum to Docket A-2001-28, Document IV-B-21, October 17, 2003.
- <sup>23</sup> USEPA, “EPA Science Inventory. Peer Review: Nonroad (NR) Updates to Population Growth, Compression Ignition (CI) Criteria, Toxic Emission Factors and Speciation Profiles,” 2018 ([https://cfpub.epa.gov/si/si\\_public\\_record\\_report.cfm?dirEntryId=339678](https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=339678)).
- <sup>24</sup> The California Air Resources Board, “Mobile Source Emissions Inventory – Off-Road Diesel Vehicles,” 2017 (<https://www.arb.ca.gov/msei/ordiesel.htm>).

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<sup>25</sup> The California Air Resources Board, “2017 Off-road Emissions Factor Documentation,” 2017 ([https://www.arb.ca.gov/msei/ordiesel/ordas\\_ef\\_fcf\\_2017.pdf](https://www.arb.ca.gov/msei/ordiesel/ordas_ef_fcf_2017.pdf)).

<sup>26</sup> USEPA, “Annual Certification Data for Vehicles, Engines, and Equipment,” 2018 (<https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment>).

<sup>27</sup> For example: James Pang, The California Air Resources Board, “Proposal to Investigate Real-World In-Use and Engine Dynamometer Test Results from Off-Road Diesel Equipment,” 2018, the 28<sup>th</sup> CRC Real World Emissions Workshop.

## **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<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp)   | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|---------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                     |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp)   | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|---------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                     |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Model Year | Fraction of Population in Each Technology Type <sup>b</sup> |        |        |        |                     |                       |          |          |          |                       |          |          |          |
|-------------------|------------|-------------------------------------------------------------|--------|--------|--------|---------------------|-----------------------|----------|----------|----------|-----------------------|----------|----------|----------|
|                   |            | Base                                                        | Tier 0 | Tier 1 | Tier 2 | Tier 3 <sup>c</sup> | Tier 4IA <sup>d</sup> | Tier 4IB | Tier 4IC | Tier 4ID | Tier 4FA <sup>e</sup> | 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      |          |          |

<sup>a</sup> 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.

<sup>b</sup> 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.

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

<sup>d</sup> For engine power categories where hp ≤ 75, tech type T4A instead of T4IA is used.

<sup>e</sup> 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<sup>a</sup>**

| Engine Power<br>(hp) | Model Year | Fraction of Population in Each Technology Type |                     |        |        |        |                     |
|----------------------|------------|------------------------------------------------|---------------------|--------|--------|--------|---------------------|
|                      |            | Base <sup>b</sup>                              | Tier 0 <sup>b</sup> | Tier 1 | Tier 2 | Tier 3 | Tier 4 <sup>c</sup> |
| ≤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.)<sup>a</sup>**

| Engine Power<br>(hp) | Model Year | Fraction of Population in Each Technology Type |                     |        |        |        |                     |
|----------------------|------------|------------------------------------------------|---------------------|--------|--------|--------|---------------------|
|                      |            | Base <sup>b</sup>                              | Tier 0 <sup>b</sup> | Tier 1 | Tier 2 | Tier 3 | Tier 4 <sup>c</sup> |
|                      | 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  |                     |

<sup>a</sup> The technology fractions are contained in the nrengtechfraction MOVES input DB file. Blank cells have a technology fraction of 0.000.

<sup>b</sup> Base = pre-control, pre-1988 MY engines. Tier 0 = pre-control 1988+ MY engines prior to Tier 1.

<sup>c</sup> 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<sup>a</sup>**

| Engine Power<br>(hp) | Model Year | Fraction of Population in Each Technology Type |                     |        |        |
|----------------------|------------|------------------------------------------------|---------------------|--------|--------|
|                      |            | Base <sup>b</sup>                              | Tier 0 <sup>b</sup> | 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.)<sup>a</sup>**

| Engine Power<br>(hp) | Model Year | Fraction of Population in Each Technology Type |                     |        |        |
|----------------------|------------|------------------------------------------------|---------------------|--------|--------|
|                      |            | Base <sup>b</sup>                              | Tier 0 <sup>b</sup> | 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  |

<sup>a</sup> The technology fractions are contained in the nrengetchfraction MOVES input DB file. Blank cells have a technology fraction of 0.000.

<sup>b</sup> 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<sup>a</sup>**

| Engine Power (hp) | Technology Type | BSFC (lb/hp-hr)    | Emission Factors (g/hp-hr)     |        |                 |        |
|-------------------|-----------------|--------------------|--------------------------------|--------|-----------------|--------|
|                   |                 |                    | HC                             | CO     | NO <sub>x</sub> | PM     |
| >0 to 11          | Base            | 0.408 <sup>b</sup> | 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.)<sup>a</sup>**

| Engine Power (hp) | Technology Type | BSFC (lb/hp-hr) | Emission Factors (g/hp-hr)     |       |                 |       |
|-------------------|-----------------|-----------------|--------------------------------|-------|-----------------|-------|
|                   |                 |                 | HC                             | CO    | NO <sub>x</sub> | 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.)<sup>a</sup>**

| Engine Power (hp)          | Technology Type | BSFC (lb/hp-hr) | Emission Factors (g/hp-hr)     |       |                 |       |
|----------------------------|-----------------|-----------------|--------------------------------|-------|-----------------|-------|
|                            |                 |                 | HC                             | CO    | NO <sub>x</sub> | 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 |

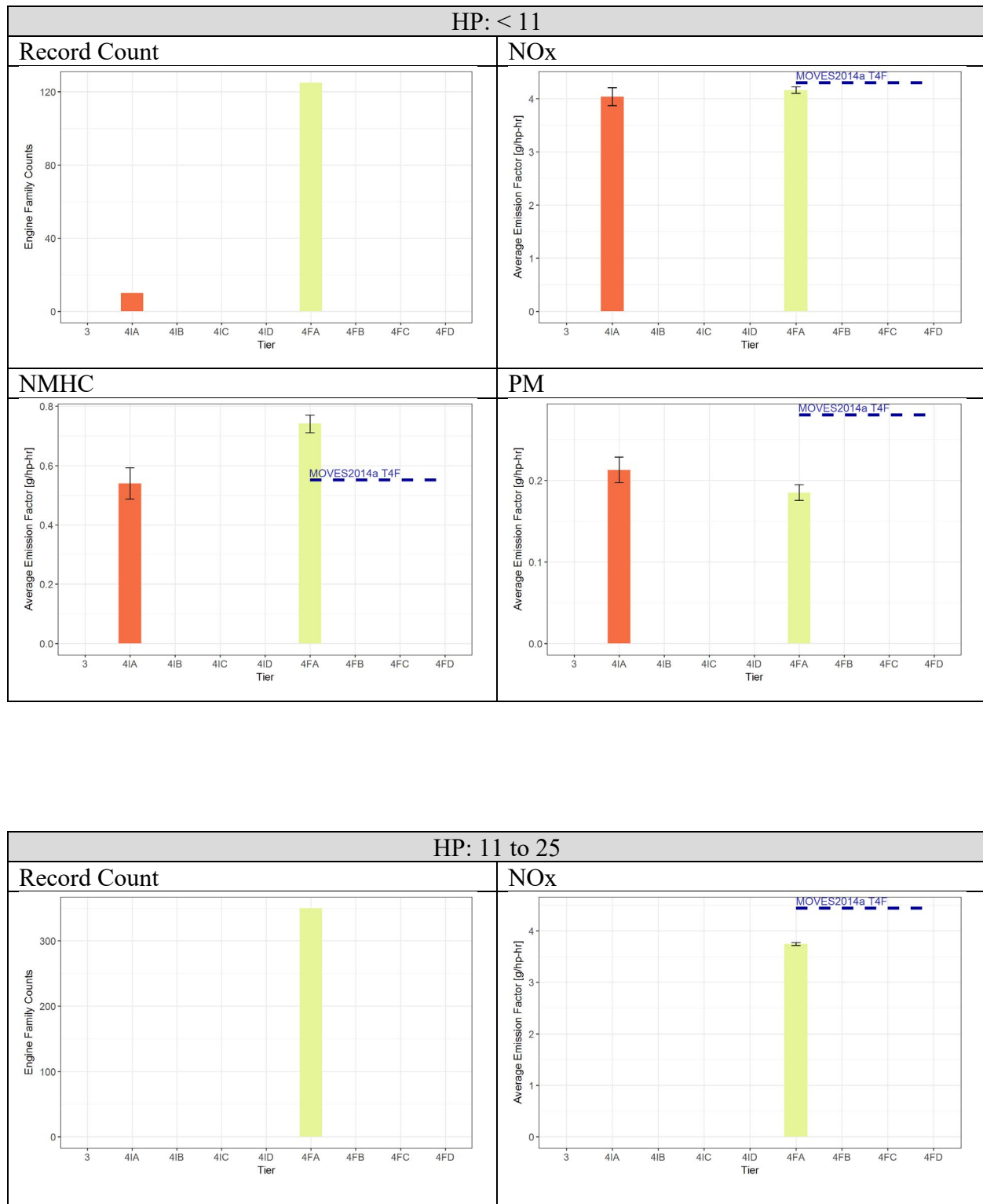
**Table A4. Zero-Hour, Steady-State Emission Factors for Nonroad CI Engines (cont.)<sup>a</sup>**

| Engine Power (hp)     | Technology Type | BSFC (lb/hp-hr) | Emission Factors (g/hp-hr)     |       |                 |       |
|-----------------------|-----------------|-----------------|--------------------------------|-------|-----------------|-------|
|                       |                 |                 | HC                             | CO    | NO <sub>x</sub> | 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 |

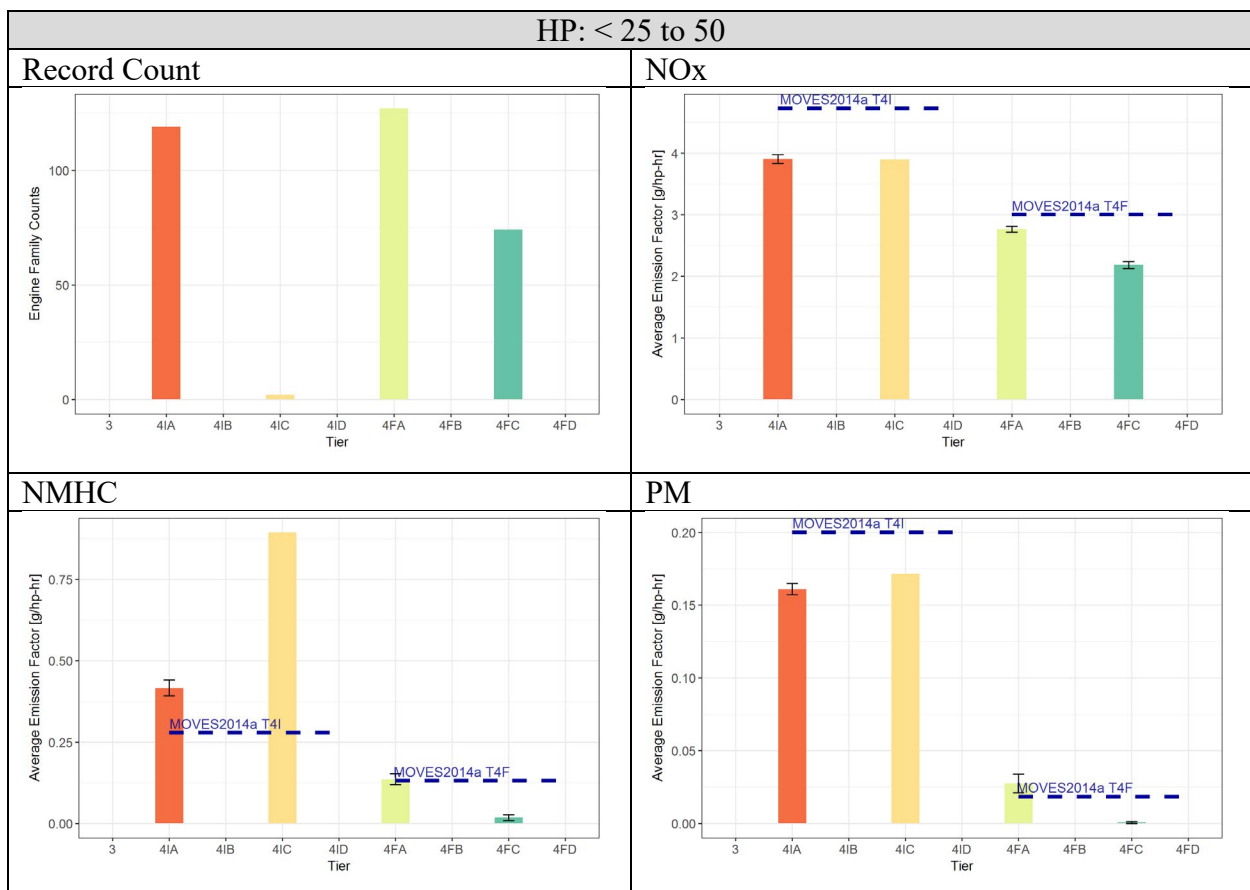
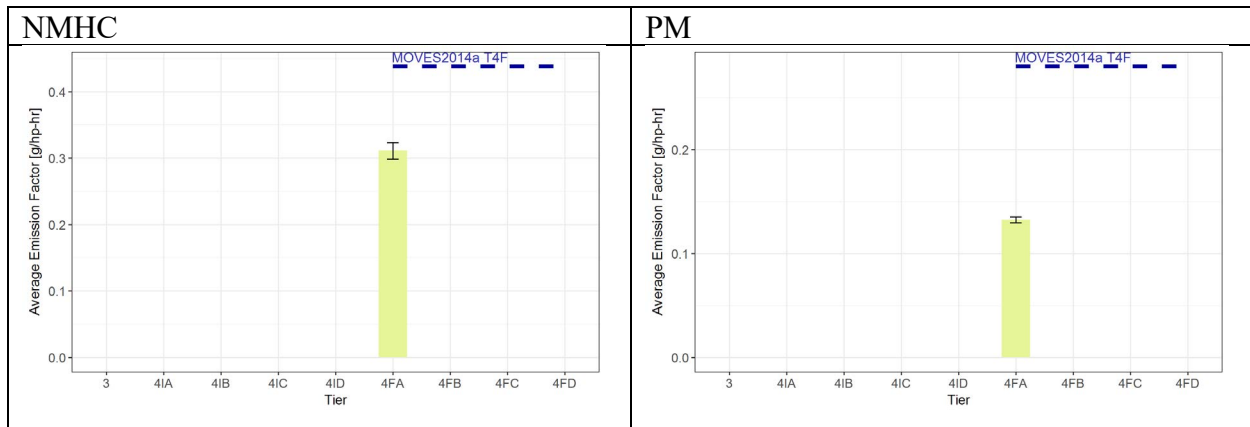
<sup>a</sup>Prior to listing in MOVES-Nonroad input files, these ISO-C1 emission factors are adjusted for in-use operation as explained in Appendix F. The emission factors in the input files are rounded to two decimal places. The emission factors for recreational marine CI engines are provided in Table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

<sup>b</sup>BSFC for engines <50 hp is assumed to be the same as 50-100 hp engines

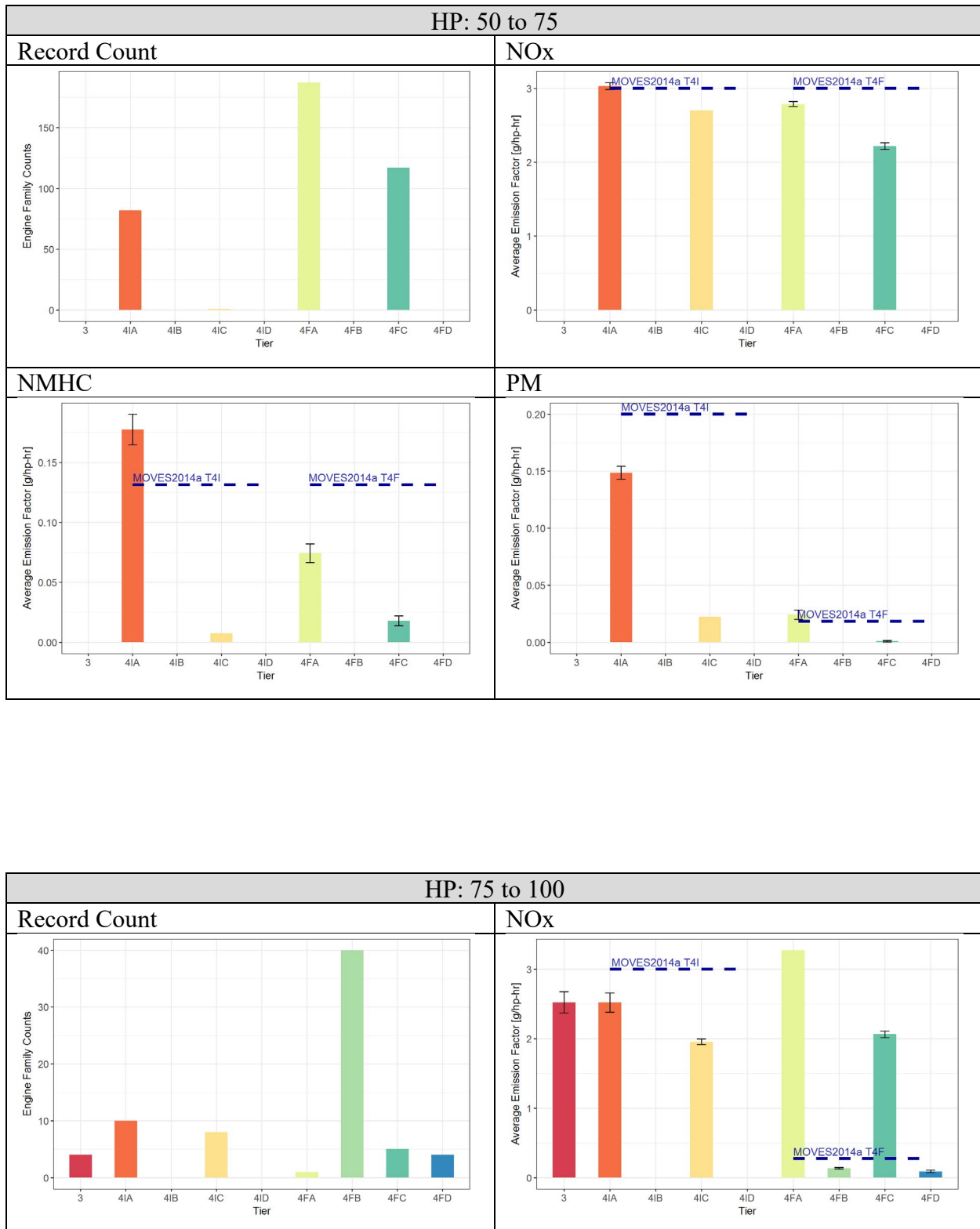
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b**



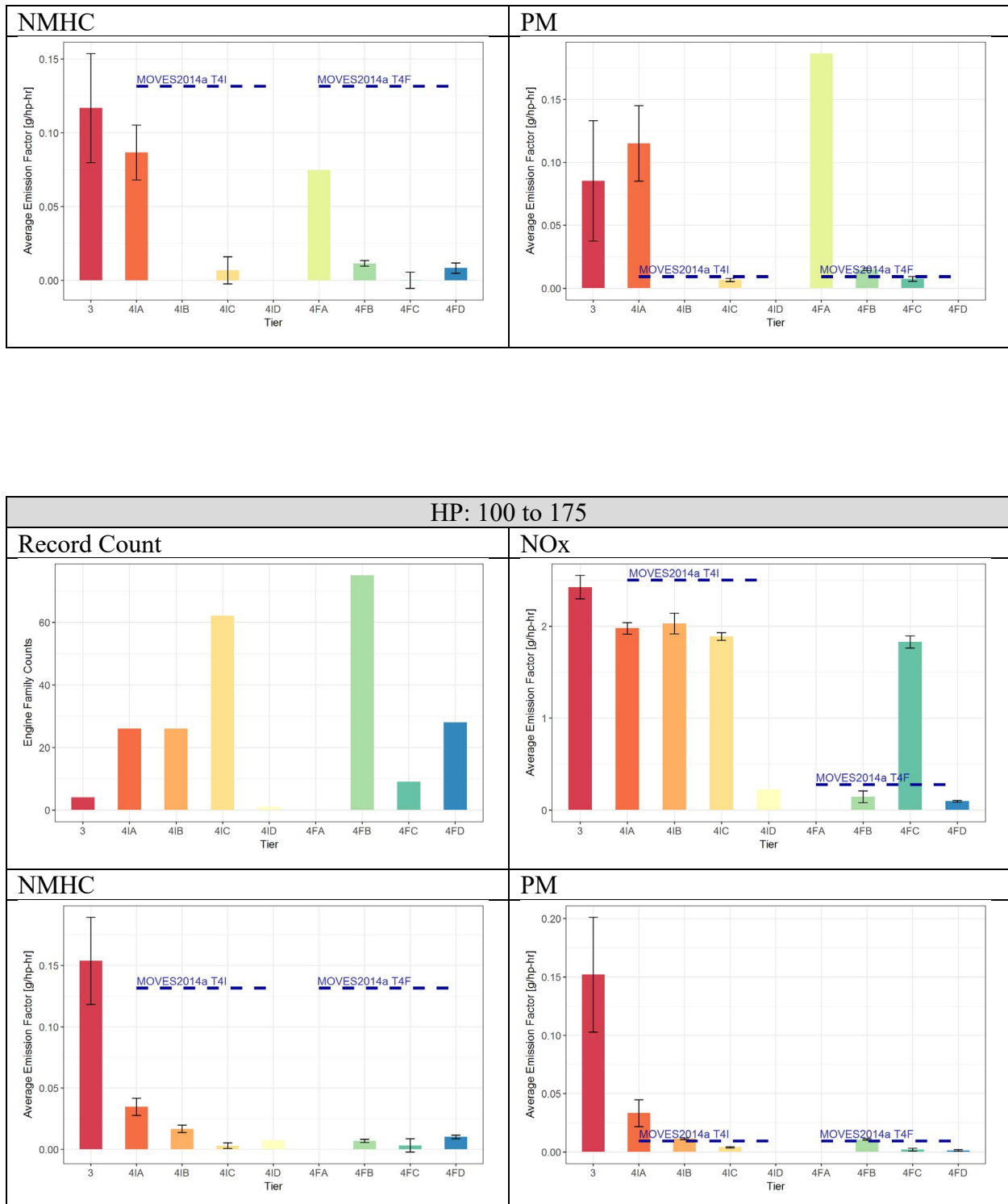
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)**



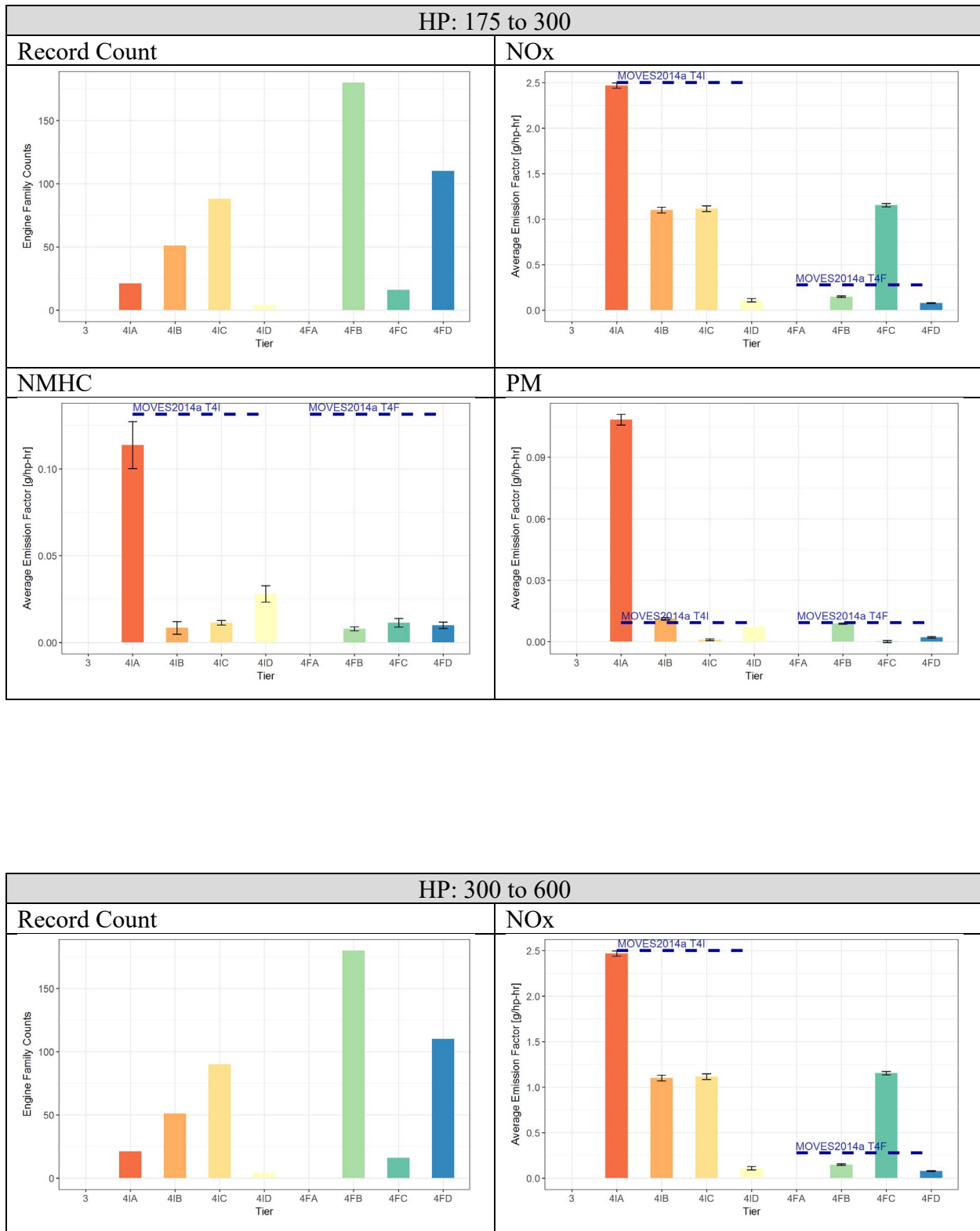
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)**



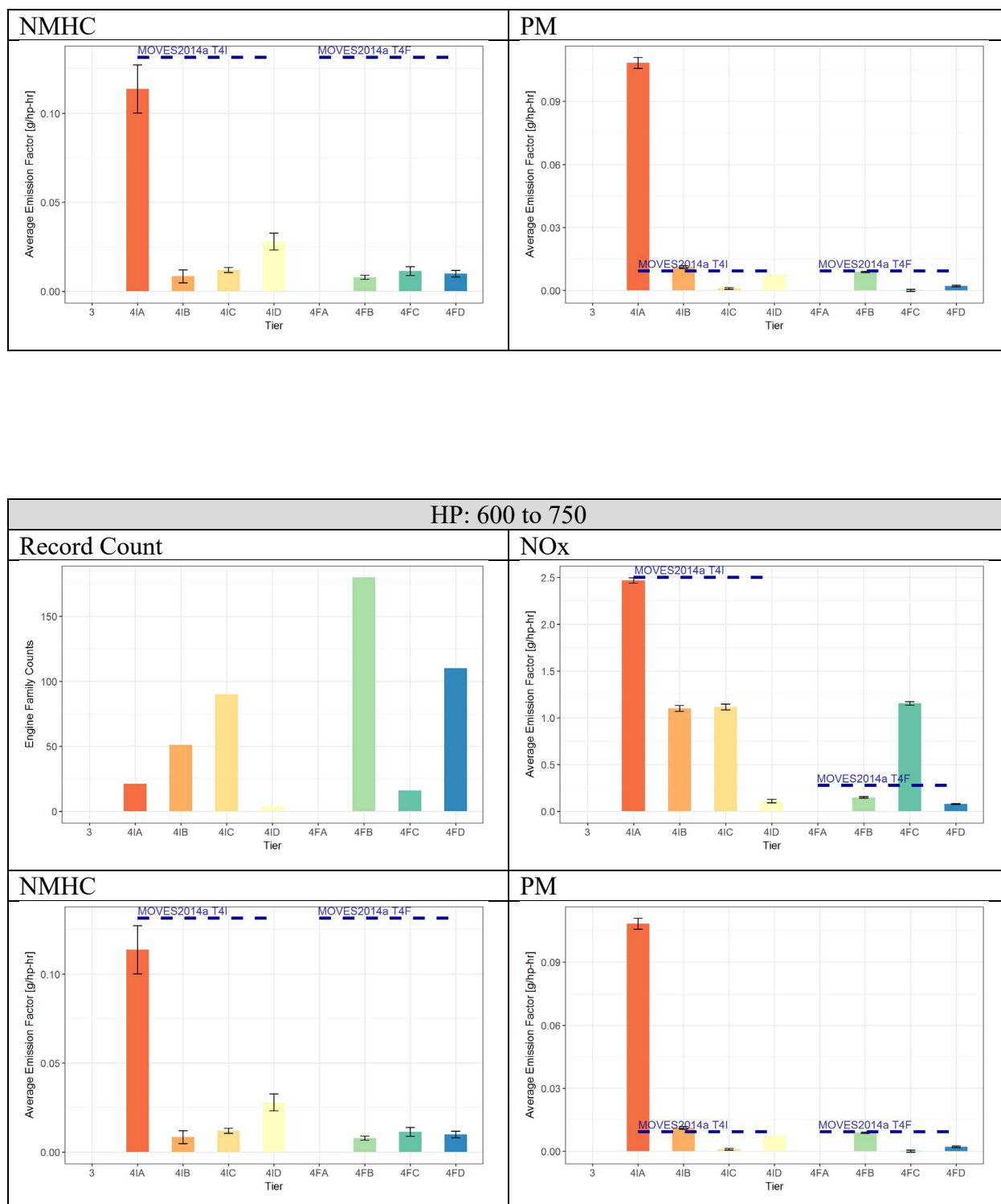
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)**



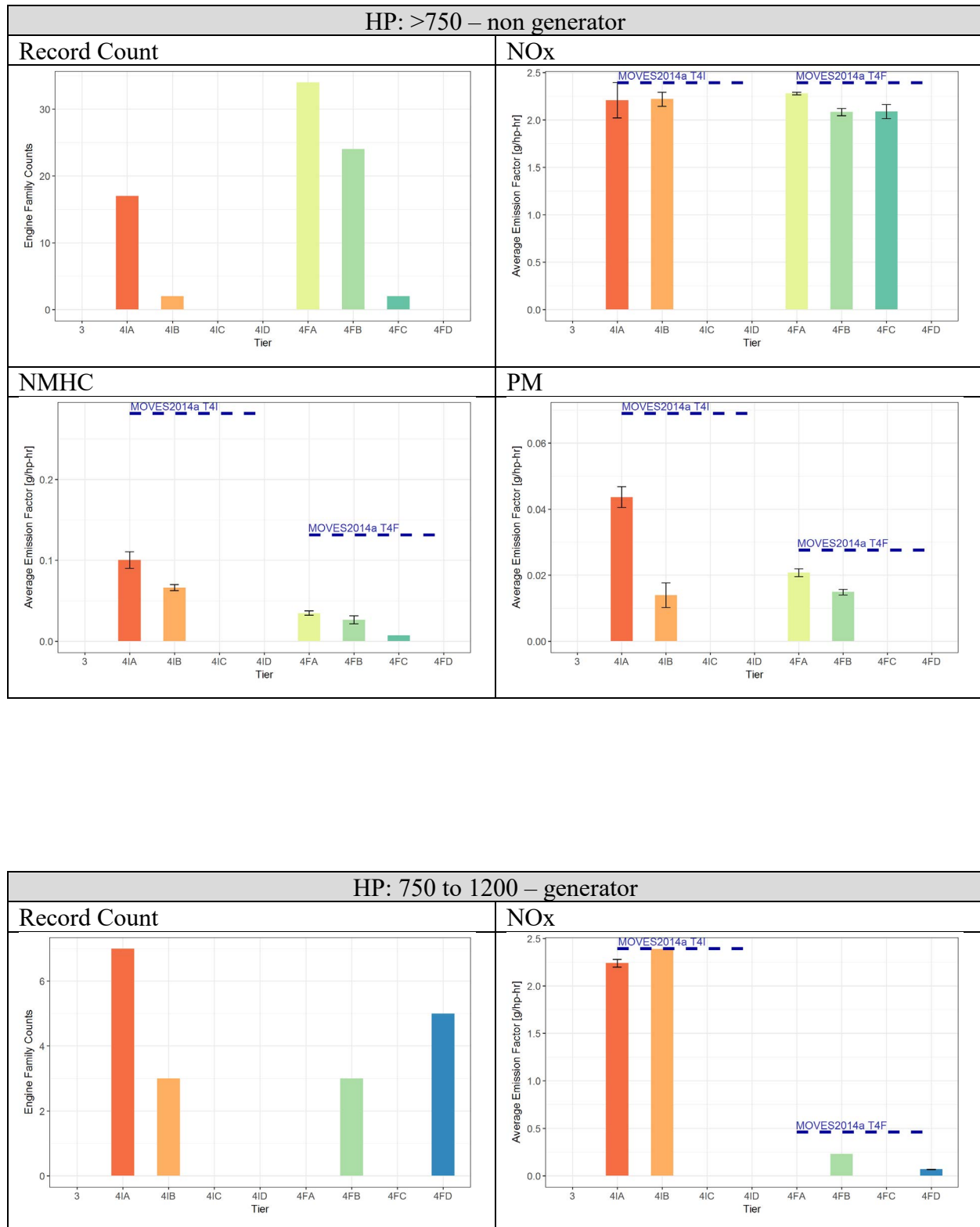
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)**



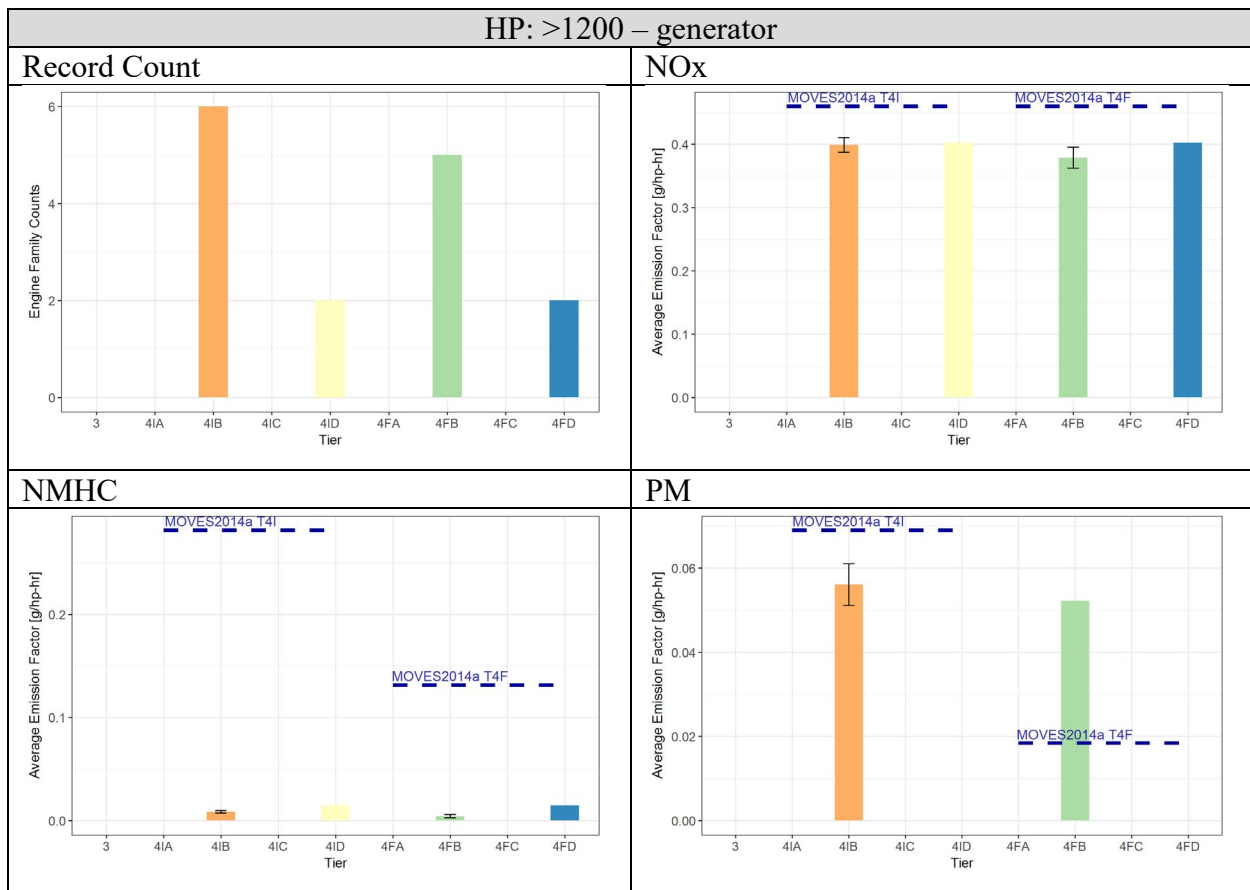
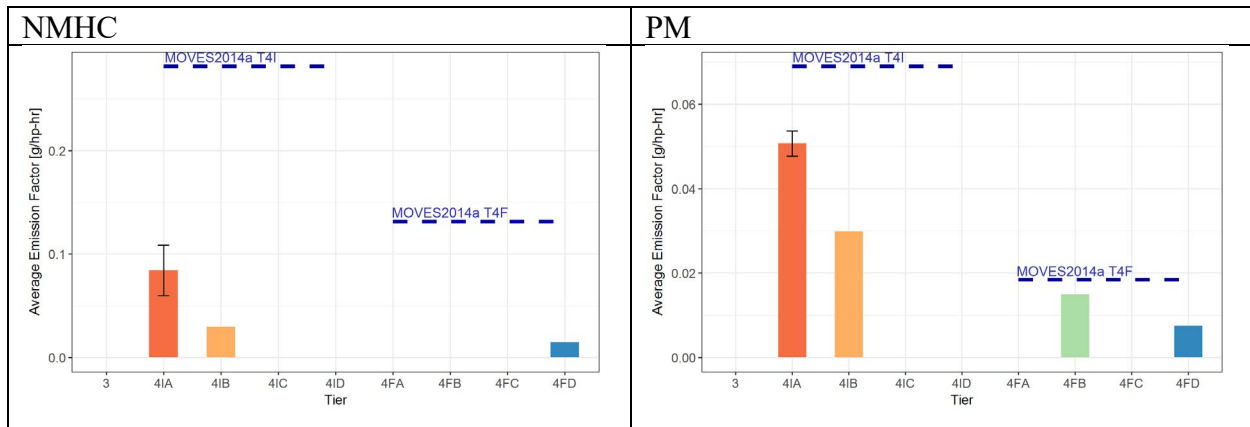
**Figure 2. Record Counts and Emission Factors for Tier 4 Based On Certification Data in MOVES2014b (cont.)**



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



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



**Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment <sup>a</sup>**

| SCC        | Equipment Type                                   | Cycle   | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|--------------------------------------------------|---------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                  |         |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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<br>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<br>Equipment    | Crawler | Hi LF             | 1.05        | 1.53        | 0.95            | 1.04   | 1.23            | 1.47   | 1.01        |

| <b>Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment <sup>a</sup></b> |                                                 |              |                           |             |             |                       |        |                 |        |             |
|-------------------------------------------------------------------------------------------------------|-------------------------------------------------|--------------|---------------------------|-------------|-------------|-----------------------|--------|-----------------|--------|-------------|
| <b>SCC</b>                                                                                            | <b>Equipment Type</b>                           | <b>Cycle</b> | <b>TAF<br/>Assignment</b> | <b>HC</b>   | <b>CO</b>   | <b>NO<sub>x</sub></b> |        | <b>PM</b>       |        | <b>BSFC</b> |
|                                                                                                       |                                                 |              |                           | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2       | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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 <sup>a</sup>**

| SCC        | Equipment Type                                      | Cycle    | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|-----------------------------------------------------|----------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                     |          |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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 <sup>a</sup>**

| SCC        | Equipment Type                                                | Cycle   | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|---------------------------------------------------------------|---------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                               |         |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>T3 |
|            | Industrial Equipment Other General<br>Industrial Equipment    |         |                   |             |             |                 |        |                 |        |             |
| 2270003050 | Industrial Equipment Other Material<br>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<br>(Residential)          | None    | None              | 1.00        | 1.00        | 1.00            | 1.00   | 1.00            | 1.00   | 1.00        |
| 2270004011 | Lawn & Garden Equipment Lawn mowers<br>(Commercial)           | None    | None              | 1.00        | 1.00        | 1.00            | 1.00   | 1.00            | 1.00   | 1.00        |
| 2270004015 | Lawn & Garden Equipment Rotary Tillers<br>< 6 HP              | None    | None              | 1.00        | 1.00        | 1.00            | 1.00   | 1.00            | 1.00   | 1.00        |
| 2270004016 | Lawn & Garden Equipment Rotary Tillers<br>< 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<br>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 <sup>a</sup>**

| SCC        | Equipment Type                                                     | Cycle | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|--------------------------------------------------------------------|-------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                                    |       |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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 <sup>a</sup>**

| SCC        | Equipment Type                                                 | Cycle | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|----------------------------------------------------------------|-------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                                |       |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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 <sup>a</sup>**

| SCC        | Equipment Type                                                     | Cycle     | TAF Assignment | HC      | CO      | NO <sub>x</sub> |        | 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 <sup>a</sup>**

| SCC        | Equipment Type                                      | Cycle     | TAF<br>Assignment | HC          | CO          | NO <sub>x</sub> |        | PM              |        | BSFC        |
|------------|-----------------------------------------------------|-----------|-------------------|-------------|-------------|-----------------|--------|-----------------|--------|-------------|
|            |                                                     |           |                   | Base-<br>T3 | Base-<br>T3 | Base, T0-<br>T2 | Tier 3 | Base, T0-<br>T2 | Tier 3 | Base-<br>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        |

| <b>Table A5. Transient Adjustment Factors by Equipment Type for Nonroad CI Equipment <sup>a</sup></b> |                                                     |              |                       |           |           |                       |        |             |        |             |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------|-----------------------|-----------|-----------|-----------------------|--------|-------------|--------|-------------|
| <b>SCC</b>                                                                                            | <b>Equipment Type</b>                               | <b>Cycle</b> | <b>TAF Assignment</b> | <b>HC</b> | <b>CO</b> | <b>NO<sub>x</sub></b> |        | <b>PM</b>   |        | <b>BSFC</b> |
|                                                                                                       |                                                     |              |                       | 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        |

<sup>a</sup> 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 ( <i>A</i> )<br>(% 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 <sub>x</sub> | 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)<sup>b</sup>

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<sub>x</sub>, PM, SO<sub>x</sub> 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<br>SwRI, 1973<br>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 SO <sub>x</sub> . |
| 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<sub>x</sub>, PM, SO<sub>2</sub>, and CO<sub>2</sub>. 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--<br>2 Yanmar engines<br>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<br>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<sub>x</sub> 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<sub>x</sub> and PM. Emissions of SO<sub>x</sub> 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<sub>x</sub> 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*.<sup>28</sup> Reports HC, NO<sub>x</sub> 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.)

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## 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<br>(Reference)     | HC<br>(g/hp-hr) | CO<br>(g/hp-hr) | NO <sub>x</sub><br>(g/hp-hr) | PM<br>(g/hp-hr) | BSFC<br>(lb/hp-hr) |
|---------------------------|-----------------|-----------------|------------------------------|-----------------|--------------------|
| Average (50 to<br>100 hp) | 0.99            | 3.49            | 8.30                         | 0.722           | 0.408              |
| Average<br>(≥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<br>(Reference)          | Model<br>Year | Age<br>(Hrs) | Fuel<br>Sulfur<br>(wt. %) | Power<br>Level<br>(hp) | HC<br>(g/hp-hr) | CO<br>(g/hp-hr) | NO <sub>x</sub><br>(g/hp-hr) | PM<br>(g/hp-hr) | BSFC<br>(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<br>(Reference)                 | Model<br>Year | Age<br>(Hrs) | Fuel<br>Sulfur<br>(wt. %) | Power<br>Level<br>(hp) | HC<br>(g/hp-hr) | CO<br>(g/hp-hr) | NO <sub>x</sub><br>(g/hp-hr) | PM<br>(g/hp-hr) | BSFC<br>(lb/hp-hr) |
|---------------------------------------|---------------|--------------|---------------------------|------------------------|-----------------|-----------------|------------------------------|-----------------|--------------------|
| John Deere<br>4039 (7)                |               |              | 0.035                     |                        |                 |                 |                              | 0.256           |                    |
| John Deere<br>7076 (7)                | 1993          | 3,300        | 0.28                      | 174                    | 0.53            | 2.05            | 10.22                        | 0.250           | 0.385              |
|                                       |               |              | 0.035                     |                        |                 |                 |                              | 0.205           |                    |
| Consolidated<br>Diesel<br>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<br>6619 (7)                | 1993          | 4,970        | 0.28                      | 275                    | 0.82            | 4.69            | 7.29                         | 0.662           | 0.397              |
|                                       |               |              | 0.035                     |                        |                 |                 |                              | 0.556           |                    |
| Consolidated<br>Diesel 4039<br>(7)    | 1988          | 3,570        | 0.28                      | 71                     | 1.32            | 3.37            | 7.57                         | 0.581           | 0.389              |
|                                       |               |              | 0.035                     |                        |                 |                 |                              | 0.484           |                    |
| Caterpillar<br>3306 (7)               | 1990          | 6,700        | 0.28                      | 278                    | 1.27            | 1.46            | 6.52                         | 0.248           | 0.373              |
|                                       |               |              | 0.035                     |                        |                 |                 |                              | 0.245           |                    |
| <b>Average<br/>(50 to 100 hp)</b>     |               |              | <b>0.33</b>               |                        | <b>0.99</b>     | <b>3.49</b>     | <b>8.30</b>                  | <b>0.722*</b>   | <b>0.408</b>       |
| <b>Average<br/>(≥100 hp)</b>          |               |              | <b>0.33</b>               |                        | <b>0.68</b>     | <b>2.70</b>     | <b>8.38</b>                  | <b>0.402*</b>   | <b>0.367</b>       |

\* 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**

| <b>Engine</b>  | <b>MY</b> | <b>Fuel Sulfur<br/>(wt percent)</b> | <b>PM<br/>(g/hp-hr)</b> | <b>BSFC<br/>(lb/hp-hr)</b> | <b>Delta<br/>PM<br/>(g/hp-hr)</b> | <b>Delta Fuel<br/>Sulfur<br/>Consumed*</b><br>(g/hp-hr) | <b>Delta PM<br/>/ Delta<br/>Sulfur</b> |
|----------------|-----------|-------------------------------------|-------------------------|----------------------------|-----------------------------------|---------------------------------------------------------|----------------------------------------|
| 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:     |      |       |       |       |       |       | <b>0.1573</b> |

\* 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 H<sub>2</sub>SO<sub>4</sub>:7H<sub>2</sub>O (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<sub>2</sub>. 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  
 $A = 0.157 \text{ g PM/hp-hr/Weight Fraction sulfur/BSFC}$   
 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**

- (1) “Nonroad Engine and Vehicle Emission Study” (NEVES), U.S. EPA, Office of Air and Radiation, 21A-2001. November, 1991.
- (2) Doorlag, M. and M. Samulski. “Heavy-Duty Engine Testing Report: Non-Road Engine Configurations, Test Results 1991” EPA Technical Report, 1991.
- (3) Hedbom, A. “Emission tests of two Volvo//VME Heavy Duty Off Road Engines.” Motortestcenter, Hanige, Sweden. MTC 9307A. March. 1994.
- (4) Carroll, J.N. and C. M. Urban. “Emission Testing of Nonroad Compression Ignition Engines.” Draft Final Report. Southwest Research Institute, 6886-802. September 1995.
- (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<sub>x</sub> is expressed as a combination of HC and NO<sub>x</sub> (HC+NO<sub>x</sub>, refer to Table 1). As a result, most of the certification data for these engines is provided as the sum of HC and NO<sub>x</sub>, although there are some data reported for HC and NO<sub>x</sub> separately. To obtain separate HC and NO<sub>x</sub> emission factors for categories less than 50 hp, HC fractions of HC+NO<sub>x</sub> emissions were calculated for those tests which reported both HC and HC+NO<sub>x</sub> emission factors. The average HC fraction was then calculated and multiplied by the sales-weighted average HC+NO<sub>x</sub> emission factor to obtain an HC emission factor (referred to as HC calc in the tables). The remaining fraction of the HC+NO<sub>x</sub> emission factor was assigned as the NO<sub>x</sub> emission factor (referred to as NO<sub>x</sub> 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<sub>x</sub> calc emission factors are also provided. The HC calc and NO<sub>x</sub> calc emission factors are used in the model.

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

|                        |           |                       |                          |               |               |                |                |                            |
|------------------------|-----------|-----------------------|--------------------------|---------------|---------------|----------------|----------------|----------------------------|
| <b>&gt;0 to 11 hp</b>  |           |                       |                          |               |               |                |                |                            |
| g/hp-hr                | <b>HC</b> | <b>NO<sub>x</sub></b> | <b>HC+NO<sub>x</sub></b> | <b>CO</b>     | <b>PM</b>     | <b>HC frac</b> | <b>HC calc</b> | <b>NO<sub>x</sub> calc</b> |
| 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                 | <b>4.1127</b> | <b>0.4474</b> |                | <b>0.7628</b>  | <b>5.2298</b>              |
| sample size            | HC        | NO <sub>x</sub>       | HC+NO <sub>x</sub>       | CO            | PM            |                |                |                            |
| 2000                   | 4         | 6                     | 20                       | 20            | 20            |                |                |                            |
| 2001                   | 5         | 5                     | 19                       | 19            | 19            |                |                |                            |
| total                  | 9         | 11                    | 39                       | 39            | 39            |                |                |                            |
| <b>&gt;11 to 25 hp</b> |           |                       |                          |               |               |                |                |                            |
| g/hp-hr                | <b>HC</b> | <b>NO<sub>x</sub></b> | <b>HC+NO<sub>x</sub></b> | <b>CO</b>     | <b>PM</b>     | <b>HC frac</b> | <b>HC calc</b> | <b>NO<sub>x</sub> calc</b> |
| 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                  | <b>2.1610</b> | <b>0.2665</b> |                | <b>0.4380</b>  | <b>4.4399</b>              |
| sample size            | HC        | NO <sub>x</sub>       | HC+NO <sub>x</sub>       | CO            | PM            |                |                |                            |
| 2000                   | 9         | 10                    | 40                       | 39            | 40            |                |                |                            |
| 2001                   | 16        | 16                    | 43                       | 43            | 43            |                |                |                            |
| total                  | 25        | 26                    | 83                       | 82            | 83            |                |                |                            |
| <b>&gt;25 to 50 hp</b> |           |                       |                          |               |               |                |                |                            |
| g/hp-hr                | <b>HC</b> | <b>NO<sub>x</sub></b> | <b>HC+NO<sub>x</sub></b> | <b>CO</b>     | <b>PM</b>     | <b>HC frac</b> | <b>HC calc</b> | <b>NO<sub>x</sub> calc</b> |
| 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                 | <b>1.5323</b> | <b>0.3389</b> |                | <b>0.2789</b>  | <b>4.7279</b>              |
| sample size            | HC        | NO <sub>x</sub>       | HC+NO <sub>x</sub>       | 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.)\***

| <b>&gt;50 to 100 hp</b>  |               |               |          |               |               |
|--------------------------|---------------|---------------|----------|---------------|---------------|
| 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                  | <b>0.5213</b> | <b>5.5988</b> | 5.254402 | <b>2.3655</b> | <b>0.4730</b> |
| 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           |
| <b>&gt;100 to 175 hp</b> |               |               |          |               |               |
| 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                  | <b>0.3384</b> | <b>5.6523</b> |          | <b>0.8667</b> | <b>0.2799</b> |
| 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           |
| <b>&gt;175 to 300 hp</b> |               |               |          |               |               |
| 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                  | <b>0.3085</b> | <b>5.5772</b> | 4.371648 | <b>0.7475</b> | <b>0.2521</b> |
| 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.)\***

|                          |               |               |               |               |               |
|--------------------------|---------------|---------------|---------------|---------------|---------------|
| <b>&gt;300 to 600 hp</b> |               |               |               |               |               |
| g/hp-hr                  | <b>HC</b>     | <b>NOx</b>    | <b>HC+NOx</b> | <b>CO</b>     | <b>PM</b>     |
| 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                  | <b>0.2025</b> | <b>6.0153</b> | 5.24          | <b>1.3060</b> | <b>0.2008</b> |
| 2001Tier 2               | <b>0.1669</b> | <b>4.3351</b> | 4.345348      | <b>0.8425</b> | <b>0.1316</b> |
| 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           |
| <b>&gt;600 to 750 hp</b> |               |               |               |               |               |
| g/hp-hr                  | <b>HC</b>     | <b>NOx</b>    | <b>HC+NOx</b> | <b>CO</b>     | <b>PM</b>     |
| 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                  | <b>0.1473</b> | <b>5.8215</b> | 3.975047      | <b>1.3272</b> | <b>0.2201</b> |
| 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.)\***

| <b>&gt;750 hp</b> |               |                       |                          |               |               |
|-------------------|---------------|-----------------------|--------------------------|---------------|---------------|
| g/hp-hr           | <b>HC</b>     | <b>NO<sub>x</sub></b> | <b>HC+NO<sub>x</sub></b> | <b>CO</b>     | <b>PM</b>     |
| 2000              | 0.25906       | 6.252638              |                          | 0.727419      | 0.183308      |
| 2001              | 0.313093      | 6.052394              |                          | 0.800887      | 0.203589      |
| average           | <b>0.2861</b> | <b>6.1525</b>         |                          | <b>0.7642</b> | <b>0.1934</b> |
| sample size       | HC            | NO <sub>x</sub>       | HC+NO <sub>x</sub>       | 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  | <b>0.331633</b> | <b>5.667602</b>            | <b>0.834876</b> | <b>0.239994</b> | 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  | <b>0.260521</b>            | <b>6.264393</b> | <b>1.353145</b> | <b>0.195978</b> | 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  | <b>0.174804</b> | <b>6.063537</b>            | <b>1.502117</b> | <b>0.242149</b> | 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  | <b>0.297479</b>            | <b>5.599201</b> | <b>0.745072</b> | <b>0.281314</b> | 1.0000           | 1.0000  | 1.0000 | 1.0000 |
| Sample Size   | <b>29</b>                  | <b>43</b>       | <b>29</b>       | <b>25</b>       |                  |         |        |        |

**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  | <b>0.307044</b>            | <b>5.723983</b> | <b>0.819777</b> | <b>0.245420</b> | 1.0000           | 1.0000  | 1.0000 | 1.0000 |
| Sample Size   | <b>43</b>                  | <b>43</b>       | <b>43</b>       | <b>43</b>       |                  |         |        |        |

**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  | <b>0.155300</b>            | <b>5.865363</b> | <b>1.431343</b> | <b>0.213156</b> | 1.0000           | 1.0000  | 1.0000 | 1.0000 |
| Sample Size   | <b>35</b>                  | <b>35</b>       | <b>35</b>       | <b>35</b>       |                  |         |        |        |

**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<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | Sales Weightings |         |        |        |
|-----------------------|------|----------------------------|--------|------|------|------------------|---------|--------|--------|
|                       |      | 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   | <b>0.52884</b>             | <b>5.68241</b> |                 |                 |                 |                  |         |        |        |
| EF          | <b>5</b>                   | <b>1</b>       | <b>4.235576</b> | <b>2.753546</b> | <b>0.472055</b> | 1.0000           | 1.0000  | 1.0000 | 1.0000 |
| Sample Size | <b>18</b>                  | <b>71</b>      | <b>1</b>        | <b>21</b>       | <b>19</b>       |                  |         |        |        |

**Table D4. 1998 MY Certification Data (cont.)**

| 100-175 hp<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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          | 0.54                       | 6.23     |          |          | 0.0000           | 0.0027  | 0.0000 | 0.0000 |
| 173          |                            | 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<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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 | <b>0.209071</b> | <b>6.126551</b>            | <b>1.289223</b> | <b>0.198893</b> | 1.0000 | 1.0000           | 1.0000 | 1.0000 |  |
| Sample Size  | <b>48</b>       | <b>48</b>                  | <b>48</b>       | <b>48</b>       |        |                  |        |        |  |

**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<br>HC+NOx* | HC wgt          | NOx wgt | HC+NOx<br>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<br>Rated HP | HC            | Emission Factors (g/hp-hr) |               |               |               | HC frac of<br>HC+NOx* | HC wgt | Sales Weighting |               |        |        |
|----------------------|---------------|----------------------------|---------------|---------------|---------------|-----------------------|--------|-----------------|---------------|--------|--------|
|                      |               | NOx                        | HC+NOx        | CO            | PM            |                       |        | NOx wgt         | HC+NOx<br>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<br>EF      | <b>0.4965</b> | <b>4.5584</b>              | <b>4.9834</b> | <b>1.5421</b> | <b>0.3561</b> |                       | 1.0000 | 1.0000          | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size       | <b>11</b>     | <b>15</b>                  | <b>72</b>     | <b>72</b>     | <b>72</b>     | <b>0.047095</b>       |        |                 |               |        |        |
| Calc HC*             | <b>0.2347</b> |                            |               |               |               |                       |        |                 |               |        |        |
| Calc NOx*            |               | <b>4.7487</b>              |               |               |               |                       |        |                 |               |        |        |

\* 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<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |        |        |        |
|-----------------------|----------------------------|------|--------|------|------|------------------|---------|--------|--------|--------|
|                       | 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 |  |
|              |          |                            |          | 2.3468 |         |        |                  |        |        |        |  |
|              |          |                            |          | 7      | 0.45255 |        |                  |        |        |        |  |
| Sales-wgt EF | 0.517642 | 5.613376                   | 6.569501 |        | 3       | 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<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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<br>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<br>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<br>Rated HP | HC              | Emission Factors (g/hp-hr) |           |                 |                 | HC frac of<br>HC+NOx* | Sales Weightings |         |               |        |        |
|---------------------|-----------------|----------------------------|-----------|-----------------|-----------------|-----------------------|------------------|---------|---------------|--------|--------|
|                     |                 | NOx                        | HC+NOx    | CO              | PM              |                       | HC wgt           | NOx wgt | HC+NOx<br>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<br>EF     | 0.692103        | 5.170337                   | 5.966223  | <b>4.051366</b> | <b>0.452858</b> |                       | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size      | <b>4</b>        | <b>6</b>                   | <b>20</b> | <b>20</b>       | <b>20</b>       | <b>0.113196</b>       |                  |         |               |        |        |
| Calc HC*            | <b>0.675351</b> |                            |           |                 |                 |                       |                  |         |               |        |        |
| Calc NOx*           | <b>5.290871</b> |                            |           |                 |                 |                       |                  |         |               |        |        |

\* 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<br>Rated HP | HC              | Emission Factors (g/hp-hr) |           |                 |                 | HC frac of<br>HC+NOx* | HC wgt | Sales Weightings |               |        |        |
|----------------------|-----------------|----------------------------|-----------|-----------------|-----------------|-----------------------|--------|------------------|---------------|--------|--------|
|                      |                 | NOx                        | HC+NOx    | CO              | PM              |                       |        | NOx wgt          | HC+NOx<br>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  | <b>2.207041</b> | <b>0.289982</b> |                       | 1.0000 | 1.0000           | 1.0000        | 1.0000 | 1.0000 |
| Sample               |                 |                            |           |                 |                 |                       |        |                  |               |        |        |
| Size                 | <b>9</b>        | <b>10</b>                  | <b>40</b> | <b>39</b>       | <b>40</b>       | <b>0.081156</b>       |        |                  |               |        |        |
| Calc HC*             | <b>0.401631</b> |                            |           |                 |                 |                       |        |                  |               |        |        |

**Table D6. 2000 MY Certification Data**

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

\* HC fraction of HC+NOx =  $HC \div (HC+NOx)$ . 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<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | HC frac of<br>HC+NOx* | Sales Weightings |         |               |        |        |
|----------------------|------|----------------------------|--------|------|------|-----------------------|------------------|---------|---------------|--------|--------|
|                      |      | NOx                        | HC+NOx | CO   | PM   |                       | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | HC frac of<br>HC+NOx* | Sales Weightings |         |               |        |        |
|----------------------|------|----------------------------|--------|------|------|-----------------------|------------------|---------|---------------|--------|--------|
|                      |      | NOx                        | HC+NOx | CO   | PM   |                       | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | HC              | Emission Factors (g/hp-hr) |           |                 |                 | HC frac of<br>HC+NOx* | HC wgt | Sales Weightings |               |        |        |
|----------------------|-----------------|----------------------------|-----------|-----------------|-----------------|-----------------------|--------|------------------|---------------|--------|--------|
|                      |                 | NOx                        | HC+NOx    | CO              | PM              |                       |        | NOx wgt          | HC+NOx<br>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<br>EF      | 0.452946        | 4.893606                   | 5.083919  | <b>1.522782</b> | <b>0.331337</b> |                       | 1.0000 | 1.0000           | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size       | <b>14</b>       | <b>22</b>                  | <b>95</b> | <b>96</b>       | <b>96</b>       | <b>0.056039</b>       |        |                  |               |        |        |
| Calc HC*             | <b>0.284899</b> |                            |           |                 |                 |                       |        |                  |               |        |        |
| Calc NOx*            |                 | <b>4.799020</b>            |           |                 |                 |                       |        |                  |               |        |        |

\* 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<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | Sales Weightings |         |               |        |        |
|-----------------------|------|----------------------------|--------|------|------|------------------|---------|---------------|--------|--------|
|                       |      | NOx                        | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | Sales Weightings |         |               |        |        |
|-----------------------|------|----------------------------|--------|------|------|------------------|---------|---------------|--------|--------|
|                       |      | NOx                        | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | HC            | Emission Factors (g/hp-hr) |                 |                |                | Sales Weightings |               |               |               |               |
|-----------------------|---------------|----------------------------|-----------------|----------------|----------------|------------------|---------------|---------------|---------------|---------------|
|                       |               | NOx                        | HC+NOx          | CO             | PM             | HC wgt           | NOx wgt       | HC+NOx<br>wgt | CO wgt        | PM wgt        |
| 50                    | 0.03          | 5.80                       |                 | 1.78           | 0.38           | 0.0000           | 0.0008        | 0.0000        | 0.0034        | 0.0035        |
| 77                    |               | 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             | <b>0.4628</b> |                            |                 |                |                |                  |               |               |               |               |
| EF                    | <b>9</b>      | <b>5.494892</b>            | <b>4.235576</b> | <b>2.04706</b> | <b>0.46043</b> | <b>1.0000</b>    | <b>1.0000</b> | <b>1.0000</b> | <b>1.0000</b> | <b>1.0000</b> |
| Sample<br>Size        | <b>35</b>     | <b>104</b>                 | <b>1</b>        | <b>38</b>      | <b>36</b>      |                  |               |               |               |               |

**Table D6. 2000 MY Certification Data (cont.)**

| 100-175 hp<br>Rated HP | Emission Factors (g/hp-hr) |      |      |      | Sales Weightings |         |        |        |
|------------------------|----------------------------|------|------|------|------------------|---------|--------|--------|
|                        | 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<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|------|--------|------|------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx  | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | Emission Factors (g/hp-hr) |                 |          |                 |                 | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|-----------------|----------|-----------------|-----------------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx             | HC+NOx   | CO              | PM              | HC wgt           | NOx wgt | HC+NOx<br>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           | <b>0.266310</b>            | <b>5.441729</b> | 4.540000 | <b>0.666725</b> | <b>0.240685</b> | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample Size            | <b>64</b>                  | <b>64</b>       | <b>2</b> | <b>64</b>       | <b>64</b>       |                  |         |               |        |        |

**Table D6. 2000 MY Certification Data (cont.)**

| 300-600 hp<br>Rated HP | HC   | Emission Factors (g/hp-hr) |        |      |      | Sales Weightings |         |               |        |        |
|------------------------|------|----------------------------|--------|------|------|------------------|---------|---------------|--------|--------|
|                        |      | NOx                        | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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 | <b>0.186024</b> | <b>5.770260</b>            | 5.240000 | <b>1.254546</b> | <b>0.203148</b> | 1.0000           | 1.0000  | 1.0000     | 1.0000 | 1.0000 |
| Sample Size  | <b>51</b>       | <b>51</b>                  | <b>1</b> | <b>51</b>       | <b>51</b>       |                  |         |            |        |        |

**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 | <b>0.126821</b> | <b>5.790567</b>            | <b>1.368105</b> | <b>0.225632</b> | 1.0000 | 1.0000           | 1.0000 | 1.0000 |  |
| Sample Size  | <b>15</b>       | <b>15</b>                  | <b>15</b>       | <b>15</b>       |        |                  |        |        |  |

**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<br>Rated HP | HC              | Emission Factors (g/hp-hr) |           |                 |                 | HC frac of<br>HC+NOx* | HC wgt | Sales Weightings |               |        |        |
|---------------------|-----------------|----------------------------|-----------|-----------------|-----------------|-----------------------|--------|------------------|---------------|--------|--------|
|                     |                 | NOx                        | HC+NOx    | CO              | PM              |                       |        | NOx wgt          | HC+NOxw<br>gt | 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<br>EF     | 0.828378        | 5.073763                   | 6.018891  | <b>4.174066</b> | <b>0.442010</b> |                       | 1.0000 | 1.0000           | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size      | <b>5</b>        | <b>5</b>                   | <b>19</b> | <b>19</b>       | <b>19</b>       | <b>0.141247</b>       |        |                  |               |        |        |
| Calc HC*            | <b>0.850153</b> |                            |           |                 |                 |                       |        |                  |               |        |        |
| Calc<br>NOx*        |                 | <b>5.168738</b>            |           |                 |                 |                       |        |                  |               |        |        |

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

\* 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<br>Rated<br>HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings      |        |         |               |        |        |
|-------------------------|----------------------------|------|--------|------|------|-----------------------|--------|---------|---------------|--------|--------|
|                         | HC                         | NOx  | HC+NOx | CO   | PM   | HC frac of<br>HC+NOx* | HC wgt | NOx wgt | HC+NOx<br>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<br>Rated<br>HP | HC   | Emission Factors (g/hp-hr) |        |      |      | HC frac of<br>HC+NOx* | Sales Weightings |         |               |        |        |
|-------------------------|------|----------------------------|--------|------|------|-----------------------|------------------|---------|---------------|--------|--------|
|                         |      | NOx                        | HC+NOx | CO   | PM   |                       | HC wgt           | NOx wgt | HC+NOx<br>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<br>HP      | HC                         | NOx            | HC+NOx     | CO            | PM            | HC frac of<br>HC+NOx* | HC wgt | NOx wgt | HC+NOx<br>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-<br>wgt EF | 0.4729                     | 4.4696         | 4.9529     | <b>1.5320</b> | <b>0.3292</b> |                       |        |         |               |        |        |
| Sample<br>Size   | 17                         | 47             | 01         | <b>28</b>     | <b>22</b>     |                       | 1.0000 | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
|                  | <b>25</b>                  | <b>35</b>      | <b>103</b> | <b>104</b>    | <b>104</b>    | <b>0.064006</b>       |        |         |               |        |        |
| Calc HC*         | <b>0.317014</b>            |                |            |               |               |                       |        |         |               |        |        |
| Calc<br>NOx*     |                            | <b>4.63588</b> |            |               |               |                       |        |         |               |        |        |
|                  |                            | <b>7</b>       |            |               |               |                       |        |         |               |        |        |

\* 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<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |               |        |        |
|-----------------------|----------------------------|------|--------|------|------|------------------|---------|---------------|--------|--------|
|                       | HC                         | NOx  | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |               |        |        |
|-----------------------|----------------------------|------|--------|------|------|------------------|---------|---------------|--------|--------|
|                       | HC                         | NOx  | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | HC             | Emission Factors (g/hp-hr) |                 |                |                | Sales Weightings |         |               |        |        |
|-----------------------|----------------|----------------------------|-----------------|----------------|----------------|------------------|---------|---------------|--------|--------|
|                       |                | NOx                        | HC+NOx          | CO             | PM             | HC wgt           | NOx wgt | HC+NOx<br>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             | <b>0.57586</b> | <b>5.60451</b>             |                 | <b>2.31437</b> | <b>0.50682</b> |                  |         |               |        |        |
| EF                    | <b>7</b>       | <b>5</b>                   | <b>5.976957</b> | <b>2</b>       | <b>4</b>       | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size        | <b>40</b>      | <b>127</b>                 | <b>3</b>        | <b>47</b>      | <b>43</b>      |                  |         |               |        |        |

**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<br>EF | <b>0.355107</b>            | <b>5.574714</b> | <b>1.003922</b> | <b>0.289340</b> | 1.0000           | 1.0000  | 1.0000 | 1.0000 |
| Sample Size     | <b>34</b>                  | <b>69</b>       | <b>37</b>       | <b>36</b>       |                  |         |        |        |

**Table D7. 2001 MY Certification Data (cont.)**

| 175-300 hp<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|------|--------|------|------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx  | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | Emission Factors (g/hp-hr) |      |        |      |      | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|------|--------|------|------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx  | HC+NOx | CO   | PM   | HC wgt           | NOx wgt | HC+NOx<br>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<br>Rated HP | Emission Factors (g/hp-hr) |                |          |                |                | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|----------------|----------|----------------|----------------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx            | HC+NOx   | CO             | PM             | HC wgt           | NOx wgt | HC+NOx<br>wgt | CO wgt | PM wgt |
| Sales-wgt              | <b>0.31476</b>             | <b>5.50654</b> |          | <b>0.74463</b> | <b>0.26662</b> |                  |         |               |        |        |
| EF                     | <b>5</b>                   | <b>5</b>       | 4.203295 | <b>3</b>       | <b>2</b>       | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size         | <b>86</b>                  | <b>86</b>      | <b>6</b> | <b>88</b>      | <b>88</b>      |                  |         |               |        |        |

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

| 300-600 hp<br>Rated HP | Emission Factors (g/hp-hr) |               |                |               |               | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|---------------|----------------|---------------|---------------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx           | HC+NOx         | CO            | PM            | HC wgt           | NOx wgt | HC+NOx<br>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              | <b>0.1669</b>              | <b>4.3351</b> | <b>4.34534</b> | <b>0.8424</b> | <b>0.1315</b> |                  |         |               |        |        |
| EF                     | <b>24</b>                  | <b>13</b>     | <b>8</b>       | <b>60</b>     | <b>81</b>     | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size         | <b>14</b>                  | <b>14</b>     | <b>35</b>      | <b>35</b>     | <b>35</b>     |                  |         |               |        |        |

**Table D7. 2001 MY Certification Data (cont.)**

| 600-750 hp<br>Rated HP | Emission Factors (g/hp-hr) |                |          |                |                | Sales Weightings |         |               |        |        |
|------------------------|----------------------------|----------------|----------|----------------|----------------|------------------|---------|---------------|--------|--------|
|                        | HC                         | NOx            | HC+NOx   | CO             | PM             | HC wgt           | NOx wgt | HC+NOx<br>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              | <b>0.13806</b>             | <b>5.61241</b> |          | <b>0.88330</b> | <b>0.18377</b> |                  |         |               |        |        |
| EF                     | <b>5</b>                   | <b>8</b>       | 3.975047 | <b>5</b>       | <b>3</b>       | 1.0000           | 1.0000  | 1.0000        | 1.0000 | 1.0000 |
| Sample<br>Size         | <b>16</b>                  | <b>16</b>      | <b>3</b> | <b>17</b>      | <b>17</b>      |                  |         |               |        |        |

**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<br>EF | <b>0.313093</b> | <b>6.052394</b>            | <b>0.800887</b> | <b>0.203589</b> | 1.0000 | 1.0000           | 1.0000 | 1.0000 |  |
| Sample<br>Size  | <b>18</b>       | <b>18</b>                  | <b>18</b>       | <b>18</b>       |        |                  |        |        |  |

## 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  $HCCM_{ij}$ ,  $HS_{ij}$  and  $AHC_{ij}$  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 <sub>x</sub>                                                                                                                                      |              |                            |             |
|                                      |                                | VWC <sup>1</sup>                                                                                                                                     | HS (g/hp-hr) | AHC <sup>2</sup> (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          |

<sup>1</sup> LHDD = “light heavy-duty diesel,” MHDD = “medium heavy-duty diesel,” and HHDD = “heavy heavy-duty diesel.”

<sup>2</sup> Source: USEPA (1999), for NO<sub>x</sub>, Table 10 or MY 1997-2001 highway certification data; for PM, Table 11 or MY 1997-2001 highway 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 <sub>x</sub> | 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<sub>x</sub> and PM. The rationale for the NO<sub>x</sub> and PM Tier 3 TAFs is described in detail below.

### **Transient Emission Control and Implications for Tier 3 NO<sub>x</sub> and PM TAFs**

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<sub>x</sub> emissions. This is because the recirculated gases have a lower oxygen content (the very reason they help to lower NO<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> emissions under the highway transient test procedure. Failure to do so would lead to higher NO<sub>x</sub> emissions. Absent a transient NO<sub>x</sub> standard, the EGR system could be turned off for a long period under transient operation, leading to substantially higher NO<sub>x</sub> emissions than what would be expected based upon a steady state emission test level alone. The extent of this increase in NO<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> TAF should be adjusted in a similar manner. For NO<sub>x</sub> 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<sub>x</sub> emission for the period that the EGR rate is modulated below the steady-state level. For example, a 10 percent increase in NO<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> 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.

| <b>Table F2. CI Engine Emissions Data Used to Calculate Transient Adjustment Factors</b> |      |                |                 |                 |                              |                 |                    |
|------------------------------------------------------------------------------------------|------|----------------|-----------------|-----------------|------------------------------|-----------------|--------------------|
| Engine<br>(reference)                                                                    | Tier | Test Cycle     | HC<br>(g/hp-hr) | CO<br>(g/hp-hr) | NO <sub>x</sub><br>(g/hp-hr) | PM<br>(g/hp-hr) | BSFC<br>(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<br>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<br>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 <sub>x</sub> (g/hp-hr) | PM (g/hp-hr) | BSFC (lb/hp-hr) |
| Caterpillar 3306 (2)                                                              | 0    | Backhoe Loader  | 2.89         | 3.31         | 6.52                      | 0.725        | 0.436           |
|                                                                                   |      | Crawler Dozer   | 1.22         | 2.1          | 7.4                       | 0.413        | 0.364           |
|                                                                                   |      | 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 <sub>x</sub> (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 <sub>x</sub> | 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 |

| <b>Table F3. CI Transient Adjustment Factors for Various Nonroad Test Cycles</b> |      |                 |      |      |                 |      |      |
|----------------------------------------------------------------------------------|------|-----------------|------|------|-----------------|------|------|
| Engine                                                                           | Tier | Test Cycle      | HC   | CO   | NO <sub>x</sub> | 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 |
| <b>Average of Individual TAFs</b>                                                |      | 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 |
| <b>Standard Deviation of TAFs</b>                                                |      | 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 |
| <b>Student's <i>t</i>-test:<br/>P value*<br/>T0 vs T1</b>                        |      | 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 <sub>x</sub> |          |
|----------------------|---------------------|------------|------------|----------|------------|----------|-----------------|----------|
|                      |                     |            | 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 <sub>x</sub> |         | 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<sub>x</sub> Tier 3 TAF = 1.1\*(NO<sub>x</sub> 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**

| <b>SCC</b> | <b>Equipment Type</b>                               | <b>Representative Cycle</b> | <b>TAF Assignment</b> |
|------------|-----------------------------------------------------|-----------------------------|-----------------------|
| 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**

| <b>SCC</b> | <b>Equipment Type</b>                                              | <b>Representative Cycle</b> | <b>TAF Assignment</b> |
|------------|--------------------------------------------------------------------|-----------------------------|-----------------------|
| 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**

| <b>SCC</b> | <b>Equipment Type</b>                                              | <b>Representative Cycle</b> | <b>TAF Assignment</b> |
|------------|--------------------------------------------------------------------|-----------------------------|-----------------------|
| 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**

| <b>SCC</b> | <b>Equipment Type</b>                               | <b>Representative Cycle</b> | <b>TAF Assignment</b> |
|------------|-----------------------------------------------------|-----------------------------|-----------------------|
| 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**

| <b>Model Date</b>                                 | <b>Model Version Name</b>                                                | <b>Data as Basis (# of engines)</b>                  | <b>Cycles Used</b>                                                                                    | <b>Treatment of Tier 0 vs Tier 1 Data</b>                | <b>Ratio of Averages or Average of Ratios?</b> | <b>TAFs Used and Assignments</b>                                                             |
|---------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------|
| June 1998                                         | "Original"                                                               | 9 engines (8 Tier 0 and 1 Tier 1 engines)            | Ag tractor<br>Backhoe<br>Loader<br>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<br>Backhoe<br>Loader<br>Crawler Dozer<br>RT Loader<br>SS Loader<br>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<br>Backhoe<br>Loader<br>Crawler Dozer<br>RT Loader<br>SS Loader<br>Arc Welder              | Tier 0 and Tier 1 data re-combined                       | Average of ratios                              | 6 cycle TAFs. One assigned to each equipment type                                            |
| March 2002<br>April 2004<br>Dec 2005<br>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<br>Backhoe<br>Loader<br>Crawler Dozer<br>RT Loader<br>SS Loader<br>Arc Welder<br>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 NO<sub>x</sub>), 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<sub>x</sub>, 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<sub>x</sub> 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<sup>2</sup>) 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<sup>2</sup>) (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.

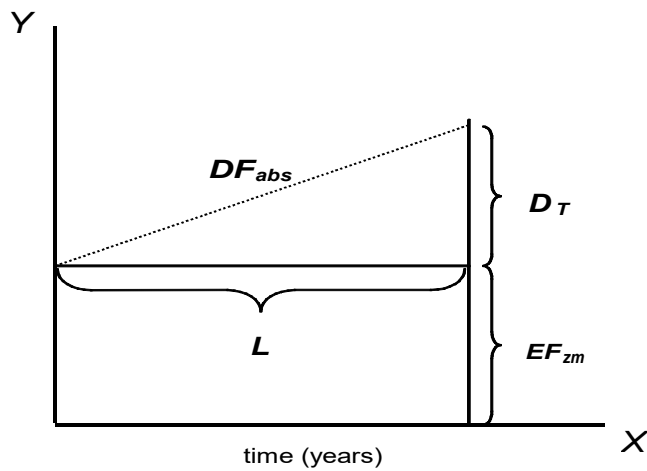


Figure 1. Conceptual representation of absolute linear emissions deterioration over the useful life of a diesel engine.

| Table G1. Hydrocarbon (HC) Deterioration Factors by Tier and Horsepower Category |                                                         |                                        |                                                                            |                     |                                           |
|----------------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------|----------------------------------------------------------------------------|---------------------|-------------------------------------------|
| Nonroad Engine Power Categories (hp)                                             | Corresponding Highway Vehicle Weight Class <sup>1</sup> | Corresponding Highway Model-Year Group | Corresponding Highway Certification Test Results and Deterioration Factors |                     |                                           |
|                                                                                  |                                                         |                                        | $EF_{ZM}^2$<br>(g/hp-hr)                                                   | $DT^3$<br>(g/hp-hr) | $DF_{rel}^4$<br>(%increase/% useful life) |
| <b>Tier 0</b>                                                                    |                                                         |                                        |                                                                            |                     |                                           |
| < 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                                     |
| <b>Tiers 1-3</b>                                                                 |                                                         |                                        |                                                                            |                     |                                           |
| < 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  $DT/EF_{ZM}$ . For discussion, see text.

**Table G2. CO Deterioration Factors by Tier and Horsepower Category<sup>1</sup>**

| Nonroad Engine Power Categories (hp) | Correspondin g Highway Vehicle Weight Class <sup>1</sup> | Correspondin g Highway Model-Year Group | Corresponding Highway Certification Test Results and Deterioration Factors |                        |                          |
|--------------------------------------|----------------------------------------------------------|-----------------------------------------|----------------------------------------------------------------------------|------------------------|--------------------------|
|                                      |                                                          |                                         | $EF_{ZM}^2$<br>(g/hp-hr)                                                   | $D\tau^3$<br>(g/hp-hr) | $EF_{ZM}^2$<br>(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  $DT/EF_{ZM}$ . For discussion, see text.

| Table G3. NOx Deterioration Factors by Pollutant and Horsepower Category <sup>1</sup> |                                                         |                                        |                                                                            |                     |                          |
|---------------------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------|----------------------------------------------------------------------------|---------------------|--------------------------|
| Nonroad Engine Power Categories (hp)                                                  | Corresponding Highway Vehicle Weight Class <sup>1</sup> | Corresponding Highway Model-Year Group | Corresponding Highway Certification Test Results and Deterioration Factors |                     |                          |
|                                                                                       |                                                         |                                        | $EF_{ZM}^2$<br>(g/hp-hr)                                                   | $DT^3$<br>(g/hp-hr) | $EF_{ZM}^2$<br>(g/hp-hr) |
| <b>Tier 0-1</b>                                                                       |                                                         |                                        |                                                                            |                     |                          |
| < 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                    |
| <b>Tier 2</b>                                                                         |                                                         |                                        |                                                                            |                     |                          |
| < 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                    |
| <b>Tier 3</b>                                                                         |                                                         |                                        |                                                                            |                     |                          |
| 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/EF<sub>zm</sub>. For discussion, see text.

**Table G4. Deterioration Factors for Nonroad Diesel Engines**

| Pollutant       | Relative Deterioration Factor ( $DF_{rel}$ ) (% increase/%useful life) <sup>1</sup> |        |        |                 |
|-----------------|-------------------------------------------------------------------------------------|--------|--------|-----------------|
|                 | 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           |
| NO <sub>x</sub> | 0.024                                                                               | 0.024  | 0.009  | 0.008           |
| PM              | 0.473                                                                               | 0.473  | 0.473  | 0.473           |

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