

# **Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition**

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## **NR-010e**

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 which  
may form the basis for a final EPA decision, position, or regulatory action.*

## **Purpose**

This report describes and documents exhaust emission factors, crankcase estimates, and brake specific fuel consumption (BSFC) estimates used for spark ignition (SI) engines in EPA's final NONROAD2005 emission inventory model. It covers engines powered by gasoline, natural gas and liquefied petroleum gas.

Additional EPA reports describe other issues relating to emission factors including NONROAD evaporative emission rates (NR-012c), refueling emissions (NR-013b), adjustments to emission rates due to variations in fuel and temperature (NR-001c), speciation of hydrocarbon emissions (NR-002c), and adjustments to emission rates as equipment deteriorates due to time and use (NR-011c). Emission factors for compression ignition (diesel) engines are covered in a separate report (NR-009c).

## **Introduction**

The U.S. EPA's NONROAD model computes county-level emission inventories for nonroad engines. These 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 sources are reported in grams per horsepower-hour (g/hp-hr), but they also may be reported in grams per mile (g/mile), grams per hour, grams per gallon, etc. The SI exhaust emission factors in the NONROAD model are reported in g/hp-hr, with the exception of nonroad motorcycles and all-terrain vehicles, which are reported in g/mile. The SI BSFCs are reported in lb/hp-hr, with the exception of nonroad motorcycles and all-terrain vehicles, which are reported in lb/mile.

The pollutants covered by this report include exhaust total hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), total particulate matter (PM), carbon dioxide (CO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>). For nonroad engines, all PM emissions are assumed to be smaller than 10 microns (PM<sub>10</sub>), and 92% of the PM from gasoline fueled engines is assumed to be smaller than 2.5 microns (PM<sub>2.5</sub>). For gaseous fueled engines (LPG/CNG), 100% of the PM emissions are assumed to be smaller than PM<sub>2.5</sub>. The NONROAD Reporting Utility allows the user to select the desired size range.

Zero-mile, steady-state emission factors for HC, CO, NO<sub>x</sub>, PM, and steady-state BSFCs are discussed first, followed by adjustments (where applicable) to account for transient operation. Technology distributions by model year, to account for changes in emission factors over time, are then discussed. Derivation of CO<sub>2</sub> and SO<sub>2</sub> emission factors follows. Crankcase emissions are then discussed.

As explained in NR-006c, spark-ignition engine equipment population under 25 horsepower will be combined into one source classification code (SCC) per application to handle expected shifts in market share between 2 and 4-stroke gasoline, LPG, and CNG engines. In the model, the distinction between two- and four-stroke spark-ignition engine emission factors will be maintained using the technology groups described in this report. In this current document, the

SCC distinction between 2 and 4-stroke gasoline, LPG, and CNG engines is maintained; however, in the model, we will distinguish emission factors between them by using the technology group methodology.

## **Background**

Prior to the NONROAD model, there have been three major efforts to estimate nonroad spark ignition emission inventories. We have reviewed these efforts in our work to select emission factors for the final version of NONROAD. The three inventories/models are:

- EPA's Nonroad Engine and Vehicle Emission Study ("NEVES").[1] Published in November, 1991, this study was mandated by Congress to determine whether nonroad sources made a significant contribution to urban air pollution. The study covers emissions from all nonroad engines and includes hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), total particulates (PM), sulfur dioxide (SO<sub>2</sub>) and other pollutants. It provides inventories for 19 ozone and 16 CO nonattainment areas.
- California Air Resources Board's nonroad model ("OFF-ROAD") [2], designed to estimate nonroad emissions for the state of California only. A draft version of this model was released August 1, 1997. The model covers HC, CO, NO<sub>x</sub>, PM, sulfur dioxide (SO<sub>2</sub>), and carbon dioxide (CO<sub>2</sub>) for all nonroad engines. ARB periodically revises components of the OFF-ROAD model.
- EPA's "Small Engine Model"--designed as an internal tool for evaluating various control scenarios, EPA has used this model to estimate the effect of regulations on small spark-ignition (SI) engines under 19 kW (25 hp). This model has evolved over time, but the pre-control exhaust emission factors have not changed since the model was documented in 1995.[3] The model computes national-level inventories of nonroad HC, CO, and NO<sub>x</sub>.

The emission factors used in these prior efforts have been based on a very small number of engine studies, particularly when compared to the large body of data available for highway vehicles.

## **Emission Factor Categories**

NEVES defines emission factors by the equipment use (i.e., by "application") but does not assign different emission factors to engines of different sizes within the same application. On the other hand, OFF-ROAD and the Small Engine Model define emission factors by engine size (by horsepower in OFF-ROAD and by displacement in the Small Engine Model), but do not assign different emission factors to engines used in different applications that are of the same size. Given the structure of emission control regulations and the design similarities between engines of the same horsepower used in various applications, we define emission factors primarily by power level in final NONROAD2005. Appendix A provides a comparison of the power categories in OFF-ROAD, the Small Engine Model, and NONROAD. The NONROAD

model allows for the use of application-specific emission factors if there is sufficient information to justify their use. We use application-based emission factor categories only to distinguish recreational marine engines and selected recreational vehicles.

### **Emission Standards**

In addition to estimating emissions from pre-controlled engines, the NONROAD model is designed to account for the effect of federal emissions standards. The model does not cover California emission standards and federal standards that are not yet final. Thus, NONROAD will include emission factors under the following final regulations that cover SI engines at or below 19 kilowatts (25 hp) and SI marine engines:

- Emissions for New Nonroad Spark Ignition Engines at or below 19 Kilowatts. (“Small Engine Rule, Phase 1”) [4]
- Phase 2: Emission Standards for New Nonroad Nonhandheld Spark-Ignition Engines At or Below 19 Kilowatts. (“Small Engine Nonhandheld Rule, Phase 2”) [5]
- Phase 2: Emission Standards for New Nonroad Spark-Ignition Handheld Engines At or Below 19 Kilowatts and Minor Amendments to Emission Requirements Applicable to Small Spark-Ignition Engines and Marine Spark-Ignition Engines. (“Small Engine Handheld Rule, Phase 2”) [6]
- Final Rule for New Gasoline Spark-Ignition Marine Engines; Exemptions for New Nonroad Compression-Ignition engines at or Above 37 Kilowatts and New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts (“Marine Rule”) [7]
- Control of Emissions From Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based); Final Rule [8]

For final NONROAD2005, there have also been additional revisions to inputs for SI recreational marine engines to account for more recent information available since the regulations were issued. These revisions are described in the following memorandum:

- “Updates to Technology Mix, Emissions Factors, Deterioration Rates, Power Distribution, and Fuel Consumption Estimates for SI Marine Engines in the NONROAD Emissions Inventory Model,” Memo from Mike Samulski to Docket OAR-2004-0008, November 30, 2005. [9]

### **Zero-Hour, Steady-State Emission Factors for HC, CO, NO<sub>x</sub>, PM, and Steady-State BSFCs**

This section describes the zero-hour, steady-state emission factors and steady-state BSFCs that are used in final NONROAD2005. Pre-controlled (baseline) and controlled (where applicable) emission factors are described for each of the following regulatory equipment

categories: small SI engines  $\leq 25$  hp, large SI engines  $> 25$  hp, land-based recreational engines, and recreational marine engines.

### Spark-Ignition (SI) Engines $\leq 25$ hp

This category includes all engines  $\leq 25$  hp except those used for recreational applications (such as motorcycles or snowmobiles), for marine propulsion, or for toy boats and airplanes. The engines in this category are used primarily in lawn and garden equipment.

For this category, engines are segregated by the class of the engine (I - V). Each class is determined by the use of the engine, i.e., handheld or nonhandheld, and engine displacement. Classes I and II refer to nonhandheld small SI engines; classes III, IV, and V refer to handheld small SI engines. The classes have the following displacements: Class I ( $< 225$ cc); Class II ( $\geq 225$ cc); Class III ( $< 20$ cc); Class IV ( $\geq 20$ cc and  $< 50$ cc); Class V ( $\geq 50$ cc).

Each class in turn is subject to two phases of regulation (Phase 1 and Phase 2). Under the Phase 1 regulations, new engines have had to meet emission standards for HC, CO, and  $\text{NO}_x$  since 1997. For nonhandheld applications (such as lawn and garden tractors and lawnmowers), more stringent Phase 2 standards phase in between 2001 and 2007. For handheld applications (such as leaf blowers and chainsaws), more stringent Phase 2 standards phase in between 2002 and 2007. The test procedure used for these regulations is the Small SI Engine Federal Steady-State Test Procedure.

Tables 1-5 contain the baseline and Phase 1 and 2 controlled emission factors for these five classes of engines. There are no LPG or CNG engines less than 25 hp in final NONROAD2005; therefore, the emission factors in these tables are used for gasoline engines in the model.

In order to account for the effect of the rulemaking and the phase-in of the new standards, engines meeting the new standards were defined by the technology types in Tables 1-5. (A complete list and description of SI technology types used in final NONROAD2005 is provided in Appendix B, Table B3.) Handheld engines (Classes III-V) are not expected to include any 4-stroke engines (but emission factors are supplied for users) but are expected to include a small fraction of catalyst equipped engines. Nonhandheld engines include both 2 and 4-stroke engines, but manufacturers are expected to build only 4-stroke engines with the advent of the new regulations. Nonhandheld 4-stroke engine production is split between two technical types, side-valve and overhead valve systems, which have been shown to exhibit significantly different emission characteristics.

In general, for baseline emissions, NONROAD uses emission factors based on those in the Small Engine Model. [3] Also, the PM emission factors for the entire category (both baseline and controlled) are based on values in NEVES. [1]

For nonhandheld (class I and II) engines, NONROAD uses the brake-specific fuel consumption (BSFC), HC, CO, and  $\text{NO}_x$  emission factors for Phase 1 and 2 that are contained in

the final regulatory impact analysis. [10] (The baseline emission factors are also contained in this reference.) The Phase 1 emission factors were based on values obtained from the EPA 1998 Phase 1 Certification database. For Phase 2, the emission factors were back-calculated using 1) the Phase 2 standards, and 2) a multiplicative deterioration factor for each pollutant. The deterioration factors are described in more detail in NR-011c.

For handheld (class III, IV, and V) engines, NONROAD also uses the BSFC, HC, CO, and NO<sub>x</sub> emission factors for Phase 1 and 2 that are contained in the final regulatory impact analysis. [11] (The baseline emission factors are also contained in this reference.) For Phase 1, the emission factors were back-calculated using 1) the Phase 1 standards, and 2) a multiplicative deterioration factor for each pollutant. For Phase 2, the emission factors were determined using the same methodology. As mentioned above, the deterioration factors are described in more detail in NR-011c.

Table 1. Emissions and BSFCs for Class III Handheld Small SI Engines (< 20cc)\*

<b>Engine Tech Type</b>	<b>HC g/hp-hr</b>	<b>CO g/hp-hr</b>	<b>NO<sub>x</sub> g/hp-hr</b>	<b>PM g/hp-hr</b>	<b>BSFC lb/hp-hr</b>
G2H3 (gas 2-stroke handheld Class III, baseline)	261.00	718.87	0.97	7.7	1.365
G2H31 (Phase 1)	219.99	480.31	0.78	7.7	1.184
G2H3C1 (Phase 1 with catalyst)	219.99	480.31	0.78	7.7	1.184
G2H32 (Phase 2)	33.07	283.37	0.91	7.7	0.822
G2H3C2 (Phase 2 with catalysts)	26.87	141.69	1.49	7.7	0.822

\* Assigned NONROAD hp range: 0-1 hp

Table 2. Emissions and BSFCs for Class IV Handheld Small SI Engines ( $\geq 20\text{cc}$  and  $< 50\text{cc}$ )\*

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
G2H4 (gas 2-stroke handheld Class IV, baseline)	261.00	718.87	0.94	7.7	1.365
G2H41 (Phase 1)	179.72	407.38	0.51	7.7	1.184
G2H4C1 (Phase 1 with catalyst)	179.72	407.38	0.51	7.7	1.184
G4H41 (Phase 1 4-stroke)	22.37	533.42	1.79	0.06	0.847
G2H42 (Phase 2)	33.07	283.37	0.91	7.7	0.822
G2H4C2 (Phase 2 with catalysts)	26.87	141.69	1.49	7.7	0.822
G4H42 (Phase 2 4-stroke)	25.83	432.51	1.13	0.06	0.847

\* Assigned NONROAD hp range: 1-3 hp

Table 3. Emissions and BSFCs for Class V Handheld Small SI Engines ( $> 50\text{cc}$ )\*

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
G2H5 (gas 2-stroke handheld Class V, baseline)	159.58	519.02	0.97	7.7	0.921
G2H51 (Phase 1)	120.06	351.02	1.82	7.7	0.870
G2H5C1 (Phase 1 with catalyst)	120.06	351.02	1.82	7.7	0.870
G2H52 (Phase 2)	47.98	283.37	0.91	7.7	0.608
G2H5C2 (Phase 2 with catalysts)	40.15	141.69	1.49	7.7	0.608

\* Assigned NONROAD hp range: 3-6 hp



Table 4. Emissions and BSFCs for Class I Nonhandheld Small SI Engines (< 225cc)\*

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
G2N1 (gas 2-stroke nonhandheld Class I, baseline)	207.92	485.81	0.29	7.7	0.870
G4N1S (gas, side-valved, 4-stroke nonhandheld Class I, baseline)	38.99	430.84	2.00	0.06	1.365
G4N1O (gas, overhead-valved, 4-stroke nonhandheld Class I, baseline)	13.39	408.84	1.80	0.06	0.991
G2N11 (2-stroke, Phase 1)	120.06	449.66	4.00	7.7	0.870
G4N1S1 (Phase 1 side-valved, 4-stroke)	8.40	353.69	3.60	0.06	0.921
G4N1O1 (Phase 1 overhead valved 4-stroke)	8.40	351.16	3.24	0.06	0.781
G4N1SC1 (Phase 1 side-valved, 4-stroke with catalyst)	8.40	353.69	3.60	0.06	0.921
G4N1S2 (Phase 2 side-valved)	7.93	353.69	2.37	0.06	0.921
G4N1O2 (Phase 2 overhead valved)	6.13	351.16	1.83	0.06	0.781

\* Assigned NONROAD hp range: 3-6 hp

Table 5. Emissions and BSFCs for Class II Nonhandheld Small SI Engines ( $\geq$  225cc)\*

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
G2N2 (gas 2-stroke nonhandheld Class II, baseline)	207.92	485.81	0.29	7.7	0.870
G4N2S (gas, side-valved, 4-stroke nonhandheld Class II, baseline)	9.66	430.84	2.06	0.06	0.937
G4N2O (gas, overhead-valved, 4-stroke nonhandheld Class II, baseline)	5.20	408.84	3.50	0.06	0.937
G4N2S1 (Phase 1 side-valved, 4-stroke)	5.50	387.02	4.50	0.06	0.868
G4N2O1 (Phase 1 overhead valved 4-stroke)	5.20	352.57	3.50	0.06	0.740
G4N2S2 (Phase 2 side-valved)	5.50	387.02	4.50	0.06	0.868
G4N2O2 (Phase 2 overhead valved)	4.16	352.57	2.77	0.06	0.740

\* Assigned NONROAD hp range: 6-25 hp

### Spark-Ignition Engines > 25 hp

Nonroad SI engines above 25 hp are generally found in industrial equipment and are used in a wide variety of applications, including forklifts, airport ground-service equipment, terminal tractors, generators, compressors, welders, aerial lifts, and ice grooming machines. These

engines may operate on gasoline, LPG, or CNG. Emission standards for SI engines >25 hp have recently been finalized. [9] Both uncontrolled and Phase 1 and 2 controlled emission factors are included in NONROAD2005.

Summaries of the precontrolled, Phase 1 controlled, and Phase 2 controlled emission factors used for this equipment category are provided in Tables 6 through 8. Emission factors for the gasoline 4-stroke, LPG, and CNG engines were taken from the regulatory support document for the final rule, and are based on a summary of available test data. [12]

Table 6. Emission Factors and BSFCs for Spark-Ignition Engines > 25 HP

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
<b>Uncontrolled</b>					
G4GT25 (gas, 4-stroke, baseline)	3.85	107.23	8.43	0.06	0.605
LGT25 (LPG, baseline)	1.68	28.23	11.99	0.05	0.507
NGT25 (CNG, baseline)	24.64	28.23	11.99	0.05	0.507
<b>Phase 1</b>					
G4GT251 (gas, 4-stroke)	0.59	29.86	1.51	0.06	0.484
LGT251 (LPG)	0.25	24.49	2.10	0.05	0.406
NGT251 (CNG)	3.69	24.49	2.10	0.05	0.406
<b>Phase 2</b>					
G4GT252 (gas, 4-stroke)	0.27	11.94	0.69	0.06	0.484
LGT252 (LPG)	0.10	3.92	0.85	0.05	0.406
NGT252 (CNG)	1.57	3.92	0.89	0.05	0.406

### Motorcycles, All-Terrain Vehicles (ATVs), and Snowmobiles

These engines differ significantly from other SI engines in their basic design, operating characteristics, and emission rates. Emission standards have recently been finalized for these engines. [8]

A summary of the emission factors for these engines is provided in Table 7. The HC, CO, and NO<sub>x</sub> emission data for ATVs and motorcycles were provided by a manufacturer and represent various makes, models, model years, and engine sizes. The emission factors for ATVs and motorcycles are expressed as gram/mile (lb/mile for BSFC). The HC, CO, and NO<sub>x</sub> test data used for snowmobiles came from the International Snowmobile Manufacturers Association (ISMA) and Southwest Research Institute (SwRI). The emission factors for snowmobiles are

expressed as gram/hp-hr (lb/hp-hr for BSFC). The emission factors are documented in regulatory support documents for the final rule. [12,13]

Table 7. Emission Factors and BSFCs for Offroad Motorcycles, ATVs, and Snowmobiles

<b>Equipment/Tech Type</b>	<b>HC g/mile</b>	<b>CO g/mile</b>	<b>NO<sub>x</sub> g/mile</b>	<b>PM g/mile</b>	<b>BSFC lb/mile</b>
Precontrol 2-stroke offroad motorcycles (R12S)	55.70	54.10	0.150	2.10	0.268 0.201*
Precontrol 4-stroke offroad motorcycles (R14S)	2.40	48.50	0.410	0.06	0.158
Phase 1 4-stroke offroad motorcycles (R14S1)	2.10	30.60	0.340	0.06	0.158
2-stroke all terrain vehicles (R12S)	53.90	54.10	0.150	2.10	0.213 0.160*
4-stroke all terrain vehicles (R14S)	2.40	48.50	0.410	0.06	0.167
Phase 1 4-stroke all terrain vehicles (R14S1)	1.60	30.60	0.260	0.06	0.167
	<b>HC g/hp-hr</b>	<b>CO g/hp-hr</b>	<b>NO<sub>x</sub> g/hp-hr</b>	<b>PM g/hp-hr</b>	<b>BSFC lb/hp-hr</b>
Precontrol 2-stroke snowmobiles (R12S)	111.0	296.0	0.86	2.70	1.660
Modified 2-stroke snowmobiles (R12S1)	53.70	146.9	0.86	2.70	1.660
Direct Injection 2-stroke snowmobiles (R12S2)	21.80	90.0	2.80	0.57	1.245
4-stroke snowmobiles (R14S)	7.80	123.0	9.20	0.15	1.245

\* The standards for off-road motorcycle and ATV recreational engines allow the engine manufacturers to meet the controlled 4-stroke engine standard with a 2-stroke engine. If a manufacturer succeeds in meeting the 4-stroke controlled standard with a two-stroke engine, this is the estimate of what the BSFC for the controlled 2-stroke engine would be.

### Recreational SI Marine Engines

Recreational SI marine engines are divided into three categories: outboard, personal watercraft (PWC), and sterndrive/inboard (SD/I) engines. For outboard and PWC, final NONROAD2005 contains updated emission factors developed using certification data from eight model years (1998-2005). In addition, updated fuel consumption estimates were developed based on test data. [9]

Emission factors (HC, CO, and NO<sub>x</sub>) for SD/I engines have not changed since draft NONROAD2004. They were taken from work accomplished in support of the 1996 rulemaking for new emission standards for these engines, as well as newer information and analysis related to SD/I engines. [14,15] BSFCs and PM emission factors were derived from NEVES. [1] Table 8 shows how the power level ranges used in the 1996 rulemaking analysis were matched to the power levels used in NONROAD.

Table 8. Mapping of Recreational Marine Engine Power Ranges

	<b>EPA-RIA</b>	<b>NONROAD Model</b>
<b>Outboard</b>	<3.9 hp	0 - 3 hp
	3.9 - 9.9	3 - 11
	9.9 - 29.9	11 - 25
	29.9 - 49.9	25 - 50
	49.9 - 74.9	-----
	74.9 - 99.9	50 - 100
	99.9 - 149.9	-----
	149.9 - 199.9	100 - 175
<b>PWC</b>	30 - 50 hp	0 - 50 hp
	50 - 75	50 - 175
<b>Inboard</b>	100 - 150 hp	0 - 100 hp
	150 - 200	100 - 175
	>200	>175

To determine the effect of the Federal rulemaking for these types of engines, technical types were defined to reflect new technologies that would be employed to meet the emission levels required.<sup>1</sup> These new technologies would be employed to various degrees to reflect the phase-in of the new emission standards. Technical types were defined to incorporate the emission reductions expected and the phase-in of the standards. For final NONROAD2005, the list of technology classes was changed using information in the certification database to better reflect actual production. Table 9 presents a comparison of the NONROAD2004 and NONROAD2005 technology designations for recreational SI marine engines.

The updated designations are comprised of 4-5 characters. The first character is “M” for marine. The second character is either “O”, “P” or “S” for outboard, personal watercraft, or sterndrive/inboard. The third character refers to the cycle (2 or 4-stroke), and the fourth character refers to the fuel system (“C” for carbureted, “I” for indirect injection, and “D” for direct injection). The final character denotes aftertreatment with an “A.” For two-stroke engines, “indirect injection” refers to any fuel injection that is not directly injected into the cylinder (such

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1 It should be noted that there are recreational marine tech types in the input files that are not yet defined and are not used at this time.

as throttle body fuel injection). For four-stroke engines, “direct injection” includes port fuel injection.

Table 9. Marine Engine Technology Class and Designations

Technology Class Differentiation				Class Designation	
Type	Cycle	Fuel System	Aftertreatment	NONROAD 2004*	NONROAD 2005
Outboard	2-Stroke	Carbureted	none	M1	MO2C
		Carburetor Modifications	none	M5	--
		Carbureted	3- Way Catalyst	M6	--
		Indirect Injection	none	M8	MO2I
		Direct Injection	none	M9	MO2D
	4-Stroke	Carbureted	none	M4	MO4C
		Indirect Injection	none	--	MO4I
		Direct Injection	none	--	MO4D
PWC	2-Stroke	Carbureted	none	M2	MP2C
		Carburetor Modifications	none	M14	--
		Carbureted	2- Way Catalyst	--	MP2CA
		Indirect Injection	none	--	MP2I
		Direct Injection	none	--	MP2D
	4-Stroke	Carbureted	none	M13	MP4C
		Indirect Injection	none	--	MP4I
		Direct Injection	none	--	MP4D
SD/I	4-stroke	Carbureted	none	M3	MS4C
		Direct Injection	none	M10	MS4D

\* NONROAD2004 has additional marine designations that have placeholders but are not used.

Tables 10 and 11 show the HC, NO<sub>x</sub>, CO, and PM emission rates by power range and technology type for outboard and PWC engines, respectively. Table 12 provides the fuel consumption estimates by power range and technology type for outboard and PWC engines.

Table 10. Outboard Emission Factors [g/bhp-hr]

Pollutant	HP Bin	Technology Type					
		MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
HC	0-3	271.92	230.39	38.74	25.60	31.77	19.27
	3-6	236.73	200.58	33.73	19.09	23.69	14.37
	6-11	201.55	170.77	28.72	12.61	15.65	9.49
	11-16	166.37	140.96	23.70	8.89	11.03	6.69
	16-25	131.18	111.15	18.69	6.17	7.66	4.65
	25-40	126.53	107.21	18.03	5.31	6.59	4.00
	40-50	120.97	102.50	15.55	4.81	5.97	3.62
	50-100	109.11	92.45	15.55	4.69	5.82	3.53
	100-175	109.11	92.45	15.55	4.69	5.82	3.53
175+	109.11	92.45	15.55	4.69	5.82	3.53	
NOx	0-3	1.34	1.96	4.32	5.18	5.44	5.82
	3-6	1.34	1.96	4.32	5.18	5.44	5.82
	6-11	1.34	1.96	4.32	5.18	5.44	5.82
	11-16	1.34	1.96	4.32	5.18	5.44	5.82
	16-25	1.34	1.96	4.32	5.18	5.44	5.82
	25-40	1.34	1.96	4.32	5.18	5.44	5.82
	40-50	1.34	1.96	4.32	5.18	5.44	5.82
	50-100	1.34	1.96	4.32	5.18	5.44	5.82
	100-175	1.34	1.96	4.32	5.18	5.44	5.82
175+	1.34	1.96	4.32	5.18	5.44	5.82	
CO	0-3	522.44	443.81	168.07	404.36	442.11	417.79
	3-6	357.31	303.53	114.95	265.94	303.68	279.37
	6-11	316.77	269.10	101.91	217.89	255.64	231.32
	11-16	276.23	234.66	88.87	184.91	222.65	198.34
	16-25	240.34	204.16	77.32	153.03	190.78	166.46
	25-40	240.34	204.16	77.32	121.16	158.91	134.59
	40-50	240.34	204.16	77.32	114.51	152.25	127.94
	50-100	240.34	204.16	77.32	114.51	152.25	127.94
	100-175	240.34	204.16	77.32	114.51	136.58	120.62
175+	240.34	204.16	77.32	114.51	140.71	120.31	
PM	0-3	5.5	4.7	0.33	0.06	0.06	0.06
	3-6	4.8	4.1	0.33	0.06	0.06	0.06
	6-11	4.1	3.5	0.33	0.06	0.06	0.06
	11-16	3.4	2.9	0.30	0.06	0.06	0.06
	16-25	2.7	2.3	0.26	0.06	0.06	0.06
	25-40	2.6	2.2	0.26	0.06	0.06	0.06
	40-50	2.5	2.1	0.22	0.06	0.06	0.06
	50-100	2.2	1.9	0.22	0.06	0.06	0.06
	100-175	2.2	1.9	0.22	0.06	0.06	0.06
175+	2.2	1.9	0.22	0.06	0.06	0.06	

Table 11. Personal Watercraft Emission Factors [g/bhp-hr]

Pollutant	HP Bin	Technology Type						
		MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D
HC	0-3	271.92	205.35	60.78	106.70	25.84	31.75	30.09
	3-6	230.19	173.84	51.46	90.32	15.13	21.04	19.38
	6-11	188.47	142.33	42.13	73.95	4.43	10.33	8.67
	11-16	146.74	110.82	32.80	57.58	4.43	10.33	8.67
	16-25	105.02	79.31	23.48	41.21	4.43	10.33	8.67
	25-40	105.02	79.31	23.48	41.21	3.73	9.63	7.97
	40-50	105.02	79.31	23.48	41.21	3.73	9.63	7.97
	50-100	105.02	79.31	24.74	41.21	3.63	9.54	7.88
	100-175	105.02	79.31	24.37	41.21	3.63	9.54	7.88
175+	105.02	79.31	15.76	41.21	3.63	9.54	7.88	
NOx	0-3	1.08	1.31	3.78	0.27	1.47	4.90	3.55
	3-6	1.08	1.31	3.78	0.27	1.07	4.90	3.55
	6-11	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	11-16	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	16-25	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	25-40	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	40-50	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	50-100	1.08	1.31	3.78	0.27	5.98	4.90	3.55
	100-175	1.08	1.31	3.78	0.27	5.98	4.90	3.55
175+	1.08	1.31	3.78	0.27	5.98	4.90	3.55	
CO	0-3	522.44	477.03	231.18	547.75	476.96	476.96	476.96
	3-6	444.63	405.98	196.75	469.94	401.31	401.31	401.31
	6-11	366.82	334.94	162.32	392.13	181.13	181.13	181.13
	11-16	289.01	263.89	127.89	314.32	171.94	171.94	171.94
	16-25	211.20	192.84	93.46	236.51	162.74	162.74	162.74
	25-40	211.20	192.84	93.46	236.51	153.54	153.54	153.54
	40-50	211.20	192.84	93.46	236.51	153.54	153.54	153.54
	50-100	211.20	193.65	100.82	236.51	153.54	153.54	153.54
	100-175	211.20	193.65	94.68	236.51	153.54	153.54	153.54
175+	211.20	193.65	85.06	236.51	153.54	153.54	153.54	
PM	0-3	5.5	4.7	0.33	4.7	0.06	0.06	0.06
	3-6	4.8	4.1	0.33	4.1	0.06	0.06	0.06
	6-11	4.1	3.5	0.33	3.5	0.06	0.06	0.06
	11-16	3.4	2.9	0.30	2.9	0.06	0.06	0.06
	16-25	2.7	2.3	0.26	2.3	0.06	0.06	0.06
	25-40	2.6	2.2	0.26	2.2	0.06	0.06	0.06
	40-50	2.5	2.1	0.22	2.1	0.06	0.06	0.06
	50-100	2.2	1.9	0.22	1.9	0.06	0.06	0.06
	100-175	2.2	1.9	0.22	1.9	0.06	0.06	0.06
175+	2.2	1.9	0.22	1.9	0.06	0.06	0.06	

Table 12. Fuel Consumption Factors for Outboards and PWC [lbs/bhp-hr]

HP Bin	Technology Type				
	MO2C MP2C, MP2CA	MO2I MP2I	MO2D MP2D	MO4C MP4C	MO4I, MO4D MP4I, MP4D
0-3	1.803	1.623	1.443	0.925	0.832
3-6	1.618	1.456	1.295	0.920	0.828
6-11	1.479	1.332	1.184	0.911	0.820
11-16	1.387	1.248	1.110	0.906	0.816
16-25	1.341	1.207	1.073	0.892	0.803
25-40	1.156	1.040	0.925	0.867	0.780
40-50	1.110	0.999	0.888	0.832	0.749
50-100	1.063	0.957	0.851	0.798	0.718
100-175	0.925	0.832	0.740	0.694	0.624
175+	0.832	0.749	0.667	0.657	0.567

In NONROAD, the technology types for SD/I engines are MS4C for carbureted engines and MS4D for direct injection engines. Table 13 presents the emission factors and fuel consumption estimates for SD/I engines.

Table 13. Emissions and Fuel Consumption for Inboard Engines (MS4C and MS4D tech types)\*

Tech Type	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
MS4C	5.88	153.8	5.35	0.06	0.657
MS4D	3.02	71.8	8.48	0.06	0.567

\* These rates apply to all hp bins.

### **Accounting for In-Use Operation**

Many nonroad engines operate under transient loads, but the engines are typically tested with steady-state tests. For small SI engines ( $\leq 25$  hp), three studies have compared transient and steady-state emissions in SI engines, but they have not found consistent results and, in most cases, transient and steady-state have produced equivalent emission factors. [16,17,18] At present, EPA believes there is not sufficient information to justify an in-use transient adjustment factor (TAF) for small SI engines, so the NONROAD model will use emission factors based on unadjusted steady-state test results. Similarly, TAFs are not applied to the zero hour, steady-state emission factors for recreational equipment and SI marine engines.

For large SI engines  $>25$  hp, based on emission measurements from highway engines comparable to uncontrolled large SI engines, transient emission levels are 30 percent higher for HC and 45 percent higher for CO relative to steady-state measurements. [12, 19] The



NONROAD model therefore multiplies steady-state emission factors for SI engines >25 hp by a TAF of 1.3 for HC and 1.45 for CO to estimate emission levels during normal, transient operation. Test data do not support adjusting NO<sub>x</sub> emission levels for transient operation and so a TAF of 1.0 is used for NO<sub>x</sub> emissions. Also, the model applies no TAFs for generators, pumps, or compressors, since engines in these applications are less likely to experience transient operation. A summary of the TAFs used for large SI engines >25 hp is provided in Table 20.

Table 20. Transient Adjustment Factors (TAFs) for Spark-Ignition Engines >25 hp

Tech Types	HC g/hp-hr	CO g/hp-hr	NO <sub>x</sub> g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
<b>Pre-control TAFs</b>					
Gasoline	1.3	1.45	1.0	1.0	1.0
LPG	1.3	1.45	1.0	1.0	1.0
CNG	1.3	1.45	1.0	1.0	1.0
<b>Phase 1 Control TAFs</b>					
Gasoline	1.7	1.7	1.4	1.0	1.0
LPG	2.9	1.45	1.5	1.0	1.0
CNG	2.9	1.45	1.5	1.0	1.0
<b>Phase 2 Control TAFs</b>					
Gasoline	1.0	1.0	1.0	1.0	1.0
LPG	1.0	1.0	1.0	1.0	1.0
CNG	1.0	1.0	1.0	1.0	1.0

TAFs are applied to gasoline 2-stroke (G2GT25), gasoline 4-stroke (G4GT25), LPG (LGT25), and CNG (NGT25) engines. TAFs are not applied to generator sets, pumps, or air compressors, as these are less likely to experience transient operation.

### **Technology Distributions**

NONROAD accounts for changes in sales fractions and emissions from the advent of emission standards or other changes by assigning technology groups to each Source Classification Code (SCC). Each technology group has its own emission factors as described above, and the fraction of the population assigned to each group can change over time. These “technology fractions” by year are contained in an input file in NONROAD called tech.dat.

The regulations previously discussed for small SI and SI recreational marine engines are expected to influence the sales fraction of various technology types and the emission rates of those technologies. These anticipated changes are described in the regulatory support documents

for the rulemakings and were used directly in NONROAD2004. For NONROAD2005, the technology mixes for recreational SI marine have been updated, as described below. [9]

The outboard and PWC exhaust emission standards are phased in over nine years from 1998-2006. For model years before 1998, no changes were made to the technology mix for NONROAD2005. The technology mix for model years 1998-2005 was revised, however, using the certification data. For the 2006 model year, the technology mix was extrapolated based on the trend in technology development observed in the previous years for each power bin. For the 2007 and later model years, the 2006 technology mix is assumed to remain constant because this is the final year of the standards phase-in.

The SD/I technology fractions in NONROAD2004 were developed based on information available in 2000. At that time, about half of new SD/I sales were estimated by industry to use electronic fuel injection. Industry projections were that most, if not all, SD/I engines would be fuel injected by 2004.

For SD/I engines, we do not have an EPA certification database because there are currently no federal exhaust emission standards in place for these engines. However, the first Tier of California exhaust emission standards for SD/I engines began in 2003. Six SD/I manufacturers certified in California for 2003. We estimate that these six manufacturers make up more than 90 percent of the total national SD/I engine sales. Therefore, we believe it is reasonable to use the California data to estimate the SD/I technology mix for 2003.

The California certification database shows that about 40% of the engines certified in 2003 are still equipped with carburetors. Based on this information, we have updated the technology mix for SD/I engines to reflect this slower introduction of electronic fuel injection.

The technology fractions by SCC in tech.dat are provided in Appendix B.

### **Carbon Dioxide Emission Factors**

Emission factors for CO<sub>2</sub> are rarely measured; instead, they typically are calculated based on brake-specific fuel consumption (BSFC). The NONROAD model uses 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. This does not require a CO<sub>2</sub> emission factors input file.

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

where

*CO<sub>2</sub> is in g/hp-hr*

*BSFC is the fuel consumption in lb/hp-hr*

*453.6 is the conversion factor from pounds to grams*

*HC is the in-use adjusted hydrocarbon emissions in g/hp-hr*

*0.87 is the carbon mass fraction of gasoline and diesel fuel*

44/12 is the ratio of CO<sub>2</sub> mass to carbon mass

### **Sulfur Dioxide Emission Factors**

Sulfur dioxide emissions are rarely measured. Instead, they typically are calculated from fuel consumption and fuel sulfur content. We have retained this approach for the NONROAD model. Sulfur dioxide emission factors for gasoline engines are calculated using the following equation:

$$SO_2 = (BSFC * 453.6 * (1 - soxcnv) - HC) * 0.01 * soxbas * 2$$

where

*SO<sub>2</sub> is in g/hp-hr*

*BSFC is the 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 (soxcnv = 0.03 for gasoline engines)*

*HC is the in-use adjusted hydrocarbon emissions in g/hp-hr*

*0.01 is the conversion factor from weight percent to weight fraction*

*soxbas is the episodic weight percent of sulfur in the fuel (default value for gasoline is 0.0339)*

*2 is the grams of SO<sub>2</sub> formed from a gram of sulfur*

The calculation for CNG/LPG engines is similar, with an average default fuel sulfur weight percent (soxbas) of 0.008 and the same sulfur conversion rate (soxcnv = 0.03).

The SO<sub>2</sub> emission factors are calculated based on the default fuel sulfur contents listed here. NONROAD users may use the model interface to adjust the fuel sulfur content without changing the input files.

### **Crankcase Emissions**

Crankcase emissions are those emissions that escape from the combustion chamber past the piston rings into the crankcase of four-stroke spark-ignition engines. Crankcase emissions from 2-stroke engines do not exist due to the free flow of gases from the crankcase to the combustion chamber in these engines. EPA Phase I regulations require closed crankcases for all 1997 and later spark-ignition engines under 19 kilowatts (25 hp), so these are assumed to have zero crankcase emissions.[20] Also, all 4-stroke engines used in marine vessels are assumed to have closed crankcases, including inboard, sterndrive, and 4-stroke outboards. All other gasoline 4-stroke equipment are assumed to have open crankcases, except lawn and garden equipment produced prior to 1997. The final NONROAD2005 model uses the estimate that 21

percent of pre-1997 lawn and garden equipment have open crankcases. In addition, the model assumes that all compression ignition diesel engines have crankcase emissions.

Regarding crankcase emissions from chippers/stump grinders, previous versions of this technical report stated: "All pre-1997 chippers/stump grinders are assumed to have open crankcases." However, it should be noted that prior versions of the draft NONROAD model did not conform to the technical report, using the 21% estimate applied to pre-1997 lawn and garden equipment mentioned above. EPA corrected the draft NONROAD2002 model and all subsequent versions to assume that all pre-1997 chippers/stump grinders have open crankcases.

It should be noted that the final Nonroad Diesel Engine Tier 4 Rule assumes zero crankcase emissions for Tier 4 nonroad engines, and this is reflected in the draft NONROAD2004 and final NONROAD2005 models.

#### Crankcase Emissions: Sources of Values Used in NONROAD

Due to lack of any other sources of crankcase emission data, the final NONROAD2005 model uses the crankcase emission factors from NEVES for all engines produced without closed crankcases. NEVES uses data from on-highway engines to estimate nonroad crankcase emission rates. Using the NEVES data, NONROAD assumes the crankcase HC emission factor is equal to 33% of the exhaust HC emission factor for 4-stroke engines with open crankcases. For diesel engines with open crankcases, NONROAD assumes the HC emission factor is equal to 2.0% of the exhaust HC emission factor. 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.

Although NEVES also provides diesel crankcase emission factors for CO (0.2% of exhaust CO) and NO<sub>x</sub> (0.05% of exhaust NO<sub>x</sub>), there is no provision within NONROAD for modeling these since they are so small. Comments are welcome regarding the need for inclusion of CO and NO<sub>x</sub> crankcase emissions either within the model or as a manual addition to the exhaust estimates produced by the model.

## **References**

- [1] "Nonroad Engine and Vehicle Emission Study" (NEVES), U.S. EPA, Office of Air and Radiation, 21A-2001, November, 1991.
- [2] "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.
- [3] "Documentation of the OMS Small Gasoline Engine Spreadsheet System, Final Technical Memorandum," Dan Bowman, TRC Environmental Corporation, August 1995.
- [4] "Emissions for New Nonroad Spark-Ignition Engines At or Below 19 Kilowatts; Final Rule," 60 FR 34581, July 3, 1995.
- [5] "Phase 2: Emission Standards for New Nonroad Nonhandheld Spark Ignition Engines At or Below 19 Kilowatts," Amendments to 40 CFR Part 90, March 1999.
- [6] "Phase 2: Emission Standards for New Nonroad Spark-Ignition Handheld Engines At or Below 19 Kilowatts and Minor Amendments to Emission Requirements Applicable to Small Spark-Ignition Engines and Marine Spark-Ignition Engines; Final Rule," 65 FR 24268, April 25, 2000.
- [7] "Final Rule for New Gasoline Spark-Ignition Marine Engines; Exemptions for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts and New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts," 61 FR 52088, October 4, 1996.
- [8] "Control of Emissions From Nonroad Large Spark-Ignition Engines and Recreational Engines (Marine and Land-Based); Final Rule," 67 FR 68241, November 8, 2002.
- [9] "Updates to Technology Mix, Emissions Factors, Deterioration Rates, Power Distribution, and Fuel Consumption Estimates for SI Marine Engines in the NONROAD Emissions Inventory Model," Memo from Mike Samulski to Docket OAR-2004-0008, November 30, 2005.
- [10] "Final Regulatory Impact Analysis, Phase 2: Emission Standards for New Nonroad Nonhandheld Spark-Ignition Engines At or Below 19 Kilowatts," U.S. EPA, EPA420-R-99-003, March 1999.
- [11] "Final Regulatory Impact Analysis, Phase 2 Final Rule: Emission Standards for New Nonroad Handheld Spark-Ignition Engines At or Below 19 Kilowatts," U.S. EPA, EPA420-R-00-004, March 2000.
- [12] "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," U.S. EPA, EPA420-R-02-022, September 2002.

- [13] "Emission Modeling for Recreational Vehicles," EPA Memorandum from Linc Wehrly to Docket A-98-01, EPA420-F-00-051, November 13, 2000.
- [14] "Regulatory Impact Analysis: Control of Air Pollution Emission Standards for New Spark-Ignition Marine Engines," U.S. EPA, October, 1996.
- [15] "Revisions to the June 2000 Release of NONROAD to Reflect New Information and Analysis on Marine and Industrial Engines," EPA Memorandum from Mike Samulski to Docket A-98-01, Docket Item IV-8-1, November 2, 2000.
- [16] "Emissions Analysis of Small Utility Engines." Sun, X., et al. SAE paper 952080. 1995.
- [17] "Emissions from 4-Cycle Walk-Behind-Mower Engines: Test Cycle Effects." Gabele, Peter. SAE Paper 972793. 1997
- [18] "Transient versus steady-state test procedure evaluation of 4-cycle utility engines," Carpenter, T., Buszkiewicz, T., Trimble, T. EPA regulation negotiation test procedure task group, November, 1994. EPA Air Docket A-93-29, Docket Item II-M-27 and "Final Report - Handheld Subgroup of the Test Procedure Task Group", EPA Air Docket A-93-29, Docket Item II-M-40.
- [19] "Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and Later Model Year Heavy Duty Engines," p. 189, U.S. EPA, Docket A-2000-01, December 1979.
- [20] Federal Register: July 3, 1995 (Volume 60, Number 127), Page 34581-34657, "Control of Air Pollution; Emission Standards for New Nonroad Spark-ignition Engines At or Below 19 Kilowatts," and Code of Federal Regulations 40 CFR 90.109 "Requirement of certification--closed crankcase."

## Appendix A Cross-Inventory Comparison of SI Emission Factors

Comparing emission factors between inventory models (NEVES, OFF-ROAD, EPA's Small Engine Model) is not straightforward because the different models and inventories use different units and different categories in distinguishing emission factors. To compare the factors, all factors were converted to list emission factors in g/hp-hr by engine type, application and horsepower. This conversion required mapping both the ARB horsepower groups and the Small Engine Model's displacement classes to the horsepower groups used by the NONROAD model (see Tables A1 and A2). It was also necessary to combine the Small Engine Model's overhead-valve and side-valve categories into a single category by using a sales-weighted average, using the sales mix listed in Table A3.

Table A1. Mapping of small engine groupings used in the Small Engine Model and ARB's OFF-ROAD model to the small engine groupings used in the NONROAD model

Small Engine Model Class/Displacement	ARB Power Range	NONROAD Power Range	NONROAD source classification
Non-Handheld, I <225 cc	2-5 hp	3-6 hp	All engines except 2-stroke trimmers/edgers/cutters, chainsaws, leafblowers, and snowblowers
Non-Handheld, II >225 cc	5-15 hp 15-25 hp	6-16 hp 16-25 hp	All engines except 2-stroke trimmers/edgers/cutters, chainsaws, leafblowers, and snowblowers
Handheld, III 0-20 cc	≤ 2 hp	0-1 hp	All engines
Handheld, IV 20-50 cc	≤ 2 hp	1-3 hp	All engines
Handheld, V >50 cc	2-15 hp	3-6 hp	All 2-stroke trimmers/edgers/cutters, chainsaws, leafblowers, and snowblowers

Table A2. Mapping of large engine groupings used in ARB's OFF-ROAD model to the large engine groupings used in the NONROAD model.

ARB hp range	NONROAD hp Range
5-15	6-11 & 11-16
15-25	16-25
25-50	25-50
50-120	50-100
120-175	100-175
175-250	175-250
250-500	250-500
500-750	500-750
750-9999	750-3000+



Table A3. Sales Mix for Small Engine Model, Pre-control [1]

Application	Sales Mix									
	2-stroke handheld			2-stroke non-handheld		4-stroke non-handheld, overhead- and side-valve				
	Class 3	Class 4	Class 5	Class 1	Class 2	Class 1 OHV	Class 1 SV	Class 2 OHV	Class 2 SV	Class 2 SV
Lawn Mowers				0.1		0.065	0.835		0.0014	
Trimmers/ Edgers/ Cutters	0.0501	0.9173	0.0077			0.0016	0.0231		0.0002	
Chain Saws	0.0035	0.6426	0.3539							
Leaf Blowers/ Vacuums	0.0528	0.6299	0.2086			0.0007	0.0721	0.0001	0.0359	
Generator Sets				0.0017		0.0057	0.2853	0.0551	0.6522	
Tillers		0.0101	0				0.7938	0.0001	0.196	
Snowblowers			0.3205				0.3732		0.3063	
Commercial Turf Equipment				0.0099		0.04	0.0647	0.3658	0.5196	
Rear Engine Riding Mowers							0.0499	0.1563	0.7939	
Lawn & Garden Tractors						0.0222	0.804	0.0013	0.1725	
Pumps							0.0049	0.1421	0.8531	
All Other Equipment				0.0974	0.0024	0.0375	0.4064	0.0081	0.4482	

[1] "Documentation of the OMS Small Gasoline Engine Spreadsheet System, Final Technical Memorandum" TRC Environmental Corporation for U.S. EPA Air and Energy Research Laboratory. August 1995.

## Appendix B Technology Groups and Distributions by Year

NONROAD accounts for changes in sales fractions and emissions from the advent of emission standards or other changes by assigning technology groups to each Source Classification Code (SCC). (SCC descriptions are given in NR-006d.) Each technology group has its own emission factor and the fraction of the population assigned to each group can change over time. These “technology fractions” are contained in an input file in NONROAD called *tech.dat*. A sample record for 4-stroke lawnmowers might show a shift in engine sales from side-valve engines (Tech Group 1) to overhead valve engines (Tech Group 2) as illustrated in Table B1, which shows side-valve engines declining from 90% of sales in 1991 to 50% of sales in 1997.

Table B1. Sample Technology Fractions

SCC/Year	Horsepower Range	Tech group/fraction	Tech group/fraction
2260004010	3-6 hp	1	2
1990		0.90	0.10
1997		0.50	0.50

Each technology group has an associated emission factor given in the emission factor input file for that pollutant. This emission factor can change with time. For example, CO emissions from Technology Group 1 (side-valve engines) might decrease from 819 g/hp-hr for model year engines 1990 through 1996 to 387 g/hp-hr for model years 1997 and later as shown in Table B2. The year listed in the emission factor input file is the first year in which the new emission factor applies.

Table B2. Sample Emission Factors

SCC/Year	Horsepower Range	Technology group/emissions	Units	Pollutant
2265004010	3-6 hp	1	g/hp-hr	CO
1990		819		
2265004010	3-6 hp	1	g/hp-hr	CO
1997		387		

For pre-controlled engines, the only technology groups currently identified are those used to combine SCCs for spark-ignition engines <25 hp as described in NR-006d. Technology groups primarily will be used for engines subject to emissions regulations. The regulations discussed in the main body of this report (for small SI engines  $\leq 25$  hp and SI recreational marine engines) are expected to influence the sales fraction of various technology types and the emission rates of those technologies. The technology types meeting the new standards (with appropriately lower emission factors) then gain market share during the appropriate model years which represent the start year of the regulations. These anticipated changes are described in EPA's rulemakings.

Table B3 provides a list and description of the SI technology groups used in final NONROAD2005. Table B4 contains the technology fractions in tech.dat.

If new emission factors are developed for other parts of the inventory (e.g., larger SI engines) to reflect distinctions between different engine technologies with different emission levels, then appropriate technology groups, technology fractions, and emission factors will be added to the model. Similarly, appropriate emission factors will be added to the model if new emission standards are implemented.

Table B3. Spark-Ignition Technologies in the Final NONROAD2005 Model

Engine Tech Type Code	SI Engine Category	Description
G2GT25	Large SI > 25hp	Gasoline, 2-stroke, Baseline
G2H3	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class III (<20cc), Baseline
G2H31	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class III (<20cc), Phase 1
G2H3C1	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class III (<20cc), Phase 1 with catalyst
G2H32	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class III (<20cc), Phase 2
G2H3C2	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class III (<20cc), Phase 2 with catalyst
G2H4	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class IV ( $\geq 20$ cc and <50cc), Baseline
G2H41	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class IV ( $\geq 20$ cc and <50cc), Phase 1
G2H4C1	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class IV ( $\geq 20$ cc and <50cc), Phase 1 with catalyst
G2H42	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class IV ( $\geq 20$ cc and <50cc), Phase 2
G2H4C2	Small SI $\leq 25$ hp	Gasoline, 2-stroke, handheld Class IV ( $\geq 20$ cc and <50cc), Phase 2 with catalyst

Table B3. Spark-Ignition Technologies in the Final NONROAD2005 Model

<b>Engine Tech Type Code</b>	<b>SI Engine Category</b>	<b>Description</b>
G2H5	Small SI $\leq$ 25hp	Gasoline, 2-stroke, handheld Class V ( $>50\text{cc}$ ), Baseline
G2H51	Small SI $\leq$ 25hp	Gasoline, 2-stroke, handheld Class V ( $>50\text{cc}$ ), Phase 1
G2H5C1	Small SI $\leq$ 25hp	Gasoline, 2-stroke, handheld Class V ( $>50\text{cc}$ ), Phase 1 with catalyst
G2H52	Small SI $\leq$ 25hp	Gasoline, 2-stroke, handheld Class V ( $>50\text{cc}$ ), Phase 2
G2H5C2	Small SI $\leq$ 25hp	Gasoline, 2-stroke, handheld Class V ( $>50\text{cc}$ ), Phase 2 with catalyst
G2N1	Small SI $\leq$ 25hp	Gasoline, 2-stroke, nonhandheld Class I ( $<225\text{cc}$ ), Baseline
G2N11	Small SI $\leq$ 25hp	Gasoline, 2-stroke, nonhandheld Class I ( $<225\text{cc}$ ), Phase 1
G2N2	Small SI $\leq$ 25hp	Gasoline, 2-stroke, nonhandheld Class II ( $\geq 225\text{cc}$ ), Baseline
G4GT25	Large SI $>$ 25hp	Gasoline, 4-stroke, Baseline
G4GT251	Large SI $>$ 25hp	Gasoline, 4-stroke, Phase 1
G4GT252	Large SI $>$ 25hp	Gasoline, 4-stroke, Phase 2
G4H41	Small SI $\leq$ 25hp	Gasoline, 4-stroke, handheld Class IV ( $\geq 20\text{cc}$ and $<50\text{cc}$ ), Phase 1
G4H42	Small SI $\leq$ 25hp	Gasoline, 4-stroke, handheld Class IV ( $\geq 20\text{cc}$ and $<50\text{cc}$ ), Phase 2
G4N1O	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I ( $<225\text{cc}$ ), Baseline
G4N1O1	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I ( $<225\text{cc}$ ), Phase 1
G4N1O2	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I ( $<225\text{cc}$ ), Phase 2
G4N1S	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I ( $<225\text{cc}$ ), Baseline
G4N1S1	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I ( $<225\text{cc}$ ), Phase 1
G4N1SC1	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I ( $<225\text{cc}$ ), Phase 1 with catalyst
G4N1S2	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I ( $<225\text{cc}$ ), Phase 2
G4N2O	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II ( $\geq 225\text{cc}$ ), Baseline

Table B3. Spark-Ignition Technologies in the Final NONROAD2005 Model

<b>Engine Tech Type Code</b>	<b>SI Engine Category</b>	<b>Description</b>
G4N2O1	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II ( $\geq$ 225cc), Phase 1
G4N2O2	Small SI $\leq$ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II ( $\geq$ 225cc), Phase 2
G4N2S	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II ( $\geq$ 225cc), Baseline
G4N2S1	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II ( $\geq$ 225cc), Phase 1
G4N2S2	Small SI $\leq$ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II ( $\geq$ 225cc), Phase 2
LGT25	Large SI $>$ 25hp	Liquid Petroleum Gas, Baseline
LGT251	Large SI $>$ 25hp	Liquid Petroleum Gas, Phase 1
LGT252	Large SI $>$ 25hp	Liquid Petroleum Gas, Phase 2
MO2C	Recreational Marine	Outboard, 2-stroke, carbureted, no aftertreatment
MO2I	Recreational Marine	Outboard, 2-stroke, indirect injection, no aftertreatment
MO2D	Recreational Marine	Outboard, 2-stroke, direct injection, no aftertreatment
MO4C	Recreational Marine	Outboard, 4-stroke, carbureted, no aftertreatment
MO4I	Recreational Marine	Outboard, 4-stroke, indirect injection, no aftertreatment
MO4D	Recreational Marine	Outboard, 4-stroke, direct injection, no aftertreatment
MP2C	Recreational Marine	Personal Watercraft, 2-stroke, carbureted, no aftertreatment
MP2CA	Recreational Marine	Personal Watercraft, 2-stroke, carbureted, 2-way catalyst
MP2I	Recreational Marine	Personal Watercraft, 2-stroke, indirect injection, no aftertreatment
MP2D	Recreational Marine	Personal Watercraft, 2-stroke, direct injection, no aftertreatment
MP4C	Recreational Marine	Personal Watercraft, 4-stroke, carbureted, no aftertreatment
MP4I	Recreational Marine	Personal Watercraft, 4-stroke, indirect injection, no aftertreatment
MP4D	Recreational Marine	Personal Watercraft, 4-stroke, direct injection, no aftertreatment
MS4C	Recreational Marine	Sterndrive/Inboard, 4-stroke, carbureted, no aftertreatment
MS4I	Recreational Marine	Sterndrive/Inboard, 4-stroke, indirect injection, no aftertreatment
MS4D	Recreational Marine	Sterndrive/Inboard, 4-stroke, direct injection, no aftertreatment

Table B3. Spark-Ignition Technologies in the Final NONROAD2005 Model

<b>Engine Tech Type Code</b>	<b>SI Engine Category</b>	<b>Description</b>
NGT251	Large SI > 25hp	Compressed Natural Gas, Phase 1
NGT252	Large SI > 25hp	Compressed Natural Gas, Phase 2
R12S	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 2-stroke, Baseline
R12S1	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 2-stroke, Phase 1
R12S2	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 2-stroke, Phase 2
R14S	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 4-stroke, Baseline
R14S	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 4-stroke, Phase 1

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type															
				G2GT25	G4GT251	G4GT252	G2H3	G2H31	G2H3C1	G2H32	G4H31	G2H3C2	G4H32	G2H4	G2H41	G2H4C1	G4H41	G2H42	G2H4C2
	2260000000	0	9999																
1900				1	0	0													
2004				0	1	0													
2007				0	0	1													
	2265000000	0	9999																
1900				1	0	0													
2004				0	1	0													
2007				0	0	1													
	2260000000	0	1																
1900				1	0	0													
1996				0.5	0.495	0.005													
1997				0	0.99	0.01													
2002				0	0.7425	0.0075													
2003				0	0.495	0.005													
2004				0	0.2475	0.0025													
2005				0	0	0													
2006				0	0	0													
	2260000000	1	3																
1900				1	0	0													
1996				0.5	0	0													
1997				0	0	0													
2002				0	0	0													
2003				0	0	0													
2004				0	0	0													
2005				0	0	0													
2006				0	0	0													
	2260000000	3	6																
1900				1	0	0													
1996				0.5	0	0.495													
1997				0	0	0.99													
2002				0	0	0.99													
2003				0	0	0.99													
2004				0	0	0.99													
2006				0	0	0													
	2260000000	3	6																
1900				1	0	0													
1996				0.5	0	0.495													
1997				0	0	0.99													
2002				0	0	0.99													
2003				0	0	0.99													
2004				0	0	0.99													

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type															
				G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2	G2N1	G4N1O	G4N1S	G4N1O1	G4N1S1	G4N1O2	G4N1S2
2005				0	0	0.495	0.005	0.5	0										
2006				0	0	0.2475	0.0025	0.75	0										
2007				0	0	0	0	1	0										
2008				0	0	0	0	1	0										
	2260000000	6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2							
1900				0.005	0.018	0.977	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.003	0.009	0.488	0	0.5	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0.017	0.983	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0.008	0.492	0.5	0	0	0	0	0	0	0	0	0	0
2002				0	0	0	0.006	0.369	0.625	0	0	0	0	0	0	0	0	0	0
2003				0	0	0	0.004	0.246	0.75	0	0	0	0	0	0	0	0	0	0
2004				0	0	0	0.002	0.123	0.875	0	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	2265000000	0	6	G2N1	G4N1O	G4N1S	G2N11	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N1							
1900				0.18	0.069	0.751	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.09	0.035	0.375	0	0.083	0.417	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	0.167	0.833	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0	0	0
2008				0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	2265000000	6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2							
1900				0.005	0.018	0.977	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.003	0.009	0.488	0	0.5	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0.017	0.983	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0.008	0.492	0.5	0	0	0	0	0	0	0	0	0	0
2002				0	0	0	0.006	0.369	0.625	0	0	0	0	0	0	0	0	0	0
2003				0	0	0	0.004	0.246	0.75	0	0	0	0	0	0	0	0	0	0
2004				0	0	0	0.002	0.123	0.875	0	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	2260001010	0	9999	R12S	R12SP	R14S1	R14S1P												
1900				1	0	0	0												
2006				0.76	0	0.24	0												
2007				0.53	0	0.47	0												
2008				0.49	0	0.51	0												



Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type																
				R14S	R14S1	R14S2	R14S	R14S1	R14S2	R14S1P	R14S2C	R14S2CP	R14S2C	R14S2CP						
2009				0.46	0	0.54	0													
	2265001010	0	9999	<b>R14S</b>	<b>R14SP</b>	<b>R14S1</b>	<b>R14S1P</b>													
1900				1	0	0	0													
2006				0.56	0	0.44	0													
2007				0.12	0	0.88	0													
2008				0.06	0	0.94	0													
2009				0	0	1	0													
	2260001020	0	9999	<b>R12S</b>	<b>R12S1</b>	<b>R12S2</b>	<b>R14S</b>													
1900				1	0	0	0													
2005				0.86	0	0.07	0.07													
2006				0.53	0.3	0.085	0.085													
2007				0.2	0.6	0.1	0.1													
2010				0.2	0.3	0.35	0.15													
2012				0.1	0.2	0.5	0.2													
	2265001020	0	9999	<b>R14S</b>	<b>R14S1</b>	<b>R14S2</b>														
1900				1	0	0	0													
2006				0	1	0	0													
2010				0	0	1	0													
	2260001030	0	9999	<b>R12S</b>	<b>R12SP</b>	<b>R14S1</b>	<b>R14S1P</b>	<b>R14S2</b>	<b>R14S2P</b>	<b>R14S2C</b>	<b>R14S2CP</b>									
1900				1	0	0	0	0	0	0	0									
2006				0.65	0	0.35	0	0	0	0	0									
2007				0.3	0	0.7	0	0	0	0	0									
2008				0.15	0	0.85	0	0	0	0	0									
2009				0	0	1	0	0	0	0	0									
2010				0	0	1	0	0	0	0	0									
2010				0	0	1	0	0	0	0	0									
2010				0	0	1	0	0	0	0	0									
	2265001030	0	9999	<b>R14S</b>	<b>R14SP</b>	<b>R14S1</b>	<b>R14S1P</b>	<b>R14S2</b>	<b>R14S2P</b>	<b>R14S2C</b>	<b>R14S2CP</b>									
1900				1	0	0	0	0	0	0	0									
2006				0.5	0	0.5	0	0	0	0	0									
2007				0	0	1	0	0	0	0	0									
2009				0	0	1	0	0	0	0	0									
2010				0	0	1	0	0	0	0	0									

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type																					
				G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1SC1	G4N1O2	G4NIS2	L4N1	G2H5	G2H5C	G2H51	G2H5C1	G2H52	G2H5C2	G4N1O1	G4NIS1	G4N1SC1	G4N1O2	G4NIS2	L4N1
1900	2265004010	0	6	0.05	0.07	0.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.025	0.035	0.44	0	0.052	0.448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	0.1038	0.8962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0	0	0.417	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	2265004011	0	6	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1SC1	G4N1O2	G4NIS2	L4N1												
1996				0.15	0.06	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0.075	0.03	0.395	0	0.072	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.143	0.857	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	2265004015	0	6	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1SC1	G4N1O2	G4NIS2	L4N1												
1996				0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0.5	0	0.005	0.495	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.01	0.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	2260004020	6	9999	G2H5	G2H5C	G2H51	G2H5C1	G2H52	G2H5C2																
1996				1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0.5	0	0.495	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002				0	0	0.99	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003				0	0	0.99	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004				0	0	0.7425	0.0075	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005				0	0	0.495	0.005	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006				0	0	0.2475	0.0025	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	2260004021	6	9999	G2H5	G2H5C	G2H51	G2H5C1	G2H52	G2H5C2																
1996				1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0.5	0	0.495	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type															
				G2H3	G2H31	G2H3C1	G2H32	G4H31	G2H3C2	G4H32	G2H4	G2H4C	G4H4	G2H41	G2H4C1	G4H41	G2H42	G2H4C2	G4H42
2002				0	0	0.99	0.01	0	0										
2003				0	0	0.99	0.01	0	0										
2004				0	0	0.7425	0.0075	0.25	0										
2005				0	0	0.495	0.005	0.5	0										
2006				0	0	0.2475	0.0025	0.75	0										
2007				0	0	0	0	1	0										
2008				0	0	0	0	1	0										
	2260004025	0	1	<b>G2H3</b>	<b>G2H31</b>	<b>G2H3C1</b>	<b>G2H32</b>	<b>G4H31</b>	<b>G2H3C2</b>	<b>G4H32</b>									
1900				1	0	0	0	0	0										
1996				0.5	0.495	0.005	0	0	0										
1997				0	0.99	0.01	0	0	0										
2002				0	0.7425	0.0075	0	0	0.25										
2003				0	0.495	0.005	0	0	0.5										
2004				0	0.2475	0.0025	0	0	0.75										
2005				0	0	0	0	0	1										
2006				0	0	0	0	0	1										
	2260004025	1	3	<b>G2H4</b>	<b>G2H4C</b>	<b>G4H4</b>	<b>G2H41</b>	<b>G2H4C1</b>	<b>G4H41</b>	<b>G2H42</b>	<b>G2H4C2</b>	<b>G4H42</b>							
1900				1	0	0	0	0	0										
1996				0.5	0	0	0.49	0.005	0.005										
1997				0	0	0	0.98	0.01	0.01										
1998				0	0	0	0.97208081	0.00991919	0.018										
2002				0	0	0	0.675	0.075	0										
2003				0	0	0	0.45	0.05	0										
2004				0	0	0	0.225	0.025	0										
2005				0	0	0	0	0	0										
2006				0	0	0	0	0	0										
	2265004025	3	6	<b>G2N1</b>	<b>G4N10</b>	<b>G4NIS</b>	<b>G2N11</b>	<b>G4N101</b>	<b>G4NIS1</b>	<b>G4NIS2</b>	<b>G4N102</b>	<b>G4NIS2</b>	<b>L4N1</b>						
1900				0	0.063	0.936	0	0	0										
1996				0	0.032	0.468	0	0.037	0.463										
1997				0	0	0	0	0.073	0.927										
2007				0	0	0	0	0.097	0.486										
2008				0	0	0	0	0	0										
	2265004025	6	25	<b>G2N2</b>	<b>G4N20</b>	<b>G4N2S</b>	<b>G4N201</b>	<b>G4N2S1</b>	<b>G4N202</b>	<b>G4N2S2</b>	<b>L4N2</b>	<b>N4N2</b>							

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type													
				G2H3	G2H31	G2H3C1	G2H3C2	G2H3C3	G4H31	G2H3C2	G4H32	G2H41	G2H4C1	G4H41	G2H4C2	G4H42	G2H4C2
1900				0	0	1	0	0	0	0	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	1	0	0	0	0	0	0	0	0	0
2001				0	0	0	0	0.5	0.5	0	0	0.5	0	0	0	0	0
2002				0	0	0	0	0.375	0.625	0	0	0.625	0	0	0	0	0
2003				0	0	0	0	0.25	0.75	0	0	0.75	0	0	0	0	0
2004				0	0	0	0	0.125	0.875	0	0	0.875	0	0	0	0	0
2005				0	0	0	0	0	1	0	0	1	0	0	0	0	0
	2260004026	0	1	<b>G2H3</b>	<b>G2H31</b>	<b>G2H3C1</b>	<b>G2H3C2</b>	<b>G2H3C3</b>	<b>G4H31</b>	<b>G2H3C2</b>	<b>G4H32</b>	<b>G4H32</b>					
1900				1	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.5	0.495	0.005	0	0	0	0	0	0	0	0	0	0	0
1997				0	0.99	0.01	0	0	0	0	0	0	0	0	0	0	0
2002				0	0.7425	0.0075	0	0	0	0.25	0	0.25	0	0	0	0	0
2003				0	0.495	0.005	0	0	0	0.5	0	0.5	0	0	0	0	0
2004				0	0.2475	0.0025	0	0	0	0.75	0	0.75	0	0	0	0	0
2005				0	0	0	0	0	0	1	0	1	0	0	0	0	0
2006				0	0	0	0	0	0	1	0	1	0	0	0	0	0
	2260004026	1	3	<b>G2H4</b>	<b>G2H4C</b>	<b>G4H4</b>	<b>G2H41</b>	<b>G2H4C1</b>	<b>G4H41</b>	<b>G2H4C2</b>	<b>G4H41</b>	<b>G2H4C2</b>	<b>G4H42</b>	<b>G2H4C2</b>	<b>G4H42</b>		
1900				1	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.5	0	0	0.49	0.005	0.005	0.005	0.005	0	0	0	0	0	0
1997				0	0	0	0.98	0.01	0.01	0.01	0.01	0	0	0	0	0	0
1998				0	0	0	0.97208081	0.00991919	0.018	0.018	0	0	0	0	0	0	0
2002				0	0	0	0.675	0.075	0	0	0.2	0.05	0.05	0.05	0.05	0.05	0.05
2003				0	0	0	0.45	0.05	0	0	0.4	0.1	0.1	0.1	0.1	0.1	0.1
2004				0	0	0	0.225	0.025	0	0	0.6	0.15	0.15	0.15	0.15	0.15	0.15
2005				0	0	0	0	0	0	0	0.8	0.2	0.2	0.2	0.2	0.2	0.2
2006				0	0	0	0	0	0	0	0.8	0.2	0.2	0.2	0.2	0.2	0.2
	2265004026	3	6	<b>G2N1</b>	<b>G4N10</b>	<b>G4N1S</b>	<b>G2N11</b>	<b>G4N101</b>	<b>G4N1S1</b>	<b>G4N102</b>	<b>G4N1S2</b>	<b>G4N102</b>	<b>G4N1S2</b>	<b>L4N1</b>			
1900				0	0.063	0.936	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.032	0.468	0	0.037	0.463	0	0	0	0	0	0	0	0
1997				0	0	0	0	0.073	0.927	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0	0.417	0	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type																				
				G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1S1	G4N1O2	G4NIS2	L4N1		
1900	2265004026	6	25	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1997				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2001				0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	
2002				0	0	0	0	0	0	0.375	0	0.625	0	0	0	0	0	0	0	0	0	0	0	
2003				0	0	0	0	0	0	0.25	0	0.75	0	0	0	0	0	0	0	0	0	0	0	
2004				0	0	0	0	0	0	0.125	0	0.875	0	0	0	0	0	0	0	0	0	0	0	
2005				0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
1900	2265004030	0	6	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1S1	G4N1O2	G4NIS2	L4N2	N4N2	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1S1	G4N1O2	G4NIS2	L4N1
1996				0	0.01	0.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0.005	0.495	0	0.01	0.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.019	0.981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0.097	0.486	0	0	0	0.417	0	0	0	0	0	0	0	0	0.417	0	0
1900	2265004030	6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4NIS2	L4N2	N4N2	G2N2	G4N2O	L4N1
1996				0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0.002	0.998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002				0	0	0	0.001	0.499	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003				0	0	0	0	0.375	0.625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004				0	0	0	0	0.25	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0.125	0.875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	2265004031	0	6	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1S1	G4N1O2	G4NIS2	L4N2	N4N2	G2N1	G4N1O	G4NIS	G2N11	G4N1O1	G4NIS1	G4N1S1	G4N1O2	G4NIS2	L4N1
1996				0	0.01	0.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0.005	0.495	0	0.01	0.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.019	0.981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0.097	0.486	0	0	0	0.417	0	0	0	0	0	0	0	0	0.417	0	0
1900	2265004031	6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	L4N2	N4N2	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4NIS2	L4N2	N4N2	G2N2	G4N2O	L4N1
1996				0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type															
				G2N1	G4N1O	G4NIS	G2N1	G4N2O1	G4N2S	G4N2O	G4N2S1	G4N2O2	G4N2S2	G4N1O1	G4N1S1	G4N1O2	G4N1S2	G4N1O2	G4N1S2
2002				0	0	0	0	0.062	0.313	0.625	0	0	0	0	0	0	0	0	0
2003				0	0	0	0	0.041	0.209	0.75	0	0	0	0	0	0	0	0	0
2004				0	0	0	0	0.02	0.105	0.875	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2265004041		0	6	G2N1	G4N1O	G4NIS	G2N1	G4N2O1	G4N2S1	G4N2O2	G4N2S2	G4N1O1	G4N1S1	G4N1O2	G4N1S2	G4N1O2	G4N1S2	L4N1	
1900				0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0	0	0.5	0	0.005	0.495	0	0.005	0.495	0	0	0	0	0	0
1997				0	0	0	0	0	0.01	0.99	0	0.01	0.99	0	0	0	0	0	0
2007				0	0	0	0	0	0.097	0.486	0	0.097	0.486	0	0.417	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2265004041		6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N2	N4N2			
1900				0	0.164	0.836	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.082	0.418	0.082	0.418	0	0	0.418	0	0	0	0	0	0	0	0
1997				0	0	0	0.164	0.836	0	0	0.836	0	0	0	0	0	0	0	0
2001				0	0	0	0.082	0.418	0.5	0	0.418	0.5	0	0	0	0	0	0	0
2002				0	0	0	0.062	0.313	0.625	0	0.313	0.625	0	0	0	0	0	0	0
2003				0	0	0	0.041	0.209	0.75	0	0.209	0.75	0	0	0	0	0	0	0
2004				0	0	0	0.02	0.105	0.875	0	0.105	0.875	0	0	0	0	0	0	0
2005				0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
2265004055		0	6	G2N1	G4N1O	G4NIS	G2N1	G4N2O1	G4N2S1	G4N2O2	G4N2S2	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N2	N4N2	L4N1	
1900				0	0.027	0.973	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.013	0.487	0	0	0.018	0.481	0	0.018	0.481	0	0	0	0	0	0
1997				0	0	0	0	0	0.037	0.963	0	0.037	0.963	0	0	0	0	0	0
2007				0	0	0	0	0	0.097	0.486	0	0.097	0.486	0	0.417	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2265004055		6	25	G2N2	G4N2O	G4N2S	G4N2O1	G4N2S1	G4N2O2	G4N2S2	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N2	N4N2			
1900				0	0.007	0.993	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.003	0.497	0.003	0.497	0	0	0.497	0	0	0	0	0	0	0	0
1997				0	0	0	0.007	0.993	0	0	0.993	0	0	0	0	0	0	0	0
2001				0	0	0	0.003	0.497	0.5	0	0.497	0.5	0	0	0	0	0	0	0
2002				0	0	0	0.002	0.373	0.625	0	0.373	0.625	0	0	0	0	0	0	0
2003				0	0	0	0.001	0.249	0.75	0	0.249	0.75	0	0	0	0	0	0	0
2004				0	0	0	0	0.125	0.875	0	0.125	0.875	0	0	0	0	0	0	0





Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type																		
				G2N1	G4N10	G4NIS	G2N11	G4N101	G4NIS1	G4N1SC1	G4N102	G4NIS2	N4N1	G2N2	G4N20	G4N2S	G4N201	G4N2S1	G4N202	G4N2S2	L4N2	N4N2
1996				0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
2002				0	0	0	0	0	0	0.375	0	0	0	0	0	0	0	0	0	0	0	0
2003				0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0
2004				0	0	0	0	0	0	0.125	0	0	0	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2265006005	0	6	G2N1	G4N10	G4NIS	G2N11	G4N101	G4NIS1	G4N1SC1	G4N102	G4NIS2	N4N1									
1900				0.006	0.02	0.974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0.003	0.01	0.487	0	0.016	0.484	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	0.032	0.968	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2265006005	6	25	G2N2	G4N20	G4N2S	G4N201	G4N2S1	G4N202	G4N2S2	L4N2	N4N2										
1900				0	0.078	0.922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.039	0.461	0.039	0.461	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0.078	0.922	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0.039	0.461	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
2002				0	0	0	0.03	0.345	0.625	0	0	0	0	0	0	0	0	0	0	0	0	0
2003				0	0	0	0.02	0.23	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0
2004				0	0	0	0.01	0.115	0.875	0	0	0	0	0	0	0	0	0	0	0	0	0
2005				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2265006010	0	6	G2N1	G4N10	G4NIS	G2N11	G4N101	G4NIS1	G4N1SC1	G4N102	G4NIS2	N4N1									
1900				0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.005	0.495	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0	0.01	0.99	0	0	0	0	0	0	0	0	0	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0	0	0	0	0	0
2008				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2265006010	6	25	G2N2	G4N20	G4N2S	G4N201	G4N2S1	G4N202	G4N2S2	L4N2	N4N2										
1900				0	0.143	0.857	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996				0	0.072	0.428	0.072	0.428	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997				0	0	0	0.143	0.857	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001				0	0	0	0.071	0.429	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type															
				G2H5	G2H5C	G2H51	G2H5C1	G2H52	G2H5C2	G4N10	G4N1S	G4N1O1	G4N1S1	G4N1O2	G4N1S2	G4N1O2	G4N1S2	N4N1	
2002				0	0	0	0.053	0.322	0.625	0	0	0	0	0	0	0	0		
2003				0	0	0	0.035	0.215	0.75	0	0	0	0	0	0	0	0		
2004				0	0	0	0.017	0.108	0.875	0	0	0	0	0	0	0	0		
2005				0	0	0	0	0	1	0	0	0	0	0	0	0	0		
	2260007005	6	9999	<b>G2H5</b>	<b>G2H5C</b>	<b>G2H51</b>	<b>G2H5C1</b>	<b>G2H52</b>	<b>G2H5C2</b>										
1900				1	0	0	0	0	0	0	0	0	0	0	0	0	0		
1996				0.5	0	0.495	0.005	0	0	0	0	0	0	0	0	0	0		
1997				0	0	0.99	0.01	0	0	0	0	0	0	0	0	0	0		
2002				0	0	0.99	0.01	0	0	0	0	0	0	0	0	0	0		
2003				0	0	0.99	0.01	0	0	0	0	0	0	0	0	0	0		
2004				0	0	0.7425	0.0075	0.25	0	0	0	0	0	0	0	0	0		
2005				0	0	0.495	0.005	0.5	0	0	0	0	0	0	0	0	0		
2006				0	0	0.2475	0.0025	0.75	0	0	0	0	0	0	0	0	0		
2007				0	0	0	0	1	0	0	0	0	0	0	0	0	0		
2008				0	0	0	0	1	0	0	0	0	0	0	0	0	0		
	2265010010	0	6	<b>G2N1</b>	<b>G4N1O</b>	<b>G4N1S</b>	<b>G2N11</b>	<b>G4N1O1</b>	<b>G4N1S1</b>	<b>G4N1O2</b>	<b>G4N1S2</b>	<b>G4N1O2</b>	<b>G4N1S2</b>	<b>N4N1</b>					
1900				0.18	0.069	0.751	0	0	0	0	0	0	0	0	0	0	0		
1996				0.09	0.035	0.375	0	0.083	0.417	0	0	0	0	0	0	0	0		
1997				0	0	0	0	0.167	0.833	0	0	0	0	0	0	0	0		
2007				0	0	0	0	0.097	0.486	0	0.417	0	0	0	0	0	0		
2008				0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2267000000	25	9999	<b>LGT25</b>	<b>LGT251</b>	<b>LGT252</b>													
1900				1	0	0													
2004				0	1	0													
2007				0	0	1													
	2268000000	25	9999	<b>NGT25</b>	<b>NGT251</b>	<b>NGT252</b>													
1900				1	0	0													
2004				0	1	0													
2007				0	0	1													
	2282005010	0	3	<b>MO2C</b>	<b>MO21</b>	<b>MO2D</b>	<b>MO4C</b>	<b>MO4I</b>	<b>MO4D</b>										
1900				0.900	0.000	0.000	0.100	0.000	0.000										
1998				1.000	0.000	0.000	0.000	0.000	0.000										
1999				0.620	0.000	0.000	0.380	0.000	0.000										

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type									
				MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO4I	MO4D		
2000				0.673	0.000	0.000	0.327	0.000	0.000				
2001				0.601	0.000	0.000	0.399	0.000	0.000				
2002				0.350	0.000	0.000	0.650	0.000	0.000				
2003				0.104	0.000	0.000	0.896	0.000	0.000				
2004				0.088	0.000	0.000	0.912	0.000	0.000				
2005				0.104	0.000	0.000	0.896	0.000	0.000				
2006				0.100	0.000	0.000	0.900	0.000	0.000				
	2282005010	3	6	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D				
1900				0.957	0.000	0.000	0.043	0.000	0.000				
1997				0.870	0.000	0.000	0.130	0.000	0.000				
1998				0.707	0.000	0.000	0.293	0.000	0.000				
1999				0.730	0.000	0.000	0.270	0.000	0.000				
2000				0.596	0.000	0.000	0.404	0.000	0.000				
2001				0.547	0.000	0.000	0.453	0.000	0.000				
2002				0.463	0.000	0.000	0.537	0.000	0.000				
2003				0.443	0.000	0.000	0.557	0.000	0.000				
2004				0.554	0.000	0.000	0.446	0.000	0.000				
2005				0.386	0.000	0.000	0.614	0.000	0.000				
2006				0.400	0.000	0.000	0.600	0.000	0.000				
	2282005010	6	11	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D				
1900				0.957	0.000	0.000	0.043	0.000	0.000				
1997				0.870	0.000	0.000	0.130	0.000	0.000				
1998				0.710	0.000	0.000	0.290	0.000	0.000				
1999				0.672	0.000	0.000	0.328	0.000	0.000				
2000				0.523	0.000	0.000	0.477	0.000	0.000				
2001				0.169	0.000	0.000	0.831	0.000	0.000				
2002				0.269	0.000	0.000	0.731	0.000	0.000				
2003				0.222	0.000	0.000	0.778	0.000	0.000				
2004				0.185	0.000	0.000	0.815	0.000	0.000				
2005				0.157	0.000	0.000	0.843	0.000	0.000				
2006				0.150	0.000	0.000	0.850	0.000	0.000				
	2282005010	11	16	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D				
1900				0.989	0.000	0.000	0.011	0.000	0.000				

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type													
				MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D		
1998				0.732	0.000	0.000	0.268	0.000	0.000								
1999				0.802	0.000	0.000	0.198	0.000	0.000								
2000				0.546	0.000	0.000	0.454	0.000	0.000								
2001				0.124	0.000	0.000	0.876	0.000	0.000								
2002				0.203	0.000	0.000	0.797	0.000	0.000								
2003				0.282	0.000	0.000	0.718	0.000	0.000								
2004				0.240	0.000	0.000	0.760	0.000	0.000								
2005				0.132	0.000	0.000	0.868	0.000	0.000								
2006				0.150	0.000	0.000	0.850	0.000	0.000								
	2282005010	16	25	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D								
1900				0.989	0.000	0.000	0.011	0.000	0.000								
1998				0.928	0.000	0.000	0.072	0.000	0.000								
1999				0.866	0.000	0.000	0.134	0.000	0.000								
2000				0.720	0.000	0.000	0.280	0.000	0.000								
2001				0.748	0.000	0.000	0.252	0.000	0.000								
2002				0.678	0.000	0.000	0.322	0.000	0.000								
2003				0.535	0.000	0.000	0.465	0.000	0.000								
2004				0.295	0.000	0.000	0.705	0.000	0.000								
2005				0.406	0.000	0.000	0.594	0.000	0.000								
2006				0.300	0.000	0.000	0.700	0.000	0.000								
	2282005010	25	40	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D								
1900				1.000	0.000	0.000	0.000	0.000	0.000								
1998				0.688	0.000	0.000	0.312	0.000	0.000								
1999				0.794	0.000	0.000	0.206	0.000	0.000								
2000				0.569	0.000	0.000	0.431	0.000	0.000								
2001				0.421	0.000	0.000	0.579	0.000	0.000								
2002				0.385	0.000	0.000	0.566	0.049	0.000								
2003				0.515	0.000	0.000	0.396	0.089	0.000								
2004				0.390	0.000	0.000	0.368	0.242	0.000								
2005				0.267	0.000	0.000	0.532	0.201	0.000								
2006				0.250	0.000	0.000	0.500	0.250	0.000								
	2282005010	40	50	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D								
1900				1.000	0.000	0.000	0.000	0.000	0.000								

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type											
				MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
	2282005010	50	75	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
1998				0.945	0.000	0.000	0.055	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.000
1999				0.758	0.000	0.000	0.242	0.000	0.000	0.000	0.000	0.000	0.242	0.000	0.000
2000				0.460	0.000	0.001	0.249	0.000	0.000	0.000	0.000	0.000	0.249	0.000	0.290
2001				0.689	0.000	0.019	0.155	0.000	0.000	0.000	0.000	0.000	0.155	0.000	0.137
2002				0.615	0.000	0.051	0.181	0.000	0.000	0.000	0.000	0.000	0.181	0.000	0.153
2003				0.566	0.000	0.029	0.299	0.000	0.000	0.000	0.000	0.000	0.299	0.000	0.106
2004				0.645	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.230
2005				0.412	0.000	0.026	0.127	0.000	0.000	0.000	0.000	0.000	0.127	0.000	0.435
2006				0.400	0.000	0.050	0.150	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.400
	2282005010	50	75	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998				0.791	0.000	0.000	0.156	0.000	0.000	0.000	0.000	0.000	0.156	0.000	0.054
1999				0.785	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.148
2000				0.639	0.000	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.145	0.000	0.216
2001				0.460	0.000	0.000	0.456	0.000	0.000	0.000	0.000	0.000	0.456	0.000	0.084
2002				0.362	0.000	0.000	0.423	0.000	0.179	0.037	0.037	0.037	0.423	0.179	0.037
2003				0.384	0.000	0.000	0.439	0.000	0.127	0.051	0.051	0.051	0.439	0.127	0.051
2004				0.197	0.000	0.000	0.287	0.000	0.428	0.088	0.088	0.088	0.287	0.428	0.088
2005				0.193	0.000	0.000	0.148	0.000	0.405	0.254	0.254	0.254	0.148	0.405	0.254
2006				0.200	0.000	0.100	0.000	0.000	0.300	0.400	0.400	0.400	0.000	0.300	0.400
	2282005010	75	100	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999				0.837	0.000	0.000	0.163	0.000	0.000	0.000	0.000	0.000	0.163	0.000	0.000
2000				0.519	0.000	0.120	0.362	0.000	0.000	0.000	0.000	0.000	0.362	0.000	0.000
2001				0.472	0.000	0.085	0.421	0.000	0.000	0.022	0.022	0.022	0.421	0.000	0.022
2002				0.476	0.000	0.069	0.300	0.000	0.000	0.155	0.155	0.155	0.300	0.000	0.155
2003				0.470	0.000	0.007	0.237	0.000	0.000	0.286	0.286	0.286	0.237	0.000	0.286
2004				0.275	0.000	0.170	0.207	0.000	0.000	0.348	0.348	0.348	0.207	0.000	0.348
2005				0.310	0.000	0.114	0.001	0.000	0.000	0.575	0.575	0.575	0.001	0.000	0.575
2006				0.200	0.000	0.100	0.000	0.000	0.300	0.400	0.400	0.400	0.000	0.300	0.400
	2282005010	100	175	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MO2C	MO2I	MO2D	MO4C	MO4I	MO4D
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type														
				MO2C	MO2I	MO2D	MO4C	MO4I	MO4D	MP2C	MP2I	MP2D	MP4C	MP4I	MP4D			
1997				0.988	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998				0.914	0.000	0.086	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999				0.702	0.029	0.227	0.000	0.000	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000				0.622	0.068	0.178	0.000	0.000	0.059	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001				0.559	0.028	0.202	0.000	0.000	0.127	0.084	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002				0.487	0.050	0.253	0.000	0.000	0.102	0.108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003				0.390	0.041	0.261	0.000	0.000	0.105	0.202	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004				0.382	0.026	0.055	0.000	0.000	0.378	0.159	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005				0.167	0.004	0.301	0.000	0.000	0.037	0.491	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006				0.150	0.050	0.300	0.000	0.000	0.050	0.450	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2282005010	175	9999															
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997				0.967	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998				0.740	0.072	0.188	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999				0.250	0.424	0.326	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000				0.338	0.204	0.459	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001				0.222	0.150	0.628	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002				0.039	0.378	0.449	0.000	0.000	0.072	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003				0.005	0.308	0.487	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004				0.026	0.106	0.583	0.000	0.000	0.243	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005				0.004	0.259	0.595	0.000	0.000	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006				0.000	0.250	0.600	0.000	0.000	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2282005015	0	3															
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2282005015	3	6															
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2282005015	6	11															
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2282005015	11	16															
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type									
				MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D	MP4I		
2005				0.800	0.000	0.000	0.000	0.200	0.000	0.000	0.000		
2006				0.600	0.000	0.000	0.000	0.400	0.000	0.000	0.000		
1900	2282005015	16	25	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D			
2005				0.218	0.000	0.000	0.000	0.782	0.000	0.000			
2005				0.200	0.000	0.000	0.000	0.800	0.000	0.000			
1900	2282005015	25	40	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D			
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
1999				0.000	0.000	0.000	0.000	1.000	0.000	0.000			
2000				0.640	0.000	0.000	0.000	0.360	0.000	0.000			
2001				0.000	0.000	0.000	0.000	1.000	0.000	0.000			
2002				0.017	0.000	0.000	0.000	0.983	0.000	0.000			
2003				0.019	0.000	0.000	0.000	0.981	0.000	0.000			
1900	2282005015	40	50	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D			
2005				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
2006				0.700	0.000	0.300	0.000	0.000	0.000	0.000			
1900	2282005015	50	75	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D			
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
1999				0.991	0.000	0.000	0.000	0.009	0.000	0.000			
2000				0.932	0.000	0.000	0.000	0.068	0.000	0.000			
2001				0.928	0.000	0.000	0.000	0.072	0.000	0.000			
2002				0.976	0.000	0.000	0.000	0.024	0.000	0.000			
2003				0.906	0.000	0.000	0.000	0.094	0.000	0.000			
2004				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
2005				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
2006				0.900	0.000	0.000	0.000	0.100	0.000	0.000			
1900	2282005015	75	100	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D			
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000			
1999				0.394	0.606	0.000	0.000	0.000	0.000	0.000			
2000				0.803	0.197	0.000	0.000	0.000	0.000	0.000			
2001				0.770	0.230	0.000	0.000	0.000	0.000	0.000			
2002				0.700	0.150	0.150	0.000	0.000	0.000	0.000			
2003				0.720	0.219	0.061	0.000	0.000	0.000	0.000			
2004				0.541	0.459	0.000	0.000	0.000	0.000	0.000			

Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type											
				MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D	MS4C	MS4D			
2005				0.340	0.660	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
2006				0.300	0.600	0.100	0.000	0.000	0.000	0.000	0.000	0.000			
	2282005015	100	175	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D					
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
1999				0.957	0.000	0.043	0.000	0.000	0.000	0.000	0.000	0.000			
2000				0.655	0.000	0.229	0.116	0.000	0.000	0.000	0.000	0.000			
2001				0.496	0.000	0.242	0.262	0.000	0.000	0.000	0.000	0.000			
2002				0.343	0.000	0.245	0.149	0.000	0.000	0.072	0.191	0.000			
2003				0.137	0.000	0.336	0.037	0.000	0.000	0.192	0.299	0.000			
2004				0.174	0.000	0.055	0.000	0.000	0.000	0.455	0.316	0.000			
2005				0.059	0.000	0.036	0.000	0.000	0.000	0.068	0.837	0.000			
2006				0.050	0.000	0.050	0.000	0.000	0.000	0.050	0.850	0.000			
	2282005015	175	9999	MP2C	MP2I	MP2D	MP2CA	MP4C	MP4I	MP4D					
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
2000				0.480	0.520	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
2001				0.588	0.300	0.112	0.000	0.000	0.000	0.000	0.000	0.000			
2002				0.000	0.686	0.314	0.000	0.000	0.000	0.000	0.000	0.000			
2003				0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000			
2004				0.000	0.863	0.137	0.000	0.000	0.000	0.000	0.000	0.000			
2005				0.000	0.690	0.310	0.000	0.000	0.000	0.000	0.000	0.000			
2006				0.000	0.700	0.300	0.000	0.000	0.000	0.000	0.000	0.000			
	2282010005	0	50	MS4C	MS4D										
1900				1.000	0.000										
	2282010005	50	175	MS4C	MS4D										
1900				1.000	0.000										
2004				0.917	0.083										
2005				0.833	0.167										
2006				0.750	0.250										
2007				0.667	0.333										
2008				0.583	0.417										
	2282010005	175	300	MS4C	MS4D										
1900				1.000	0.000										
1996				0.900	0.100										
1997				0.800	0.200										



Table B4. Nonroad SI Technology Distributions by SCC and HP Category\*

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type																	
				MS4C	MS4D	G2N1	G4N10	G4N1S	G2N11	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N1							
1998				0.700	0.300																
1999				0.600	0.400																
2000				0.562	0.439																
2001				0.523	0.477																
2002				0.485	0.516																
2003				0.446	0.554																
2004				0.388	0.612																
2005				0.331	0.669																
2006				0.273	0.727																
2007				0.215	0.785																
2008				0.158	0.842																
	2282010005	300	600	MS4C	MS4D																
1900				1.000	0.000																
1995				0.900	0.100																
1996				0.800	0.200																
1997				0.700	0.300																
1998				0.600	0.400																
1999				0.500	0.500																
2000				0.375	0.625																
2001				0.250	0.750																
2002				0.125	0.875																
2003				0.000	1.000																
	2282010005	600	9999	MS4C	MS4D																
1900				1.000	0.000																
1995				0.900	0.100																
1996				0.800	0.200																
1997				0.700	0.300																
1998				0.600	0.400																
1999				0.500	0.500																
	2285004015	0	6	G2N1	G4N10	G4N1S	G2N11	G4N1O1	G4N1S1	G4N1O2	G4N1S2	L4N1									
1900				0.180	0.069	0.751	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.090	0.035	0.375	0.000	0.083	0.000	0.417	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.167	0.833	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.417	0.000	0.000	0.000	0.000	0.417	0.000	0.000	0.000	0.000	0.000	0.000

