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Exhaust Emission Factors for Nonroad Engine Modeling--Spark-Ignition

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Assessment and Standards Division
Office of Transportation and Air Quality
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Purpose

This report describes and documents exhaust emission factors and brake specific fuel consumption (BSFC) estimates used for spark ignition (SI) engines in EPA's draft NONROAD2004 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 emission factors for evaporative emissions, crankcase emissions, spillage and other non-exhaust emissions (NR-012b), adjustments to emission rates due to variations in fuel and temperature (NR-001b), speciation of hydrocarbon emissions (NR-002b), and adjustments to emission rates as equipment deteriorates due to time and use (NR-011b). 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_x), total particulate matter (PM), carbon dioxide (CO_2), and sulfur dioxide (SO_2). For nonroad engines, all PM emissions are assumed to be smaller than 10 microns (PM10), and 92% of the PM from gasoline and diesel fueled engines is assumed to be smaller than 2.5 microns (PM2.5). For gaseous fueled engines (LPG/CNG), 100% of the PM

emissions are assumed to be smaller than PM2.5. The NONROAD Reporting Utility allows the user to select the desired size range.

Zero-mile, steady-state emission factors for HC, CO, NO_x, 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_2 and SO_2 emission factors follows.

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 draft 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_x), total particulates (PM), sulfur dioxide (SO_2) 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_x, PM, sulfur dioxide (SO_2), and carbon dioxide (CO_2) 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_x.

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 draft NONROAD2004. 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]

Zero-Hour, Steady-State Emission Factors for HC, CO, NO_x, PM, and Steady-State BSFCs

This section describes the zero-hour, steady-state emission factors and steady-state BSFCs that are used in draft NONROAD2004. Pre-controlled (baseline) and controlled (where applicable) emission factors are described for each of the following regulatory equipment categories: small SI engines ≤25 hp, large SI engines >25 hp, land-based recreational engines, and recreational marine engines.

Spark-Ignition (SI) Engines ≤25 hp

This category includes all engines ≤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 (< 225cc); Class II (≥ 225cc); Class III (< 20cc); Class IV (≥ 20cc and < 50cc); Class V (≥ 50cc).

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 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 draft NONROAD2004; 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 draft NONROAD2004 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 NO_x emission factors for Phase 1 and 2 that are contained in the final regulatory impact analysis. [9] (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-011a.

For handheld (class III, IV, and V) engines, NONROAD also uses the BSFC, HC, CO, and 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.) 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-011a.

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

Engine Tech Type	**HC g/hp-hr**	**CO g/hp-hr**	**NO_x g/hp-hr**	**PM g/hp-hr**	**BSFC lb/hp-hr**
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 (≥20cc and <50cc)*

Engine Tech Type	**HC g/hp-hr**	**CO g/hp-hr**	**NO_x 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 (>50cc)*

Engine Tech Type	**HC g/hp-hr**	**CO g/hp-hr**	**NO_x 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_x 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 (≥ 225cc)*

Engine Tech Type	HC g/hp-hr	CO g/hp-hr	NO_x 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. [8] Both uncontrolled and Phase 1 and 2 controlled emission factors are included in NONROAD2004.

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. [11]

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

Engine Tech Type	**HC g/hp-hr**	**CO g/hp-hr**	**NO_x g/hp-hr**	**PM g/hp-hr**	**BSFC lb/hp-hr**
Uncontrolled					
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
Phase 1					
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
Phase 2					
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_x 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_x 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. [11,12]

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

Equipment/Tech Type	**HC g/mile**	**CO g/mile**	**NO_x g/mile**	**PM g/mile**	**BSFC lb/mile**
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
	HC g/hp-hr	**CO g/hp-hr**	**NO_x g/hp-hr**	**PM g/hp-hr**	**BSFC lb/hp-hr**
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 engines. Emission factors (HC, CO, and NO_x) for these engines 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 SI inboard engines. [13,14] 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. Tables 9-12 show the emission rates by power range for precontrolled outboard, PWC, and inboard engines.

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.[1] 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.

The pre-controlled outboard two-stroke and four-stroke engines were defined by the technical types M1 and M4. Four additional engine technical types (M5, M6, M8, and M9) were defined to account for the new standards and allows for phase-in of the standards. Emission factors for these technical types are given in Tables 13-16.

Table 8. Mapping of Recreational Marine Engine Power Ranges

	EPA-RIA	**NONROAD Model**
Outboard	<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
PWC	30 - 50 hp	0 - 50 hp
	50 - 75	50 - 175
Inboard	100 - 150 hp	0 - 100 hp
	150 - 200	100 - 175
	>200	>175

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.

Table 9. Two-Stroke Outboard (SCC - 2282005010) Emission Factors and BSFCs for Precontrolled Engines (M1 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	254.01	396.5	3.072	7.7	1.3
3 - 11	218.43	335.7	2.521	7.7	1.3
11 - 25	164.49	301.4	1.002	7.7	1.3
25 - 50	116.38	231.3	1.190	7.7	1.3
50 - 100	101.95	233.5	1.833	7.7	1.3
100 - 175	128.69	313.3	4.476	7.7	1.3
>175	128.69	313.3	4.476	7.7	1.3

Table 10. Four-Stroke Outboard (SCC - 2282005010) Emission Factors and BSFCs for Precontrolled Engines (M4 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	90.42	436.4	3.678	0.06	0.7
3 - 11	22.16	436.4	3.879	0.06	0.7
11 - 25	13.70	339.2	5.953	0.06	0.7
25 - 50	14.92	339.2	7.460	0.06	0.7
50 - 100	8.21	258.1	7.460	0.06	0.7
100 - 175	7.46	258.1	8.952	0.06	0.7
>175	7.46	258.1	8.952	0.06	0.7

Table 11. Personal Watercraft (SCC - 2282005015) Precontrolled Emission Factors and BSFCs (M2 Tech Type. For 4-stroke see Tech Type M13 in Table 17)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 50 hp	135.10	257.9	0.701	7.7	1.3
50 - 175	153.66	252.7	1.001	7.7	1.3

Table 12. Inboard (SCC - 2282010005) Precontrolled Emission Factors and BSFCs

(M3 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
all	5.88	153.7	5.350	0.06	0.7

Table 13. Two-Stroke Outboard (SCC - 2282005010) Emission Factors and BSFCs with Carburetor & Ignition Modifications (M5 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	254.01	484.9	3.072	7.7	1.3
3 - 11	218.43	484.9	2.521	7.7	1.3
11 - 25	161.51	430.8	1.002	7.7	1.3
25 - 50	116.38	422.2	1.190	7.7	1.3
50 - 100	101.95	276.0	1.833	7.7	1.3
100 - 175	115.63	289.4	8.206	7.7	1.3
>175	115.63	289.4	8.206	7.7	1.3

Table 14. Two-Stroke Outboard (SCC - 2282005010) Emission Factors and BSFCs with Modifications and Catalyst (M6 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	123.69	311.5	2.560	7.7	1.3
3 - 11	106.37	263.8	2.101	7.7	1.3
11 - 25	80.10	236.8	0.835	7.7	1.3
25 - 50	56.67	181.7	0.992	7.7	1.3
50 - 100	49.65	183.5	1.527	7.7	1.3
100 - 175	62.66	246.2	3.730	7.7	1.3
>175	62.66	246.2	3.730	7.7	1.3

Table 15. Two-Stroke Outboard (SCC - 2282005010) Emission Factors and BSFCs with Electronic Fuel Injection (M8 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	45.59	466.8	15.406	7.7	1.3
3 - 11	39.21	395.3	12.647	7.7	1.3
11 - 25	29.52	354.9	5.023	7.7	1.3
25 - 50	20.89	272.3	5.968	7.7	1.3
50 - 100	19.77	255.5	7.087	7.7	1.3
100 - 175	19.15	242.5	8.206	7.7	1.3
>175	18.65	242.5	8.206	7.7	1.3

Table 16. Direct-Injection Type A Outboard (SCC - 2282005010) Emission Factors and BSFCs (M9 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 3 hp	57.60	430.8	11.440	7.7	1.3
3 - 11	49.53	364.8	9.391	7.7	1.3
11 - 25	37.30	327.5	3.730	7.7	1.3
25 - 50	28.35	194.7	3.730	7.7	1.3
50 - 100	32.08	191.0	3.730	7.7	1.3
100 - 175	40.28	305.5	3.730	7.7	1.3
>175	38.05	284.2	3.730	7.7	1.3

Personal watercraft (PWC) emissions are characterized by three technical types: 2-stroke (labeled M2), 4-stroke (M13), and 2-stroke with major modifications (M14). Type M2 has the emission factors given above in Table 11. The emission factors for the M13 and M14 technical types are given in Tables 17 and 18, respectively.

Table 17. Personal Watercraft (SCC - 2282005015) 4-Stroke Emission Factors and BSFCs (M13 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 50 hp	11.56	256.3	4.821	0.06	0.7
50 - 175	12.73	252.4	5.437	0.06	0.7

Table 18. Personal Watercraft (SCC - 2282005015) 2-Stroke with Major Modifications Emission Factors and BSFCs (M14 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
0 - 50 hp	127.69	269.6	1.268	7.7	1.3
50 - 175	143.78	258.6	0.837	7.7	1.3

The sterndrive/inboard market has changed considerably over the past five or six years. Electronic fuel injection is used on more than half of new engine sales. Based on industry trends, we predict that most, if not all, inboard engines will be fuel injected by 2004. In NONROAD, the technology type for engines using electronic fuel injection is designated as M10. Table 19 presents the emission factors for the M10 technology type.

Table 19. Inboard (SCC - 2282010005) with Electronic Fuel Injection Emission Factors and BSFCs (M10 Tech Type)

NONROAD Power Range	HC g/hp-hr	CO g/hp-hr	NO_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
all	3.02	71.8	8.480	0.06	0.7

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 (≤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. [15,16,17] 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. [11, 18] 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_x emission levels for transient operation and so a TAF of 1.0 is used for NO_X 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_x g/hp-hr	PM g/hp-hr	BSFC lb/hp-hr
Pre-control TAFs					
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
Phase 1 Control TAFs					
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
Phase 2 Control TAFs					
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. EPA simply formats this information for the NONROAD input files.

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

Carbon Dioxide Emission Factors

Emission factors for CO_2 are rarely measured; instead, they typically are calculated based on brake-specific fuel consumption (BSFC). The NONROAD model uses BSFC to compute CO_2 emissions directly, as shown in the equation below. The carbon that goes to exhaust HC emissions is subtracted. This does not require a CO_2 emission factors input file.

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

where

CO_2 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 diesel
44/12 is the ratio of CO_2 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_2 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_2 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_2 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.

Note that this version of the model corrects errors in the equation to calculate SO_2 emissions. In previous versions, the conversion from g/hp-hr to g/hr was missing the load factor term. The net effect of making this correction was to lower SO_2 by roughly 40-50 percent.

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] "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.

[10] "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.

[11] "Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," U.S. EPA, EPA420-R-02-022, September 2002.

[12] "Emission Modeling for Recreational Vehicles," EPA Memorandum from Linc Wehrly to Docket A-98-01, EPA420-F-00-051, November 13, 2000.

[13] "Regulatory Impact Analysis: Control of Air Pollution Emission Standards for New Spark-Ignition Marine Engines," U.S. EPA, October, 1996.

[14] "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.

[15] "Emissions Analysis of Small Utility Engines." Sun, X., et al. SAE paper 952080. 1995.

[16] "Emissions from 4-Cycle Walk-Behind-Mower Engines: Test Cycle Effects." Gabele, Peter. SAE Paper 972793. 1997

[17] "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.

[18] "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.

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
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-006b.) 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-006b. 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 ≤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. In draft NONROAD2004, EPA simply formats this information for the NONROAD input files.

Table B3 provides a list and description of the SI technology groups used in draft NONROAD2004. Tables B4-B17 contain 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 Draft NONROAD2004 Model

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

Table B3. Spark-Ignition Technologies in the Draft NONROAD2004 Model

Engine Tech Type Code	SI Engine Category	Description
G2H5	Small SI ≤ 25hp	Gasoline, 2-stroke, handheld Class V (>50cc), Baseline
G2H51	Small SI ≤ 25hp	Gasoline, 2-stroke, handheld Class V (>50cc), Phase 1
G2H5C1	Small SI ≤ 25hp	Gasoline, 2-stroke, handheld Class V (>50cc), Phase 1 with catalyst
G2H52	Small SI ≤ 25hp	Gasoline, 2-stroke, handheld Class V (>50cc), Phase 2
G2H5C2	Small SI ≤ 25hp	Gasoline, 2-stroke, handheld Class V (>50cc), Phase 2 with catalyst
G2N1	Small SI ≤ 25hp	Gasoline, 2-stroke, nonhandheld Class I (<225cc), Baseline
G2N11	Small SI ≤ 25hp	Gasoline, 2-stroke, nonhandheld Class I (<225cc), Phase 1
G2N2	Small SI ≤ 25hp	Gasoline, 2-stroke, nonhandheld Class II (≥225cc), 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 ≤ 25hp	Gasoline, 4-stroke, handheld Class IV (≥20cc and <50cc), Phase 1
G4H42	Small SI ≤ 25hp	Gasoline, 4-stroke, handheld Class IV (≥20cc and <50cc), Phase 2
G4N1O	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I (<225cc), Baseline
G4N1O1	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I (<225cc), Phase 1
G4N1O2	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class I (<225cc), Phase 2
G4N1S	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I (<225cc), Baseline
G4N1S1	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I (<225cc), Phase 1
G4N1SC1	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I (<225cc), Phase 1 with catalyst
G4N1S2	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class I (<225cc), Phase 2
G4N2O	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II (≥225cc), Baseline
G4N2O1	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II (≥225cc), Phase 1

Table B3. Spark-Ignition Technologies in the Draft NONROAD2004 Model

Engine Tech Type Code	SI Engine Category	Description
G4N2O2	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II (≥225cc), Phase 2
G4N2S	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II (≥225cc), Baseline
G4N2S1	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II (≥225cc), Phase 1
G4N2S2	Small SI ≤ 25hp	Gasoline, 4-stroke, side-valved, nonhandheld Class II (≥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
M1	Recreational Marine	Outboard, 2-stroke, Baseline
M2	Recreational Marine	Personal Watercraft, 2-stroke, Baseline
M3	Recreational Marine	Inboard, Baseline
M4	Recreational Marine	Outboard, 4-stroke, Baseline
M5	Recreational Marine	Outboard, 2-stroke, with carburetor and ignition modifications
M6	Recreational Marine	Outboard, 2-stroke, with modifications and catalyst
M8	Recreational Marine	Outboard, 2-stroke, with electronic fuel injection
M9	Recreational Marine	Outboard, direct-injection
M10	Recreational Marine	Inboard, with electronic fuel injection
M13	Recreational Marine	Personal Watercraft, 4-stroke, Baseline
M14	Recreational Marine	Personal Watercraft, 2-stroke, with major modifications
NGT25	Large SI > 25hp	Compressed Natural Gas, Baseline
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

Table B3. Spark-Ignition Technologies in the Draft NONROAD2004 Model

Engine Tech Type Code	SI Engine Category	Description
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									
	2260000000	0	9999	**G2GT25**	**G4GT251**	**G4GT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							
	2265000000	0	9999	**G4GT25**	**G4GT251**	**G4GT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							
	2260000000	0	1	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**			
1900				1	0	0	0	0	0	0			
1996				0.5	0.495	0.005	0	0	0	0			
1997				0	0.99	0.01	0	0	0	0			
2002				0	0.7425	0.0075	0	0	0.25	0			
2003				0	0.495	0.005	0	0	0.5	0			
2004				0	0.2475	0.0025	0	0	0.75	0			
2005				0	0	0	0	0	1	0			
2006				0	0	0	0	0	1	0			
	2260000000	1	3	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**	
1900				1	0	0	0	0	0	0	0	0	
1996				0.5	0	0	0.495	0.005	0	0	0	0	
1997				0	0	0	0.99	0.01	0	0	0	0	
2002				0	0	0	0.675	0.075	0	0	0.2	0.05	
2003				0	0	0	0.45	0.05	0	0	0.4	0.1	
2004				0	0	0	0.225	0.025	0	0	0.6	0.15	
2005				0	0	0	0	0	0	0	0.8	0.2	
2006				0	0	0	0	0	0	0	0.8	0.2	
	2260000000	3	6	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**				
1900				1	0	0	0	0	0				
1996				0.5	0	0.495	0.005	0	0				
1997				0	0	0.99	0.01	0	0				
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				

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

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type									
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	
1996				0.003	0.009	0.488	0	0.5	0	0	0	0	
1997				0	0	0	0.017	0.983	0	0	0	0	
2001				0	0	0	0.008	0.492	0.5	0	0	0	
2002				0	0	0	0.006	0.369	0.625	0	0	0	
2003				0	0	0	0.004	0.246	0.75	0	0	0	
2004				0	0	0	0.002	0.123	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265000000	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0.18	0.069	0.751	0	0	0	0	0	0	0
1996				0.09	0.035	0.375	0	0.083	0.417	0	0	0	0
1997				0	0	0	0	0.167	0.833	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	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	
1996				0.003	0.009	0.488	0	0.5	0	0	0	0	
1997				0	0	0	0.017	0.983	0	0	0	0	
2001				0	0	0	0.008	0.492	0.5	0	0	0	
2002				0	0	0	0.006	0.369	0.625	0	0	0	
2003				0	0	0	0.004	0.246	0.75	0	0	0	
2004				0	0	0	0.002	0.123	0.875	0	0	0	
2005				0	0	0	0	0	1	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						
2009				0.46	0	0.54	0						
	2265001010	0	9999	**R14S**	**R14SP**	**R14S1**	**R14S1P**						
1900				1	0	0	0						
2006				0.56	0	0.44	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									
2007				0.12	0	0.88	0						
2008				0.06	0	0.94	0						
2009				0	0	1	0						
	2260001020	0	9999	**R12S**	**R12S1**	**R12S2**	**R14S**						
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	**R14S**	**R14S1**	**R14S2**							
1900				1	0	0							
2006				0	1	0							
2010				0	0	1							
	2260001030	0	9999	**R12S**	**R12SP**	**R14S1**	**R14S1P**	**R14S2**	**R14S2P**	**R14S2C**	**R14S2CP**		
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	**R14S**	**R14SP**	**R14S1**	**R14S1P**	**R14S2**	**R14S2P**	**R14S2C**	**R14S2CP**		
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		
	2265004010	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0.05	0.07	0.88	0	0	0	0	0	0	0
1996				0.025	0.035	0.44	0	0.052	0.448	0	0	0	0
1997				0	0	0	0	0.1038	0.8962	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	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									
	2265004011	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0.15	0.06	0.79	0	0	0	0	0	0	0
1996				0.075	0.03	0.395	0	0.072	0.429	0	0	0	0
1997				0	0	0	0	0.143	0.857	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004015	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0	1	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.005	0.495	0	0	0	0
1997				0	0	0	0	0.01	0.99	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2260004020	6	9999	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**				
1900				1	0	0	0	0	0				
1996				0.5	0	0.495	0.005	0	0				
1997				0	0	0.99	0.01	0	0				
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				
	2260004021	6	9999	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**				
1900				1	0	0	0	0	0				
1996				0.5	0	0.495	0.005	0	0				
1997				0	0	0.99	0.01	0	0				
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	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**			
1900				1	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									
1996				0.5	0.495	0.005	0	0	0	0			
1997				0	0.99	0.01	0	0	0	0			
2002				0	0.7425	0.0075	0	0	0.25	0			
2003				0	0.495	0.005	0	0	0.5	0			
2004				0	0.2475	0.0025	0	0	0.75	0			
2005				0	0	0	0	0	1	0			
2006				0	0	0	0	0	1	0			
	2260004025	1	3	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**	
1900				1	0	0	0	0	0	0	0	0	
1996				0.5	0	0	0.49	0.005	0.005	0	0	0	
1997				0	0	0	0.98	0.01	0.01	0	0	0	
1998				0	0	0	0.97208081	0.00991919	0.018	0	0	0	
2002				0	0	0	0.675	0.075	0	0	0.2	0.05	
2003				0	0	0	0.45	0.05	0	0	0.4	0.1	
2004				0	0	0	0.225	0.025	0	0	0.6	0.15	
2005				0	0	0	0	0	0	0	0.8	0.2	
2006				0	0	0	0	0	0	0	0.8	0.2	
	2265004025	3	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.063	0.936	0	0	0	0	0	0	0
1996				0	0.032	0.468	0	0.037	0.463	0	0	0	0
1997				0	0	0	0	0.073	0.927	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004025	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0	1	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	
1997				0	0	0	0	1	0	0	0	0	
2001				0	0	0	0	0.5	0.5	0	0	0	
2002				0	0	0	0	0.375	0.625	0	0	0	
2003				0	0	0	0	0.25	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2260004026	0	1	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**			
1900				1	0	0	0	0	0	0			
1996				0.5	0.495	0.005	0	0	0	0			
1997				0	0.99	0.01	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									
2002				0	0.7425	0.0075	0	0	0.25	0			
2003				0	0.495	0.005	0	0	0.5	0			
2004				0	0.2475	0.0025	0	0	0.75	0			
2005				0	0	0	0	0	1	0			
2006				0	0	0	0	0	1	0			
	2260004026	1	3	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**	
1900				1	0	0	0	0	0	0	0	0	
1996				0.5	0	0	0.49	0.005	0.005	0	0	0	
1997				0	0	0	0.98	0.01	0.01	0	0	0	
1998				0	0	0	0.97208081	0.00991919	0.018	0	0	0	
2002				0	0	0	0.675	0.075	0	0	0.2	0.05	
2003				0	0	0	0.45	0.05	0	0	0.4	0.1	
2004				0	0	0	0.225	0.025	0	0	0.6	0.15	
2005				0	0	0	0	0	0	0	0.8	0.2	
2006				0	0	0	0	0	0	0	0.8	0.2	
	2265004026	3	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.063	0.936	0	0	0	0	0	0	0
1996				0	0.032	0.468	0	0.037	0.463	0	0	0	0
1997				0	0	0	0	0.073	0.927	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004026	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0	1	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	
1997				0	0	0	0	1	0	0	0	0	
2001				0	0	0	0	0.5	0.5	0	0	0	
2002				0	0	0	0	0.375	0.625	0	0	0	
2003				0	0	0	0	0.25	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004030	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.01	0.99	0	0	0	0	0	0	0
1996				0	0.005	0.495	0	0.01	0.49	0	0	0	0
1997				0	0	0	0	0.019	0.981	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	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									
	2265004030	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0	1	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	
1997				0	0	0	0.002	0.998	0	0	0	0	
2001				0	0	0	0.001	0.499	0.5	0	0	0	
2002				0	0	0	0	0.375	0.625	0	0	0	
2003				0	0	0	0	0.25	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004031	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.01	0.99	0	0	0	0	0	0	0
1996				0	0.005	0.495	0	0.01	0.49	0	0	0	0
1997				0	0	0	0	0.019	0.981	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004031	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0	1	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	
1997				0	0	0	0.002	0.998	0	0	0	0	
2001				0	0	0	0.001	0.499	0.5	0	0	0	
2002				0	0	0	0	0.375	0.625	0	0	0	
2003				0	0	0	0	0.25	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2260004035	0	6	**G2N1**									
1900				1									
	2260004035	6	25	**G2N2**									
1900				1									
	2260004036	0	6	**G2N1**									
1900				1									
	2260004036	6	25	**G2N2**									
1900				1									
	2265004035	0	6	**G4N1O**	**G4N1S**								
1900				0.8	0.2								
	2265004035	6	25	**G4N2O**	**G4N2S**								
1900				0.8	0.2								

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

Year	SCC	HP Min	HP Max	Fraction of Population in Each Technology Type									
	2265004036	0	6	**G4N1O**	**G4N1S**								
1900				0.8	0.2								
	2265004036	6	25	**G4N2O**	**G4N2S**								
1900				0.8	0.2								
	2265004040	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0	1	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.005	0.495	0	0	0	0
1997				0	0	0	0	0.01	0.99	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004040	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.164	0.836	0	0	0	0	0	0	
1996				0	0.082	0.418	0.082	0.418	0	0	0	0	
1997				0	0	0	0.164	0.836	0	0	0	0	
2001				0	0	0	0.082	0.418	0.5	0	0	0	
2002				0	0	0	0.062	0.313	0.625	0	0	0	
2003				0	0	0	0.041	0.209	0.75	0	0	0	
2004				0	0	0	0.02	0.105	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004041	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0	1	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.005	0.495	0	0	0	0
1997				0	0	0	0	0.01	0.99	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004041	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.164	0.836	0	0	0	0	0	0	
1996				0	0.082	0.418	0.082	0.418	0	0	0	0	
1997				0	0	0	0.164	0.836	0	0	0	0	
2001				0	0	0	0.082	0.418	0.5	0	0	0	
2002				0	0	0	0.062	0.313	0.625	0	0	0	
2003				0	0	0	0.041	0.209	0.75	0	0	0	
2004				0	0	0	0.02	0.105	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004055	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.027	0.973	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									
1996				0	0.013	0.487	0	0.018	0.481	0	0	0	0
1997				0	0	0	0	0.037	0.963	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004055	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.007	0.993	0	0	0	0	0	0	
1996				0	0.003	0.497	0.003	0.497	0	0	0	0	
1997				0	0	0	0.007	0.993	0	0	0	0	
2001				0	0	0	0.003	0.497	0.5	0	0	0	
2002				0	0	0	0.002	0.373	0.625	0	0	0	
2003				0	0	0	0.001	0.249	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004056	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0	0.027	0.973	0	0	0	0	0	0	0
1996				0	0.013	0.487	0	0.018	0.481	0	0	0	0
1997				0	0	0	0	0.037	0.963	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004056	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.007	0.993	0	0	0	0	0	0	
1996				0	0.003	0.497	0.003	0.497	0	0	0	0	
1997				0	0	0	0.007	0.993	0	0	0	0	
2001				0	0	0	0.003	0.497	0.5	0	0	0	
2002				0	0	0	0.002	0.373	0.625	0	0	0	
2003				0	0	0	0.001	0.249	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265004071	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0.086	0.349	0.565	0	0	0	0	0	0	0
1996				0.043	0.175	0.282	0	0.199	0.301	0	0	0	0
1997				0	0	0	0	0.398	0.602	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265004071	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.413	0.587	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									
1996				0	0.207	0.293	0	0.5	0	0	0	0	
1997				0	0	0	0.413	0.587	0	0	0	0	
2001				0	0	0	0.206	0.294	0.5	0	0	0	
2002				0	0	0	0.155	0.22	0.625	0	0	0	
2003				0	0	0	0.104	0.146	0.75	0	0	0	
2004				0	0	0	0.052	0.073	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265005040	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0	1	0	0	0	0	0	0	
1996				0	0	0.5	0	0.5	0	0	0	0	
1997				0	0	0	0	1	0	0	0	0	
2001				0	0	0	0	0.5	0.5	0	0	0	
2002				0	0	0	0	0.375	0.625	0	0	0	
2003				0	0	0	0	0.25	0.75	0	0	0	
2004				0	0	0	0	0.125	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265006005	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**N4N1**
1900				0.006	0.02	0.974	0	0	0	0	0	0	0
1996				0.003	0.01	0.487	0	0.016	0.484	0	0	0	0
1997				0	0	0	0	0.032	0.968	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2265006005	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.078	0.922	0	0	0	0	0	0	
1996				0	0.039	0.461	0.039	0.461	0	0	0	0	
1997				0	0	0	0.078	0.922	0	0	0	0	
2001				0	0	0	0.039	0.461	0.5	0	0	0	
2002				0	0	0	0.03	0.345	0.625	0	0	0	
2003				0	0	0	0.02	0.23	0.75	0	0	0	
2004				0	0	0	0.01	0.115	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2265006010	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**N4N1**
1900				0	0	1	0	0	0	0	0	0	0
1996				0	0	0.5	0	0.005	0.495	0	0	0	0
1997				0	0	0	0	0.01	0.99	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	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									
2008				0	0	0	0	0	0	0	1		
	2265006010	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0	0.143	0.857	0	0	0	0	0	0	
1996				0	0.072	0.428	0.072	0.428	0	0	0	0	
1997				0	0	0	0.143	0.857	0	0	0	0	
2001				0	0	0	0.071	0.429	0.5	0	0	0	
2002				0	0	0	0.053	0.322	0.625	0	0	0	
2003				0	0	0	0.035	0.215	0.75	0	0	0	
2004				0	0	0	0.017	0.108	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2260007005	6	9999	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**				
1900				1	0	0	0	0	0				
1996				0.5	0	0.495	0.005	0	0				
1997				0	0	0.99	0.01	0	0				
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				
	2265010010	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**N4N1**
1900				0.18	0.069	0.751	0	0	0	0	0	0	0
1996				0.09	0.035	0.375	0	0.083	0.417	0	0	0	0
1997				0	0	0	0	0.167	0.833	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2267000000	25	9999	**LGT25**	**LGT251**	**LGT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							
	2268000000	25	9999	**NGT25**	**NGT251**	**NGT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	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									
	2282005010	0	3	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				0.9	0.1	0	0	0	0	0			
	2282005010	3	11	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				0.957	0.043	0	0	0	0	0			
1997				0.87	0.13	0	0	0	0	0			
2000				0.537	0.463	0	0	0	0	0			
2003				0.276	0.724	0	0	0	0	0			
2005				0.26	0.724	0.016	0	0	0	0			
	2282005010	11	25	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				0.989	0.011	0	0	0	0	0			
2002				0.962	0.038	0	0	0	0	0			
2003				0.78	0.216	0.004	0	0	0	0			
2004				0.64	0.349	0.011	0	0	0	0			
2005				0.633	0.356	0.011	0	0	0	0			
2006				0.091	0.62	0.011	0	0	0	0.277			
	2282005010	25	50	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				1	0	0	0	0	0	0			
1998				0.972	0.028	0	0	0	0	0			
2001				0.683	0.049	0	0	0	0.268	0			
2002				0.105	0.049	0	0	0	0.268	0.578			
2003				0.098	0.049	0.007	0	0	0.268	0.578			
2005				0.085	0.063	0.007	0	0	0.268	0.578			
	2282005010	50	100	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				1	0	0	0	0	0	0			
1999				0.95	0.05	0	0	0	0	0			
2000				0.917	0.05	0.033	0	0	0	0			
	2282005010	100	175	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				1	0	0	0	0	0	0			
1997				0.988	0	0	0	0	0.012	0			
1998				0.954	0	0.034	0	0	0.012	0			
1999				0.575	0	0.034	0	0	0.012	0.379			
2003				0.302	0	0.035	0.267	0	0.012	0.384			
2004				0	0	0.035	0.267	0	0.314	0.384			
	2282005010	175	9999	**M1**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**			
1900				1	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									
1997				0.967	0	0	0	0	0.033	0			
1998				0.234	0	0	0	0	0.033	0.733			
2004				0	0	0	0	0	0.29	0.71			
	2282005015	0	25	**M2**	**M13**	**M14**							
1900				0.218	0.782	0							
2005				0.075	0.925	0							
	2282005015	25	50	**M2**	**M13**	**M14**							
1900				1	0	0							
1999				0.68	0	0.32							
2002				0.68	0.136	0.184							
2003				0.496	0.32	0.184							
2004				0.496	0.504	0							
2005				0.075	0.925	0							
	2282005015	50	9999	**M2**	**M13**	**M14**							
1900				1	0	0							
1999				0.177	0.092	0.731							
2000				0.177	0.259	0.564							
2001				0.177	0.533	0.29							
2002				0.177	0.823	0							
2004				0.039	0.961	0							
	2282010005	0	50	**M3**	**M10**								
1900				1	0								
2007				0	0								
	2282010005	50	175	**M3**	**M10**								
1900				1	0								
1997				0.9	0.1								
1998				0.8	0.2								
1999				0.7	0.3								
2000				0.6	0.4								
2001				0.5	0.5								
2002				0.4	0.6								
2003				0.3	0.7								
2004				0.2	0.8								
2007				0	0								
	2282010005	175	300	**M3**	**M10**								
1900				1	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									
1996				0.9	0.1								
1997				0.8	0.2								
1998				0.7	0.3								
1999				0.6	0.4								
2000				0.5	0.5								
2001				0.4	0.6								
2002				0.3	0.7								
2003				0.2	0.8								
2004				0.1	0.9								
2007				0	0								
	2282010005	300	999	**M3**	**M10**								
1900				1	0								
1995				0.9	0.1								
1996				0.8	0.2								
1997				0.7	0.3								
1998				0.6	0.4								
1999				0.5	0.5								
2000				0.4	0.6								
2001				0.3	0.7								
2002				0.2	0.8								
2003				0.1	0.9								
2004				0	1								
2007				0	0								
	2285004015	0	6	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**	**L4N1**
1900				0.18	0.069	0.751	0	0	0	0	0	0	0
1996				0.09	0.035	0.375	0	0.083	0.417	0	0	0	0
1997				0	0	0	0	0.167	0.833	0	0	0	0
2007				0	0	0	0	0.097	0.486	0	0.417	0	0
2008				0	0	0	0	0	0	0	1		
	2285004015	6	25	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**	
1900				0.005	0.018	0.977	0	0	0	0	0	0	
1996				0.003	0.009	0.488	0	0.5	0	0	0	0	
1997				0	0	0	0.017	0.983	0	0	0	0	
2001				0	0	0	0.008	0.492	0.5	0	0	0	
2002				0	0	0	0.006	0.369	0.625	0	0	0	
2003				0	0	0	0.004	0.246	0.75	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									
2004				0	0	0	0.002	0.123	0.875	0	0	0	
2005				0	0	0	0	0	1	0	0	0	
	2285004015	25	9999	**G4GT25**	**G4GT251**	**G4GT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							
	2285006015	25	9999	**LGT25**	**LGT251**	**LGT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							
	2285008015	25	9999	**NGT25**	**NGT251**	**NGT252**							
1900				1	0	0							
2004				0	1	0							
2007				0	0	1							

* Taken from tech.dat input file.