United States
Environmental Protection
Agency

Air and Radiation

EPA420-P-02-015
November 2002
NR-010c

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

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Spark Ignition

Report No. NR-010c
revised November 27, 2002

Assessment and Standards Division
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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 NONROAD2002 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-012a), adjustments to emission rates due to variations in fuel and temperature (NR-001a), speciation of hydrocarbon emissions (NR-002), and adjustments to emission rates as equipment deteriorates due to time and use (NR-011a). Emission factors for compression ignition (diesel) engines are covered in a separate report (NR-009b).

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-006b, 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 NONROAD2002. 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]

There is also now a final rulemaking for large spark-ignition engines (> 25hp) and recreational engines (both marine and land-based). [8] Since this rulemaking was just published in November 2002, the final standards for these equipment categories are not included in this version of the model, although updated pre-controlled emission factors developed as part of the rulemaking process have been incorporated in draft NONROAD2002.

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 NONROAD2002. 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 NONROAD2002; 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 NONROAD2002 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, draft NONROAD2002 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, generators, compressors, welders, aerial lifts, and ice grooming machines. These engines may

operate on gasoline, LPG, or CNG. SI engines >25 hp are currently unregulated, although emission standards have recently been proposed. [8] As a result, only pre-controlled (baseline) emission factors are included in draft NONROAD2002.

A summary of the emission factors used for this equipment category is provided in Table 6. The gasoline 2-stroke engine emission factors and the PM emission factors generally were taken from NEVES. [1] Emission factors for the gasoline 4-stroke, LPG, and CNG engines were taken from the draft regulatory support document for the proposed rule, and are based on a summary of available test data. [11]

Table 6. Emissions 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**
G2GT25 (gas, 2-stroke, baseline)	208.00	486.00	0.290	7.70	1.30
G4GT25 (gas, 4-stroke, baseline)	6.22	203.4	7.130	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

* These are pre-control emission factors, as this category of nonroad engines is currently not subject to regulation. These emission factors are also used for 2-stroke and 4-stroke snowblowers <25hp, since snowblowers are currently not regulated.
Snowmobiles are categorized as recreational equipment, and are covered under a different tech type (R12S).

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

These engines differ significantly from other SI engines in their basic design, operating characteristics, and emission rates. They are currently unregulated, although emission standards have recently been proposed. [8] As a result, only pre-controlled (baseline) emission factors are included in draft NONROAD2002.

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 proposed rule. [11,12]

Table 7. Emissions and BSFCs for Motorcycles, ATVs, and Snowmobiles

Equipment/Tech Type	**HC g/mile**	**CO g/mile**	**NO_x g/mile**	**PM g/mile**	**BSFC lb/mile**
2-stroke offroad motorcycle (R12S)	55.7	52.7	0.150	0.016	0.291
4-stroke offroad motorcycle (R14S)	2.2	48.3	0.340	0.011	0.170
2-stroke all terrain vehicles (R12S)	55.7	52.7	0.150	0.016	0.197
4-stroke all terrain vehicles (R14S)	2.2	48.3	0.340	0.022	0.332
	HC g/hp-hr	**CO g/hp-hr**	**NO_x g/hp-hr**	**PM g/hp-hr**	**BSFC lb/hp-hr**
2-stroke snowmobiles (R12S)	111.0	296.0	0.860	2.70	1.66

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. 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 precontrolled 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

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 ($\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. [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 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
all*	1.3	1.45	1.0	1.0	1.0

* All = 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. In draft NONROAD2002, 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] "Draft Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines," U.S. EPA, EPA420-D-01-004, September 2001.

[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 NONROAD2002, 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 NONROAD2002. 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 NONROAD2002 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 NONROAD2002 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
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
G4N2O2	Small SI ≤ 25hp	Gasoline, 4-stroke, overhead-valved, nonhandheld Class II (≥225cc), Phase 2

Table B3. Spark-Ignition Technologies in the Draft NONROAD2002 Model

Engine Tech Type Code	SI Engine Category	Description
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
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
R12S	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 2-stroke, Baseline
R14S	Recreational Equipment	Offroad Motorcycles, All-Terrain Vehicles, and Snowmobiles, 4-stroke, Baseline

Table B4. Technical Type Fleet Fractions for 3 - 11 hp Outboard Engines

Year	M1	M4	M5
1900	0.957	0.043	0.000
1997	0.870	0.130	0.000
2000	0.537	0.463	0.000
2003	0.276	0.724	0.000
2005	0.260	0.724	0.016

Table B5. Technical Type Fleet Fractions for 11 - 25 hp Outboard Engines

Year	M1	M4	M5	M9
1900	0.989	0.011	0.000	0.000
2002	0.962	0.038	0.000	0.000
2003	0.780	0.216	0.004	0.000
2004	0.640	0.349	0.011	0.000
2005	0.633	0.356	0.011	0.000
2006	0.091	0.620	0.011	0.277

Table B6. Technical Type Fleet Fractions for 25 - 50 hp Outboard Engines

Year	M1	M4	M5	M8	M9
1900	1.000	0.000	0.000	0.000	0.000
1998	0.972	0.028	0.000	0.000	0.000
2001	0.683	0.049	0.000	0.268	0.000
2002	0.105	0.049	0.000	0.268	0.578
2003	0.098	0.049	0.007	0.268	0.578
2005	0.085	0.063	0.007	0.268	0.578

Table B7. Technical Type Fleet Fractions for 50 - 100 hp Outboard Engines

Year	M1	M4	M5
1900	1.000	0.000	0.000
1999	0.950	0.050	0.000
2000	0.917	0.050	0.033

Table B8. Technical Type Fleet Fractions for 100- 175 hp Outboard Engines

Year	M1	M5	M6	M8	M9
1900	1.000	0.000	0.000	0.000	0.000
1997	0.988	0.000	0.000	0.012	0.000
1998	0.954	0.034	0.000	0.012	0.000
1999	0.575	0.034	0.000	0.012	0.379
2003	0.302	0.035	0.267	0.012	0.384
2004	0.000	0.035	0.267	0.314	0.384

Table B9. Technical Type Fleet Fractions for >175 hp Outboard Engines

Year	M1	M8	M9
1900	1.000	0.000	0.000
1997	0.967	0.033	0.000
1998	0.234	0.033	0.733
2004	0.000	0.290	0.710

Table B10. Technical Type Fleet Fractions of New Personal Water Craft Engines 0-25 hp*

Year	M2	M13
1900	0.218	0.782
2005	0.075	0.925

* The RIA assumed there were no engines under 30hp. As described in technical report NR-006b, "Nonroad Engine Population Estimates," the PSR data that NONROAD uses as a basis for most of the SI engine population inputs does indicate some engines in this power range, including some 4-strokes. Draft NONROAD2002 takes into account those PSR population fractions.

Table B11. Technical Type Fleet Fractions of New Personal Water Craft Engines 25-50 hp

Year	M2	M13	M14
1900	1.000	0.000	0.000
1999	0.680	0.000	0.320
2002	0.680	0.136	0.184
2003	0.496	0.320	0.184
2004	0.496	0.504	0.000
2005	0.075	0.925	0.000

Table B12. Technical Type Fleet Fractions of New Personal Water Craft Engines >50 hp

Year	M2	M13	M14
1900	1.000	0.000	0.000
1999	0.177	0.092	0.731
2000	0.177	0.259	0.564
2001	0.177	0.533	0.290
2002	0.177	0.823	0.000
2004	0.039	0.961	0.000

Table B13. Technical Type Fleet Fractions of New Inboard Engines <50 hp

Year	M3	M10
1900	1.000	0.000

Table B14. Technical Type Fleet Fractions of New Inboard Engines 50-175 hp

Year	M3	M10
1900	1.000	0.000
1997	0.900	0.100
1998	0.800	0.200
1999	0.700	0.300
2000	0.600	0.400
2001	0.500	0.500
2002	0.400	0.600
2003	0.300	0.700
2004	0.200	0.800

Table B15. Technical Type Fleet Fractions of New Inboard Engines 175-300 hp

Year	M3	M10
1900	1.000	0.000
1996	0.900	0.100
1997	0.800	0.200
1998	0.700	0.300
1999	0.600	0.400
2000	0.500	0.500
2001	0.400	0.600
2002	0.300	0.700
2003	0.200	0.800
2004	0.100	0.900

Table B16. Technical Type Fleet Fractions of New Inboard Engines >300 hp

Year	M3	M10
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	0.400	0.600
2001	0.300	0.700
2002	0.200	0.800
2003	0.100	0.900
2004	0.000	1.000

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2260000000	**0**	**9999**	**G2GT25**								
1900				1.000								
	2265000000	**0**	**9999**	**G4GT25**								
1900				1.000								
	2260000000	**0**	**1**	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**		
1900				1.000	0.0000	0.0000	0.000	0.000	0.000	0.000		
1996				0.500	0.4950	0.0050	0.000	0.000	0.000	0.000		
1997				0.000	0.9900	0.0100	0.000	0.000	0.000	0.000		
2002				0.000	0.7425	0.0075	0.000	0.000	0.250	0.000		
2003				0.000	0.4950	0.0050	0.000	0.000	0.500	0.000		
2004				0.000	0.2475	0.0025	0.000	0.000	0.750	0.000		
2005				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
2006				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
	2260000000	**1**	**3**	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.500	0.000	0.000	0.495	0.005	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.990	0.010	0.000	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.675	0.075	0.000	0.000	0.200	0.050
2003				0.000	0.000	0.000	0.450	0.050	0.000	0.000	0.400	0.100
2004				0.000	0.000	0.000	0.225	0.025	0.000	0.000	0.600	0.150
2005				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200
2006				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200
	2260000000	**3**	**6**	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**			
1900				1.000	0.000	0.0000	0.0000	0.000	0.000			
1996				0.500	0.000	0.4950	0.0050	0.000	0.000			
1997				0.000	0.000	0.9900	0.0100	0.000	0.000			
2002				0.000	0.000	0.9900	0.0100	0.000	0.000			
2003				0.000	0.000	0.9900	0.0100	0.000	0.000			
2004				0.000	0.000	0.7425	0.0075	0.250	0.000			
2005				0.000	0.000	0.4950	0.0050	0.500	0.000			
2006				0.000	0.000	0.2475	0.0025	0.750	0.000			
2007				0.000	0.000	0.0000	0.0000	1.000	0.000			
2008				0.000	0.000	0.0000	0.0000	1.000	0.000			

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2260000000	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.005	0.018	0.977	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.003	0.009	0.488	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.017	0.983	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.008	0.492	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.006	0.369	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.004	0.246	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.002	0.123	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265000000	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.180	0.069	0.751	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.090	0.035	0.375	0.000	0.083	0.417	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
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265000000	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.005	0.018	0.977	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.003	0.009	0.488	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.017	0.983	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.008	0.492	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.006	0.369	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.004	0.246	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.002	0.123	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2260001010	**0**	**9999**	**R12S**								
1900				1.000								
	2265001010	**0**	**9999**	**R14S**								
1900				1.000								
	2260001020	**0**	**9999**	**R12S**								
1900				1.000								
	2265001020	**0**	**9999**	**R14S**								
1900				1.000								
	2260001030	**0**	**9999**	**R12S**								
1900				1.000								
	2265001030	**0**	**9999**	**R14S**								
1900				1.000								

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004010	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.050	0.070	0.880	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.025	0.035	0.440	0.000	0.052	0.448	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.104	0.896	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004011	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.150	0.060	0.790	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.075	0.030	0.395	0.000	0.072	0.429	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.143	0.857	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004015	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.005	0.495	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.010	0.990	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2260004020	**6**	**9999**	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**			
1900				1.000	0.000	0.0000	0.0000	0.000	0.000			
1996				0.500	0.000	0.4950	0.0050	0.000	0.000			
1997				0.000	0.000	0.9900	0.0100	0.000	0.000			
2002				0.000	0.000	0.9900	0.0100	0.000	0.000			
2003				0.000	0.000	0.9900	0.0100	0.000	0.000			
2004				0.000	0.000	0.7425	0.0075	0.250	0.000			
2005				0.000	0.000	0.4950	0.0050	0.500	0.000			
2006				0.000	0.000	0.2475	0.0025	0.750	0.000			
2007				0.000	0.000	0.0000	0.0000	1.000	0.000			
2008				0.000	0.000	0.0000	0.0000	1.000	0.000			

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2260004021	**6**	**9999**	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**			
1900				1.000	0.000	0.0000	0.0000	0.000	0.000			
1996				0.500	0.000	0.4950	0.0050	0.000	0.000			
1997				0.000	0.000	0.9900	0.0100	0.000	0.000			
2002				0.000	0.000	0.9900	0.0100	0.000	0.000			
2003				0.000	0.000	0.9900	0.0100	0.000	0.000			
2004				0.000	0.000	0.7425	0.0075	0.250	0.000			
2005				0.000	0.000	0.4950	0.0050	0.500	0.000			
2006				0.000	0.000	0.2475	0.0025	0.750	0.000			
2007				0.000	0.000	0.0000	0.0000	1.000	0.000			
2008				0.000	0.000	0.0000	0.0000	1.000	0.000			
	2260004025	**0**	**1**	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**		
1900				1.000	0.0000	0.0000	0.000	0.000	0.000	0.000		
1996				0.500	0.4950	0.0050	0.000	0.000	0.000	0.000		
1997				0.000	0.9900	0.0100	0.000	0.000	0.000	0.000		
2002				0.000	0.7425	0.0075	0.000	0.000	0.250	0.000		
2003				0.000	0.4950	0.0050	0.000	0.000	0.500	0.000		
2004				0.000	0.2475	0.0025	0.000	0.000	0.750	0.000		
2005				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
2006				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
	2260004025	**1**	**3**	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.500	0.000	0.000	0.490	0.005	0.005	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.980	0.010	0.010	0.000	0.000	0.000
1998				0.000	0.000	0.000	0.972	0.010	0.018	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.675	0.075	0.000	0.000	0.200	0.050
2003				0.000	0.000	0.000	0.450	0.050	0.000	0.000	0.400	0.100
2004				0.000	0.000	0.000	0.225	0.025	0.000	0.000	0.600	0.150
2005				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200
2006				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004025	**3**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.063	0.936	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.032	0.468	0.000	0.037	0.463	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.073	0.927	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004025	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.375	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.250	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2260004026	**0**	**1**	**G2H3**	**G2H31**	**G2H3C1**	**G2H32**	**G4H31**	**G2H3C2**	**G4H32**		
1900				1.000	0.0000	0.0000	0.000	0.000	0.000	0.000		
1996				0.500	0.4950	0.0050	0.000	0.000	0.000	0.000		
1997				0.000	0.9900	0.0100	0.000	0.000	0.000	0.000		
2002				0.000	0.7425	0.0075	0.000	0.000	0.250	0.000		
2003				0.000	0.4950	0.0050	0.000	0.000	0.500	0.000		
2004				0.000	0.2475	0.0025	0.000	0.000	0.750	0.000		
2005				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
2006				0.000	0.0000	0.0000	0.000	0.000	1.000	0.000		
	2260004026	**1**	**3**	**G2H4**	**G2H4C**	**G4H4**	**G2H41**	**G2H4C1**	**G4H41**	**G2H42**	**G2H4C2**	**G4H42**
1900				1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.500	0.000	0.000	0.490	0.005	0.005	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.980	0.010	0.010	0.000	0.000	0.000
1998				0.000	0.000	0.000	0.972	0.010	0.018	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.675	0.075	0.000	0.000	0.200	0.050
2003				0.000	0.000	0.000	0.450	0.050	0.000	0.000	0.400	0.100
2004				0.000	0.000	0.000	0.225	0.025	0.000	0.000	0.600	0.150
2005				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200
2006				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.800	0.200

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004026	**3**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.063	0.936	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.032	0.468	0.000	0.037	0.463	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.073	0.927	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004026	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.375	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.250	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265004030	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.010	0.990	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.005	0.495	0.000	0.010	0.490	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.019	0.981	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004030	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.002	0.998	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.001	0.499	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.375	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.250	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265004031	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.010	0.990	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.005	0.495	0.000	0.010	0.490	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.019	0.981	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004031	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.002	0.998	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.001	0.499	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.375	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.250	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2260004035	**0**	**25**	**G2GT25**								
1900				1.000								
	2260004036	**0**	**25**	**G2GT25**								
1900				1.000								
	2265004035	**0**	**25**	**G4GT25**								
1900				1.000								
	2265004036	**0**	**25**	**G4GT25**								
1900				1.000								
	2265004040	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.005	0.495	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.010	0.990	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004040	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.164	0.836	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.082	0.418	0.082	0.418	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.164	0.836	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.082	0.418	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.062	0.313	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.041	0.209	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.020	0.105	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004041	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.005	0.495	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.010	0.990	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004041	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.164	0.836	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.082	0.418	0.082	0.418	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.164	0.836	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.082	0.418	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.062	0.313	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.041	0.209	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.020	0.105	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265004055	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.027	0.973	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.013	0.487	0.000	0.018	0.481	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.037	0.963	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004055	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.007	0.993	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.003	0.497	0.003	0.497	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.007	0.993	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.003	0.497	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.002	0.373	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.001	0.249	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265004056	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.027	0.973	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.013	0.487	0.000	0.018	0.481	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.037	0.963	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265004056	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.007	0.993	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.003	0.497	0.003	0.497	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.007	0.993	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.003	0.497	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.002	0.373	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.001	0.249	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265004071	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.086	0.349	0.565	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.043	0.175	0.282	0.000	0.199	0.301	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.398	0.602	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265004071	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.413	0.587	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.207	0.293	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.413	0.587	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.206	0.294	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.155	0.220	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.104	0.146	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.052	0.073	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265005040	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.000	0.375	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.000	0.250	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2265006005	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.006	0.020	0.974	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.003	0.010	0.487	0.000	0.016	0.484	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.032	0.968	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265006005	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.078	0.922	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.039	0.461	0.039	0.461	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.078	0.922	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.039	0.461	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.030	0.345	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.020	0.230	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.010	0.115	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
	2265006010	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.000	0.500	0.000	0.005	0.495	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.000	0.010	0.990	0.000	0.000	0.000
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2265006010	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.000	0.143	0.857	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.000	0.072	0.428	0.072	0.428	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.143	0.857	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.071	0.429	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.053	0.322	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.035	0.215	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.017	0.108	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2260007005	**6**	**9999**	**G2H5**	**G2H5C**	**G2H51**	**G2H5C1**	**G2H52**	**G2H5C2**			
1900				1.000	0.000	0.0000	0.0000	0.000	0.000			
1996				0.500	0.000	0.4950	0.0050	0.000	0.000			
1997				0.000	0.000	0.9900	0.0100	0.000	0.000			
2002				0.000	0.000	0.9900	0.0100	0.000	0.000			
2003				0.000	0.000	0.9900	0.0100	0.000	0.000			
2004				0.000	0.000	0.7425	0.0075	0.250	0.000			
2005				0.000	0.000	0.4950	0.0050	0.500	0.000			
2006				0.000	0.000	0.2475	0.0025	0.750	0.000			
2007				0.000	0.000	0.0000	0.0000	1.000	0.000			
2008				0.000	0.000	0.0000	0.0000	1.000	0.000			
	2265010010	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.180	0.069	0.751	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.090	0.035	0.375	0.000	0.083	0.417	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
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2267000000	**25**	**9999**	**LGT25**								
1900				1.000								
	2268000000	**25**	**9999**	**NGT25**								
1900				1.000	0.000	0.000						
	2285004015	**0**	**6**	**G2N1**	**G4N1O**	**G4N1S**	**G2N11**	**G4N1O1**	**G4N1S1**	**G4N1SC1**	**G4N1O2**	**G4N1S2**
1900				0.180	0.069	0.751	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.090	0.035	0.375	0.000	0.083	0.417	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
2007				0.000	0.000	0.000	0.000	0.097	0.486	0.000	0.417	0.000
2008				0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	
	2285004015	**6**	**25**	**G2N2**	**G4N2O**	**G4N2S**	**G4N2O1**	**G4N2S1**	**G4N2O2**	**G4N2S2**	**L4N2**	**N4N2**
1900				0.005	0.018	0.977	0.000	0.000	0.000	0.000	0.000	0.000
1996				0.003	0.009	0.488	0.000	0.500	0.000	0.000	0.000	0.000
1997				0.000	0.000	0.000	0.017	0.983	0.000	0.000	0.000	0.000
2001				0.000	0.000	0.000	0.008	0.492	0.500	0.000	0.000	0.000
2002				0.000	0.000	0.000	0.006	0.369	0.625	0.000	0.000	0.000
2003				0.000	0.000	0.000	0.004	0.246	0.750	0.000	0.000	0.000
2004				0.000	0.000	0.000	0.002	0.123	0.875	0.000	0.000	0.000
2005				0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000

Table B17. Nonroad SI Technology Distributions by SCC and HP Category (except Recreational Marine)*												
Year	**SCC**	**HPmn**	**HPmx**	**Fraction of Population in Each Technology Type**								
	2285004015	**25**	**9999**	**G4GT25**								
1900				1.000								
	2285006015	**25**	**9999**	**LGT25**								
1900				1.000								
	2285008015	**25**	**9999**	**NGT25**								
1900				1.000								

* Taken from tech.dat input file.