Control of Emissions from Marine SI and Small SI Engines, Vessels, and Equipment

Draft Regulatory Impact Analysis

Chapter 3
Emission Inventory

Assessment and Standards Division
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This chapter presents our analysis of the emission impact of the proposed rule for spark ignition (SI) small nonroad engines (≤25 horsepower (hp) or ≤19 kilowatts (kW) used in land-based or auxiliary marine applications (hereafter collectively termed small nonroad SI engines) and Marine SI engines. The control requirements include exhaust and evaporative emission standards for small non-handheld SI engines (Class I <225 cubic centimeters (cc) and Class II ≥225 cc), an evaporative emission standards for small handheld SI engines (Classes III-V), and exhaust and evaporative emission standards for all Marine SI engines.

Section 3.1 presents an overview of methodology used to develop the emission inventories for the small nonroad and marine engines that are subject to the proposed rulemaking. Section 3.2 identifies the specific modeling inputs that were used to develop the baseline scenario emission inventories. The resulting baseline emission inventories are also presented in that section. Section 3.3 then describes the contribution of the small nonroad and Marine SI engines to national baseline inventories. Section 3.4 describes the development of the controlled inventories, specifically the changes made to the baseline modeling inputs to incorporate the new standards. The control inventories are also presented in this section. Section 3.5 follows with the projected emission reductions resulting from the proposed rule. Section 3.6 describes the emission inventories used in the air quality modeling described in Chapter 2. This discussion includes a description of the changes in the inputs and resulting emission inventories between the preliminary baseline and control scenarios used for the air quality modeling and the more refined final baseline and control scenarios reflected in the actual proposal.

In Sections 3.2, 3.4 and 3.5, the estimates of baseline, controlled, and emission reduction inventories, respectively, for criteria pollutants from small nonroad and Marine SI engines are reported for the 50-state geographic area (including the District of Columbia). These inventories reflect the emissions from the engines subject to the proposed Phase 3 standards. As such, they exclude the emissions from engines that are regulated by the State of California as provided for by section 209 of the Clean Air Act.

More specifically, California is prevented from regulating nonroad engines with less than 175 horsepower that are used in farm and construction equipment. Therefore, those engines are subject to federal regulation and included in our 50-state inventories. By contrast, we do not include the emissions from California marine engines in our inventories. California has also been granted a waiver under the Clean Air Act to regulate exhaust emissions form all Marine SI engines and evaporative emissions from outboard and personal watercraft SI engines. That State also has indicted its intent to adopt the proposed Phase III standards for evaporative emissions from stern drive engines. Therefore, are excluded in our 50-state inventories.

In Section 3.3, 50-state inventories are used to compare the nationwide importance of these sources to other source categories, i.e., stationary, area, and other mobile sources. Finally, Section 3.6 presents inventories for 37 of the most eastern states in the nation that were included in the air quality modeling domain for this proposal. Unlike the 50-state inventories in the other sections, these inventories include all small nonroad SI and marine engines. The 37-state control scenarios assume federal standards apply only to those engines that are not subject to California emission regulations as described earlier.

Inventories are generally presented for the following pollutants: exhaust and evaporative total hydrocarbons (THC), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$ and PM_{10}), and carbon monoxide (CO). The PM inventories include directly emitted PM only, although secondary sulfates are taken into account in the air quality modeling as noted below. The proposed requirements would also reduce hazardous air pollutants such as benzene, formaldeyde, acetaldehyde, 1,3-butadiene, acrolein, napthalene, and 15 other compounds grouped together as polycyclic organic matter (POM).

The hydrocarbon inventories in Sections 3.3 and 3.5 for the nationwide comparison and air quality modeling, respectively, are presented as volatile organic compounds (VOC) rather than THC. This is a broader class of hydrocarbon compounds that is important for air quality modeling purposes. The additional compounds that comprise VOC are reactive oxygenated species represented by aldehydes (RCHO) and alcohols (RCOH), and less reactive species represented by methane (CH_4) and ethane (CH_3CH_3).

Finally, none of the controlled inventory estimates include the potential uses of the averaging, banking, and trading (ABT) program for engine manufacturers, since these are flexibilities that would be difficult to predict and model. More information regarding these provisions can be found in the preamble for this proposal that is published in the Federal Register.

3.1 Overview of Small Nonroad and Marine SI Engine Emissions Inventory Development

This section describes how the baseline emission inventories were modeled for the small nonroad and Marine SI engines affected by the proposed rule. Section 3.1 focuses on exhaust and evaporative hydrocarbons, and exhaust NO_x, PM, and CO.

The primary emission inventories associated with the small nonroad and Marine SI engine proposed rule, which are summarized in Sections 3.2 through 3.5, were generated using a modified version of our NONROAD2005 model. More specifically we started with the most recent public version of the model, i.e., NONROAD2005a, which was released in February 2006. A copy of that model and the accompanying technical reports that detail of the modeling inputs (e.g., populations, activity, etc.) are available in the docket for this proposal.[1] They can also be accessed on our website at: http://www.epa.gov/otaq/nonrdmdl.htm.

The NONROAD2005a model was modified to incorporate new emission test data and other improvements for this rulemaking. This special version is named NONROAD2005c. A copy of the model and most of the accompanying documentation are available in the docket.[2,3,4] The documentation for evaporative emission changes is in Chapter 5. The modifications we made to NONROAD2005a to reflect the baseline and control scenarios related to the proposed rule are fully described in Sections 3.2 and 3.4, respectively.

The nonroad model estimates emission inventories of important air emissions from a diverse universe of nonroad equipment. The model's scope includes all off-highway sources with the exception of locomotives, aircraft and commercial marine vessels. The model can distinguish emissions on the basis of equipment type, horsepower, and technology group. For the engines subject to the proposal, the nonroad model evaluates numerous equipment types with each type containing multiple horsepower categories and technology groups. A central feature of the model is the projection of future or past emissions between 1970 and 2050.

The chemical species NOx, PM, and CO are exhaust emissions, i.e., pollutants emitted directly as exhaust from combustion of gasoline fuel in the engine. Hydrocarbon species, e.g., THC and VOC, consist of both exhaust and evaporative emissions. The exhaust component represents hydrocarbons emitted as products of combustion, which can also include emissions vented from the crankcase. The evaporative hydrocarbon component includes compounds from unburned fuel that are emitted either while the engine being operated or when the equipment is not in use. The various categories of evaporative emissions that are included in the nonroad model are:

Diurnal. These emissions result from changes in temperature during the day. As the day gets warmer there is a concomitant rise in the temperature of the liquid fuel in the fuel tank. This causes the vapor pressure inside the tank to increase, forcing vaporized fuel to escape into the atmosphere. For modeling purposes, this category also includes diffusion losses that come from fuel vapor exiting the orifice of a vented fuel tank cap regardless of temperature.

Permeation. These emissions occur when fuel molecules transfuse through plastic or rubber fuel-related components (fuel lines and fuel tanks) into the atmosphere.

Hot Soak. These emissions occur after the engine is shut off and the engine's residual heat causes fuel vapors from the fuel tank or fuel metering device to be released into the atmosphere.

Running Loss. Similar in form to diurnal losses, these emissions are caused from the engine's heat during equipment operation.

Vapor Displacement or Refueling Loss. These are vapors displaced from the fuel tank when liquid fuel is being added during a refueling event.

Liquid Spillage. This refers to the liquid fuel that is spilled when equipment is refueled either from a portable fuel container or fuel pump, which subsequently evaporates into the atmosphere.

Equipment fueled by compressed natural gas, liquified petroleum gas, or diesel fuel are assumed to have zero evaporative emissions. Consequently, all evaporative emissions are from gasoline or gasoline blends, i.e., ethanol and gasoline.

The control scenario analyzed in Section 3.4 reflects the proposed standards for exhaust hydrocarbons, CO, and NOx from small nonhandheld nonroad and Marine SI engines.[1] New standards to control evaporative emissions from hose permeation and tank permeation from these engine classes and handheld equipment are also included. Further, the proposal also would establish new standards for running loss and diffusion emissions from small nonhandheld nonroad SI engines and diurnal emissions from Marine SI engines. Finally, we expect that the technology necessary to achieve the proposed exhaust emission standards will indirectly lower exhaust PM. All of these effects are reflected in the controlled emission inventories presented in this chapter.

3.2 Baseline Emission Inventory Estimates

This section describes more specifically how we developed the baseline exhaust and evaporative inventories for small nonroad and Marine SI engines. The resulting baseline inventories are also presented. Section 3.2.1 provides this information for exhaust and evaporative emissions.

The inventory estimates presented throughout this section include only equipment that would be subject to the proposed standards. For small nonroad SI equipment, California's Air Resources Board (ARB) has promulgated standards that are roughly equivalent in stringency overall to our proposed national standards, although some of the specific requirements and test procedures are different. However, the Clean Air Act prohibits California from regulating engines used in farm and construction equipment with maximum power levels below 175 hp or 130 kW. Therefore, the requirements contained in this proposal for small nonroad SI engines will apply in California to the above farm and construction equipment power levels. As a result, these engines are included in the inventories presented in this chapter.

For Marine SI engines, ARB also has its own exhaust emission standards that are roughly equivalent overall to our proposed national standards. In addition, ARB has stated its intend to develop evaporative emissions standards for boats in California. Therefore, exhaust and evaporative inventory estimates contained in this proposal are modeled for 49 states (excluding California) for Marine SI engines.

3.2.1 Baseline Exhaust and Evaporative Emissions Estimates for THC, NOx, $PM_{2.5}$, PM_{10}, and CO

The baseline exhaust and evaporative emission inventories for small nonroad and Marine SI engines include the effects of all existing applicable federal emission standards. We

[1] The CO standard applies to small nonhandheld SI engines used in auxiliary marine applications.

generated these inventories by starting with the NONROAD2005a emissions model, which was released to the public in February 2005. That model was then modified to incorporate new emission test data and other improvements for this rulemaking. This special version of the model is named NONROAD2005c. The modifications to the base model are described below.

3.2.1.1 Changes from NONROAD2005a to NONROAD2005c

As already mentioned, a number of improvements to the most publically available nonroad emissions inventory model were made to develop the NONROAD2005c, which is used in this proposed rulemaking. These revisions were based on recent testing programs, other information, and model enhancements. The changes are summarized below for Small SI and Marine SI engines. Many of the most important revisions are discussed in greater detail in the following sections.

3.2.1.1.1 Revisions for Small SI Engines

The modifications that we made to the NONROAD2005a model for Small SI engines that are most relevant to the proposal are summarized below:

1. Revised fuel tank and hose permeation emission factors;
2. Explicitly separated fuel tank diffusion losses to diurnal emission estimates;
3. Updated exhaust emission factors and deterioration rates, and technology-type sales fractions for Phase 2 engines;
4. Adjusted equipment populations to properly account for the application of federal emission requirements to engines in California; and
5. Added the ability to specifically model the effects of ethanol blends on fuel tank and hose permeation.

3.2.1.1.2 Revisions for Recreation Marine SI Engines

The modifications that we made to the NONROAD2005a model for Marine SI engines that are most relevant to the proposal are summarized below:

1. Revised brake-specific fuel consumption factors;
2. Revised PM emission factors for 2-stroke technology engines;
3. Revised fuel tank and hose permeation emission factors and temperature effects;
4. Updated modeling inputs for high performance sterndrive and inboard (SD/I) engines; and
5. Added the ability to specifically model the effects of ethanol blends on fuel tank and hose permeation.

3.2.1.2 Baseline Exhaust Emission Calculations

3.2.1.2.1 Small SI Exhaust Calculations

We revised the Phase 2 exhaust emission factors in the NONROAD2005a inventory model to reflect new information and our better understanding of the in-use emissions of these engines, as discussed further below.

The nonroad model estimates exhaust emissions in a given year by applying an appropriate emission factor based on the engines age or hours of use.[5] This reflects the fact that an engine's exhaust emissions performance degrades over its lifetime due to normal use or misuse (i.e., tampering or neglect). More specifically, the emission factor is a combination of a "zero-hour" emission level (ZHL) and a deterioration factor (DF). The ZHL represents the emission rate for recently manufactured engines, i.e., engines with few operating hours. The DF to the degree of emissions degradation per unit of activity. Nonroad engine activity is expressed in terms of hours of use or fraction of its median life. This later term refers to the age at which 50 percent of the engines sold in a given year ceased to function and have been scrapped. The following formula describes the basic form of the calculation:

$$EF_{aged} = ZHL \times DF$$

where: EF_{aged} is the emission factor for an aged engine
ZML is the zero hour emission factor for a new engine
DF is the deterioration factor

The form of the DF for nonroad SI engines is as follows:

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

where: $$\text{Age Factor} = \frac{[\text{Cumulative Hours} \times \text{Load Factor}]}{\text{Median Life at Full Load, in Hours}}$$

$A,\ ^{b}$ = constants for a given technology type; $b \leq 1$.

The constants A and b can be varied to approximate a wide range of deterioration patterns. "A" can be varied to reflect differences in maximum deterioration. For example, setting A equal to 2.0 would result in emissions at the engine's median life being three times the emissions when new. The shape of the deterioration function is determined by the second constant, b. This constant can be set at any level between zero and 1.0; currently, the NONROAD model sets b equal to either 0.5 or 1.0. The first case results in a curvilinear deterioration rate in which most of the deterioration occurs in the early part of an engine's life. The second case results in a linear deterioration pattern in which the rate of deterioration is constant throughout the median life of an engine. In both cases, we previously decided to cap deterioration at the end of an engine's median life, under the assumption that an engine can only deteriorate to a certain point beyond which it becomes inoperable. For spark ignition engines at or below 25 horsepower, which are the subject of this proposal, the nonroad model sets the constant b equal to 0.5. The emission factor inputs for Phase 2 small nonroad SI engines used in this analysis are shown in Table 3.2-1

Table 3.2-1: Phase 2 Modeling Emission Factors for Small SI Engines(g/kW-hr)

Class/ Technology	HC ZML	HC "A"	NOx ZML	NOx "A"	CO ZML	CO "A"	PM10 ZML*	PM10 "A"*
Class I - SV	10.30	1.753	2.57	0.000	386.53	0.070	0.35	1.753
Class I - OHV	8.73	1.753	3.28	0.000	392.93	0.070	0.05	1.753
Class II	5.58	1.095	3.71	0.000	472.80	0.080	0.08	1.095

* The nonroad model calculates PM2.5 as 92 percent of PM10.

Some of the values shown in Table 3.2-1 have been updated from the NONROAD2005a inventory model based on data collected by EPA on in-use engines as well as manufacturer-supplied certification data. The ZHL emission factors for Class I engines were updated based on testing performed by EPA on 16 in-use walk-behind lawnmowers. The Class I side-valve engine A values were revised to be the same as the Class I overhead engine A values based on the same in-use testing of lawnmowers which showed similar in-use deterioration characteristics between overhead valve and sidevalve Class I engines. The Class I and Class II engine A values for CO emissions were revised to better reflect the level of deterioration seen in both the in-use lawnmower testing noted above as well as certification data provided by manufacturers to EPA. Finally, based on data collected from another test program of in-use lawnmowers, the assumption that there was no deterioration of Class I and II emissions after the median life was reached was revised to reflect further continued emissions deterioration after that point.

Also, the model was modified to acknowledge the continued use of side-valve engine designs in Class I nonhandheld engines meeting Phase 2 standards. In the rulemaking that established those regulatory requirements, side-valve technology was assumed to be superceded by overhead valve designs and was modeled accordingly. In reality, side-valve technology has continued to be used in small nonroad SI engines. The resulting technology mixture is shown in Table 3.2-2. The estimated sales fractions by engine class and technology are based on sales information provided by engine manufacturers to EPA for the 2005 model year. A full description of the emission modeling information for Phase 2 engines and the basis for the estimates can be found in the docket for this rule.

Table 3.2-2: Phase 3 Small Nonroad SI Engine Technology Classes

Engine Class	Technology Class	Percent Sales (%)
Class I	Side Valve	60
Class I	Overhead Valve	40
Class II	Overhead Valve	100

3.2.1.2.2 Marine SI Exhaust Calculations

The NONROAD2005a model included a number of recent updates to the emission rates and technology mix of Marine SI engines.[6] These updates were largely based on data submitted to EPA by marine engine manufacturers as part of the certification process and on new test data collected by EPA.[7] However, NONROAD2005a does not include high-performance SD/I marine engines. High-performance marine engines are niche product and were not included in the data set used to develop the engine populations for the NONROAD2005a model.

Manufacturers have recently commented that approximately 1,500 high-performance engines are produced in the U.S. per year. These engines range from 500 to 1500 horsepower and are used in both racing and non-racing applications. Based on conversations with individual high-performance engine manufacturers, we estimate that about two thirds of these engines are sold for use in the U.S. with an average power of about 650 horsepower. These engines are designed to sacrifice service life for power, but with rebuilds, generally are used for 7-8 years (we use 8 years for our modeling). Based on these estimates and the growth rate in the NONROAD2005a model, we estimate a 1998 population of SD/I engines >600 horsepower of 7500 units. One manufacturer stated that they performed a survey on the annual use of these engines for warranty purposes and the result was an average annual use of about 30 hours per year. We also updated the baseline emission factors for high performance marine engines based on the emission data presented in Chapter 4. Note that no changes were made to the PM emission factors because no new data was available. Table 3.2-3 presents the updated emission factors for high-performance SD/I marine engines.

Table 3.2-3: Emission Factors for High-Performance Marine Engines [g/kW-hr]

Pollutant	Carbureted Engines (MS4C, Bin 12)	Fuel-Injected Engines (MS4D, Bin 12)
HC	13.8	13.8
CO	253	207
NOx	8.4	6.8
PM	0.08	0.08
BSFC	400	362

3.2.1.3 Baseline Evaporative Emission Calculations

Chapter 5 presents a great deal of information on evaporative emission rates from fuel systems used in nonroad equipment. Much of this information was incorporated into the NONROAD2005a model.[8] However, we have continued to collect evaporative emission data and incorporate the new information into our evaporative emission inventory calculations. These updates are described below.

3.2.1.3.1 Fuel Ethanol Content

Currently, about 30 percent of fuel sold in the U.S. contains ethanol. With the recent establishment of the Energy Policy Act of 2005,[9] this percentage is expected to increase. The significance of the use of ethanol in fuel, for the inventory calculations, is that ethanol in fuel can affect the evaporative emissions from nonroad equipment. Fuel blends containing ethanol typically increase the permeation rate for most materials used in gasoline fuel systems. This is discussed in more detail below.

Title XV, section 1501, of the Energy Policy Act requires that the total volume of renewable fuel increase from 4.0 to 7.5 billion gallons per year from 2006 to 2012, and the Energy Information Administration (EIA) predicts that production will actually reach 9.6 billion gallons per year by then. Based on these figures and projected gasoline sales from the Energy Information Administration,[10,11,12] we estimate that about two-thirds of gasoline sold in 2012 and later will contain ethanol. Table 3.2-4 presents our estimates for ethanol blended fuels into the future. The blend market shares shown in the last column of this table assume 10 percent for ethanol content of blended gasoline in all areas except California, where it is 5.7 volume percent.

Table 3.2-4: Estimated Fraction of Gasoline Containing Ethanol

Calendar Year	U.S. Gasoline Sales [10^9 gal.]	U.S. Ethanol Sales [10^9 gal.]	Fraction of Gas with Ethanol
2000	129.9	1.6	13.5%
2001	132.0	1.8	14.5%
2002	135.6	2.1	17.0%
2003	137.0	2.8	22.2%
2004	139.6	3.4	26.3%
2005	139.9	3.8	29.7%
2006	141.3	4.1	31.6%
2007	143.0	5.2	39.2%
2008	145.4	6.0	44.9%
2009	148.1	6.9	50.4%
2010	150.9	7.9	56.4%
2011	153.3	8.8	62.2%
2012	155.6	9.6	67.1%

* ethanol fraction projected to be constant after last year of Energy Policy Act phase-in (2012)

3.2.1.3.2 Hose Permeation

We developed hose permeation emission factors based on the permeation data and hose requirements presented in Chapter 5. Because permeation is a function of surface area and because hose lengths and inner diameters are defining parameters, hose permeation rates are based on $g/m^2/day$. These emission factors incorporate a more complete set of data than those in the NONROAD2005a model. In addition, distinctions are now made between permeation rates for liquid fuel versus fuel vapor exposure and between permeation rates for gasoline versus ethanol-blend fuels. The updated hose emission factors are discussed below and presented in Table 3.2-5.

Fuel hoses in Small SI applications vary greatly in construction depending on the individual specifications of the engine and equipment manufacturers. However most fuel hose used on non-handheld equipment meets the SAE J30 R7 hose requirements which includes a permeation requirement of 550 g/m^2/day on Fuel C at 23°C.[13] Chapter 5 presents data on several hose constructions that range from 190 to 450 g/m^2/day on Fuel C. As discussed in Chapter 5, permeation is typically lower on gasoline than on Fuel C. At the same time, blending ethanol into the fuel increases permeation. Based on data presented in Chapter 5, we estimate that non-handheld fuel hose permeation rates range from 27 to 180 g/m^2/day on gasoline and 80-309 g/m^2/day on gasoline blended with 10 percent ethanol (E10). Of the data presented in Chapter 5, the lowest two permeation rates for SAE J30 R7 hose were from an unknown fuel hose construction and from a hose (used in some Small SI applications) that was specially constructed of fuel resistant materials to facilitate painting. Dropping the unknown hose construction (which is not known to be used in Small SI applications), we get average permeation rates of 122 g/m^2/day on gasoline and 222 g/m^2/day on E10 at 23˚C.

Chapter 5 also presents permeation data on nine samples of fuel lines used in handheld equipment tested using E10 fuel. The permeation rates for these samples ranged from 165 to 455 g/m^2/day at 23˚C with an average of 255 g/m^2/day. All of the hose samples, except one were made of NBR rubber, with the exception being a NBR/PVC blend. To determine an emission factor for handheld fuel lines on gasoline, we used the ratio of permeation rates for NBR rubber samples on E10 versus gasoline. The resulting permeation rate for handheld hose on gasoline was estimated to be 140 g/m^2/day at 23˚C.

Fuel hose for portable marine fuel tanks is not subject to any established recommended practice. For this reason, we consider fuel hose used on portable marine fuel tanks to be equivalent to the hose used in Small SI applications. The supply hose for each portable marine fuel tank is modeled to include a primer bulb with the same permeation rate as the hose.

Recommended practices for marine hose on SD/I vessels include a permeation rate of 100 g/m^2/day on Fuel C and 300 g/m^2/day on fuel CM15 (15 percent methanol).[14,15] Accordingly, these vessels have fuel hose with lower permeation. Rather than using the recommended permeation rate limits for this hose, we base the permeation emission factors for this hose on the data presented in Chapter 5 on gasoline with ethanol which is more representative of in-use fuels. Chapter 5 also includes data on commercially available low permeation fuel hose which is used by some manufacturers. However, we do not include this in the baseline emission factor calculation because its use is primarily in anticipation of upcoming permeation standards and would therefore not be expected to remain in the baseline without enactment of this proposed rule.

For other vessels with installed fuel tanks (OB and PWC), we based the permeation emission factors on the test data in Chapter 5 on marine hose not certified to Coast Guard Class I requirements.

The Coast Guard specifications for fill neck hose call for a permeation limit of 300 g/m^2/day on Fuel C and 600 on Fuel CM15. However, fill neck hose are not usually exposed to liquid fuel. Therefore, we used the vapor line data presented in Chapter 5 for both fill neck and vent line permeation rates. Hose permeation rates for both gasoline and E10 are presented in Table 3.2.-5.

Table 3.2-5: Hose Permeation Emission Factors at 23˚C [$g/m^2/day$]

Hose Type	Gasoline	E10
Handheld equipment fuel hose	140	255
Non-handheld equipment fuel hose	122	222
Portable fuel tank supply hose*	122	222
Installed system OB/PWC fuel lines	42	125
Installed system SD/I fuel lines	22	40
Fill necks and vent lines (vapor exposure)	2.5	4.9

* this permeation rate is used for primer bulbs as well

The above permeation rates do not include any effects of deterioration. Over time, the fuel can draw some of the plasticizers out of the rubber in the hose, making it more brittle and subject to cracking. This is especially true for higher permeation fuel hoses which are generally less fuel resistant. Exposure to ozone over time can also deteriorate the hose. This deterioration would presumably increase the permeation rate over time. However, we do not have any data to quantify this effect and are not including deterioration in this analysis at this time. Lower permeation fuel hose, such as that designed to meet the proposed standard would likely have much lower deterioration due to the use of more fuel resistant materials. Therefore this analysis may underestimate the inventory and benefits associated with the proposed fuel permeation standards.

3.2.1.3.3 Hose Lengths

The hose lengths used in NONROAD2005a are based primarily on confidential information supplied by equipment manufacturers. Hose lengths for handheld equipment are based on survey data provided by the Outdoor Power Equipment Institute.[16] Recently, we received comment from a boatbuilder using outboard motors that the hose lengths in our calculations were too short.[17] Because our existing data set did not include outboard boats with installed fuel tanks, we updated the hose lengths for these vessels based on the data supplied by this boat builder. In addition, the vent line lengths in the NONROAD2005a were divided by two to account for a vapor gradient throughout the fuel line caused by diurnal breathing and diffusion. This factor has been removed in lieu of the new emission factors for vent lines based on vapor exposure. Table 3.2-6 presents the updated hose lengths for outboard boats with installed fuel tanks.

Table 3.2-6: Updated Hose Lengths for Outboard Boats with Installed Fuel Systems

Engine Power Category	Fill Neck Length [m]	Fuel Supply Hose Length [m]	Vent Hose Length [m]
18.7-29.8 kW	1.8	1.8	1.5
29.9-37.3 kW	2.4	2.4	1.8
37.4-74.6 kW	3.1	3.1	2.1
74.7-130.5 kW	3.7	3.7	2.4
130.6+ kW	4.3	4.3	2.7

3.2.1.3.4 Tank Permeation

For fuel tanks, the NONROAD2005a model does not include a fuel ethanol effect on permeation. Data in Chapter 5 suggest that even polyethylene fuel tanks see a small increase in permeation on E10 compared to gasoline. This increase is much larger for nylon fuel tanks like those used in handheld equipment with structurally-integrated fuel tanks. Table 3.2-7 presents the updated emission factors on E10 fuel and compares them to the emission factors based on gasoline permeation rates. The primary difference between the permeation rates for installed marine tanks, compared to smaller HDPE fuel tanks, is largely due to the wall thickness of the different constructions rather than material permeation properties. Permeation rate is a function of wall thickness, so as tank thickness doubles, permeation rate halves. The model considers permeation from metal fuel tanks to be zero.

Table 3.2-7: Tank Permeation Emission Factors at 29˚C [g/m^2/day]

Tank Type	Gasoline	E10
Nylon handheld fuel tanks	1.25	2.5
Small SI HDPE <0.25 gallons	6.5	7.2
Small SI HDPE ≥0.25 gallons	9.7	10.7
Portable and PWC HDPE fuel tanks	9.9	10.9
Installed non-metal marine fuel tanks	8.0	8.8
Metal tanks	0	0

3.2.1.3.5 Diffusion

The NONROAD2005a model includes an adjustment factor to diurnal emissions to account for diffusion. The data used to create this adjustment factor is included in Chapter 5. This adjustment factor is applied to all Small SI equipment in the NONROAD2005a model. However, we believe that handheld equipment are all produced with either sealed fuel tanks or slosh/spill resistant fuel caps. Therefore, we do not include diffusion emissions for handheld equipment in this analysis.

3.2.1.3.6 Modeling of Nonlinear Ethanol Blend Permeation Effects

Based on the limited available test data it appears that the effect of alcohol-gasoline blends on permeation is nonlinear, tending to increase permeation at lower alcohol concentrations up to about 20 percent ethanol, but then decreasing permeation at higher alcohol concentrations.[18]

Starting with the zero and 10 percent ethanol points described above, a simple exponential curve was selected to connect the zero and 10 percent points continuing up to the 20 percent ethanol level. Then to get a nonlinear decreasing curve above 20 percent a simple decreasing exponential curve was used. Since effects above 85 percent are especially uncertain, and no such fuels are foreseen for use in nonroad equipment, the effect above 85 percent was set equal to the E85 effect. The equations used are shown here, and an example curve based on these equations is shown in Figure 3.2-1.

Hose and Tank Permeation for 0 - 20 percent ethanol volume percent:

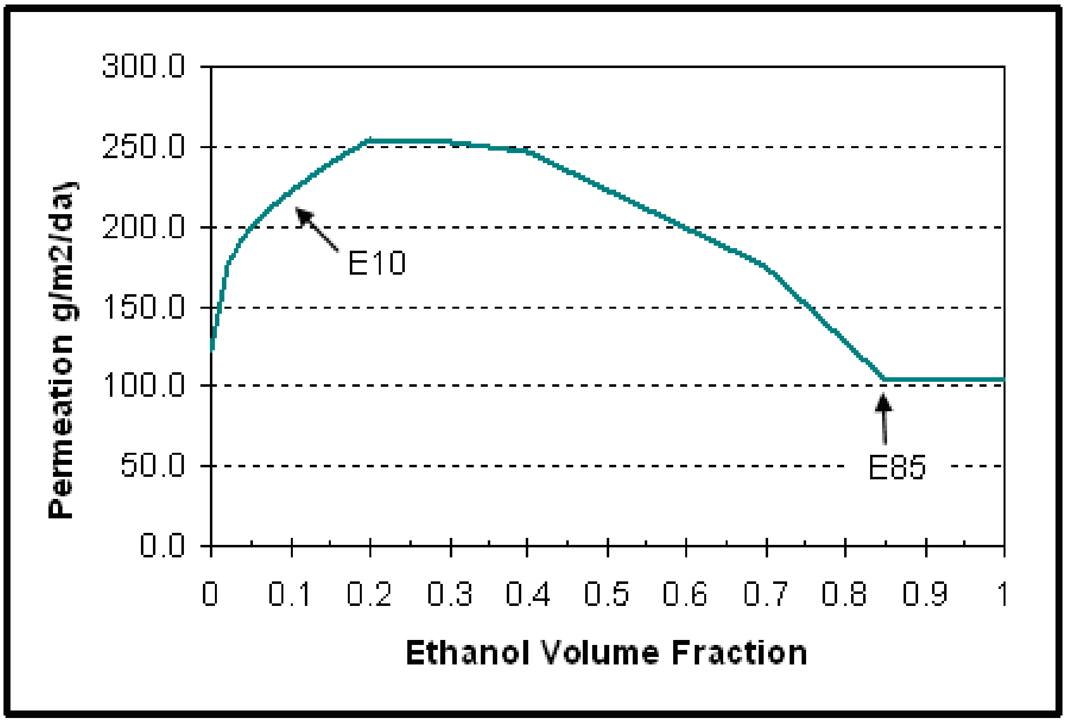
$$\text{Permeation EF} = \text{GasEF} + \text{GasEF} \times (\text{E10fac} - 1) \times [\,(\text{EthVfrac} / 0.10) \wedge 0.4\,]$$

Hose and Tank Permeation for ethanol volume percent greater than 20 percent:

$$\text{Permeation EF} = \text{GasEF} \times \{\,1 + (\text{E10fac} - 1) \times [\,(20 / 10) \wedge 0.4\,]\,\} \times \{\,1 - [\,(\text{MIN}(\text{EthVfrac}, 0.85) - 0.20\,) / 0.80\,] \wedge (1 / 0.4\,)\,\}$$

where:
Permeation EF = Permeation emission factor for modeled fuel (grams per meter^2 per day)
GasEF = Gasoline hose permeation emission factor from input EF data files (grams per meter^2 per day)
E10fac = permeation emission adjustment factor for E10 relative to gasoline. This is the ratio of the E10 to gasoline permeation emission factors (unitless)
EthVfrac = Volume fraction ethanol in the fuel being modeled. E10 = 0.10
0.4 = exponent chosen to yield a reasonable shape of curve.

Figure 3.2-1: Ethanol Blend Hose Permeation Example Curve



Note that all ethanol blends currently modeled with NONROAD or NMIM are less than or equal to E10, so no parts of this curve above E10 are used. Also note that the value of E10fac used in the modeling of the control case is 2.0 for all the tank and hose permeation sources listed above in Tables 3.2-6 and 3.2-7.

3.2.1.3.7 Modeling Effect of Ethanol Blend Market Share on Permeation

The effect of ethanol blend market share is modeled linearly. In most areas the ethanol blend market share is either zero or 100 percent, but in areas where it is between those two market shares, or when doing a nationwide model run, the effect is calculated as a simple proportion. For instance a 30 percent market share of E10 would be modeled using a permeation rate 30 percent of the way between the E0 permeation rate and the E10 permeation rate.

3.2.1.4 Baseline Exhaust and Evaporative Inventory Results for THC, NOx, $PM_{2.5}$, PM_{10}, and CO

Table 3.2-8 presents the 50-state baseline emission inventories, respectively, for small nonroad SI engines. Table 3.2-9 provides the same information for Marine SI engines.

Table 3.2-8: Baseline 50-State Annual Exhaust and Evaporative Emissions for Small Nonroad Spark-Ignition Engines (short tons)

Year	THC	NOx	PM2.5	PM10	CO
2001	1,099,402	101,928	23,163	25,177	16,108,103
2002	1,074,137	101,261	23,382	25,416	15,560,774
2003	1,039,522	99,649	23,480	25,522	14,941,296
2004	978,760	97,929	23,483	25,525	14,382,759
2005	905,814	95,779	23,417	25,453	13,784,367
2006	849,619	94,550	23,498	25,541	13,369,719
2007	794,827	92,988	23,804	25,874	12,919,586
2008	748,034	90,638	24,335	26,451	12,285,206
2009	715,943	89,272	24,882	27,045	11,775,265
2010	700,482	88,968	25,402	27,611	11,492,162
2011	698,481	89,543	25,888	28,139	11,426,366
2012	700,981	90,440	26,364	28,657	11,438,836
2013	706,486	91,607	26,832	29,165	11,517,029
2014	714,968	92,973	27,291	29,664	11,645,064
2015	724,695	94,432	27,747	30,160	11,797,078
2016	735,292	95,959	28,202	30,654	11,965,466
2017	746,447	97,519	28,655	31,146	12,143,564
2018	758,021	99,101	29,107	31,638	12,328,523
2019	769,929	100,700	29,558	32,128	12,519,136
2020	781,985	102,310	30,009	32,618	12,712,775
2021	794,072	103,922	30,460	33,109	12,907,487
2022	806,192	105,533	30,911	33,599	13,102,999
2023	818,336	107,145	31,362	34,089	13,299,184
2024	830,496	108,759	31,813	34,579	13,495,942
2025	842,686	110,379	32,265	35,070	13,693,641
2026	855,022	112,019	32,718	35,563	13,893,823
2027	867,389	113,666	33,173	36,057	14,094,990
2028	879,769	115,314	33,627	36,551	14,296,561
2029	892,157	116,964	34,081	37,045	14,498,417
2030	904,553	118,615	34,535	37,538	14,700,521
2031	916,953	120,267	34,990	38,032	14,902,797
2032	929,357	121,919	35,444	38,526	15,105,180
2033	941,764	123,571	35,898	39,020	15,307,643
2034	954,175	125,223	36,353	39,514	15,510,182
2035	966,587	126,875	36,807	40,008	15,712,789
2036	979,003	128,527	37,261	40,502	15,915,457
2037	991,420	130,179	37,716	40,995	16,118,191
2038	1,003,840	131,832	38,170	41,489	16,320,977
2039	1,016,261	133,484	38,625	41,983	16,523,816
2040	1,028,684	135,136	39,079	42,477	16,726,708

Table 3.2-9: Baseline 50-State Annual Exhaust and Evaporative Emissions for Marine Spark-Ignition Engines (Short Tons)

Year	THC	NOx	PM2.5	PM10	CO
2001	935,494	41,514	15,625	16,984	2,584,786
2002	909,607	43,401	15,092	16,404	2,552,368
2003	877,441	45,661	14,417	15,670	2,510,927
2004	841,151	48,164	13,679	14,869	2,469,934
2005	801,985	50,675	12,886	14,007	2,423,497
2006	762,092	53,207	12,090	13,142	2,375,768
2007	724,443	55,750	11,311	12,295	2,328,182
2008	687,350	58,296	10,553	11,470	2,280,928
2009	651,744	60,797	9,824	10,678	2,235,187
2010	618,843	63,228	9,149	9,945	2,191,484
2011	588,283	65,613	8,525	9,266	2,149,407
2012	561,699	67,843	7,983	8,678	2,112,511
2013	538,510	69,883	7,534	8,189	2,081,945
2014	518,615	71,789	7,144	7,766	2,054,769
2015	502,307	73,583	6,823	7,416	2,031,684
2016	488,502	75,245	6,549	7,118	2,011,569
2017	477,287	76,781	6,324	6,874	1,995,319
2018	469,041	78,169	6,156	6,691	1,983,611
2019	462,146	79,469	6,012	6,535	1,974,297
2020	457,338	80,655	5,908	6,422	1,968,663
2021	453,687	81,768	5,826	6,333	1,965,024
2022	451,360	82,796	5,768	6,270	1,963,888
2023	449,882	83,756	5,726	6,224	1,964,657
2024	449,089	84,663	5,696	6,191	1,967,014
2025	449,054	85,517	5,680	6,174	1,971,025
2026	449,611	86,327	5,675	6,168	1,976,557
2027	450,640	87,096	5,678	6,172	1,983,392
2028	451,987	87,828	5,687	6,182	1,991,331
2029	453,610	88,537	5,701	6,197	1,999,984
2030	455,480	89,225	5,719	6,217	2,009,248
2031	457,536	89,896	5,741	6,240	2,019,028
2032	459,725	90,554	5,765	6,266	2,029,227
2033	462,071	91,197	5,792	6,296	2,039,870
2034	464,529	91,828	5,821	6,327	2,050,883
2035	467,079	92,448	5,851	6,360	2,062,245
2036	469,685	93,060	5,883	6,394	2,073,873
2037	472,348	93,664	5,915	6,429	2,085,737
2038	475,055	94,261	5,948	6,465	2,097,797
2039	477,796	94,853	5,982	6,502	2,110,011
2040	480,560	95,440	6,016	6,539	2,122,336

3.2.2 Baseline Hazardous Air Pollutant Estimates

The analysis of toxic air pollutants from small nonroad and Marine SI engines focuses on seven major pollutants: benzene, formaldehyde, acetaldehyde, 1,3-butadiene, acrolein, naphthalene, and 15 other compounds grouped together as polycyclic organic matter (POM) for this analysis.[2] All of these compounds, except acetaldehyde, were identified as national or regional cancer or noncancer "risk" drivers in the 1999 National Scale Air Toxics Assessment (NATA)[19] and have significant inventory contributions from mobile sources. That is, for a significant portion of the population, these compounds pose a significant portion of the total cancer or noncancer risk from breathing outdoor air toxics. The health effects of these hazardous pollutants are specifically discussed in Section 2.3. Many of these compounds are also part of the THC inventories. An exception is formaldehyde, which is not measured by the analytic technique used to measure THC, and part of the mass of other aldehydes as well. However, all are included in the VOC inventories presented in this chapter.

The baseline inventories for each of the toxic air pollutants described above are based on the work performed for EPA's mobile source air toxic (MSAT) final rulemaking.[20] The hazardous air pollutant inventories for all nonroad equipment except aircraft, locomotives, and commercial marine vessels in MSAT were developed using EPA's National Mobile Inventory Model (NMIM). This model is an analytical framework that links a county-level database to our highway and nonroad models and collates the output into a single database table. The resulting estimates for small nonroad and Marine SI engines account for local differences in fuel characteristics and temperatures.

The modeling results reflect the future use of renewable fuels as specified in the Energy Policy Act of 2005. Emissions were modeled for each county in the continental U.S. for 1999, 2010, 2015, 2020, and 2030. For this proposal, a special NMIM simulation was also performed using the MSAT methodology for 2001 (our base year). The analysis for this additional year is also included in the MSAT documentation for completeness.

To estimate the baseline air toxics inventories for this proposal, we started with the MSAT baseline case (no air toxics control) results for the Source Category Codes (SCCs) that contain the affected small nonroad and Marine SI engines.[3] Those inventories were produced by the NMIM model using NONROAD2005a (the latest public release), so they do not reflect the emission modeling improvements we made for the proposed rule. Therefore, we corrected the MSAT air toxics inventories to mirror the results from our improved NONROAD2005c model.

[2] The 15 POMs summarized in this chapter are acenaphthene, acenapthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylkene, beno(k)fluoranthene, chrysene, dibenzo(a,h)anthracene,fluoranthene, fluorene, ideno(1,2,3,c,c)-pyrene, phenanthrene, and pyrene.

[3] MSAT controls only affect the benzene content of nonroad gasoline fuel. Therefore, if the MSAT control case was used, only the benzene inventory for the nonroad engines affected by this proposal would be significantly affected.

This adjustment was done to avoid the need to run the NMIM/MSAT model, which is quite resource intensive, using the new NONROAD2005c model.

The hazardous air pollutant inventory for each exhaust and evaporative gaseous hydrocarbon species is estimated in NMIM as a fraction of VOC emissions, except for POMs, which are found in both the gas and particle phase. For each POM hydrocarbon species, the toxics inventory is estimated as a ratio to PM. Therefore, in order to correct the MSAT results to mirror the improved model results, we multiplied each MSAT hazardous air pollutant inventory for the applicable nonroad SCCs by the ratio of the VOC or PM emission results, as appropriate, from the new NONROAD2005c model to the respective NMIM NONROAD2005a model results.

Tables 3.2-10 presents the 50-state baseline inventories, respectively, for toxic air emissions from small nonroad SI engines. Tables 3.2-11 provides the same information for Marine SI engines.

Table 3.2-10: Baseline 50-State Air Toxic Emissions for Small Nonroad Spark-Ignition Engines (short tons)

Year	Benzene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein	Napthalene	POM
2001	33,534	5,165	8,035	2,826	462	418	93
2020	22,923	3,169	5,182	2,429	270	409	107
2030	26,502	3,663	5,991	2,805	312	475	123

Table 3.2-11: Baseline 50-State Air Toxic Emissions for Marine Spark-Ignition Engines (short tons)

Year	Benzene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein	Napthalene	POM
2001	21,590	1,790	1,846	1,354	179	32	30
2020	9,144	694	606	666	47	32	15
2030	9,073	670	583	649	45	34	15

3.3 Contribution of Small Nonroad and Marine SI Engines to National Emissions Inventories

This section describes the nationwide contribution of small nonroad and Marine SI engines to the emissions of other source categories. Information is presented for the pollutants that are directly controlled by the proposed standards, i.e., VOC, NO_x, and CO, and those that are indirectly reduced by some of the requisite control technology, i.e., $PM_{2.5}$ and PM_{10}. The VOC inventories includes both exhaust and evaporative hydrocarbon emissions.

3.3.1 National Emission Inventory Development

The national inventories are presented for 2001, 2015, and 2020 for the contiguous 48-states of the U.S. and the District of Columbia.[21] The stationary, area, motorcycle, aircraft, locomotive, commercial marine inventories were taken directly from EPA's most recent air quality modeling for the PM NAAQS. The gaseous emission inventories for highway diesel vehicles and the 2001 calendar year PM emission estimates for highway diesel vehicles were also taken directly from that work. The emission inventories for on highway gasoline vehicles were taken from work performed for our Mobile Source Air Toxics (MSAT) rulemaking analysis. These inventories account for the future use of renewable fuels as required by the Energy Policy Act of 2005. Finally, the nonroad engine baseline inventories were estimated using the modified version of NONROAD2005a that was developed for this proposal, as discussed further in Section 3.2.1.

3.3.1.1 VOC Emissions Contribution

Table 3.3-1 provides the contribution of small nonroad SI engines, Marine SI engines and other source categories to total VOC emissions. The emissions from nonroad Small SI (<19kW) and Marine SI engines are 28 percent of the mobile source inventory and 13 percent of the total manmade VOC emissions in 2001. These percentages decrease slightly to 27 percent and 10 percent, respectively, by 2020.

3.3.1.2 NOx Emissions Contribution

Table 3.3-2 provides the contribution of nonroad small nonroad SI engines, Marine SI engines and other source categories to total NOx emissions. The emissions from small nonroad and Marine SI engines are 1 percent of the mobile source inventory and 1 percent of the total manmade NOx emissions in 2001. These percentages increase to 4 percent and 2 percent, respectively, by 2020.

3.3.1.3 PM Emissions Contribution

Table 3.3-3 and 3.3-4 provide the contribution of small nonroad SI engines, Marine SI engines and other source categories to total $PM_{2.5}$ and PM_{10} emissions, respectively. Both particle size categories from small nonroad and Marine SI engines are about 9 percent of the mobile source inventory and approximately 2 percent of the total manmade $PM_{2.5}$ emissions in 2001. These percentages stay about the same at about 10 percent and 2 percent, respectively, by 2020.

3.3.1.4 CO Emissions Contribution

Table 3.3-5 provides the contribution of small nonroad SI engines, Marine SI engines and other source categories to total CO emissions. The emissions from small nonroad and

Marine SI engines are 24 percent of the mobile source inventory and 22 percent of the total manmade CO emissions in 2001. These percentages decrease to 22 percent and increase to 27 percent, respectively, by 2020.

Table 3.3-1: 50-State Annual VOC Baseline Emission Levels for Mobile and Other Source Categories

Category	2OO1 short tons	% of mobile source	% of total	2015 short tons	% of mobile source	% of total	2020 short tons	% of mobile source	% of total
Small Handheld Nonroad SI	503,772	6.3%	2.9%	204,425	3.9%	1.5%	221,027	4.4%	1.6%
Small Nonhandheld Nonroad SI	699,516	8.8%	4.0%	582,107	11.1%	4.2%	627,909	12.5%	4.7%
Marine SI	1,035,768	13.0%	5.9%	552,888	10.5%	4.0%	502,803	10.0%	3.7%
SI Recreational Vehicles	497,207	6.3%	2.8%	593,624	11.3%	4.3%	443,407	8.8%	3.3%
Large Nonroad SI (>25hp)	132,820	1.7%	0.75%	20,012	0.4%	0.15%	12,220	0.2%	0.09%
Portable Fuel Containers*	244,545	3.1%	1.39%	238,055	4.5%	1.73%	254,479	5.1%	1.89%
Land-Based Nonroad Diesel	188,884	2.4%	1.07%	95,934	1.8%	0.70%	76,047	1.5%	0.56%
Marine Diesel	1,472	0.02%	0.01%	1,636	0.03%	0.01%	1,623	0.03%	0.01%
Commercial Marine	33,577	0.42%	0.19%	39,956	0.76%	0.29%	43,876	0.87%	0.33%
Locomotive	39,279	0.49%	0.22%	35,423	0.67%	0.26%	34,407	0.69%	0.26%
Aircraft	22,084	0.28%	0.13%	25,426	0.48%	0.18%	27,644	0.55%	0.20%
Total Off Highway	3,398,924	42.8%	19.3%	2,389,485	45.5%	17.3%	2,245,442	44.8%	16.6%
Total Highway	4,540,133	57.2%	25.8%	2,865,967	54.5%	20.8%	2,769,812	55.2%	20.5%
Total Mobile Sources	7,939,058	100.0%	45.0%	5,255,453	100.0%	38.2%	5,015,254	100.0%	37.2%
Stationary Point and Area Sources	9,692,344	-	55.0%	8,519,026	-	61.8%	8,475,443	-	62.8%
Total Man-Made Sources	17,631,402	-	100.0%	13,774,479	-	100.0%	13,490,697	-	100.0%

Table 3.3-2: 50-State Annual NOx Baseline Emission Levels for Mobile and Other Source Categories

Category	2001 short tons	% of mobile source	% of total	2015 short tons	% of mobile source	% of total	2020 short tons	% of mobile source	% of total
Small Handheld Nonroad SI	2,678	0.0%	0.0%	3,647	0.1%	0.0%	3,945	0.1%	0.0%
Small Nonhandheld Nonroad SI	111,641	0.9%	0.5%	102,382	1.8%	0.9%	110,936	2.3%	1.0%
Marine SI	44,732	0.4%	0.2%	79,288	1.4%	0.7%	86,908	1.8%	0.8%
SI Recreational Vehicles	5,948	0.0%	0.0%	15,287	0.3%	0.1%	18,224	0.4%	0.2%
Large Nonroad SI (>25hp)	325,636	2.7%	1.51%	63,747	1.1%	0.54%	46,888	1.0%	0.43%
Land-Based Nonroad Diesel	1,548,236	12.7%	7.18%	969,065	16.7%	8.15%	678,377	14.4%	6.26%
Marine Diesel	39,301	0.32%	0.18%	47,282	0.82%	0.40%	48,557	1.03%	0.45%
Commercial Marine	930,886	7.63%	4.32%	953,398	16.47%	8.02%	989,930	20.95%	9.14%
Locomotive	999,455	8.19%	4.64%	646,647	11.17%	5.44%	627,659	13.28%	5.79%
Aircraft	83,764	0.69%	0.39%	95,330	1.65%	0.80%	105,133	2.23%	0.97%
Total Off Highway	4,092,277	33.5%	19.0%	2,976,071	51.4%	25.0%	2,716,559	57.5%	25.1%
Total Highway	8,105,316	66.5%	37.6%	2,811,495	48.6%	23.6%	2,008,237	42.5%	18.5%
Total Mobile Sources	12,197,593	100.0%	56.6%	5,787,566	100.0%	48.7%	4,724,796	100.0%	43.6%
Stationary Point and Area Sources	9,355,659	-	43.4%	6,107,354	-	51.3%	6,111,866	-	56.4%
Total Man-Made Sources	21,553,252	-	100.0%	11,894,919	-	100.0%	10,836,662	-	100.0%

Table 3.3-3: 50-State Annual $PM_{2.5}$ Baseline Emission Levels for Mobile and Other Source Categories

Category	2001 short tons	% of mobile source	% of total	2015 short tons	% of mobile source	% of total	2020 short tons	% of mobile source	% of total
Small Handheld Nonroad SI	20,587	4.6%	0.9%	24,015	8.8%	1.2%	25,947	10.9%	1.3%
Small Nonhandheld Nonroad SI	4,879	1.1%	0.2%	6,403	2.4%	0.3%	6,957	2.9%	0.3%
Marine SI	16,837	3.7%	0.7%	7,352	2.7%	0.4%	6,367	2.7%	0.3%
SI Recreational Vehicles	12,301	2.7%	0.5%	15,864	5.8%	0.8%	11,773	4.9%	0.6%
Large Nonroad SI (>25hp)	1,610	0.4%	0.07%	2,207	0.8%	0.11%	2,421	1.0%	0.12%
Land-Based Nonroad Diesel	164,180	36.4%	6.80%	75,788	27.9%	3.68%	46,075	19.3%	2.24%
Marine Diesel	1,066	0.24%	0.04%	774	0.28%	0.04%	760	0.32%	0.04%
Commercial Marine	39,829	8.82%	1.65%	46,567	17.12%	2.26%	52,517	21.97%	2.55%
Locomotive	24,418	5.41%	1.01%	16,967	6.24%	0.82%	16,034	6.71%	0.78%
Aircraft	5,664	1.25%	0.23%	6,544	2.41%	0.32%	7,044	2.95%	0.34%
Total Off Highway	291,371	64.5%	12.1%	202,483	74.4%	9.8%	175,896	73.6%	8.6%
Total Highway	160,229	35.5%	6.6%	69,551	25.6%	3.4%	63,154	26.4%	3.1%
Total Mobile Sources	451,600	100.0%	18.7%	272,034	100.0%	13.2%	239,050	100.0%	11.6%
Stationary Point and Area Sources	1,963,264	-	81.3%	1,786,151	-	86.8%	1,817,722	-	88.4%
Total Man-Made Sources	2,414,864	-	100.0%	2,058,185	-	100.0%	2,056,773	-	100.0%

Table 3.3-4: 50-State Annual PM_{10} Baseline Emission Levels for Mobile and Other Source Categories

Category	2001 short tons	% of mobile source	% of total	2015 short tons	% of mobile source	% of total	2020 short tons	% of mobile source	% of total
Small Handheld Nonroad SI	22,378	4.3%	0.8%	26,104	7.6%	1.0%	28,204	9.0%	1.1%
Small Nonhandheld Nonroad SI	5,303	1.0%	0.2%	6,960	2.0%	0.3%	7,562	2.4%	0.3%
Marine SI	18,301	3.5%	0.6%	7,991	2.3%	0.3%	6,920	2.2%	0.3%
SI Recreational Vehicles	13,370	2.6%	0.5%	17,244	5.0%	0.7%	12,796	4.1%	0.5%
Large Nonroad SI (>25hp)	1,630	0.3%	0.06%	2,228	0.6%	0.09%	2,441	0.8%	0.09%
Land-Based Nonroad Diesel	169,258	32.5%	5.76%	78,132	22.7%	3.03%	47,500	15.1%	1.84%
Marine Diesel	1,099	0.21%	0.04%	798	0.23%	0.03%	784	0.25%	0.03%
Commercial Marine	41,409	7.96%	1.41%	48,448	14.07%	1.88%	54,649	17.40%	2.11%
Locomotive	25,173	4.84%	0.86%	17,521	5.09%	0.68%	16,535	5.26%	0.64%
Aircraft	6,490	1.25%	0.22%	7,539	2.19%	0.29%	8,108	2.58%	0.31%
Total Off Highway	304,412	58.5%	10.4%	212,964	61.8%	8.3%	185,500	59.1%	7.2%
Total Highway	216,032	41.5%	7.3%	131,415	38.2%	5.1%	128,605	40.9%	5.0%
Total Mobile Sources	520,444	100.0%	17.7%	344,379	100.0%	13.3%	314,105	100.0%	12.2%
Stationary Point and Area Sources	2,418,848	-	82.3%	2,236,080	-	86.7%	2,269,828	-	87.8%
Total Man-Made Sources	2,939,292	-	100.0%	2,580,459	-	100.0%	2,583,932	-	100.0%

Table 3.3-5: 50-State Annual CO Baseline Emission Levels for Mobile and Other Source Categories

Category	2001 short tons	% of mobile source	% of total	2015 short tons	% of mobile source	% of total	2020 short tons	% of mobile source	% of total
Small Handheld Nonroad SI	1,101,646	1.3%	1.1%	948,479	1.8%	1.6%	1,024,684	2.0%	1.7%
Small Nonhandheld Nonroad SI	16,980,598	19.4%	17.6%	12,274,519	23.7%	20.3%	13,227,534	25.3%	21.7%
Marine SI	2,785,192	3.2%	2.9%	2,189,207	4.2%	3.6%	2,121,300	4.1%	3.5%
SI Recreational Vehicles	1,220,580	1.4%	1.3%	1,982,847	3.8%	3.3%	1,903,316	3.6%	3.1%
Large Nonroad SI (>25hp)	1,787,054	2.0%	1.85%	455,196	0.9%	0.75%	302,751	0.6%	0.50%
Land-Based Nonroad Diesel	893,320	1.0%	0.93%	483,358	0.9%	0.80%	310,258	0.6%	0.51%
Marine Diesel	6,293	0.01%	0.01%	8,705	0.02%	0.01%	9,565	0.02%	0.02%
Commercial Marine	123,806	0.14%	0.13%	147,449	0.28%	0.24%	158,517	0.30%	0.26%
Locomotive	99,292	0.11%	0.10%	112,747	0.22%	0.19%	117,785	0.23%	0.19%
Aircraft	263,232	0.30%	0.27%	305,998	0.59%	0.51%	327,720	0.63%	0.54%
Total Off Highway	25,261,013	28.9%	26.2%	18,908,505	36.5%	31.2%	19,503,428	37.3%	32.0%
Total Highway	62,083,222	71.1%	64.4%	32,912,028	63.5%	54.4%	32,752,093	62.7%	53.8%
Total Mobile Sources	87,344,234	100.0%	90.6%	51,820,533	100.0%	85.6%	52,255,521	100.0%	85.8%
Stationary Point and Area Sources	9,014,249	-	9.4%	8,734,963	-	14.4%	8,641,678	-	14.2%
Total Man-Made Sources	96,358,483	-	100.0%	60,555,496	-	100.0%	60,897,199	-	100.0%

3.4 Controlled Nonroad Small Spark-Ignition and Marine Engine Emission Inventory Development

This section describes how the controlled emission inventories were developed for the small nonroad and Marine SI engines that are subject to the proposal. The resulting controlled emission inventories are also presented. Section 3.4.1 provides this information for exhaust and evaporative emissions.

Once again, the inventory estimates presented throughout this section only include equipment that would be subject to the proposed standards. Specifically for California, this includes small nonroad SI engines used in farm and construction equipment with maximum power levels below 175 hp or 130 kW. For Marine SI engines, our analysis assumes that the proposed standards have no effect because that state already has equivalent exhaust emission standards and is expected to adopt equivalent evaporative hydrocarbon requirements.

3.4.1 Controlled Exhaust and Evaporative Emissions Estimates for THC, NOx, $PM_{2.5}$, PM_{10}, and CO

The controlled exhaust and evaporative emission inventories for small nonroad and Marine SI engines include the effects of the proposed requirements and all existing applicable federal emission standards. We generated these inventories by modifying NONROAD2005c to account for the engine and equipment controls associated with the proposed standards. (See the baseline emission inventory discussion in Section 3.2 for the changes we made to the publically available NONROAD2005a model to develop NONROAD2005c.) The modifications that were made to estimate the controlled emissions inventories are described below.

3.4.1.1 Controlled Exhaust Emission Standards, Zero-Hour Emission Factors and Deterioration Rates

3.4.1.1.1 Small SI Exhaust Emission Calculations

The proposed Phase 3 emission standards and implementation schedule are shown in Table 3.4-1. While the standards are proposed to take effect in 2011 for Class II engines and 2012 for Class I engines, we proposing a number of flexibilities for engine and equipment manufacturers that will allow the continued production and use of engines meeting the Phase 2 standards in limited numbers over the first four years of the Phase 3 program. The implementation schedule shown in the table is used for modeling purposes only. It is based on our assumption that engine and equipment manufacturers take full advantage of the flexibilities being proposed.

Table 3.4-1: Phase 3 Emission Standards and Estimated Implementation Schedule for Class I and II Small SI Engines[a] (g/kW-hr or Percent)

Engine Class	Requirement	2011	2012	2013	2014	2015+
Class I	HC+NOx	--	10	10	10	10
	CO (marine generator sets only)	--	5	5	5	5
	Estimated Sales Percentage	--	95	95	100	100
Class II	HC+NOx	8	8	8	8	8
	CO (marine generator sets only)	5	5	5	5	5
	Estimated Sales Percentage	83	83	93	93	100

[a] Reflects maximum use of proposed compliance flexibilities by engine and equipment manufacturers. Used for modeling purposes only.

The modeled emission factors corresponding to the proposed Phase 3 standards are shown in Table 3.4-2. (See Section 3.2.1.2.1 for a discussion of how the model uses zero hour emission levels (ZML) and deterioration rates (A values.) We developed these new emission factors based on testing of catalyst-equipped engines both in the laboratory and in-use. A full description of the emission factor information for Phase 3 engines and the basis for the estimates can be found in the docket for this rule.

Table 3.2-2: Phase 3 Modeling Emission Factors for Small SI Engines (g/kW-hr)

Class/ Technology	HC ZML	HC "A"	NOx ZML	NOx "A"	CO ZML	CO "A"	PM10 ZML*	PM10 "A"*
Class I - SV	5.60	0.797	1.47	0.302	319.76	0.070	0.24	1.753
Class I - OHV	5.09	0.797	1.91	0.302	325.06	0.070	0.05	1.753
Class II	4.25	0.797	1.35	0.302	391.13	0.080	0.08	1.095

* The nonroad model calculates PM2.5 as 92 percent of PM10.

We left the proportion of sales in each technology classification unchanged from those used for Phase 2 engines. The technology mix was previously shown Table 3.2-2.

Finally, as discussed in more detail in Chapter 6, were developed a new brake-specific fuel consumption (BSFC) estimate for Class II engines to reflect the expected fuel consumption benefit associated with the use of additional electronic fuel injection technology on Phase 3 compliant engines. The resulting BFSC for Phase 3 Class II engines is 0.727 pounds per horsepower-hour (lb/hp-hr).

3.4.1.1.2 Marine SI Exhaust Emission Calculations

For the control case, we developed new technology classifications for engines meeting the proposed standards. For outboards and personal watercraft, we no longer will attempt to determine the technology mix between low emitting technology options (such as DI 2-stroke versus 4 stroke). The new technology classifications for these engines are simply tied to the standard. These new technology classifications are titled MO09 and MP09 for outboards and personal watercraft, respectively. In determining the combined HC+NOx emission factor, we used the proposed emission standards with a 10 percent compliance margin (with deterioration factor applied). To determine the NOx emission factors, we used certification data to determine the sales weighted average NOx for low emission technologies in each power bin. HC was then determined as the difference between the HC+NOx and the NOx emission factors. Because we are proposing the same standards for OB and PWC and because they use similar engines, we use the same HC+NOx emission factors and deterioration factors for both engine types.

Because the proposed CO standard primarily acts as a cap on CO, the CO emission factors were determined based on the emission factors for existing low emission engines in each power bin. Fuel consumption factors were calculated in the same manner. Therefore, some differences are seen between the projected CO and BSFC factors for OB and PWC. No changes were made to the PM emission factors. Also, the existing deterioration factors for 4-stroke carbureted engines were applied to the control case (1.05 for HC, NOx, and CO). Table 3.4-3 presents the zero-hour OB/PWC emission factors for the control case.

Table 3.4-3: Control Case Emission Factors for OB/PWC (g/kW-hr)

Power Bin	HC	NOx	CO		BSFC	
			OB	PWC	OB	PWC
0-2.2 kW	18.8	4.8	542	640	563	563
2.3-4.5 kW	17.4	3.6	357	538	560	560
4.6-8.2 kW	16.7	5.6	292	243	555	555
8.3-11.9 kW	14.4	6.8	248	231	552	552
12.0-18.6 kW	15.3	4.3	205	218	543	543
18.7-29.8 kW	11.9	5.7	180	206	528	528
29.9-37.3 kW	9.1	5.9	171	206	507	507
37.4-55.9 kW	8.3	5.4	173	206	471	486
55.9-74.6 kW	8.3	5.4	173	206	471	486
74.7-130.5 kW	8.7	5.0	152	202	415	394
130.6+ kW	10.0	3.7	139	178	387	380

For sterndrive and inboards, we developed a new engine classification similar to the OB/PWC discussion above. MS4A applies to SD/I engines meeting the proposed standard through the use of aftertreatment. HC and NOx emission factors are based on test data presented in Chapter 4 for SD/I engines equipped with catalysts. CO emission factors are based on meeting the proposed standard at the end of useful life (with the deterioration factor applied). No emission reductions are modeled for PM. The fuel consumption factor for fuel-injected 4-stroke SD/I engines is applied to the control case. Deterioration factors for catalyst-equipped engines are the same as those used in the NONROAD2005a model for catalyst-equipped large SI engines. Table 3.4-4 presents the zero-hour emission factors and the accompanying deterioration factors for the control case.

Table 3.4-4: Control Case EFs (g/kW-hr) and DFs for SD/I

Engine Category	HC		NOx		CO		BSFC
	EF	DF	EF	DF	EF	DF	
All (MS4A)	1.80	1.64	1.60	1.15	55.0	1.36	345

3.4.1.2 Controlled Evaporative Emission Rates

Below, we present the effect of the proposed evaporative emission standards on hose permeation, tank permeation, diurnal, and running loss emission inventories.

3.4.1.2.1 Hose Permeation

Similar to the baseline case, hose permeation rates are based on $g/m^2/day$ and are modeled as a function of temperature. The fuel hose test procedures are based on Fuel CE10 as a test fuel. Based on data presented in Chapter 5, we would expect in-use emissions on gasoline-based E10 to be about half of the measured level on Fuel CE10. In addition, we believe that hose designed to meet the proposed 15 $g/m^2/day$ standard on 10 percent ethanol fuel will permeate at least 50 percent less when gasoline is used. Therefore, we model permeation from hoses designed to meet 15 $g/m^2/day$ on Fuel CE10 to be 7.5 $g/m^2/day$ on E10 and 3.75 $g/m^2/day$ on gasoline at 23°C. Consistent with the baseline emission case, we weight the gasoline and E10 emission factors by our estimates of gasoline sales with and without ethanol added.

Fill neck and vent hose containing vapor rather than liquid fuel are not subject to the proposed standards. Neither is hose on handheld equipment with winter use applications (e.g. handheld Class V chainsaws). No emission reductions are modeled for these hose types.

3.4.1.2.2 Tank Permeation

Similar to the baseline case, fuel tank permeation rates are based on units of $g/m^2/day$ and are modeled as a function of temperature. We believe that fuel tanks using alternative materials to meet the proposed 1.5 $g/m^2/day$ standard on 10 percent ethanol fuel will typically permeate at least 50 percent less when gasoline is used. Therefore, we model permeation from fuel tanks to be 1.5 $g/m^2/day$ on fuel E10 and 0.75 g/gal/day at 29°C, regardless of fuel used.

Two exceptions to the above discussion are nylon tanks used on handheld equipment and metal tanks. For these fuel tanks, we do not include any emissions reductions from baseline.

3.4.1.2.3 Diurnal

We are not proposing a diurnal emission requirement for Small SI equipment. Therefore, we do not model direct reductions in diurnal emissions. However, we are proposing a limit on diffusion emissions. As a result, we set the diffusion multiplier to 1.0 for all non-handheld Small SI equipment for the control case. Note that this multiplier was already set to 1.0 for handheld equipment in the baseline case. This is equivalent to applying a 32 percent reduction to the diurnal emission factors.

In the control case for marine, we model portable fuel tanks as having 90 percent lower diurnal emissions than an open vent system. Also, we set the diffusion multiplier to 1.0 because the tanks would be sealed. Presumably, the diurnal temperature cycles would build some pressure in the fuel tank causing hydrocarbons to be released when the tank is opened. Therefore, we do not model these tanks as having zero diurnal emissions. For PWC, we use the baseline scenario of sealed systems with a 1.0 psi pressure relief valve. For installed fuel tanks, we model a 60 percent reduction due to a carbon canister in the fuel line with passive purge. This reduction is based on data presented in Chapter 5. As in the baseline case, no diffusion is modeled for PWC and installed fuel tanks.

3.4.1.2.4 Running Loss

For Class I engines, we believe that the proposed running loss control requirement will be met by routing vapor from the fuel take to the engine air intake system. Therefore, all vapor generated in the fuel tank should be consumed by the engine, thereby eliminating running loss emissions. However, there may be some inefficiencies in the system such as vapor escaping out the intake at idle. Therefore, we model the running loss emission reduction as only 90 percent. For Class II equipment, we believe that some equipment will inherently meet the proposed standard because they will have low enough temperature fluctuation in the fuel tanks during operation to certify by design. Based on the data presented in Chapter 5 on fuel tank temperatures during operation, we estimate an 80 percent reduction in running loss for Class II equipment.

3.4.1.3 Controlled Exhaust and Evaporative Inventory Results for THC, NOx, $PM_{2.5}$, PM_{10}, CO and SO_2

Tables 3.4-5 presents the 50-state controlled emission inventories, respectively, for small nonroad SI engines. Tables 3.4-6 provides the same information for Marine SI engines.

Table 3.4-5: Controlled 50-State Annual Exhaust and Evaporative Emissions for Small Nonroad Spark-Ignition Engines (short tons)

Year	THC	NOx	PM2.5	PM10	CO
2001	1,099,402	101,928	23,163	25,177	16,108,103
2002	1,074,137	101,261	23,382	25,416	15,560,774
2003	1,039,522	99,649	23,480	25,522	14,941,296
2004	978,760	97,929	23,483	25,525	14,382,759
2005	905,814	95,779	23,417	25,453	13,784,367
2006	849,619	94,550	23,498	25,541	13,369,719
2007	794,827	92,988	23,804	25,874	12,919,586
2008	743,099	90,638	24,335	26,451	12,285,206
2009	705,099	89,272	24,882	27,045	11,775,265
2010	683,397	88,968	25,402	27,611	11,492,162
2011	653,532	80,103	25,888	28,139	11,091,811
2012	605,062	72,135	26,037	28,301	10,733,334
2013	562,800	65,271	26,172	28,447	10,467,631
2014	535,060	61,428	26,344	28,635	10,363,567
2015	519,198	58,117	26,647	28,965	10,317,051
2016	509,608	56,053	26,985	29,332	10,334,605
2017	506,270	55,149	27,353	29,732	10,408,287
2018	507,491	54,869	27,751	30,164	10,515,612
2019	511,030	54,946	28,159	30,607	10,642,994
2020	515,956	55,241	28,574	31,058	10,782,258
2021	522,022	55,772	28,993	31,515	10,932,278
2022	528,733	56,409	29,416	31,974	11,087,748
2023	535,947	57,121	29,842	32,437	11,247,239
2024	543,403	57,866	30,270	32,902	11,408,690
2025	550,981	58,643	30,699	33,368	11,572,096
2026	558,690	59,447	31,128	33,835	11,738,240
2027	566,466	60,268	31,559	34,303	11,905,720
2028	574,280	61,097	31,989	34,770	12,073,845
2029	582,125	61,934	32,419	35,238	12,242,505
2030	590,000	62,778	32,849	35,706	12,411,661
2031	597,896	63,627	33,280	36,173	12,581,170
2032	605,803	64,479	33,710	36,641	12,750,877
2033	613,723	65,333	34,140	37,109	12,920,739
2034	621,652	66,188	34,571	37,577	13,090,731
2035	629,588	67,045	35,001	38,044	13,260,842
2036	637,536	67,905	35,431	38,512	13,431,126
2037	645,494	68,767	35,862	38,980	13,601,583
2038	653,458	69,631	36,292	39,448	13,772,142
2039	661,426	70,496	36,722	39,915	13,942,788
2040	669,399	71,361	37,153	40,383	14,113,517

Table 3.4-6: Controlled 50-State Annual Exhaust and Evaporative Emissions for Marine Spark-Ignition Engines (short tons)

Year	THC	NOx	PM2.5	PM10	CO
2001	935,494	41,514	15,625	16,984	2,584,786
2002	909,607	43,401	15,092	16,404	2,552,368
2003	877,441	45,661	14,417	15,670	2,510,927
2004	841,151	48,164	13,679	14,869	2,469,934
2005	801,985	50,675	12,886	14,007	2,423,497
2006	762,092	53,207	12,090	13,142	2,375,768
2007	724,443	55,750	11,311	12,295	2,328,182
2008	687,350	58,296	10,553	11,470	2,280,928
2009	634,175	58,835	9,508	10,335	2,214,580
2010	582,548	59,308	8,520	9,261	2,150,304
2011	532,769	59,541	7,584	8,243	2,086,638
2012	485,231	59,635	6,733	7,319	2,028,270
2013	441,421	59,547	5,978	6,497	1,976,179
2014	401,152	59,336	5,286	5,746	1,927,610
2015	364,619	59,024	4,666	5,072	1,883,241
2016	330,888	58,595	4,099	4,455	1,842,019
2017	300,138	58,051	3,588	3,900	1,804,951
2018	272,927	57,378	3,143	3,416	1,772,827
2019	249,343	56,577	2,767	3,007	1,743,893
2020	228,847	55,656	2,448	2,661	1,718,956
2021	210,304	54,638	2,164	2,352	1,696,117
2022	194,021	53,570	1,920	2,087	1,676,245
2023	180,805	52,527	1,729	1,880	1,659,281
2024	169,904	51,497	1,577	1,714	1,644,771
2025	160,668	50,466	1,452	1,578	1,632,439
2026	152,898	49,451	1,348	1,465	1,622,175
2027	146,673	48,468	1,267	1,377	1,614,086
2028	141,435	47,561	1,200	1,304	1,608,064
2029	137,294	47,142	1,148	1,248	1,606,899
2030	134,028	46,859	1,107	1,203	1,607,678
2031	131,342	46,691	1,073	1,166	1,610,007
2032	129,305	46,590	1,046	1,137	1,613,454
2033	127,751	46,531	1,025	1,114	1,617,823
2034	126,621	46,503	1,010	1,097	1,622,954
2035	125,891	46,508	999	1,086	1,628,820
2036	125,434	46,536	992	1,079	1,635,236
2037	125,187	46,587	988	1,074	1,642,153
2038	125,113	46,659	986	1,071	1,649,518
2039	125,179	46,755	985	1,070	1,657,283
2040	125,343	46,874	985	1,071	1,665,392

3.4.2 Controlled Hazardous Air Pollutant Estimates

The proposed hydrocarbon emission standards for small nonroad and Marine SI engines will also reduce toxic air pollutants. To calculate the controlled toxic air emission inventories, we used the same methodology that was used for the baseline inventories along with the results of the controlled emission inventories for VOC or PM, as appropriate. The methodology is described in Section 3.2.

Controlled inventories were calculated for the seven major types of air toxic emissions: benzene, formaldeyde, acetaldehyde, 1,3-butadiene, acrolein, napthalene, and 15 other compounds grouped together as polycyclic organic matter (POM) for this analysis.[4] Table 3.4-7 presents the 50-state controlled inventories, respectively, small nonroad SI engines. Table 3.4-8 provide the same information for Marine SI engines.

Table 3.4-7: Controlled 50-State Air Toxic Emissions for Small Nonroad Spark-Ignition Engines (short tons)

Year	Benzene	1,3 Butadiene	Formalde-hyde	Acetalde-hyde	Acrolein	Naptha-lene	POM
2001	33,534	5,165	8,035	2,826	462	418	93
2020	16,018	2,214	3,621	1,697	189	286	102
2030	18,341	2,535	4,146	1,941	216	329	118

Table 3.4-8: Controlled 50-State Air Toxic Emissions for Marine Spark-Ignition Engines (short tons)

Year	Benzene	1,3 Butadiene	Formalde-hyde	Acetalde-hyde	Acrolein	Naptha-lene	POM
2001	21,590	1,790	1,846	1,354	179	32	30
2020	4,890	371	324	356	25	17	7
2030	3,117	230	200	223	15	12	4

3.5 Projected Emissions Reductions from the Proposed Rule

This section presents the projected total emission reductions associated with the proposed rule. We calculated the reductions by subtracting the baseline inventories from Section 3.2 by the controlled inventories from Section 3.4.

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[4] The 15 POMs summarized in this chapter are acenaphthene, acenapthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylkene, beno(k)fluoranthene, chrysene, dibenzo(a,h)anthracene,fluoranthene, fluorene, ideno(1,2,3,c,c)-pyrene, phenanthrene, and pyrene.

3.5.1 Results for THC, NOx, $PM_{2.5}$, PM_{10}, and CO

Tables 3.5-1 presents the 50-state exhaust and evaporative emission inventories and percent reductions, respectively, for small nonroad SI engines. Tables 3.5-2 provides the same information for Marine SI engines. Tables 3.5-3 summarizes the combined emission reductions for the proposal. The earliest proposed Phase 3 standards for small nonroad SI engines begin in 2008. Similar proposed standards affect Marine SI engines one year later. Therefore the emission reductions are shown beginning in 2008 for small nonroad SI engines and 2009 for Marine SI engines. Figures 3.5-1 though 3.5-6 show the combined baseline, controlled, and by contrast the reduction emission inventories over time for small nonroad and Marine SI engines.

Table 3.5-1: Total 50-State Annual Exhaust and Evaporative Emission Reductions for Small SI Spark-Ignition Engines (short tons)

Year	THC		NOx		PM2.5		PM10		CO	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2008	4,935	1	0	0	0	0	0	0	0	0
2009	10,844	2	0	0	0	0	0	0	0	0
2010	17,085	2	0	0	0	0	0	0	0	0
2011	44,949	6	9,440	11	0	0	0	0	334,555	3
2012	95,920	14	18,305	20	327	1	356	1	705,503	6
2013	143,686	20	26,336	29	661	2	718	2	1,049,398	9
2014	179,908	25	31,545	34	947	3	1,029	3	1,281,497	11
2015	205,497	28	36,315	38	1,100	4	1,195	4	1,480,027	13
2016	225,684	31	39,906	42	1,216	4	1,322	4	1,630,861	14
2017	240,176	32	42,370	43	1,301	5	1,414	5	1,735,277	14
2018	250,529	33	44,232	45	1,356	5	1,474	5	1,812,911	15
2019	258,899	34	45,754	45	1,399	5	1,521	5	1,876,142	15
2020	266,030	34	47,069	46	1,435	5	1,560	5	1,930,518	15
2021	272,051	34	48,150	46	1,466	5	1,594	5	1,975,208	15
2022	277,458	34	49,124	47	1,495	5	1,624	5	2,015,250	15
2023	282,389	35	50,024	47	1,520	5	1,652	5	2,051,946	15
2024	287,093	35	50,893	47	1,543	5	1,677	5	2,087,252	15
2025	291,705	35	51,737	47	1,566	5	1,702	5	2,121,545	15
2026	296,331	35	52,572	47	1,590	5	1,728	5	2,155,582	16
2027	300,923	35	53,398	47	1,614	5	1,754	5	2,189,270	16
2028	305,489	35	54,217	47	1,638	5	1,780	5	2,222,715	16
2029	310,032	35	55,030	47	1,662	5	1,807	5	2,255,912	16
2030	314,553	35	55,837	47	1,686	5	1,833	5	2,288,860	16
2031	319,057	35	56,640	47	1,710	5	1,859	5	2,321,627	16
2032	323,554	35	57,440	47	1,734	5	1,885	5	2,354,303	16
2033	328,042	35	58,238	47	1,758	5	1,911	5	2,386,904	16
2034	332,523	35	59,035	47	1,782	5	1,937	5	2,419,451	16
2035	336,999	35	59,830	47	1,806	5	1,963	5	2,451,948	16
2036	341,467	35	60,623	47	1,830	5	1,989	5	2,484,331	16
2037	345,926	35	61,412	47	1,854	5	2,015	5	2,516,608	16
2038	350,382	35	62,201	47	1,878	5	2,042	5	2,548,836	16
2039	354,835	35	62,988	47	1,902	5	2,068	5	2,581,029	16
2040	359,285	35	63,775	47	1,926	5	2,094	5	2,613,191	16

Table 3.5-2: Total 50-State Annual Exhaust and Evaporative Emission Reductions for Marine SI Spark-Ignition Engines (short tons)

Year	THC		NOx		PM2.5		PM10		CO	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2009	17,569	3	1,962	3	315	3	343	3	20,607	1
2010	36,295	6	3,920	6	629	7	683	7	41,179	2
2011	55,514	9	6,072	9	941	11	1,023	11	62,769	3
2012	76,468	14	8,208	12	1,250	16	1,359	16	84,241	4
2013	97,088	18	10,336	15	1,556	21	1,692	21	105,767	5
2014	117,463	23	12,453	17	1,858	26	2,019	26	127,160	6
2015	137,688	27	14,558	20	2,157	32	2,344	32	148,443	7
2016	157,614	32	16,650	22	2,450	37	2,663	37	169,550	8
2017	177,149	37	18,730	24	2,737	43	2,975	43	190,368	10
2018	196,113	42	20,792	27	3,013	49	3,275	49	210,784	11
2019	212,803	46	22,892	29	3,246	54	3,528	54	230,404	12
2020	228,491	50	24,999	31	3,461	59	3,762	59	249,707	13
2021	243,383	54	27,131	33	3,662	63	3,981	63	268,906	14
2022	257,338	57	29,226	35	3,849	67	4,183	67	287,643	15
2023	269,076	60	31,228	37	3,997	70	4,344	70	305,376	16
2024	279,185	62	33,166	39	4,119	72	4,477	72	322,243	16
2025	288,385	64	35,051	41	4,228	74	4,596	74	338,585	17
2026	296,713	66	36,877	43	4,327	76	4,703	76	354,383	18
2027	303,966	67	38,628	44	4,411	78	4,795	78	369,306	19
2028	310,552	69	40,267	46	4,487	79	4,877	79	383,267	19
2029	316,315	70	41,395	47	4,553	80	4,949	80	393,085	20
2030	321,452	71	42,366	47	4,613	81	5,014	81	401,570	20
2031	326,194	71	43,206	48	4,668	81	5,074	81	409,021	20
2032	330,420	72	43,964	49	4,719	82	5,130	82	415,773	20
2033	334,319	72	44,666	49	4,767	82	5,181	82	422,048	21
2034	337,908	73	45,325	49	4,811	83	5,230	83	427,929	21
2035	341,188	73	45,940	50	4,852	83	5,274	83	433,425	21
2036	344,251	73	46,524	50	4,890	83	5,315	83	438,637	21
2037	347,161	73	47,077	50	4,927	83	5,355	83	443,584	21
2038	349,942	74	47,602	51	4,962	83	5,394	83	448,279	21
2039	352,617	74	48,098	51	4,997	84	5,431	84	452,729	21
2040	355,217	74	48,567	51	5,031	84	5,468	84	456,943	22

Table 3.5-3: Total 50-State Annual Exhaust and Evaporative Emission Reductions for Small Nonroad and Marine SI Spark-Ignition Engines (short tons)

Year	THC		NOx		PM2.5		PM10		CO	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2008	4,935	0	0	0	0	0	0	0	0	0
2009	28,413	2	1,962	1	315	1	343	1	20,607	0
2010	53,380	4	3,920	3	629	2	683	2	41,179	0
2011	100,463	8	15,512	10	941	3	1,023	3	397,324	3
2012	172,387	14	26,513	17	1,578	5	1,715	5	789,744	6
2013	240,774	19	36,672	23	2,217	6	2,410	6	1,155,165	8
2014	297,371	24	43,998	27	2,805	8	3,049	8	1,408,656	10
2015	343,185	28	50,874	30	3,256	9	3,539	9	1,628,471	12
2016	383,298	31	56,556	33	3,666	11	3,985	11	1,800,412	13
2017	417,325	34	61,099	35	4,038	12	4,389	12	1,925,645	14
2018	446,643	36	65,024	37	4,369	12	4,749	12	2,023,696	14
2019	471,702	38	68,646	38	4,645	13	5,049	13	2,106,545	15
2020	494,520	40	72,069	39	4,896	14	5,322	14	2,180,225	15
2021	515,434	41	75,281	41	5,129	14	5,575	14	2,244,115	15
2022	534,797	43	78,350	42	5,343	15	5,808	15	2,302,893	15
2023	551,465	43	81,252	43	5,516	15	5,996	15	2,357,322	15
2024	566,279	44	84,059	43	5,662	15	6,154	15	2,409,495	16
2025	580,091	45	86,788	44	5,794	15	6,298	15	2,460,130	16
2026	593,044	45	89,448	45	5,917	15	6,431	15	2,509,965	16
2027	604,889	46	92,025	46	6,025	16	6,549	16	2,558,576	16
2028	616,041	46	94,484	47	6,125	16	6,658	16	2,605,982	16
2029	626,348	47	96,425	47	6,215	16	6,755	16	2,648,997	16
2030	636,005	47	98,203	47	6,299	16	6,847	16	2,690,429	16
2031	645,251	47	99,845	48	6,379	16	6,933	16	2,730,649	16
2032	653,974	47	101,403	48	6,454	16	7,015	16	2,770,076	16
2033	662,361	47	102,904	48	6,525	16	7,092	16	2,808,952	16
2034	670,431	47	104,360	48	6,593	16	7,167	16	2,847,380	16
2035	678,187	47	105,770	48	6,658	16	7,237	16	2,885,372	16
2036	685,717	47	107,146	48	6,720	16	7,305	16	2,922,968	16
2037	693,087	47	108,489	48	6,781	16	7,371	16	2,960,192	16
2038	700,324	47	109,803	49	6,841	16	7,436	16	2,997,115	16
2039	707,452	47	111,087	49	6,899	15	7,499	15	3,033,757	16
2040	714,503	47	112,342	49	6,957	15	7,562	15	3,070,134	16

Note: annualized tons (2008-2038) for HC and NOx are 374,500 and 55,800 at a 7% discount and 431,800 and 64,800 at a 3% discount.

Figure 3.5-1: 50-State Annual THC Exhaust and Evaporative Emissions for Small SI and Marine SI

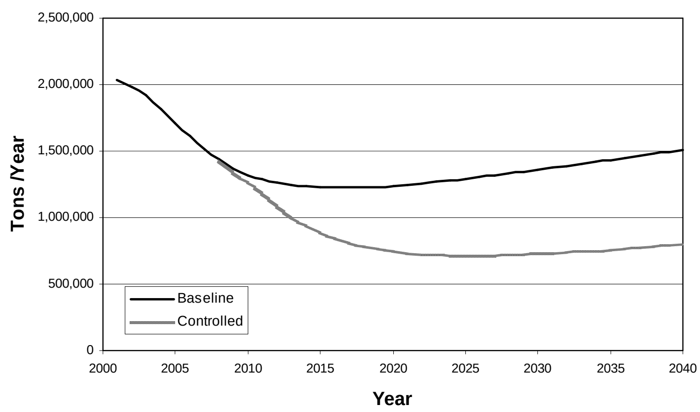


Figure 3.5-2: 50-State Annual NOx Exhaust Emissions for Small SI and Marine SI

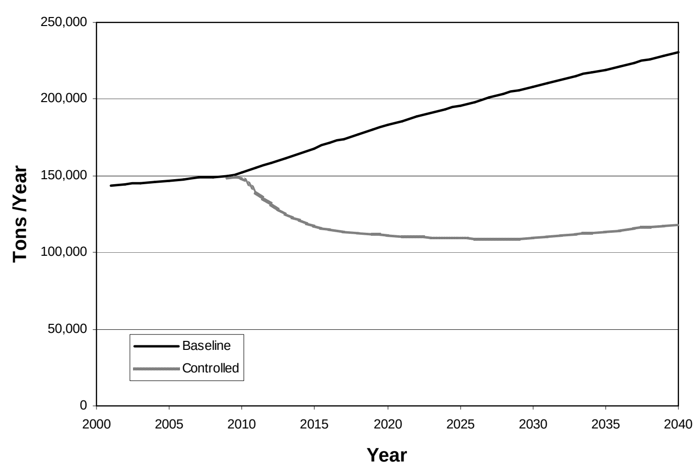


Figure 3.5-3: 50-State Annual PM2.5 Exhaust Emissions for Small SI and Marine SI

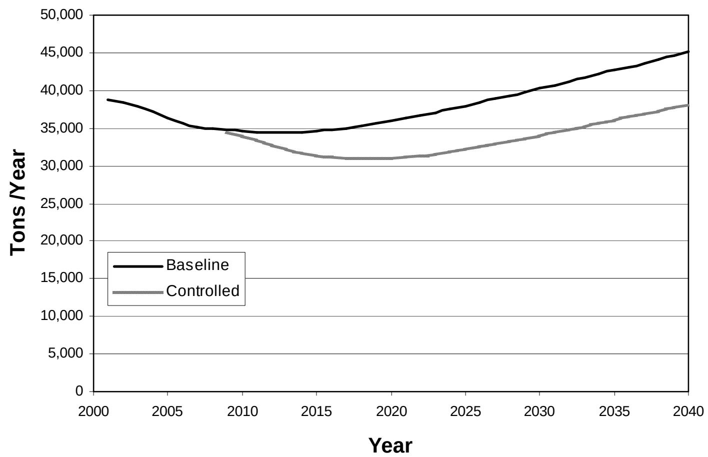


Figure 3.5-4: 50-State Annual PM10 Emissions for Small SI and Marine SI Engines

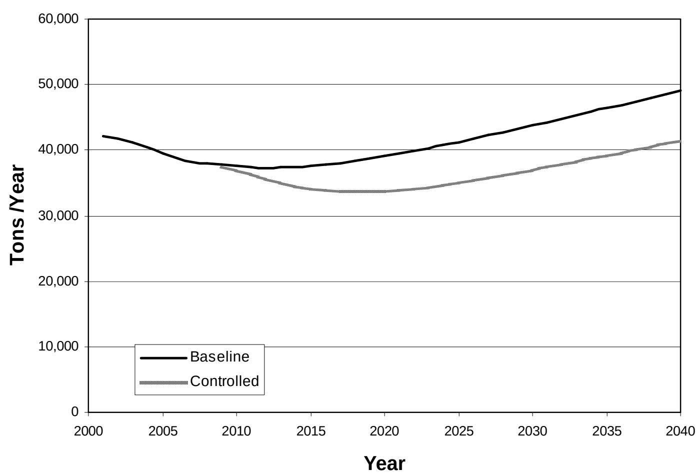
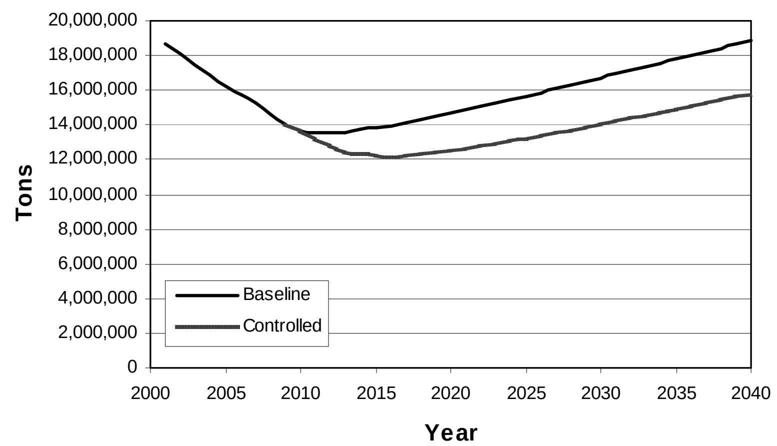


Figure 3.4-5: 50-State Annual CO Emissions from Small SI and Marine SI Engines



3.5.2 Results for Hazardous Air Pollutants

Tables 3.5-4 presents the 50-state exhaust and evaporative air toxics emission inventory and percent reductions, respectively, for small nonroad SI engines that are expected to accompany the proposed standards. Table 3.5-5 provides the same information for Marine SI engines. Tables 3.5-6 summarizes the combined hazardous air pollutant reductions for the proposal. These results are displayed for 2020 and 2030, when most or all of the engines subject to the proposed standards are represented in the respective fleets.

Table 3.5-4: 50-State Air Toxic Emission Reductions for Small Nonroad Spark-Ignition Engines (short tons)

Year	Benzene		1,3 Butadiene		Formaldehyde		Acetaldehyde		Acrolein		Napthalene		POM	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2020	6,906	30	955	30	1,561	30	732	30	81	30	123	30	5	4
2030	8,160	31	1,128	31	1,845	31	864	31	96	31	146	31	6	5

Table 3.5-5: 50-State Air Toxic Emission Reductions for Marine Spark-Ignition Engines (short tons)

Year	Benzene		1,3 Butadiene		Formaldehyde		Acetaldehyde		Acrolein		Napthalene		POM	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2020	4,254	47	323	47	282	47	310	47	22	47	15	47	8	54
2030	5,955	66	440	66	382	66	426	66	30	66	23	66	11	75

Table 3.5-6: 50-State Air Toxic Emission Reductions for Small Nonroad and Marine Spark-Ignition Engines (short tons)

Year	Benzene		1,3 Butadiene		Formaldehyde		Acetaldehyde		Acrolein		Napthalene		POM	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2020	11,160	35	1,278	33	1,843	32	1,041	34	103	33	138	31	13	10
2030	14,116	40	1,567	36	2,227	34	1,290	37	126	35	169	33	17	12

3.6 Emission Inventories Used for Air Quality Modeling

This section describes the methodology we used to develop the emission inventories for the air quality modeling. The inventories represent emissions for the summer ozone season (i.e., June, July, and August) in calendar years 2001, 2015, 2020, and 2030. Emissions were estimated are for 37 of the most eastern states, which is the geographic area of the air quality modeling domain.

The emission inputs for the air quality modeling are required early in the analytical process to ensure there is adequate time to complete the analysis and incorporate the results into the rulemaking process. Given that lead time requirement, air quality modeling is often based analytical methods that may be superceded or on a control scenario that does not specifically match the final set of emission standards. Indeed, for this proposed rulemaking both instances have occurred. Therefore, this section also describes the changes to our emission inventory models, modeling inputs, and resulting emission inventories between the preliminary baseline and control scenarios used for the air quality modeling, and the updated final baseline and control scenarios for the proposed rule.

3.6.1 Methodology for Air Quality Modeling

The air quality modeling for the proposal is in large part taken from the work performed for EPA's Clean Air Interstate Rule (CAIR) for stationary sources.[22] This approach was adopted to be consistent with, what was then, EPA's most recent ozone-related rulemaking and to conserve resources by taking advantage of the existing inventory preparation (i.e., input files) and results. The CAIR modeling domain consists of 37 states in the eastern U.S. and the District of Columbia. Emission inventories were developed for the following pollutants: VOC, NOx, PM2.5, PM10, CO, SOx, and NH3. Air quality results were generated for the summer ozone season (i.e., June, July, and August) and the CAIR calendar years 2001, 2015, and 2020. We also modeled calendar year 2030 specifically for this proposal as described below.

The special 2030 calendar year model simulation was performed by preparing CAIR-like emission inventories for all source categories. For non-mobile sources, we simply carried forward the inventories from 2020. For mobile sources, we prepared highway and off- highway inventories for 2030 using the same methodology that was used to prepare the CAIR inventories for the previous calendar years.

The emissions inventory methodology and results for the nonroad sources and the results for small nonroad and Marine SI engines are in the docket for this proposed rule.[23,24,25,26]

3.6.2 Baseline Scenario Emission Inventories

Our preliminary baseline emission inventories without the proposed controls for small nonroad and Marine SI engines were the same as the CAIR rule's "control" scenario. A special version of the draft NONROAD2004 model was used to generate the nonroad engine inventories for that rule. That version of the model is referred to as NONROAD2004n. It is identical to the draft NONROAD2004 model, which was the most recent publically available nonroad model at the time, except for a modification to allow a separate diesel fuel sulfur value for marine equipment (an unremarkable feature relative to the proposed rule). NONROAD2004n was executed within the framework of EPA's National Mobile Source Inventory Model (NMIM) that links a county-level database to model and collates the output into a single database table. The resulting estimates for nonroad and Marine SI engines account for local differences in fuel characteristics and temperatures. NONROAD2004n is discussed in more detail later in this section.

Table 3.6-1 presents the preliminary 37-state baseline inventories for VOC, NOx, PM2.5, PM10, and CO during the 3-month summer ozone season that were used in the air quality modeling for small nonroad and Marine SI engines.[5] These values are an aggregation of the county-level NMIM results.

Table 3.6-1 37-State Preliminary Baseline Scenario Emissions for Air Quality Modeling

Application	Year	VOC	PM_{10}	$PM_{2.5}$	NOx	CO
Small Nonroad SI Subject to the Proposal	2001	264,951	6,738	6,199	37,466	4,795,058
	2020	156,401	7,968	7,330	31,477	6,660,408
	2030	179,717	9,114	8,385	36,084	7,691,956
Marine SI	2001	264,951	18,397	16,925	18,576	927,890
	2020	162,488	13,930	12,815	33,061	904,964
	2030	157,380	14,534	13,371	36,332	949,504

The final baseline inventories for the proposal were estimated with a special version of the NONROAD2005a model, which is the newest public release of our nonroad model. This special version is named NONROAD2005c. Generally, we revised the model to incorporate new test results for nonhandheld Small SI engines that comply with the existing Phase 2 standards. Also, the model was modified to acknowledge the continued use of side-valve engine designs in Class I nonhandheld engines meeting those standards. In the Phase 2 rulemaking for small nonroad SI engines, side-valve technology was assumed to be superceded by overhead valve designs and was modeled accordingly. In reality, side-valve technology has continued to be used in small nonroad SI engines. The revisions we made to develop this new version is also described in Section 3.2.

Table 3.6-2 compares the preliminary and final 37-state baseline scenario inventories for

[5] Inventories for SOx and NH4 are not important for the purposes of this discussion and can be found in the docket along with information on the other pollutants presented here. See reference 26.

small nonroad and Marine SI engines. This information is presented primarily for information purposes, since it is the percentage difference between a model's baseline and control scenario that is used for comparing the inventories from the final proposal to those used in the air quality modeling as discussed further in Section 3.6.3. As shown, the difference in the baseline scenarios between the two models ranges from about -2 percent for VOC in 2020 to about 50 percent for PM2.5 in 2020 for the combined Small SI engine and Marine SI engine categories.

Table 3.6-2: Comparison of 37-State Baseline Scenario Emissions for Preliminary Air Quality Modeling and Final Proposal

Applications	Year	VOC [short tons]			NO_x [short tons]			$PM_{2.5}$ [short tons]		
		Final	Preliminary	**Difference**	Final	Preliminary	**Difference**	Final	Preliminary	**Difference**
Small Nonroad SI Subject to the Proposal	2020	219,404	156,401	**63,003**	26,947	31,477	**(4,530)**	7,946	7,330	**616**
	2030	253,162	179,717	**73,445**	31,101	36,084	**(4,983)**	9,141	8,385	**756**
Marine SI	2020	230,222	162,488	**67,734**	40,949	33,061	**7,888**	3,108	12,815	**(9,707)**
	2030	228,081	157,380	**70,701**	44,949	36,332	**8,617**	3,008	13,371	**(10,363)**
Total	2020	449,626	318,889	**(4,731)**	67,896	64,538	**(12,418)**	11,054	20,146	**10,323**
	2030	481,243	337,096	**2,744**	76,050	72,415	**(13,600)**	12,149	21,756	**11,119**

Table 3.6-2 (Cont'd)
Comparison of 37-State Baseline Scenario Emissions for Preliminary Air Quality Modeling and Final Proposal

Applications	Year	PM_{10} [short tons]			CO [short tons]		
		Final	Preliminary	**Difference**	Final	Preliminary	**Difference**
Small Nonroad SI Subject to the Proposal	2020	8,637	7,968	**669**	3,832,891	6,660,408	**(2,827,517)**
	2030	9,936	9,114	**822**	4,414,165	7,691,956	**(3,277,791)**
Marine SI	2020	3,378	13,930	**(10,552)**	1,040,807	904,964	**135,843**
	2030	3,270	14,534	**(11,264)**	1,061,971	949,504	**112,467**
Total	2020	12,015	21,898	**(9,883)**	4,873,698	7,565,372	**(2,691,674)**
	2030	13,206	23,648	**(10,442)**	5,476,136	8,641,460	**(3,165,324)**

These baseline inventory differences are obviously due to the differences in NONROAD2004n and the special version of the model that we developed for the final proposal, i.e., NONROAD2005c, as well as the inputs to the models. As already mentioned, NONROAD2004n is equivalent to publically available draft NONROAD model with a revision that is insignificant for the purposes of the proposal as described above. The most substantial changes between the two models occurred between publically available NONROAD2004 and the publically available NONROAD2005a. The principle revisions that are relevant to this proposal generally include:

1) All new evaporative emission categories for fuel tank permeation, hose permeation, hot soak, and running losses;
2) Added capability to model emissions using daily values for temperature and gasoline volatility at the national and state level;
3) Revised methodology for calculating diurnal evaporative emissions;
4) Added the effect of evaporative emission standards for recreational vehicles and large spark-ignition engines; and
5) Updated geographic allocation factors to distribute national equipment populations to state and local jurisdictions; and

The additional changes we made from NONROAD2005a to develop NONR2005c for the proposal are important, but less significant. These revisions are described in detail in Section 3.2.

3.6.3 Control Scenario Emission Inventories

At the time we were ready to develop the control scenario for the air quality analysis, our modeling techniques and emission inputs significantly improved beyond NONROAD2004a model, which was used to generate the CAIR-related base case. So we created a special version of NONROAD2004a to better estimate the exhaust and evaporative refueling emissions for small nonroad and Marine SI engines. The special version of the model was designated as NONROAD2004n2. We also created special spreadsheet models to expand and improve our estimates of the other evaporative emissions from these engines, i.e., diurnal (including effusion), running loss, hot soak, and hose and tank permeation.

The principle changes that were incorporated into NONROAD2004n2 for exhaust and refueling emissions are:

1. Updated the estimated sales fractions by engine class and technology to account for the continued sales of Class I Small SI engines using side-valve technology (we assumed these engines would be replaced with overhead-valve technology in the Phase 2 standard rulemaking);
2. Revised emission factors and deterioration rates for Class I Small SI engines subject to Phase 2 standards based on preliminary testing;
3. Updated Marine SI engine population distributions by horsepower category; and
4. Updated Marine SI engine emission factors for hydrocarbons, CO, and NOx.

The principle changes that were incorporated into the spreadsheet models for the other evaporative emissions are:

1. Added all new evaporative emission categories for fuel tank and hose permeation; and
2. Updated the methodology for diurnal evaporative emissions.

These new tools were utilized to derive the preliminary control inventories for the air quality modeling. More specifically, we constructed alternative baseline and control scenarios for small nonroad and Marine SI engines with the NONROAD2004n2 model for exhaust and evaporative refueling emissions, and the new spreadsheet models for the other evaporative emissions. The percent change in emissions from the alternative baseline to the alternative control inventory for each pollutant was then applied to the respective CAIR-related preliminary baseline inventories to generate the preliminary control scenario inventories for the proposed rule. This approach was taken to preserve the existing air quality modeling input files, while still reflecting the full scope of the emission reductions from the proposed rule. This methodology has been documented in detail and a copy of the NONROAD2004n2 model and evaporative emission spreadsheets have been placed in the docket for this proposal.

For this proposal, the specific emission standards and associated control requirements were not fully identified when the air quality modeling was performed. As a result, we modeled a variety of preliminary control scenarios with the improved inventory tools described above to accommodate a range of possible regulatory outcomes. The air quality modeling outcomes for the preliminary scenario that most closely matches the percent change in emissions associated with the final control scenario will be used in Chapter 8 to estimate the health and welfare benefits of the proposal. Using the percentage reduction in emissions to select the appropriate preliminary control scenario matches the methodology that was originally used to develop the preliminary air quality control scenario itself, as described in the preceding paragraph.

Before selecting the preliminary air quality control scenario for our benefits assessment in Chapter 8, we would like to reiterate that the final control scenario inventories for the proposal were estimated with a special version of the NONROAD2005a model, just as we used for the final baseline scenario inventories. It should be noted that NONROAD2005a incorporates and expands upon the modeling improvements described above for NONROADn2 and the evaporative spreadsheet models, which were used to generate the percentage reduction factors associated with the alternative baseline and control scenarios. Of course, the special version reflects further modeling improvements for the proposal. Section 3.6.2 generally describes the changes we made to the NONROAD2005a base model. A more detailed discussion of the special version of the model is also contained in Section 3.2.

Table 3.6-3 compares the percentage emission reductions that are associated with the final control scenario and preliminary air quality control scenario that most closely matches the final scenario for the 37-state modeling domain. The inventories are not shown for 2001 or 2015 because the proposed requirements either have no effect on the inventories, i.e., 2001, or have not yet significantly "rolled over" into the fleet of equipment, i.e., 2015. Also, results are presented only for the two most important pollutants relative to this rule for selection purposes, i.e., VOC and NOx. As shown, the emission reductions are, on average, very close to the final control scenario based on the selection criteria. Therefore, this case is selected as the most representative preliminary control scenario relative to the air quality results associated with the proposal.

Table 3.6-4 directly compares the emission inventories (i.e., tons) for the selected preliminary control scenario to the final control scenario. As previously described, this information is presented primarily for information purposes, since it is the percentage difference between a model's baseline and control scenario that is used for comparing the inventories from the final proposal to those used in the air quality modeling. As shown, the difference in the control scenarios for the two models ranges from about -27 percent for CO in 2030 to about 50 percent for VOC in 2030 for the combined Small SI engine and Marine SI engine categories.

As with the baseline scenarios, the differences in the preliminary and final control scenarios inventories are due to the differences in models and inputs used in the analysis. Unlike the baseline scenario discussion, however, the comparison of these differences is substantially complicated by the use of not just two, but three different modeling platforms, i.e., NONROAD2004n (used for the CAIR-related base case), NONROADn2 and the spreadsheet models (used for the percent reduction factors), and the special version of NONROAD2005a (used for the final control scenario). Generally, the greatest differences result from using the NONROAD2004n model for the preliminary baseline scenario (from which the preliminary control scenario inventories were directly calculated) and the special version of NONROAD2005a model. The differences between these two models is described in Section 3.6.2. We expect that any new air quality modeling that may be needed for the final rule would be based on a single, consistent modeling platform.

Table 3.6-3: Comparison of 37-State Emission Reductions for Small Nonroad and Marine SI Engines for Emission Benefit Analysis Purposes (Tons or Percent Reduction/Year)

		Preliminary Proposal (Air Quality Modeling)				Final Proposal			
Pollutant	Year	Base (tons)	Control (tons)	Reduction (tons)	**Percent Reduction (%)**	Base (tons)	Control (tons)	Reduction (tons)	**Percent Reductio (%)**
VOC	2020	318,889	168,589	150,300	**47**	446,626	252,287	197,339	**44**
	2030	337,096	147,664	189,432	**56**	481,243	223,834	257,409	**54**
NOx	2020	64,538	41,331	23,207	**36**	67,586	42,802	24,754	**37**
	2030	72,415	40,341	32,074	**44**	76,049	40,503	35,546	**47**

Table 3.6-4: Comparison of 37-State Control Scenario Emissions for Preliminary Air Quality Modeling Scenario and Final Proposal (Tons/Year)

Applications	Year	VOC [short tons]			NO_x [short tons]			$PM_{2.5}$ [short tons]		
		Final	Preliminary	Difference	Final	Preliminary	Difference	Final	Preliminary	Difference
Small Nonroad SI Subject to the Proposal	2020	138,406	92,605	45,801	14,416	15,240	(824)	7,507	7,330	177
	2030	157,626	105,348	52,278	16,306	17,107	(801)	8,627	8,384	243
Marine SI	2020	113,881	75,984	37,897	28,386	26,091	2,295	1,287	3,412	(2,125)
	2030	66,208	42,316	23,892	24,197	17,107	7,090	582	756	(174)
Total	2020	252,287	168,589	83,698	42,802	41,331	1,471	8,794	10,742	(1,948)
	2030	223,834	147,664	76,170	40,503	34,214	6,289	9,209	9,140	69

Table 3.6-4 (Cont'd)
Comparison of 37-State Control Scenario Emissions for
Preliminary (Nominal) Air Quality Modeling and Final Proposal

Applications	Year	PM_{10} [short tons]			CO [short tons]		
		Final	Preliminary	Difference	Final	Preliminary	Difference
Small Nonroad SI Subject to the Proposal	2020	8,160	7,967	193	3,231,266	4,868,575	(1,637,309)
	2030	9,377	9,113	264	3,703,736	5,593,529	(2,316,989)
Marine SI	2020	1,399	3,709	(2,310)	908,162	726,853	181,309
	2030	633	821	(188)	848,425	675,398	173,027
Total	2020	9,559	11,676	(2,117)	4,139,428	5,595,428	(1,456,000)
	2030	10,010	9,934	76	4,552,161	6,268,927	(1,716,766)

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