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

Final Regulatory Impact Analysis

Chapter 3
Emission Inventory

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This chapter presents our analysis of the emission impact of the final Phase 3 standards for spark ignition (SI) small nonroad engines ($\leq$25 horsepower (hp) or $\leq$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 $\geq$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 final 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 final 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 slightly refined baseline and control scenarios reflected in the actual final rule.

The emission inventory estimates contained in Sections 3.2, 3.4, 3.5, and 3.6, for small nonroad and marine SI engines are reported for the 50-state geographic area that comprises the United States (including the District of Columbia). These inventories reflect the emissions from the engines subject to the final Phase 3 standards, i.e., federal engines. 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 has been granted a waiver under the Clean Air Act to regulate the emissions from all nonroad SI engines, except for engines with less than 175 horsepower that are used in farm and construction equipment. Therefore, these latter engines are subject to federal regulation and are included in our 50-state inventories. By contrast, we do not include any of the emissions from California marine SI engines in these inventories. As with certain nonroad engine classes, the State has been granted a waiver to regulate the exhaust emissions from all marine SI engines and evaporative emissions from outboard and personal watercraft SI engines. That State also has indicated its intent to adopt the final Phase 3 standards for evaporative emissions from sterndrive engines. Therefore, the 50-state inventories presented in Sections 3.2, 3.4, 3.5, and 3.6 only reflect the emissions from small nonroad and marine SI engines that are subject to federal regulation.

Section 3.3 presents a nationwide comparison of the emissions from small nonroad and marine SI engines to those from other source categories, i.e., stationary, area, and other mobile sources. Unlike the 50-state inventories described earlier, these inventories reflect the emissions from all sources, whether they are separately regulated by a state government or the federal government, e.g., all of California's small SI and marine SI engines are included.

Inventories are generally presented for the following pollutants: exhaust and evaporative hydrocarbons reported as total hydrocarbons (THC) and volatile organic compounds (VOC), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$ and PM_{10}), and carbon monoxide (CO). The VOC category is a broader class of hydrocarbon compounds than THC that is primarily important for air quality modeling purposes. The additional compounds that comprise this category 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). The PM inventories for particle sizes of $\leq$2.5 microns or $\leq$10 microns in diameter include directly emitted PM only, although secondary sulfates are taken into account in the air quality modeling as noted below. Toxic pollutant inventories are also presented because the final Phase 3 requirements will 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).

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 final rule 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 final emission inventories were modeled for the small nonroad and marine SI engines that are affected by the Phase 3 standards. Generally, the inventories 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 final rule.[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 NONROAD2005d. A copy of the model and the accompanying documentation are available in the docket.[2,3,4] The inputs we used to model the effects of the Phase 3 standards are also described in Chapter 4 for exhaust emissions and Chapter 5 for evaporative emissions. Finally, the modifications we made to NONROAD2005a to reflect the baseline and control scenarios related to the final rule are summarized in Sections 3.2 and 3.4, respectively.

The nonroad model estimates emission inventories of important air pollutant species 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 final rule, 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 past, present, or future emissions between 1970 and 2050.

The chemical species NOx, PM, and CO are exhaust emissions, i.e., pollutants emitted directly as exhaust from the combustion of fuel (both liquid and gaseous fuels) 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 is 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 final Phase 3 standards for exhaust hydrocarbons, CO, and NOx from small nonhandheld nonroad and marine SI engines.[a] New standards to control evaporative emissions from hose permeation and tank permeation from these engine classes and handheld equipment are also included. Further, the final requirements also 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 final 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 final standards. For small nonroad SI equipment, California's Air Resources Board (ARB) has promulgated standards that are roughly equivalent in stringency overall to final Phase 3 federal 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 final rule 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. However, the majority of the small nonroad SI equipment in California is subject to ARB regulations, so the effect of the federal Phase 3 standards for these engines in that State is rather limited.

For marine SI engines, ARB also has its own exhaust emission standards that are roughly equivalent overall to the final Phase 3 federal standards. In addition, ARB has stated its intend to develop evaporative emissions standards for marine SI equipment in California. Therefore, the exhaust and evaporative inventory estimates for marine SI engines/equipment completely exclude California.

3.2.1 Baseline Exhaust and Evaporative Emissions Estimates for THC, VOC, 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

[a] 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 2006. 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 NONROAD2005d. The modifications to the base model are described below.

3.2.1.1 Changes from NONROAD2005a to NONROAD2005d

As already mentioned, a number of improvements to the most publically available nonroad emissions inventory model were made to develop the NONROAD2005d, which is used in this final rulemaking. These revisions were based on recent testing programs, other information, and model enhancements. The changes are summarized below for small nonroad 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 final rule are summarized below:

1. Revised fuel tank and hose permeation emission factors;
2. Added new fuel tank diffusion losses to the diurnal emission estimates;
3. Updated or corrected 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;
5. Added the ability to specifically model the effects of ethanol blends on exhaust emissions and on fuel tank and hose permeation losses;
6. Added hot soak and running losses for handheld equipment;
7. Corrected snowblower technology types to include 4-stroke engines; and
8. Corrected running loss emission factors for Class 1 snowblowers to account for cold weather applications.

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 final rule 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 exhaust emissions and fuel tank and hose permeation losses.

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 NONROAD2005d 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. 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 final rule, 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)[b]

Class/ Technology	THC ZML	THC "A"	NOx ZML	NOx "A"	CO ZML	CO "A"	PM10 ZML	PM10 "A"
Class I - SV	10.30	1.753	2.57	0.180	386.53	0.070	0.35	1.753
Class I - OHV	8.73	1.753	3.28	0.180	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

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.

[b] The nonroad model calculates VOC by multiplying THC by an adjustment factor depending on engine and fuel type for exhaust emissions as follows: 2-stroke gasoline = 1.034; 4-stroke gasoline = 0.933; liquified petroleum (LPG) = 0.995; and compressed natural gas (CNG) = 0.004. Crankcase and evaporative VOC for all fuels other than CNG is assumed to be equivalent to THC. CNG fueled equipment do not emit crankcase and evaporative VOC emissions because CNG is comprised almost exclusively of methane. $PM_{2.5}$ is calculated by multiplying PM_{10} 0.92.

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 updates to the emission rates and technology mix of marine SI engines.[5] 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.[6] However, NONROAD2005a did 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 more 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.[7] 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. A technical memorandum that documents the methodology and input values for modeling the effects of ethanol blends on nonroad engine fuel hose and tank permeation is also available in the docket for this final rulemaking.[8]

3.2.1.3.1 Fuel Ethanol Content

Currently, about 55 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 both exhaust and evaporative emissions from nonroad equipment. The oxygen content of the ethanol tends to make combustion mixtures leaner, which can decrease exhaust HC and CO emissions while increasing NOx. Also, 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 surpass 11 billion gallons per year by then. Based on these figures and projected gasoline sales from the Energy Information Administration,[10,11] we estimate that about three-fourths of gasoline sold in 2009 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 until switching to 10 percent in 2010.

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	12.5%
2001	132.0	1.8	13.4%
2002	135.6	2.1	15.7%
2003	137.0	2.8	22.2%
2004	140.1	3.5	27.3%
2005	140.2	4.0	31.0%
2006	142.2	5.5	41.5%
2007	141.7	6.1	46.3%
2008	142.5	7.6	57.5%
2009	144.1	10.0	75.1%
2010	145.4	10.9	78.8%
2011	147.1	11.0	*78.8%**
2012	149.0	11.2	*78.8%**

* ethanol fraction projected to be constant after 2010

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 nonroad 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.[12] 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 nonroadSI 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 fuel lines used in handheld equipment tested using E10 fuel. Based on this data, we estimate an average permeation rate at 23˚C, on fuel containing 10 percent ethanol of 255 $g/m^2/day$. 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).[13,14] 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 final 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 final 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 final 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.[15] Recently, we received comment from a boatbuilder using outboard motors that the hose lengths in our calculations were too short.[16] 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 nonroad 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.[17]

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 zero to 20 percent ethanol volume percent:

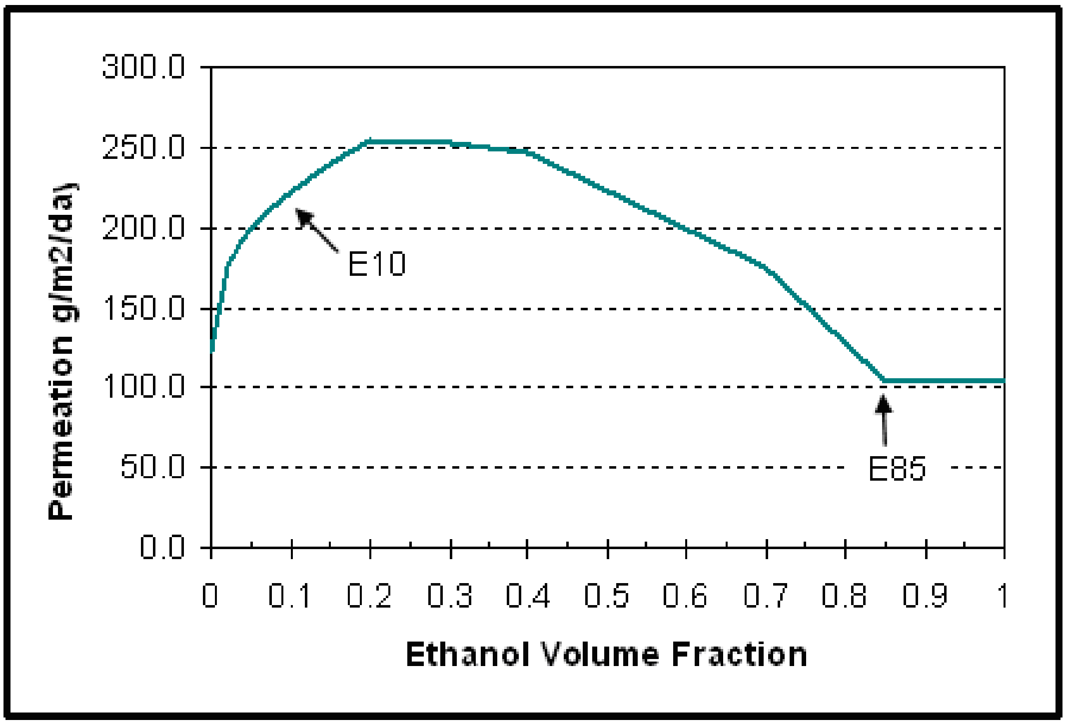
$$\text{Permeation EF} = \text{GasEF} + \text{GasEF} \times (\text{E10fac} - 1) \times [\,(\text{EthVfrac} / 0.10) \wedge 0.4\,]$$

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



It should be noted that all ethanol blends currently modeled with the NONROAD model are less than or equal to E10, so no parts of this curve above E10 are used. Also, 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, VOC, 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	VOC	NOx	PM2.5	PM10	CO
2002	1,064,625	1,047,374	106,804	23,382	25,416	15,091,835
2003	1,026,922	1,009,822	106,852	23,480	25,522	14,351,829
2004	963,709	945,601	106,610	23,483	25,525	13,690,337
2005	886,524	867,081	106,847	23,417	25,453	12,923,819
2006	825,413	804,926	109,233	23,498	25,541	12,252,479
2007	768,239	747,552	109,439	23,804	25,874	11,711,607
2008	718,564	700,010	111,235	24,335	26,451	10,861,441
2009	682,088	665,890	116,329	24,882	27,045	9,992,801
2010	665,762	650,954	118,376	25,402	27,611	9,623,727
2011	663,620	649,358	119,424	25,888	28,139	9,568,610
2012	665,666	651,743	120,820	26,364	28,657	9,579,040
2013	671,328	657,539	122,506	26,832	29,165	9,644,512
2014	679,634	665,819	124,400	27,291	29,664	9,751,728
2015	689,045	675,131	126,395	27,747	30,160	9,879,027
2016	699,225	685,164	128,468	28,202	30,654	10,020,040
2017	709,899	695,658	130,573	28,655	31,146	10,169,185
2018	720,944	706,498	132,701	29,107	31,638	10,324,079
2019	732,284	717,615	134,846	29,558	32,128	10,483,706
2020	743,755	728,853	137,002	30,009	32,618	10,645,870
2021	755,254	740,118	139,160	30,460	33,109	10,808,929
2022	766,782	751,412	141,317	30,911	33,599	10,972,659
2023	778,333	762,727	143,475	31,362	34,089	11,136,954
2024	789,900	774,056	145,636	31,813	34,579	11,301,731
2025	801,493	785,411	147,806	32,265	35,070	11,467,292
2026	813,217	796,890	150,003	32,718	35,563	11,634,934
2027	824,971	808,397	152,209	33,173	36,057	11,803,402
2028	836,736	819,915	154,418	33,627	36,551	11,972,207
2029	848,508	831,439	156,628	34,081	37,045	12,141,251
2030	860,287	842,970	158,840	34,535	37,538	12,310,505
2031	872,069	854,504	161,053	34,990	38,032	12,479,899
2032	883,856	866,042	163,266	35,444	38,526	12,649,385
2033	895,645	877,583	165,479	35,898	39,020	12,818,940
2034	907,437	889,126	167,692	36,353	39,514	12,988,554
2035	919,232	900,672	169,906	36,807	40,008	13,158,228
2036	931,029	912,219	172,119	37,261	40,502	13,327,954
2037	942,828	923,769	174,332	37,716	40,995	13,497,732
2038	954,629	935,321	176,546	38,170	41,489	13,667,556
2039	966,431	946,874	178,759	38,625	41,983	13,837,424
2040	978,235	958,429	180,973	39,079	42,477	14,007,335

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

Year	THC	VOC	NOx	PM2.5	PM10	CO
2002	906,318	931,132	46,311	15,092	16,404	2,472,251
2003	873,287	896,969	49,694	14,417	15,670	2,407,992
2004	836,493	858,916	53,397	13,679	14,869	2,346,538
2005	796,279	817,340	57,862	12,886	14,007	2,266,733
2006	756,781	776,480	63,366	12,090	13,142	2,170,374
2007	717,924	736,303	67,730	11,311	12,295	2,103,059
2008	680,702	697,795	73,894	10,553	11,470	2,007,804
2009	645,730	661,588	82,123	9,824	10,678	1,885,970
2010	612,180	626,901	87,140	9,149	9,945	1,823,844
2011	580,750	594,415	90,516	8,525	9,266	1,788,830
2012	553,441	566,191	93,662	7,983	8,678	1,758,115
2013	530,682	542,671	96,528	7,534	8,189	1,732,653
2014	511,166	522,503	99,197	7,144	7,766	1,710,005
2015	495,178	505,981	101,703	6,823	7,416	1,690,755
2016	481,650	492,000	104,022	6,549	7,118	1,673,978
2017	470,667	480,648	106,158	6,324	6,874	1,660,415
2018	462,602	472,308	108,084	6,156	6,691	1,650,631
2019	455,864	465,336	109,885	6,012	6,535	1,642,841
2020	451,176	460,481	111,525	5,908	6,422	1,638,114
2021	447,624	456,799	113,063	5,826	6,333	1,635,047
2022	445,371	454,457	114,479	5,768	6,270	1,634,065
2023	443,951	452,972	115,802	5,726	6,224	1,634,672
2024	443,203	452,179	117,052	5,696	6,191	1,636,603
2025	443,196	452,151	118,228	5,680	6,174	1,639,914
2026	443,770	452,720	119,344	5,675	6,168	1,644,492
2027	444,806	453,764	120,401	5,678	6,172	1,650,159
2028	446,152	455,126	121,411	5,687	6,182	1,656,748
2029	447,768	456,766	122,387	5,701	6,197	1,663,933
2030	449,626	458,656	123,335	5,719	6,217	1,671,627
2031	451,666	460,733	124,260	5,741	6,240	1,679,753
2032	453,836	462,943	125,166	5,765	6,266	1,688,228
2033	456,159	465,310	126,052	5,792	6,296	1,697,074
2034	458,592	467,790	126,922	5,821	6,327	1,706,229
2035	461,115	470,363	127,777	5,851	6,360	1,715,675
2036	463,691	472,990	128,621	5,883	6,394	1,725,343
2037	466,323	475,674	129,454	5,915	6,429	1,735,210
2038	468,999	478,403	130,278	5,948	6,465	1,745,240
2039	471,706	481,164	131,095	5,982	6,502	1,755,400
2040	474,437	483,949	131,907	6,016	6,539	1,765,651

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.[c] 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)[18] 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 Chapter 2. Many of these compounds are also part of the THC and VOC 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 were developed using EPA's National Mobile Inventory Model (NMIM). This model is an analytical framework that links a county-level database to our NONROAD model 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 on a much finer scale than is possible when running the standalone NONROAD model. Emissions were modeled for all of the small nonroad and marine SI equipment categories in the continental United States, including California. Hence, the hazardous emission inventories presented here include the emissions from engines that are regulated by that State. As a result, the emission inventories are slightly overstated relative to the those from the small nonroad and marine SI engines subject to the federal Phase 3 requirements.

Table 3.2-10 presents the 50-state baseline inventories for toxic air emissions from small nonroad SI engines in 2002, 2020, 2030. Table 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	Formalde-hyde	Acetalde-hyde	Acrolein	Naphthalene	POM
2002	35,086	5,561	8,664	2,900	505	447	97
2020	23,216	3,468	5,802	2,792	291	638	131
2030	26,776	3,999	6,691	3,217	336	739	152

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

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

Year	Benzene	1,3 Butadiene	Formalde-hyde	Acetalde-hyde	Acrolein	Naphthalene	POM
2002	23,110	2,053	2,153	1,543	211	37	31
2020	8,417	763	535	818	27	42	16
2030	8,476	751	525	811	27	46	16

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 final 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.

The national inventories are presented for 2002, 2020, and 2030 for all 50-states and the District of Columbia.[19] The stationary, highway, and aircraft inventories were taken directly from EPA's National Emissions Inventory (NEI) modeling platform for 2002.[20] The emission inventories for locomotives, and Classes 1 and 2 commercial marine engines were taken from our recent final rule for these mobile source categories.[21] The inventories for Class 3 commercial marine engines was take from our recent advance notice of final rulemaking for that category of engines.[22] The emission estimates for portable fuel containers was taken from the recent final MSAT rule.[23] All of the land-based nonroad engine emission inventories was developed using the NONROAD2005d model, as previously described.[d] Finally, these inventories account for the future use of renewable fuels as required by the Energy Policy Act of 2005.

3.3.1 VOC Emissions Contribution

Table 3.3-1 provides the contribution of small nonroad SI engines, marine SI engines and other source categories to nationwide VOC emissions. The emissions from small nonroad (<19kW) and marine SI engines are 26 percent of the mobile source inventory and 12 percent of the total manmade VOC emissions in 2002. These percentages decrease slightly to 23 percent and 10 percent, respectively, by 2030.

[d] The modeling inputs for diesel nonroad engines that were used in NONROAD2005d for this final rule are the same as those contained in the NONROAD2005a public.

3.3.2 NOx Emissions Contribution

Table 3.3-2 provides the contribution of nonroad small nonroad SI engines, marine SI engines and other source categories to nationwide NOx emissions. The emissions from small nonroad and marine SI engines are about 1 percent of the mobile source inventory and about 1 percent of the total manmade NOx emissions in 2002. These percentages increase to 6 percent and 3 percent, respectively, by 2030.

3.3.3 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 nationwide $PM_{2.5}$ and PM_{10} emissions, respectively. Both particle size categories from small nonroad and marine SI engines are about 8 percent of the mobile source inventory and approximately 1 percent of the total manmade $PM_{2.5}$ emissions in 2002. The mobile source percentage increases to about 12 percent and the total manmade percentage stay about the same at 1 percent by 2030.

3.3.4 CO Emissions Contribution

Table 3.3-5 provides the contribution of small nonroad SI engines, marine SI engines, and other source categories to nationwide CO emissions. The emissions from small nonroad and marine SI engines are 23 percent of the mobile source inventory and 10 percent of the total manmade CO emissions in 2002. These percentages decrease to 30 percent and increase to 25 percent, respectively, by 2030.

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

Category	2002			2020			2030		
	short tons	% of mobile	% of total	short tons	% of mobile	% of total	short tons	% of mobile	% of total
Small Nonroad SI total	*1,165,257*	*14.0%*	*6.6%*	*808,873*	*19.6%*	*6.3%*	*935,619*	*23.1%*	*7.3%*
NonHandheld Small SI	*675,311*	*8.1%*	*3.8%*	*590,186*	*14.3%*	*4.6%*	*684,057*	*16.9%*	*5.4%*
Handheld Small SI	*489,946*	*5.9%*	*2.8%*	*218,688*	*5.3%*	*1.7%*	*251,562*	*6.2%*	*2.0%*
Recreational Marine SI	*1,003,325*	*12.1%*	*5.7%*	*496,183*	*12.0%*	*3.9%*	*494,217*	*12.2%*	*3.9%*
Locomotive	50,665	0.6%	0.3%	27,974	0.7%	0.2%	17,722	0.4%	0.1%
Recreational Marine Diesel	1,538	0.0%	0.0%	2,485	0.1%	0.0%	2,912	0.1%	0.0%
Commercial Marine (C1 & C2)	17,229	0.2%	0.1%	11,478	0.3%	0.1%	6,911	0.2%	0.1%
Land-Based Nonroad Diesel	184,868	2.2%	1.0%	76,817	1.9%	0.6%	63,342	1.6%	0.5%
Commercial Marine (C3)	26,175	0.3%	0.1%	53,204	1.3%	0.4%	79,697	2.0%	0.6%
SI Recreational Vehicles	551,285	6.6%	3.1%	442,121	10.7%	3.4%	382,468	9.5%	3.0%
Large Nonroad SI (>25hp)	134,950	1.6%	0.8%	11,957	0.3%	0.1%	9,953	0.2%	0.1%
Portable Fuel Containers	243,994	2.9%	1.4%	38,185	0.9%	0.3%	43,375	1.1%	0.3%
Aircraft	52,651	0.6%	0.3%	63,251	1.5%	0.5%	67,730	1.7%	0.5%
Total Off Highway	3,431,938	41.3%	19.3%	2,032,530	49.2%	15.8%	2,103,947	52.0%	16.5%
Highway Diesel	191,514	2.3%	1.1%	129,321	3.1%	1.0%	140,959	3.5%	1.1%
Highway Non-Diesel	4,684,391	56.4%	26.4%	1,973,180	47.7%	15.3%	1,800,856	44.5%	14.1%
Total Highway	4,875,904	58.7%	27.5%	2,102,501	50.8%	16.3%	1,941,815	48.0%	15.2%
Total Diesel (distillate) Mobile	445,814	5.4%	2.5%	248,075	6.0%	1.9%	231,847	5.7%	1.8%
Total Mobile Sources	8,307,843	100%	46.8%	4,135,030	100%	32.1%	4,045,762	100%	31.6%
Stationary Point and Area Sources	9,433,356	-	53.2%	8,740,057	-	67.9%	8,740,057	-	68.4%
Total Man-Made Sources	17,741,198	-	100%	12,875,088	-	100%	12,785,819	-	100%

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

Category	2002			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Small Nonroad SI	*119,833*	*0.9%*	*0.6%*	*153,872*	*2.7%*	*1.3%*	*178,406*	*3.4%*	*1.6%*
~~NonHandheld Small SI~~	*116,743*	*0.9%*	*0.5%*	*148,004*	*2.6%*	*1.3%*	*171,650*	*3.2%*	*1.6%*
~~Handheld Small SI~~	*3,090*	*0.0%*	*0.0%*	*5,867*	*0.1%*	*0.1%*	*6,756*	*0.1%*	*0.1%*
Recreational Marine SI	*49,902*	*0.4%*	*0.2%*	*120,172*	*2.1%*	*1.0%*	*132,898*	*2.5%*	*1.2%*
Locomotive	1,118,786	8.8%	5.2%	669,405	11.7%	5.8%	437,245	8.3%	4.0%
Recreational Marine Diesel	40,437	0.3%	0.2%	43,579	0.76%	0.38%	43,665	0.8%	0.4%
Commercial Marine (C1 & C2)	834,025	6.5%	3.9%	499,798	8.77%	4.36%	308,614	5.8%	2.8%
Land-Based Nonroad Diesel	1,555,812	12.2%	7.3%	683,481	12.0%	5.96%	435,774	8.2%	3.9%
Commercial Marine (C3)	745,224	5.9%	3.5%	1,368,420	24.00%	11.93%	2,023,974	38.3%	18.3%
SI Recreational Vehicles	10,614	0.1%	0.0%	30,108	0.5%	0.3%	34,318	0.6%	0.3%
Large Nonroad SI (>25hp)	336,292	2.6%	1.6%	48,270	0.8%	0.42%	47,766	0.9%	0.4%
Aircraft	103,591	0.8%	0.5%	132,278	2.32%	1.15%	143,986	2.7%	1.3%
Total Off Highway	4,914,515	38.6%	23.0%	3,749,382	65.8%	32.7%	3,786,645	71.6%	34.2%
Highway Diesel	3,529,046	27.7%	16.5%	681,142	11.9%	5.9%	355,817	6.7%	3.2%
Highway Non-Diesel	4,293,733	33.7%	20.1%	1,270,269	22.3%	11.1%	1,144,199	21.6%	10.3%
Total Highway	7,822,779	61.4%	36.6%	1,951,411	34.2%	17.0%	1,500,016	28.4%	13.6%
Total Diesel (distillate) Mobile	7,078,105	55.6%	33.2%	2,577,404	45.2%	22.5%	1,581,115	29.9%	14.3%
Total Mobile Sources	12,737,294	100%	59.7%	5,700,793	100%	49.7%	5,286,661	100%	47.8%
Stationary Point and Area Sources	8,613,718	-	40.3%	5,773,927	-	50.3%	5,773,927	-	52.2%
Total Man-Made Sources	21,351,012	-	100%	11,474,721	-	100%	11,060,589	-	100%

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

Category	2002			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Small Nonroad SI	*25,700*	*5.2%*	*0.7%*	*32,905*	*10.0%*	*1.0%*	*37,878*	*10.7%*	*1.1%*
~~NonHandheld Small SI~~	*4,841*	*1.0%*	*0.1%*	*6,957*	*2.1%*	*0.2%*	*8,065*	*2.3%*	*0.2%*
~~Handheld Small SI~~	*20,859*	*4.2%*	*0.6%*	*25,947*	*7.9%*	*0.8%*	*29,813*	*8.4%*	*0.9%*
Recreational Marine SI	*16,262*	*3.3%*	*0.5%*	*6,367*	*1.9%*	*0.2%*	*6,163*	*1.7%*	*0.2%*
Locomotive	29,660	5.99%	0.84%	15,145	4.59%	0.45%	8,584	2.42%	0.25%
Recreational Marine Diesel	1,096	0.22%	0.03%	973	0.29%	0.03%	1,053	0.30%	0.03%
Commercial Marine (C1 & C2)	28,730	5.80%	0.82%	15,787	4.78%	0.47%	10,017	2.82%	0.29%
Land-Based Nonroad Diesel	159,111	32.1%	4.52%	46,056	13.9%	1.36%	17,902	5.0%	0.53%
Commercial Marine (C3)	54,667	11.04%	1.55%	110,993	33.61%	3.29%	166,161	46.78%	4.88%
SI Recreational Vehicles	13,710	2.8%	0.4%	11,901	3.6%	0.4%	10,090	2.8%	0.3%
Large Nonroad SI (>25hp)	1,652	0.3%	0.05%	2,421	0.7%	0.07%	2,844	0.8%	0.08%
Aircraft	17,979	3.63%	0.51%	22,176	6.72%	0.66%	24,058	6.77%	0.71%
Total Off Highway	348,568	70.4%	9.9%	264,722	80.2%	7.8%	284,749	80.2%	8.4%
Highway Diesel	94,982	19.2%	2.7%	20,145	6.1%	0.6%	18,802	5.3%	0.6%
Highway non-diesel	51,694	10.4%	1.5%	45,329	13.7%	1.3%	51,621	14.5%	1.5%
Total Highway	146,676	29.6%	4.2%	65,474	19.8%	1.9%	70,423	19.8%	2.1%
Total Diesel (distillate) Mobile	313,581	63.3%	8.9%	98,106	29.7%	2.9%	56,358	15.9%	1.7%
Total Mobile Sources	495,245	100%	14.1%	330,196	100%	9.8%	355,172	100%	10.4%
Stationary Point and Area Sources	3,025,244	-	85.9%	3,047,714	-	90.2%	3,047,714	-	89.6%
Total Man-Made Sources	3,520,488	-	100%	3,377,911	-	100%	3,402,887	-	100%

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

Category	2002			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Small Nonroad SI	*27,935*	*4.9%*	*0.7%*	*35,766*	*8.5%*	*1.0%*	*41,172*	*9.0%*	*1.1%*
~~*NonHandheld Small SI*~~	*5,262*	*0.9%*	*0.1%*	*7,562*	*1.8%*	*0.2%*	*8,767*	*1.9%*	*0.2%*
~~*Handheld Small SI*~~	*22,673*	*4.0%*	*0.6%*	*28,204*	*6.7%*	*0.8%*	*32,406*	*7.1%*	*0.9%*
Recreational Marine SI	*17,676*	*3.1%*	*0.5%*	*6,920*	*1.7%*	*0.2%*	*6,699*	*1.5%*	*0.2%*
Locomotive	30,578	5.33%	0.82%	15,613	3.73%	0.43%	8,849	1.93%	0.24%
Recreational Marine Diesel	1,130	0.20%	0.03%	1,003	0.24%	0.03%	1,086	0.24%	0.03%
Commercial Marine (C1 & C2)	29,619	5.17%	0.79%	16,275	3.89%	0.45%	10,327	2.25%	0.28%
Land-Based Nonroad Diesel	164,032	28.6%	4.40%	47,480	11.3%	1.31%	18,455	4.0%	0.51%
Commercial Marine (C3)	59,409	10.36%	1.59%	120,617	28.83%	3.34%	180,566	39.32%	4.94%
SI Recreational Vehicles	14,902	2.6%	0.4%	12,936	3.1%	0.4%	10,967	2.4%	0.3%
Large Nonroad SI (>25hp)	1,672	0.3%	0.04%	2,441	0.6%	0.07%	2,866	0.6%	0.08%
Aircraft	24,622	4.30%	0.66%	30,211	7.22%	0.84%	32,714	7.12%	0.90%
Total Off Highway	371,575	64.8%	10.0%	289,263	69.1%	8.0%	313,702	68.3%	8.6%
Highway Diesel	109,097	19.0%	2.9%	32,733	7.8%	0.9%	34,746	7.6%	1.0%
Highway non-diesel	92,531	16.1%	2.5%	96,380	23.0%	2.7%	110,796	24.1%	3.0%
Total Highway	201,628	35.2%	5.4%	129,113	30.9%	3.6%	145,542	31.7%	4.0%
Total Diesel (distillate) Mobile	334,456	58.3%	9.0%	113,105	27.0%	3.1%	73,464	16.0%	2.0%
Total Mobile Sources	573,203	100%	15.4%	418,376	100%	11.6%	459,244	100%	12.6%
Stationary Point and Area Sources	3,158,011	-	84.6%	3,194,610	-	88.4%	3,194,610	-	87.4%
Total Man-Made Sources	3,731,215	-	100%	3,612,986	-	100%	3,653,854	-	100%

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

Category	2002			2020			2030		
	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total	short tons	% of mobile source	% of total
Small Nonroad SI	*16,943,267*	*19.9%*	*17.6%*	*11,934,654*	*25.5%*	*20.6%*	*13,803,668*	*26.8%*	*22.1%*
~~NonHandheld Small SI~~	*15,884,854*	*18.7%*	*16.5%*	*11,084,472*	*23.7%*	*19.2%*	*12,826,965*	*24.9%*	*20.5%*
~~Handheld Small SI~~	*1,058,413*	*1.2%*	*1.1%*	*850,181*	*1.8%*	*1.5%*	*976,703*	*1.9%*	*1.6%*
Recreational Marine SI	*2,663,932*	*3.1%*	*2.8%*	*1,765,122*	*3.8%*	*3.1%*	*1,801,234*	*3.5%*	*2.9%*
Locomotive	123,210	0.1%	0.1%	167,488	0.4%	0.3%	195,882	0.4%	0.3%
Recreational Marine Diesel	6,467	0.0%	0.0%	9,374	0.0%	0.0%	10,930	0.0%	0.0%
Commercial Marine (C1 & C2)	151,331	0.2%	0.2%	139,712	0.3%	0.2%	143,791	0.3%	0.2%
Land-Based Nonroad Diesel	860,257	1.0%	0.9%	310,250	0.7%	0.5%	155,576	0.3%	0.2%
Commercial Marine (C3)	59,515	0.1%	0.1%	120,889	0.3%	0.2%	181,032	0.4%	0.3%
SI Recreational Vehicles	1,741,702	2.0%	1.8%	1,910,030	4.1%	3.3%	1,916,102	3.7%	3.1%
Large Nonroad SI (>25hp)	1,801,104	2.1%	1.9%	289,382	0.6%	0.5%	270,827	0.5%	0.4%
Aircraft	557,820	0.7%	0.6%	677,930	1.4%	1.2%	723,842	1.4%	1.2%
Total Off Highway	24,908,605	29.3%	25.8%	17,324,829	37.0%	29.9%	19,202,883	37.3%	30.7%
Highway Diesel	940,898	1.1%	1.0%	260,238	0.6%	0.4%	219,594	0.4%	0.4%
Highway non-diesel	59,178,847	69.6%	61.4%	29,211,716	62.4%	50.5%	32,038,635	62.3%	51.3%
Total Highway	60,119,745	70.7%	62.4%	29,471,955	63.0%	50.9%	32,258,229	62.7%	51.6%
Total Diesel (distillate) Mobile	2,082,164	2.4%	2.2%	887,061	1.9%	1.5%	725,772	1.4%	1.2%
Total Mobile Sources	85,028,351	100%	88.2%	46,796,783	100%	80.9%	51,461,112	100%	82.3%
Stationary Point and Area Sources	11,354,201	-	11.8%	11,049,239	-	19.1%	11,049,239	-	17.7%
Total Man-Made Sources	96,382,552	-	100%	57,846,022	-	100%	62,510,350	-	100%

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 Phase 3 standards. 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 final 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 final 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, VOC, NOx, $PM_{2.5}$, PM_{10}, and CO

The controlled exhaust and evaporative emission inventories for small nonroad and marine SI engines were generated by modifying the input files for NONROAD2005d to account for the engine and equipment controls associated with the Phase 3 standards. (See the baseline emission inventory discussion in Section 3.2 for the changes we made to the publically available NONROAD2005a model to develop NONROAD2005d.) 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 final Phase 3 emission standards and implementation schedule are shown in Table 3.4-1. While the new standards take effect in 2011 for Class II engines and 2012 for Class I engines, we providing a number of flexibilities for engine and equipment manufacturers that will allow the continued production and use of Class II 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 these flexibilities.

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 compliance flexibilities by engine and equipment manufacturers. Used for modeling purposes only.

The modeled emission factors corresponding to the final 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	431.72	0.080	0.08	1.095

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 0.735 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 final 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 final 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 establishing 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 final 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	20.9	4.8	542	640	563	563
2.3-4.5 kW	22.1	3.6	357	538	560	560
4.6-8.2 kW	15.5	5.6	292	243	555	555
8.3-11.9 kW	11.6	6.8	248	231	552	552
12.0-18.6 kW	12.5	4.3	205	218	543	543
18.7-29.8 kW	10.2	5.7	189	206	528	528
29.9-37.3 kW	9.3	5.9	167	206	507	507
37.4-55.9 kW	9.2	5.4	169	206	471	486
55.9-74.6 kW	9.2	5.4	169	206	471	486
74.7-130.5 kW	9.2	5.0	173	202	415	394
130.6+ kW	10.2	3.7	137	178	387	380

For sterndrive and inboards, we developed a new engine classification similar to the OB/PWC discussion above. SD/I engines at or below 373 kW are modeled to meet the final 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. High performance engines have two tiers of standards that can be achieved through the use of engine-based technology. Although the standards distinguish between two power ranges for high-performance, a single weighted EF is used here. CO emission factors are based on meeting the final 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	
kW ≤373 kW	1.80	1.64	1.60	1.15	55.0	1.36	345
> 373 kW, Tier 1	11.80	1.69	6.70	1.38	207	1.81	362
> 373 kW, Tier 2	8.58	1.69	6.80	1.38	207	1.81	362

3.4.1.2 Controlled Evaporative Emission Rates

Below, we present the effect of the final Phase 3 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 final 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 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. The same correction factors used to account for the effect of ethanol on permeation are used in the control and baseline cases.

Fill neck and vent hose containing vapor rather than liquid fuel are not subject to the final standards. No emission reductions are modeled for these hose types. In addition, no emission reductions are modeled for hose on handheld equipment used in cold weather applications (e.g. Class V chainsaws).

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 final 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 0.75 g/gal/day at 29°C on gasoline. 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. The same correction factors used to account for the effect of ethanol on permeation are used in the control and baseline cases.

One exception to the above discussion is metal tanks. For these fuel tanks, we do not include any emissions reductions from baseline.

3.4.1.2.3 Diurnal

We are not establishing a diurnal emission requirement for small nonroad SI equipment. Therefore, we do not model direct reductions in diurnal emissions. However, we are placing 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 SI engines, 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 final 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 final 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, VOC, NOx, $PM_{2.5}$, PM_{10}, CO and SO_2

Tables 3.4-5 presents the 50-state controlled emission inventories 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	VOC	NOx	PM2.5	PM10	CO
2002	1,064,625	1,047,374	106,804	23,382	25,416	15,091,835
2003	1,026,922	1,009,822	106,852	23,480	25,522	14,351,829
2004	963,709	945,601	106,610	23,483	25,525	13,690,337
2005	886,524	867,081	106,847	23,417	25,453	12,923,819
2006	825,413	804,926	109,233	23,498	25,541	12,252,479
2007	768,239	747,552	109,439	23,804	25,874	11,711,607
2008	713,266	694,712	111,235	24,335	26,451	10,861,441
2009	669,782	653,584	116,329	24,882	27,045	9,992,801
2010	646,659	631,851	118,376	25,402	27,611	9,623,727
2011	618,463	604,977	107,135	25,888	28,139	9,427,359
2012	573,611	562,317	96,222	26,364	28,445	9,240,448
2013	535,035	525,722	86,623	26,832	28,747	9,125,886
2014	509,895	501,985	81,011	27,291	29,071	9,107,104
2015	495,565	488,517	76,412	27,747	29,473	9,135,515
2016	486,951	480,492	73,517	28,202	29,896	9,201,411
2017	484,102	477,989	72,202	28,655	30,336	9,298,167
2018	485,460	479,510	71,768	29,107	30,795	9,415,010
2019	488,969	483,092	71,822	29,558	31,259	9,543,762
2020	493,763	487,905	72,175	30,009	31,727	9,679,462
2021	499,618	493,736	72,848	30,460	32,198	9,820,562
2022	506,071	500,141	73,667	30,911	32,671	9,964,572
2023	512,988	506,990	74,592	31,362	33,146	10,110,794
2024	520,130	514,054	75,564	31,813	33,622	10,258,216
2025	527,386	521,227	76,578	32,265	34,098	10,406,862
2026	534,763	528,516	77,629	32,718	34,576	10,557,631
2027	542,202	535,864	78,700	33,173	35,055	10,709,373
2028	549,676	543,246	79,782	33,627	35,534	10,861,555
2029	557,179	550,657	80,875	34,081	36,013	11,014,081
2030	564,711	558,094	81,977	34,535	36,492	11,166,921
2031	572,261	565,549	83,086	34,990	36,971	11,319,980
2032	579,823	573,015	84,197	35,444	37,450	11,473,166
2033	587,396	580,492	85,312	35,898	37,929	11,626,453
2034	594,978	587,978	86,429	36,353	38,408	11,779,824
2035	602,567	595,471	87,547	36,807	38,887	11,933,276
2036	610,167	602,974	88,669	37,261	39,366	12,086,826
2037	617,776	610,486	89,795	37,716	39,845	12,240,473
2038	625,391	618,003	90,922	38,170	40,324	12,394,188
2039	633,010	625,525	92,051	38,625	40,803	12,547,962
2040	640,633	633,050	93,181	39,079	41,282	12,701,792

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

Year	THC	VOC	NOx	PM2.5	PM10	CO
2002	906,318	931,132	46,311	15,092	16,404	2,472,251
2003	873,287	896,969	49,694	14,417	15,670	2,407,992
2004	836,493	858,916	53,397	13,679	14,869	2,346,538
2005	796,279	817,340	57,862	12,886	14,007	2,266,733
2006	756,781	776,480	63,366	12,090	13,142	2,170,374
2007	717,924	736,303	67,730	11,311	12,295	2,103,059
2008	680,702	697,795	73,894	10,553	11,470	2,007,804
2009	644,330	660,187	82,123	9,824	10,678	1,885,970
2010	593,432	607,656	84,822	8,832	9,600	1,808,304
2011	543,080	555,760	85,353	7,891	8,577	1,755,638
2012	495,189	506,468	85,673	7,035	7,647	1,707,370
2013	452,028	462,066	85,732	6,275	6,820	1,664,442
2014	412,280	421,190	85,609	5,577	6,062	1,624,423
2015	376,203	384,108	85,334	4,951	5,381	1,587,889
2016	342,807	349,793	84,890	4,376	4,756	1,553,983
2017	312,281	318,441	84,279	3,856	4,191	1,523,443
2018	285,067	290,507	83,468	3,399	3,695	1,496,863
2019	259,742	264,519	82,546	2,978	3,237	1,472,528
2020	238,704	242,957	81,398	2,640	2,869	1,452,196
2021	219,826	223,621	80,081	2,341	2,545	1,433,655
2022	203,027	206,427	78,657	2,081	2,262	1,417,440
2023	188,065	191,121	77,197	1,851	2,012	1,403,195
2024	175,954	178,752	75,802	1,673	1,818	1,391,146
2025	166,147	168,751	74,424	1,534	1,668	1,380,739
2026	157,943	160,391	73,057	1,419	1,542	1,371,913
2027	151,063	153,384	71,713	1,323	1,438	1,364,592
2028	145,397	147,624	70,421	1,247	1,355	1,358,936
2029	140,670	142,822	69,236	1,185	1,288	1,354,638
2030	136,990	139,083	68,639	1,137	1,236	1,353,989
2031	134,079	136,124	68,339	1,099	1,194	1,355,439
2032	131,797	133,803	68,148	1,067	1,160	1,357,905
2033	130,067	132,045	68,038	1,043	1,134	1,361,273
2034	128,766	130,723	67,985	1,024	1,113	1,365,343
2035	127,853	129,798	67,975	1,010	1,098	1,370,010
2036	127,275	129,212	68,009	1,001	1,088	1,375,199
2037	126,952	128,888	68,077	995	1,081	1,380,822
2038	126,816	128,753	68,174	991	1,077	1,386,805
2039	126,828	128,769	68,302	989	1,075	1,393,116
2040	126,959	128,906	68,461	989	1,075	1,399,715

3.4.2 Controlled Hazardous Air Pollutant Estimates

The final 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 multiplied the baseline hazardous air pollutant estimates (Section 3.2.2) by the ratio of control and baseline emission inventories (Section 3.2.1.4 and 3.4.1.3, respectively) for VOC or PM, as appropriate. More specifically, we used the VOC ratio for all toxic pollutant species that are found in the gas phase. The gas phase pollutants are all the species described below, except for naphthalene and the polycyclic organic matter (POM) compounds that are found in both the gas and particulate phase. In these cases, we used the PM ratio to estimate the controlled inventories.

Controlled inventories were calculated for the seven major types of air toxic emissions: benzene, formaldeyde, acetaldehyde, 1,3-butadiene, acrolein, naphthalene, and 15 other compounds grouped together as POM for this analysis.[e] Table 3.4-7 presents the 50-state controlled inventories, respectively, small nonroad SI engines. Table 3.4-8 provides 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	Naphthalene	POM
2002	35,086	5,561	8,664	2,900	505	447	97
2020	15,413	2,504	4,189	2,015	210	620	128
2030	17,577	2,859	4,784	2,300	240	718	147

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	Naphthalene	POM
2002	23,110	2,053	2,153	1,543	211	37	31
2020	4,453	390	273	418	14	19	7
2030	2,582	216	151	234	8	9	3

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

3.5 Projected Emissions Reductions from the Final Rule

This section presents the projected total emission reductions associated with the final Phase 3 standards. We calculated the reductions by subtracting the baseline inventories from Section 3.2 by the controlled inventories from Section 3.4.

3.5.1 Results for THC, VOC, 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 final rule. The earliest Phase 3 evaporative standards for small nonroad SI engines begin in 2008. Similar final evaporative 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 3.5-5 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 Spark-Ignition Engines (short tons)

	THC		VOC		NOx		PM2.5		PM10		CO	
Year	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2008	5,298	1	5,298	1	0	0	0	0	0	0	0	0
2009	12,306	2	12,306	2	0	0	0	0	0	0	0	0
2010	19,103	3	19,103	3	0	0	0	0	0	0	0	0
2011	45,157	7	44,381	7	12,289	10	0	0	0	0	141,251	1
2012	92,055	14	89,426	14	24,598	20	195	1	212	1	338,592	4
2013	136,293	20	131,817	20	35,882	29	385	1	419	1	518,625	5
2014	169,739	25	163,834	25	43,389	35	546	2	594	2	644,624	7
2015	193,479	28	186,614	28	49,983	40	632	2	687	2	743,512	8
2016	212,274	30	204,672	30	54,951	43	697	2	758	2	818,628	8
2017	225,797	32	217,669	32	58,371	45	745	3	810	3	871,019	9
2018	235,483	33	226,988	33	60,933	46	776	3	843	3	909,068	9
2019	243,315	33	234,523	33	63,024	47	800	3	870	3	939,944	9
2020	249,991	34	240,948	34	64,827	47	820	3	892	3	966,407	9
2021	255,636	34	246,382	34	66,312	48	838	3	911	3	988,367	9
2022	260,711	34	251,271	34	67,650	48	854	3	928	3	1,008,088	9
2023	265,345	34	255,737	34	68,883	48	868	3	943	3	1,026,161	9
2024	269,770	34	260,002	34	70,072	48	881	3	958	3	1,043,515	9
2025	274,107	34	264,185	34	71,228	48	894	3	972	3	1,060,430	9
2026	278,455	34	268,375	34	72,374	48	908	3	987	3	1,077,303	9
2027	282,769	34	272,533	34	73,509	48	922	3	1,002	3	1,094,028	9
2028	287,060	34	276,668	34	74,635	48	936	3	1,017	3	1,110,652	9
2029	291,328	34	280,782	34	75,753	48	949	3	1,032	3	1,127,170	9
2030	295,576	34	284,876	34	76,863	48	963	3	1,047	3	1,143,584	9
2031	299,808	34	288,955	34	77,967	48	977	3	1,062	3	1,159,920	9
2032	304,033	34	293,027	34	79,068	48	990	3	1,076	3	1,176,219	9
2033	308,250	34	297,091	34	80,167	48	1,004	3	1,091	3	1,192,487	9
2034	312,460	34	301,148	34	81,264	48	1,018	3	1,106	3	1,208,730	9
2035	316,665	34	305,201	34	82,359	48	1,031	3	1,121	3	1,224,953	9
2036	320,862	34	309,246	34	83,450	48	1,045	3	1,136	3	1,241,128	9
2037	325,052	34	313,284	34	84,537	48	1,059	3	1,151	3	1,257,259	9
2038	329,238	34	317,318	34	85,623	48	1,072	3	1,166	3	1,273,368	9
2039	333,421	35	321,349	35	86,708	49	1,086	3	1,181	3	1,289,462	9
2040	337,602	35	325,379	35	87,792	49	1,100	3	1,195	3	1,305,543	9

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

	THC		VOC		NOx		PM2.5		PM10		CO	
Year	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2009	1,400	0	1,400	0	0	0	0	0	0	0	0	0
2010	18,748	3	19,245	3	2,318	3	317	3	344	3	15,540	1
2011	37,670	6	38,656	7	5,163	6	634	7	689	7	33,192	2
2012	58,252	11	59,723	11	7,989	9	948	12	1,031	12	50,745	3
2013	78,654	15	80,605	15	10,796	11	1,259	17	1,369	17	68,211	4
2014	98,886	19	101,313	19	13,588	14	1,567	22	1,703	22	85,582	5
2015	118,974	24	121,873	24	16,369	16	1,872	27	2,035	27	102,867	6
2016	138,843	29	142,207	29	19,131	18	2,173	33	2,362	33	119,995	7
2017	158,386	34	162,207	34	21,879	21	2,468	39	2,683	39	136,972	8
2018	177,535	38	181,801	38	24,617	23	2,756	45	2,996	45	153,767	9
2019	196,122	43	200,818	43	27,340	25	3,034	50	3,298	50	170,313	10
2020	212,471	47	217,524	47	30,128	27	3,269	55	3,553	55	185,917	11
2021	227,798	51	233,178	51	32,981	29	3,485	60	3,788	60	201,392	12
2022	242,345	54	248,030	55	35,822	31	3,688	64	4,008	64	216,625	13
2023	255,886	58	261,851	58	38,605	33	3,875	68	4,212	68	231,477	14
2024	267,248	60	273,428	60	41,250	35	4,023	71	4,373	71	245,457	15
2025	277,049	63	283,400	63	43,803	37	4,146	73	4,506	73	259,174	16
2026	285,828	64	292,329	65	46,286	39	4,256	75	4,626	75	272,579	17
2027	293,743	66	300,379	66	48,689	40	4,355	77	4,734	77	285,568	17
2028	300,755	67	307,503	68	50,990	42	4,440	78	4,826	78	297,811	18
2029	307,097	69	313,944	69	53,151	43	4,516	79	4,909	79	309,295	19
2030	312,636	70	319,573	70	54,696	44	4,582	80	4,981	80	317,638	19
2031	317,588	70	324,609	70	55,921	45	4,642	81	5,046	81	324,313	19
2032	322,039	71	329,140	71	57,018	46	4,698	81	5,107	81	330,323	20
2033	326,092	71	333,265	72	58,015	46	4,749	82	5,162	82	335,801	20
2034	329,826	72	337,067	72	58,937	46	4,797	82	5,214	82	340,886	20
2035	333,261	72	340,565	72	59,802	47	4,841	83	5,262	83	345,665	20
2036	336,417	73	343,778	73	60,611	47	4,882	83	5,306	83	350,145	20
2037	339,371	73	346,786	73	61,377	47	4,920	83	5,348	83	354,388	20
2038	342,183	73	349,649	73	62,104	48	4,957	83	5,388	83	358,435	21
2039	344,878	73	352,395	73	62,793	48	4,993	83	5,427	83	362,283	21
2040	347,477	73	355,043	73	63,445	48	5,027	84	5,464	84	365,936	21

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

	THC		VOC		NOx		PM2.5		PM10		CO	
Year	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
2008	5,298	0	5,298	0	0	0	0	0	0	0	0	0
2009	13,706	1	13,706	1	0	0	0	0	0	0	0	0
2010	37,851	3	38,348	3	2,318	1	317	1	344	1	15,540	0
2011	82,827	7	83,037	7	17,451	8	634	2	689	2	174,444	2
2012	150,307	12	149,149	12	32,587	15	1,143	3	1,243	3	389,337	3
2013	214,947	18	212,422	18	46,679	21	1,644	5	1,787	5	586,836	5
2014	268,625	23	265,147	22	56,977	25	2,113	6	2,297	6	730,206	6
2015	312,454	26	308,487	26	66,353	29	2,504	7	2,722	7	846,379	7
2016	351,117	30	346,879	29	74,082	32	2,870	8	3,120	8	938,623	8
2017	384,183	33	379,875	32	80,250	34	3,213	9	3,493	9	1,007,991	9
2018	413,019	35	408,789	35	85,550	36	3,532	10	3,839	10	1,062,836	9
2019	439,437	37	435,340	37	90,363	37	3,834	11	4,168	11	1,110,258	9
2020	462,463	39	458,472	39	94,954	38	4,089	11	4,444	11	1,152,325	9
2021	483,433	40	479,560	40	99,293	39	4,323	12	4,698	12	1,189,759	10
2022	503,056	42	499,301	41	103,472	40	4,541	12	4,936	12	1,224,712	10
2023	521,231	43	517,588	43	107,488	41	4,743	13	5,155	13	1,257,637	10
2024	537,018	44	533,430	44	111,322	42	4,905	13	5,331	13	1,288,972	10
2025	551,156	44	547,584	44	115,031	43	5,040	13	5,479	13	1,319,604	10
2026	564,282	45	560,704	45	118,660	44	5,164	13	5,613	13	1,349,882	10
2027	576,512	45	572,913	45	122,198	45	5,277	14	5,736	14	1,379,596	10
2028	587,814	46	584,171	46	125,625	46	5,376	14	5,843	14	1,408,463	10
2029	598,426	46	594,726	46	128,904	46	5,465	14	5,940	14	1,436,465	10
2030	608,211	46	604,449	46	131,559	47	5,545	14	6,027	14	1,461,222	10
2031	617,396	47	613,565	47	133,888	47	5,619	14	6,107	14	1,484,233	10
2032	626,072	47	622,167	47	136,087	47	5,688	14	6,183	14	1,506,542	11
2033	634,342	47	630,356	47	138,182	47	5,753	14	6,253	14	1,528,288	11
2034	642,286	47	638,215	47	140,201	48	5,814	14	6,320	14	1,549,616	11
2035	649,926	47	645,766	47	142,161	48	5,872	14	6,383	14	1,570,618	11
2036	657,279	47	653,024	47	144,061	48	5,927	14	6,442	14	1,591,273	11
2037	664,423	47	660,069	47	145,914	48	5,979	14	6,499	14	1,611,647	11
2038	671,421	47	666,967	47	147,727	48	6,029	14	6,554	14	1,631,803	11
2039	678,299	47	673,744	47	149,501	48	6,079	14	6,607	14	1,651,746	11
2040	685,079	47	680,422	47	151,237	48	6,127	14	6,660	14	1,671,479	11

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

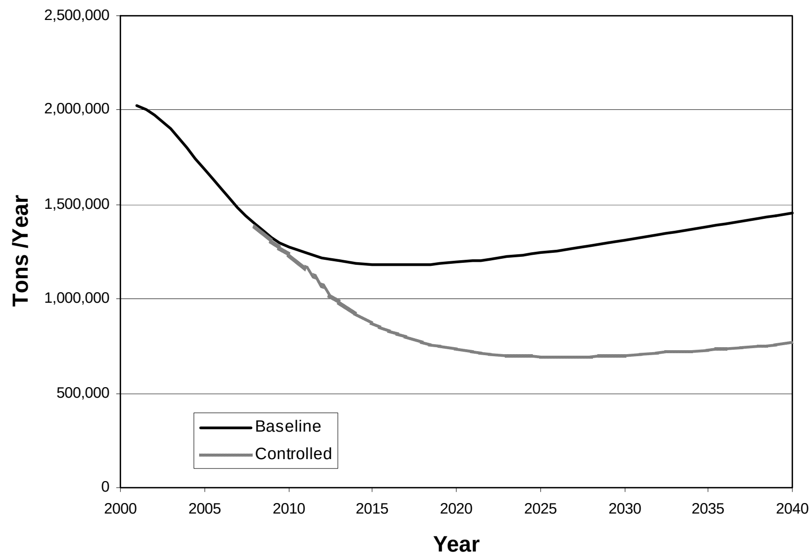


Figure 3.5-2: 50-State Annual VOC Exhaust and Evaporative Emissions for Small SI and Marine SI Engines

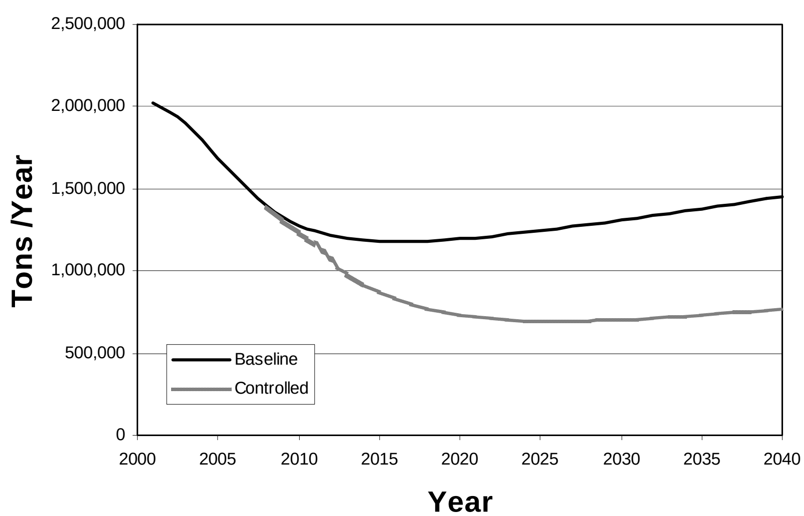


Figure 3.5-2: 50-State Annual NOx Exhaust Emissions for Small SI and Marine SI Engines

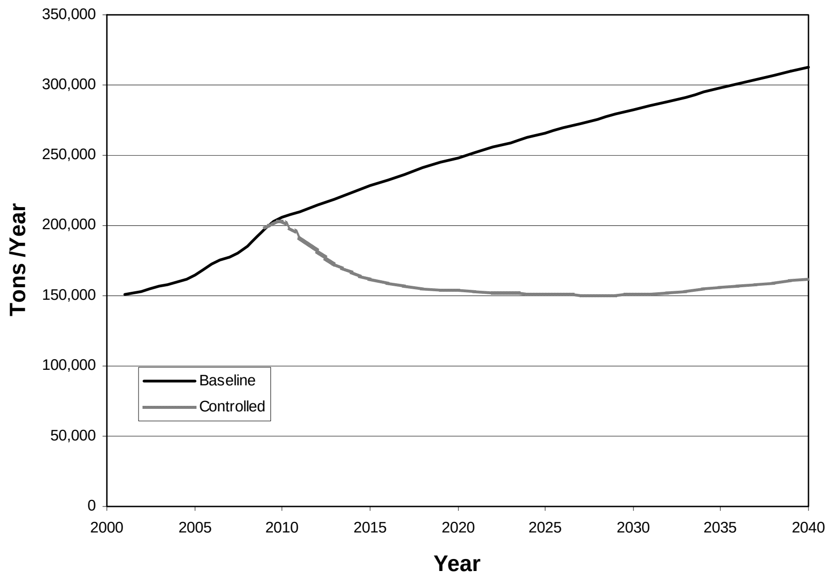


Figure 3.5-3: 50-State Annual PM2.5 Exhaust Emissions for Small SI and Marine SI Engines

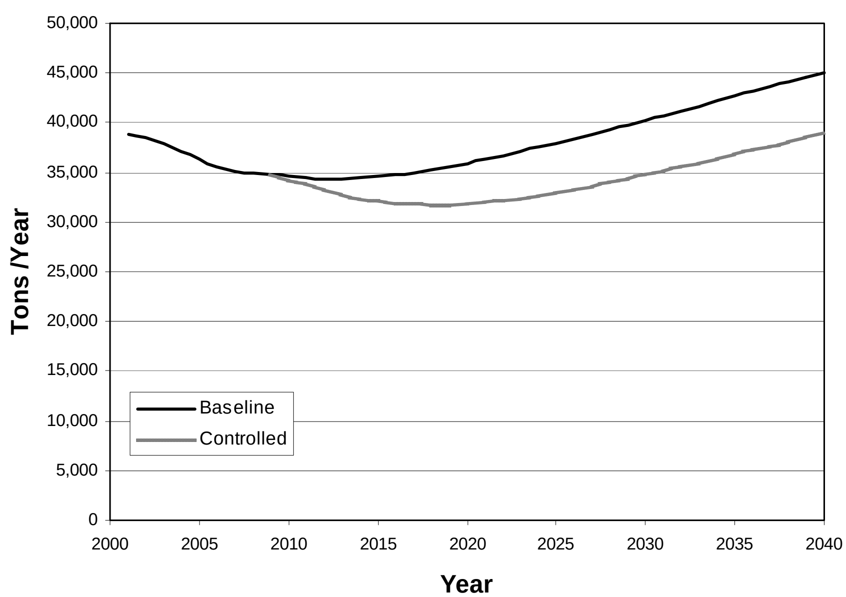
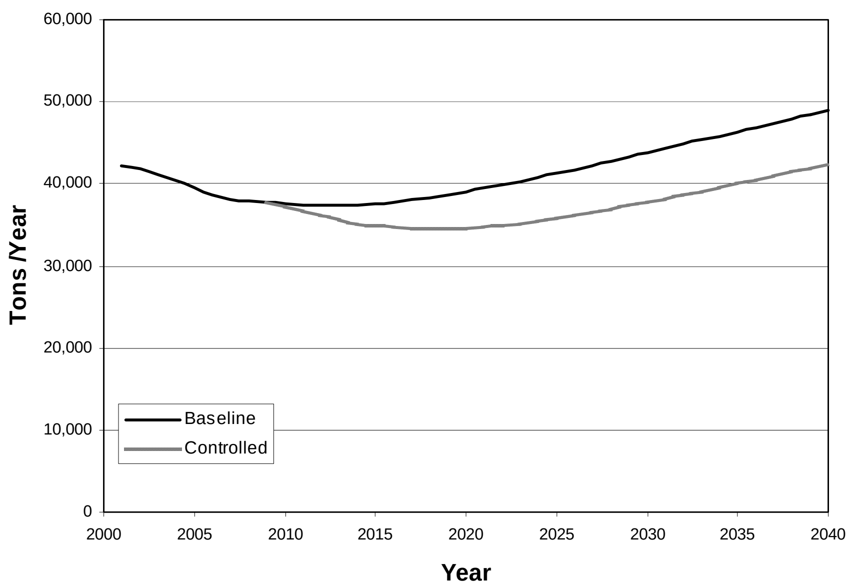
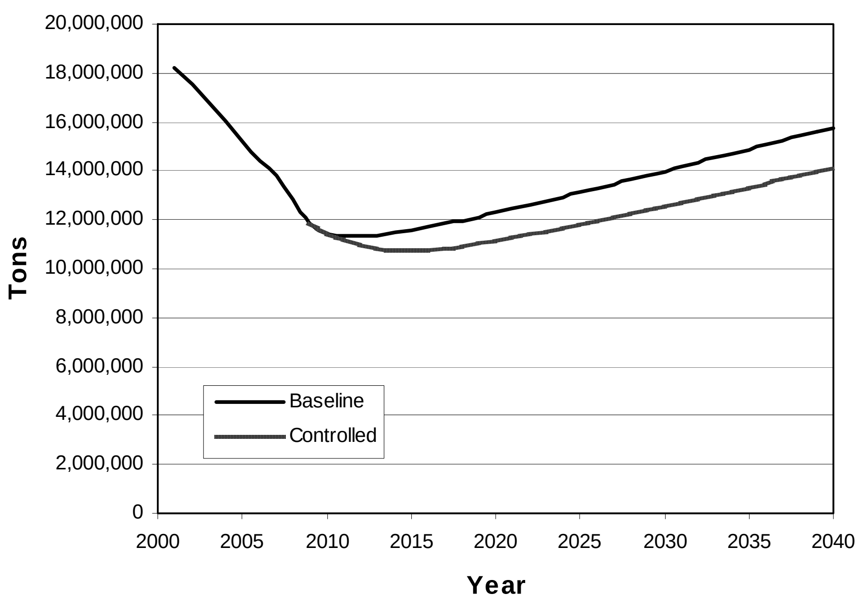


Figure 3.5-4: 50-State Annual PM10 Emissions for Small SI and Marine SI Engines



Figire 3.5-5: 50-State CO Exhaust Emission for Small SI and Marine SI Engines



3.5.2 Results for Hazardous Air Pollutants

Table 3.5-4 presents the 50-state exhaust and evaporative hazardous air pollutant emission reductions for small nonroad SI engines that are expected as a result of the final standards. Table 3.5-5 provides the same information for marine SI engines. Table 3.5-6 summarizes the combined hazardous air pollutant reductions for the final rule. These results are displayed for 2020 and 2030, when most or all of the engines subject to the 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	7,803	34	965	28	1,614	28	777	28	81	28	17	3	4	3
2030	9,200	34	1,140	29	1,907	29	917	29	96	29	21	29	4	3

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	3,964	47	373	49	261	49	400	49	13	49	23	55	9	55
2030	5,893	70	535	71	374	71	577	71	19	71	37	80	13	80

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	11,767	37	1,338	32	1,875	30	1,176	33	94	30	41	6	9	11
2030	15,093	43	1,675	35	2,281	32	1,494	37	115	32	57	7	57	10

3.6 Emission Inventories Used for Air Quality Modeling

This section briefly summaries the methodology we used for air quality modeling purposes and to develop the emission inventories for that modeling. It also describes the changes to our emission inventory modeling inputs and resulting emission inventories that were made between the preliminary baseline and control scenarios used for the air quality modeling, and the updated final baseline and control scenarios for the final Phase 3 rule. These differences often occur because 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. Given that lead time requirement, air quality modeling is often based on analytical methods and inputs that may be superceded, or on a control scenario that does not specifically match the final set of emission standards.

3.6.1 General Description of the Air Quality Modeling

Air quality modeling was performed for the 48 contiguous states and the District of Columbia to estimate the effect of the final rule on future annual fine particulate matter ($PM_{2.5}$) concentrations, 8-hour ozone concentrations, and visibility levels. The analysis was performed for calendar years 2002, 2020, and 2030 using the Community Multiscale Air Quality (CMAQ) model. The model simulates the multiple physical and chemical processes involved in the formation, transport, and destruction of fine particulate and ozone.

The air quality modeling for the final rule was predominately taken directly from the work performed for EPA's recent final rulemaking to control air emissions from locomotive engines and marine compression-ignition engines less than 20 liters per cylinder (the locomotive/marine rule). This approach was adopted to ensure that the air quality modeling for this rule included the effects all EPA's most recent air pollution control regulations and to conserve resources by taking advantage of the existing inventory preparation (i.e., input files), analytical methods, and results.

More specifically, we used the locomotive/marine rule's "control" scenario as our starting point. The resulting baseline for the Phase 3 final rule was then modified to include more recent modeling updates for small nonroad and marine SI engines based on the NONROAD2005d core model and a set of input files that closely matches those used in this final rule. (The differences in the input files used in the preliminary inventories and those for the final rule, which also used NONROAD 2005d core model, are specifically described later in this section.) For air quality modeling purposes, the nonroad model was executed within the framework of EPA's National Mobile Inventory Model (NMIM) that links a county-level database to the model and collates the output into a single database table. The resulting NMIM inventory estimates for nonroad and marine SI engines account for local differences in fuel characteristics and temperatures. By contrast, if NONROAD2005d is run as a stand alone model, results are based on a somewhat less accurate, but much less resource intensive approach that uses national average daily temperatures and fuel characteristics.

The NMIM emissions inventory methodology and results for the highway vehicles and all nonroad sources (including those for small nonroad and marine SI engines) that were used in the air quality assessment are in the docket for this final rule. [24]

3.6.2 Methodology for Comparing the Preliminary Air Quality Emission Inventories and the Final Inventories

The simplest method for comparing the preliminary emission inventories and the inventories represented in the final rule is to compare the emission results from using the NONROAD2005d core model with the national average inputs for temperature and fuel that reflect the modeling assumptions for the preliminary and final rule inventories. This is possible because of the similarities in the underlying use of the NONROAD2005d model. More specifically, even though the two modeling approaches, i.e., NMIM and the stand alone NONROAD2005 model, use different temperature and fuel characteristics, the computational method is the same.[f] This consistency means that the results of the two modeling approaches will be proportional in nature, i.e., the relative changes in the inventories will be similar. Also, as is explained in more detail later, the other basic modeling scenario inputs, e.g., emission factors and deterioration rates, are nearly identical. Taken together, the modeling results from using the NONROAD2005d model with national average inputs for temperature and fuels will closely mirror the differences in inventories produced with NMIM. This avoids the more time and resource intensive approach of rerunning the NMIM model for the final rule scenarios, while still providing a good comparison of the differences in the absolute inventories, i.e., tons, and more importantly for air quality considerations, the percent reduction between the baseline and control cases. Therefore, the comparisons of the preliminary and final emission scenarios that are presented in the following sections are based on comparing 50-state inventories using the nonroad model with national average inputs.

3.6.3 Comparison of the Baseline Scenario Emission Inventories

As described in Section 3.2., the final emission inventories for the Phase 3 rule are based on the use of a special version of the nonroad model, i.e., NONROAD2005d. Similarly, the preliminary emission inventories for air quality modeling were also constructed using the same version NONROAD2005d core model. Therefore, the only difference between the preliminary and final baseline scenarios are the modeling inputs. These differences and a comparison of the respective inventory results are presented below.

3.6.3.1 Differences Between the Preliminary and Final Baseline Scenarios

The modeling inputs for the final baseline scenario are described in Section 3.2.1. The only difference in the inputs for small nonroad SI engines between the preliminary and the final baseline scenarios is that the preliminary results did not include correction of the running loss

[f] The difference between the preliminary emission inventories using NMIM and final rule emission inventories using NONROAD2005d is that the NMIM results, which use county-level data for temperatures and fuel characteristics, are generally 10-15 percent greater depending on the pollutant.

emission factors for Class 1 snowblowers to account for cold weather applications as described in Section 3.2.1.1.1, number 8. There were no differences in the inputs for marine SI engines.

3.6.3.2 Comparison of Preliminary and Final Baseline Emission Inventories

Table 3.6-1 compares the preliminary and final 50-state baseline scenario inventories for small nonroad and marine SI engines. As shown, the differences in the baseline scenarios are insignificant.

Table 3.6-1: Comparison of 50-State Baseline Scenario Emissions for Preliminary Air Quality Modeling and Final Rule

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 Final rule	2020	728,853	729,235	(382)	137,002	137,002	0	30,009	30,009	0
	2030	842,970	843,410	(440)	158,840	158,840	0	34,535	34,535	0
Marine SI	2020	460,481	460,481	0	111,525	111,525	0	5,908	5,908	0
	2030	458,656	458,656	0	123,335	123,335	0	5,719	5,719	0
Total	2020	1,189,334	1,189,716	(382)	248,527	248,527	0	35,917	35,917	0
	2030	1,301,626	1,302,066	(440)	282,175	282,175	0	40,254	40,255	0

Table 3.6-1 (Cont'd)
Comparison of 50-State Baseline Scenario Emissions for Preliminary Air Quality Modeling and Final Rule

Applications	Year	PM_{10} [short tons]			CO [short tons]		
		Final	Preliminary	Difference	Final	Preliminary	Difference
Small Nonroad SI Subject to the Final rule	2020	32,618	32,618	0	10,645,870	10,645,870	0
	2030	37,538	37,538	0	12,310,505	12,310,505	0
Marine SI	2020	6,422	6,422	0	1,638,114	1,638,114	0
	2030	6,217	6,217	0	1,671,627	1,671,627	0
Total	2020	39,041	39,041	0	12,283,983	12,283,983	0
	2030	43,755	43,755	0	13,982,132	13,982,132	0

3.6.4 Comparison of the Control Scenario Emission Inventories

As noted above, the preliminary and final emission inventories for the Phase 3 rule are based on the same version of the nonroad model, i.e., NONROAD2005d. Therefore, the only difference between the scenarios are the modeling inputs. These differences and a comparison of the respective inventory results are presented below.

3.6.4.1 Differences Between the Preliminary and Final Control Scenarios

The modeling inputs for the final control scenario are described in Section 3.4.1. The only difference in the inputs for small nonroad SI engines between the preliminary and the final control scenarios is that the preliminary results excluded the following:

1. Update of the Phase 3 Class II zero-hour emission factor for CO from 391.13 to 431.72 g/kW-hr (321.9 g/hp-hr); and
2. Update of the Phase 3 Class II brake specific fuel consumption values from 0.666 to 0.735 lb/hp-hr to reflect a lower use of electronic fuel injection systems.

For marine SI engines, the only difference in the inputs between the preliminary and the final control scenarios is that the preliminary results excluded the following:

1. Revised several of the HC and NOx emission factors for outboards, personal watercraft, and sterndrive/inboards;
2. Revised the Phase 3 standard phase-in dates for high performance sterndrive/inboards (>600 hp);
3. Delayed by one year the implementation dates for outboards, personal watercraft, and stern drive/inboards; and

4. Delayed by one year the implementation of diurnal Phase 3 controls for portable fuel tanks to 2010 and installed fuel tanks to 2011.

3.6.4.2 Comparison of Preliminary and Final Control Emission Inventories

Table 3.6-2 compares the preliminary and final 50-state control scenario inventories for small nonroad and marine SI engines. As shown, the difference in the control scenarios are insignificant.

Table 3.6-2: Comparison of 50-State Control Scenario Emissions for Preliminary Air Quality Modeling Scenario and Final Rule (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 Final rule	2020	487,905	487,663	242	72,175	72,175	0	29,189	29,189	0
	2030	558,094	557,805	289	81,977	81,977	0	33,572	33,572	0
Marine SI	2020	242,957	241,216	1,741	81,398	81,162	236	2,640	2,640	0
	2030	139,083	136,650	2,433	68,639	68,538	101	1,137	1,137	0
Total	2020	730,862	728,879	1,983	153,573	153,336	237	31,829	31,829	0
	2030	697,177	694,455	2,722	150,616	150,515	101	34,709	34,709	0

Table 3.6-2 (Cont'd)
Comparison of 50-State Control Scenario Emissions for
Preliminary Air Quality Modeling and Final Rule

Applications	Year	PM_{10} [short tons]			CO [short tons]		
		Final	Preliminary	Difference	Final	Preliminary	Difference
Small Nonroad SI Subject to the Final rule	2020	31,727	31,727	0	9,679,462	9,029,001	650,461
	2030	36,492	36,492	0	11,166,921	10,393,508	773,413
Marine SI	2020	2,869	2,869	0	1,452,196	1,447,553	4,643
	2030	1,236	1,236	0	1,353,989	1,345,079	8,910
Total	2020	34,596	34,596	0	11,131,658	10,476,554	655,104
	2030	37,728	37,728	0	12,520,910	11,738,587	782,323

3.6.5 Comparison of the Emission Reduction Inventories

Table 3.6-3 compares the emission reductions for preliminary and final 50-state inventories for small nonroad and marine SI engines. As shown, the differences are insignificant.

Table 3.6-3: Comparison of 50-State Emissions Reductions for Preliminary Air Quality Modeling Scenario and Final Rule (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 Final rule	2020	240,948	241,572	(624)	64,827	64,827	0	820	820	0
	2030	284,876	285,605	(729)	76,863	76,863	0	963	963	0
Marine SI	2020	217,524	219,265	(1,741)	30,128	30,364	(236)	1,287	3,269	(1,982)
	2030	319,573	322,006	(2,433)	54,696	54,797	(101)	3,269	4,582	(1,313)
Total	2020	458,472	460,837	(2,365)	94,955	95,191	(236)	4,082	4,089	(7)
	2030	604,449	607,611	(3,162)	131,559	131,660	(101)	5,545	5,545	0

Table 3.6-3 (Cont'd)
Comparison of 50-State Emission Reductions for
Preliminary Air Quality Modeling and Final Rule

Applications	Year	PM_{10} [short tons]			CO [short tons]		
		Final	Preliminary	Difference	Final	Preliminary	Difference
Small Nonroad SI Subject to the Final rule	2020	892	892	0	966,407	1,616,868	(650,461)
	2030	1,047	1,047	0	1,143,584	1,916,997	(773,413)
Marine SI	2020	3,553	3,553	0	185,917	190,560	(4,643)
	2030	4,981	4,981	0	317,638	326,548	(8,910)
Total	2020	4,445	4,445	0	1,152,325	1,807,428	(655,103)
	2030	6,028	6,028	0	1,461,222	2,243,545	(782,323)

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