OFFICE OF INSPECTOR GENERAL

Catalyst for Improving the Environment

Evaluation Report

Progress Report on EPA's Nonroad Mobile Source Emissions Reduction Strategies

Report No. 2006-P-00039

September 27, 2006

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Abbreviations

CO	Carbon Monoxide
EPA	U.S. Environmental Protection Agency
MARPOL	International Convention for the Prevention of Pollution from Ships
NO_x	Nitrogen Oxides
OIG	Office of Inspector General
OTAQ	Office of Transportation and Air Quality
$PM_{2.5}$	Fine Particulate Matter
PM_{10}	Particulate Matter up to 10 micrometers in diameter
PM	Particulate Matter
PPM	Parts Per Million
SO_x	Sulfur Oxides
STAPPA/ALAPCO	State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials
THC	Total Hydrocarbons
VOC	Volatile Organic Compound

Cover photos: Various types of nonroad mobile sources of emissions (photos courtesy EPA).

U.S. Environmental Protection Agency
Office of Inspector General

2006-P-00039
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At a Glance

Catalyst for Improving the Environment

Why We Did This Review

Emissions from nonroad mobile sources can present significant health and environmental hazards. The U.S. Environmental Protection Agency (EPA) projects that emissions from these sources will decrease in some categories but increase in others. As such, we examined EPA's efforts to reduce nonroad mobile source emissions, opportunities for additional reductions, and challenges to addressing nonroad emissions problems.

Background

Nonroad mobile sources include marine vessels, locomotives, aircraft, farm and construction machinery, lawn and garden equipment, recreational vehicles, and outdoor power equipment. Nonroad mobile sources produce particulate matter and ozone-forming nitrogen oxides and volatile organic compound emissions, as well as toxic air pollutants, which contribute to a host of health and environmental hazards.

For further information, contact our Office of Congressional and Public Liaison at (202) 566-2391.

To view the full report, click on the following link:
www.epa.gov/oig/reports/2006/20060927-2006-P-00039.pdf

Progress Report on EPA's Nonroad Mobile Source Emissions Reduction Strategies

What We Found

EPA has issued nonroad mobile source emissions control regulations that, when fully implemented, should result in significant reductions in such emissions. However, more emission reduction efforts are needed and some challenges remain.

Until the mid-1990s, emissions from nonroad mobile sources were largely uncontrolled. In the 1990 Clean Air Act Amendments, Congress directed EPA to study the contribution of nonroad sources to ozone and other air pollutants, and to issue regulations if problems were found. EPA has since issued 14 regulations to control pollutants from nonroad mobile sources, with a total of 20 standards for various nonroad categories. The most recent regulation, the 2004 Nonroad Diesel Engines rule, is based on a systems approach involving a combination of engine modifications, reduced sulfur content in diesel fuel, and exhaust controls.

There are approximately 5 million nonroad diesel engines in the United States today, many of which are not subject to EPA emissions standards. These engines have the potential to continue to produce high levels of pollution over the next 20 years or more. Agency projections show that substantial emissions reductions have already been made for some source categories. However, the full benefits of EPA's regulations may not be realized until 2020-2030, when the standards are expected to be fully implemented. Projected benefits assume engine turnover and replacement – activities that may be influenced by cost, lead time, and overall feasibility. EPA has encouraged emission reductions for existing engines through voluntary efforts and incentive programs. Although a mandatory retrofit program may achieve increased health protection sooner, such a requirement from the Federal level can only come through a change in the Clean Air Act.

EPA faces significant challenges in addressing nonroad emissions, particularly among the marine, aircraft, and small gasoline engine categories. The role that other government entities and international communities play in regulating emissions from these source categories hinders EPA's progress in achieving reductions. Technical challenges, including the availability of low sulfur fuel, the diversity of nonroad engines, and the wide range of applications, also must be addressed to meet air quality standards and emission reduction goals.

This report provides information on the progress of EPA's efforts to address nonroad emissions and makes no recommendations.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
INSPECTOR GENERAL

September 27, 2006

MEMORANDUM

SUBJECT: Progress Report on EPA's Nonroad Mobile Source Emissions Reduction Strategies
Report No. 2006-P-00039

TO: William L. Wehrum
Acting Assistant Administrator for Air and Radiation

This is a report on the subject evaluation conducted by the Office of Inspector General (OIG) of the U.S. Environmental Protection Agency (EPA). The report examines current and projected nonroad mobile source emissions and how Agency actions have affected those emissions to date, and are projected to affect emissions in the future. This report represents the opinion of the OIG and the findings in this report do not necessarily represent the final EPA position. Final determinations on matters in the report will be made by EPA managers in accordance with established procedures.

The estimated cost of this report – calculated by multiplying the project's staff days by the applicable daily full cost billing rates in effect at the time – is $453,376.

Action Required

This report does not include recommendations. Therefore, you are not required to respond to this report.

We appreciate the efforts of EPA managers and staff in working with us to develop this report. If you or your staff have any questions regarding this report, please contact me at (202) 566-0847 of roderick.bill@epa.gov, or Wade Najjum at (202) 566-0827 or najjum.wade@epa.gov.

Sincerely,

Bill A. Roderick
Acting Inspector General

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Chapter 1
Introduction

Purpose

Emissions from nonroad engines contribute significantly to air pollution and health problems. The U.S. Environmental Protection Agency (EPA) projects that emissions from some nonroad engines will continue to increase and contribute large amounts of particulate matter and ozone precursor emissions,[1] while emissions from other source categories have begun to decrease. Concerned with growth in emissions from these air pollution sources, EPA has issued 14 regulations to control pollutants from nonroad engines, particularly nitrogen oxides (NO_x), a precursor to the formation of ozone, and particulate matter (PM).

Because emissions from existing engines will be a concern for many years, we reviewed the status of EPA's efforts to reduce emissions from nonroad sources. Chapter 2 presents EPA's overall approach to reducing nonroad mobile source emissions, the progress the Agency has made in taking actions to reduce emissions, and additional opportunities for nonroad ozone and particulate matter emissions reductions. Chapter 3 notes some of the major challenges EPA faces in effectively addressing nonroad emissions.

Background

Mobile sources are divided into two categories: onroad and nonroad. The onroad category includes cars and light trucks, motorcycles, and heavy-duty vehicles, such as trucks and buses. Nonroad categories cover a variety of engine configurations and applications and are divided into several sub-categories, as listed in Table 1-1.

Table 1-1: Nonroad Engine Categories

Category	Application
Land-Based Diesel Engines	Backhoes, tractors, material handling equipment, airport service vehicles, generators, and pumps
Land-Based Spark-Ignition Engines	***Small Spark-Ignition Engines:*** Lawnmowers, string trimmers, leaf blowers, and chain saws fueled with gasoline
	Large Spark-Ignition Engines: Forklifts, generators, compressors, and welders fueled with liquefied petroleum gas, gasoline, or natural gas
	Recreational Vehicles: Off-highway motorcycles, all-terrain vehicles, and snowmobiles fueled with gasoline
Marine Engines and Vessels	***Marine Spark-Ignition Engines:*** Outboard engines, personal water craft, and gasoline-fueled sterndrive and inboard engines
	Marine Diesel Engines: Recreational yachts, fishing boats, tug and towboats, dredgers, and coastal and ocean-going vessels
Locomotives	Diesel-powered engines used in freight and passenger rail, line-haul, local, and switch-yard service
Aircraft	All types of aircraft (ground support equipment not included)

Source: EPA, *Mobile Source Emissions: Past, Present and Future*

[1] Ozone is formed by a complex atmospheric chemical reaction of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight and heat. NO_X and VOCs are known as precursor emissions for ozone.

As illustrated in Table 1-1, some nonroad sources operate with the use of diesel engines and others operate with gasoline, liquefied petroleum gas, or natural gas (also known as spark ignition engines). Unlike gasoline engines, diesel engines have no spark plug, but take in air and compress it; the fuel is then injected directly into a combustion chamber and the heat of the compressed air ignites the fuel in the engine. While both engines produce air pollutants, diesel engines produce substantially more NO_x and particulates, and spark-ignition engines generally produce more volatile organic compounds (VOCs).

Until the mid-1990s, emissions from nonroad mobile sources were largely unregulated. In the 1990 Clean Air Act Amendments, Congress directed EPA to study the contribution of nonroad sources to ozone and other air pollutants, and to issue regulations for nonroad sources found to contribute to air pollution. In 1991, EPA concluded that nonroad engines contributed significantly to air quality problems related to ozone-forming NO_x and VOCs, PM, and other pollutants. Subsequently, in 2001, EPA found that nonroad and onroad engines also contributed to air pollution from 21 air toxics. EPA defines air toxics as "those pollutants that are known or suspected to cause cancer or other serious health effects or adverse environmental effects." From 1994 to 2004, EPA issued 14 regulations to control pollutants from nonroad engines.

Nonroad Emissions Pose Significant Air Quality and Health Concerns

Nonroad engines emit significant amounts of diesel exhaust, which has been designated a probable human carcinogen. EPA's most recent data[2] indicate that nonroad engines produce about 66 percent of the nation's fine particulate matter ($PM_{2.5}$) from all mobile sources. These nonroad engine emissions contribute significantly to air pollution affecting about 88 million Americans living in areas that violate $PM_{2.5}$ air quality standards. Exposure to fine particulate matter has been linked to premature death rates and the incidence of cardiovascular and respiratory illnesses. Particulate matter is a mixture of solid particles and liquid droplets found in air, and comes in a wide range of sizes. Particles less than 2.5 micrometers in diameter are referred to as fine particles, or $PM_{2.5}$, and because of their small size pose the greatest health risk compared to other particulates. These fine particles – about $1/30^{th}$ of the thickness of a human hair – can lodge deeply into the lungs and may even get into the blood stream. Additionally, fine particles are the major source of haze. Unless otherwise specified, this report focuses on $PM_{2.5}$ when addressing particulate matter.

NO_x and VOCs combine in the presence of heat and sunlight to form one of the most pervasive air pollution problems for major urban areas – ground level ozone. Ozone pollution is linked to illnesses such as asthma and heart disease. Environmental effects of ozone include crop damage, damage to trees, decreased crop yields that cost the agriculture industry billions of dollars, acid deposition,

[2] EPA 2005 Technology Transfer Network Clearinghouse for Inventories & Emissions Factors: National Emissions Inventory Air Pollutant Emissions Trends Data.

and nutrient overloads in coastal waters. Nonroad engines produce about 36 percent of NO_x and 37 percent of VOC emissions,[3] two ozone precursors contributing significantly to air pollution affecting about 159 million Americans living in areas that exceed EPA's 8-hour ozone standard.

Overall Nonroad Mobile Source Emissions Decreasing, But Some Categories Continue to Increase

Prior to EPA's 1994 regulations, emissions from nonroad mobile sources (PM, and ozone-forming NO_x and VOCs) were steadily increasing. Since the nonroad regulations came into effect, $PM_{2.5}$ and VOC emissions have generally declined, while NO_x emissions have generally begun to level off. However, EPA projects that emissions from nonroad sources such as aircraft, marine, and locomotive diesel engines will continue to increase. EPA estimates that by 2030, without new controls, locomotive and marine diesel engines, as a subset of mobile source emissions, will contribute about 27 percent of NO_x and 45 percent of fine diesel PM. While aircraft emissions contribute 1 percent of these NO_x emissions nationwide, some cities with greater airport traffic see larger NO_x emissions and these emissions levels are expected to grow.

Figures 1-1 through 1-3 illustrate the NO_x, $PM_{2.5}$, and VOC emissions for nonroad sources from 1990 to 2002. As shown, emissions for all three steadily increased prior to EPA's nonroad regulatory actions, which began to be implemented in 1996.

Figure 1-1: Change in Nonroad Mobile Source NO_x Emissions From 1990 to 2002

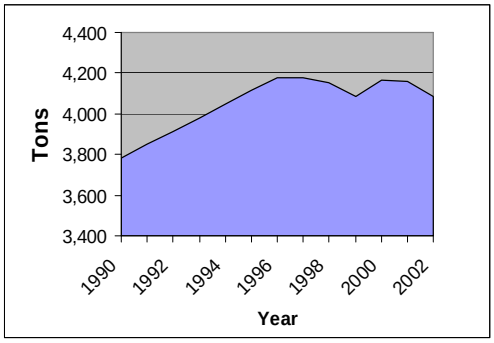
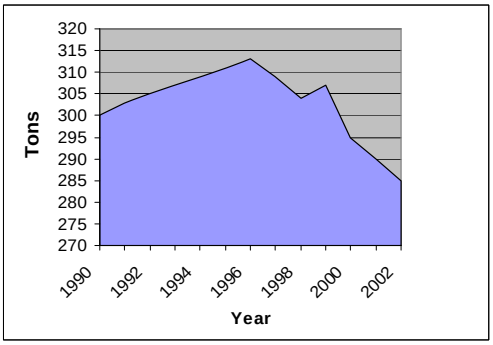
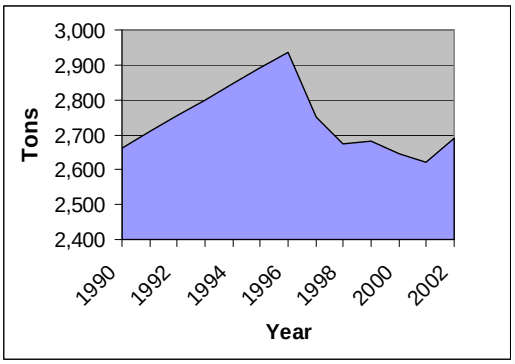


Figure 1-2: Change in Nonroad Mobile Source $PM_{2.5}$ Emissions From 1990 to 2002



[3] EPA 2005 Technology Transfer Network Clearinghouse for Inventories & Emissions Factors: National Emissions Inventory Air Pollutant Emissions Trends Data.

Figure 1-3: Change in Nonroad Mobile Source VOC Emissions From 1990 to 2002



Source for Figures 1-1 through 1-3*:*
EPA, *2005 National Emission Inventory Air Pollutant Emissions Trends Data*

Scope and Methodology

To assess EPA's efforts to reduce nonroad mobile source emissions, we reviewed EPA reports, regulations, and guidance, and EPA and external stakeholder analyses and studies of emissions from nonroad diesel engines. We also performed limited analyses from EPA's National Emissions Inventory Air Pollutant Emissions Trends Data, and interviewed officials and representatives from the EPA Office of Air and Radiation's Office of Transportation and Air Quality (OTAQ), Ann Arbor, Michigan. In addition, we conducted interviews with external stakeholder organizations, including State and local organizations, and environmental and industry groups. We also reviewed pertinent sections of the Clean Air Act, as amended. Our work was conducted from April 2005 through February 2006. We conducted our evaluation in accordance with *Government Auditing Standards*, issued by the Comptroller General of the United States. Additional details on our scope and methodology are in Appendix A.

Chapter 2
Despite Regulatory Progress, More Work Needed to Achieve Emissions Reductions

Since 1994, EPA has issued 14 regulations to control emissions from nonroad mobile sources. A number of these regulations include multiple tiers of standards, with a total of 20 standards for the various nonroad categories. Twelve of the standards have already taken effect, seven are in the process of being phased-in, and one will not begin to phase-in until 2008. There are approximately 5 million nonroad diesel engines in the United States today, many of which are not subject to any EPA diesel engine emissions standards. These engines have the potential to operate for the next 20 to 30 years and continue to produce high levels of pollution. EPA officials are aware of the need to reduce emissions from these existing engines, and have encouraged reductions through voluntary initiatives, grant awards, and technical guidance. EPA and others have identified locomotive, marine, and aircraft engines as increasingly significant sources of emissions that will require additional controls. According to EPA, when the full inventory of older nonroad engines has been replaced, the nonroad diesel program will annually prevent up to 12,000 premature deaths, 1 million lost work days, 15,000 heart attacks, and 6,000 children's asthma-related emergency room visits.

EPA Making Regulatory Progress for New Nonroad Engines

The first of the 14 regulations that EPA has issued since 1994 to control nonroad mobile emission sources went into effect in 1996, and the last is to go into effect in 2008. EPA has generally taken a phased-in approach when adopting these regulations and has issued multiple tiers for certain engine categories, with a total of 20 standards promulgated as of April 2006. To illustrate, EPA issued four tiers of land-based diesel engine emissions standards, with each tier requiring more stringent emissions reductions than the previous one. For example, Tier 4 of the land-based standards first goes into effect in 2008 and is expected to take until 2015 to achieve its 90-percent reduction goal. Additional information on EPA's nonroad emissions regulatory schedule is in Appendix B.

According to OTAQ officials, at least one set of regulations has been issued for each nonroad category, with the exception of stern-based marine engines. OTAQ is working on the following nonroad regulations/activities:

- Implementing land-based diesel engine emission standards (Tiers 3 and 4).
- Future gasoline control standards.
- Future standards for locomotive and marine diesel engines.
- Mobile source air toxics rulemaking.

- Sulfur Oxides (SO_X) Emission Control Area under the 1997 Amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL-Annex VI).
- Adopting 2004 NO_x standards approved for aircraft by the International Civil Aviation Organization.
- Pursuing international standards for ocean-going marine vessels.

In 2004, EPA developed the *Control of Emissions of Air Pollution From Nonroad Diesel Engine and Fuel* (Tier 4 standards) – commonly referred to as the Nonroad Diesel Engines rule – to reduce emissions from nonroad diesel engines by combining engine and fuel controls as a system to increase emissions reductions. This concept of integrating engine and fuel controls as a system was unprecedented in nonroad regulations.

The 2004 standards apply to land-based diesel engines, which are typically used in construction, agricultural, and industrial equipment. The standards are expected to reduce NO_x emissions by 90 percent and $PM_{2.5}$ emissions by 95 percent. EPA estimates that by 2030, these reductions will result in a variety of public health benefits, including the prevention of 12,000 premature deaths, 1 million lost work days, 15,000 heart attacks, and almost 6,000 emergency room visits by children due to asthma attacks. The sulfur fuel component of this rule applies to land based diesel engines, commercial and recreational marine diesel engines, and locomotives, and is expected to reduce sulfur levels by 99 percent. EPA's Nonroad Diesel Engines rule calls for a nationwide transition from diesel fuel containing about 3,000 parts per million (ppm) of sulfur today to 500 ppm of sulfur in 2007, and eventually to 15 ppm of sulfur by 2010. Low sulfur levels in diesel fuel will allow engine manufacturers to use advanced emission control technologies that allow emissions reductions for $PM_{2.5}$ and NO_x, and, more importantly, address health and environmental risks associated with these pollutants.

EPA Undertakes Non-Regulatory Efforts to Reduce Emissions from Existing Diesel Engines

There are approximately 5 million nonroad diesel engines in use in the United States today. Many of these are not subject to any EPA diesel engine emissions standards. Because diesel engines are durable and likely to continue operating over the next 20 years or more, high levels of pollution from these engines will persist throughout the life of these engines.

An OTAQ official highlighted the need to reduce emissions from these engines, and noted that EPA had established a goal of reducing emissions from the existing 11 million onroad and nonroad diesel engines by 2014. Reducing emissions from

these diesel engines is one of three main priorities that OTAQ plans to address.[4] According to the EPA Region 9 Administrator, reducing emissions from older diesel engines is "one of the most important air quality challenges facing the country." To meet the goal of reducing emissions from existing engines, a subcommittee of the Clean Air Act Advisory Committee – the Mobile Source Technical Review Subcommittee Clean Diesel and Retrofit Working Group – was established to:

- Address how to assess fleets to determine diesel emissions reduction strategies suitably,
- Evaluate in-use performance of retrofit technology,
- Educate the public on emissions reduction strategies, and
- Address how to establish national incentives for cleaner diesel strategies.

Voluntary Diesel Retrofit Program and National Clean Diesel Campaign

To address the challenge of reducing emissions from existing engines, EPA established the Voluntary Diesel Retrofit Program and the National Clean Diesel Campaign. Established in 2000, the Voluntary Diesel Retrofit Program verifies new retrofit technologies, awards grants, and provides technical guidance. In 2004, EPA established the National Clean Diesel Campaign, which promotes retrofit incentives and technical assistance to help reduce pollution from these engines and equipment. The campaign also established voluntary programs in the marine and construction nonroad sectors – the Clean Ports and Clean Construction USA initiatives – to encourage the use of emissions control technology, replacement of older equipment, and use of cleaner fuels. Today, the National Clean Diesel Campaign is the overall umbrella for EPA's diesel retrofit activities.

The National Clean Diesel Campaign promotes regional collaborations and partnerships, such as the West Coast Diesel Emissions Reductions Collaborative. This collaborative is a joint effort with EPA and other Federal, State, local, and non-profit and private sector partners to reduce air pollution emissions from diesel engines along the West Coast. The collaborative, for example, supported the Oregon Construction Equipment Emissions Reduction Project to reduce diesel emissions from construction equipment in the City of Portland through diesel engine retrofits, cleaner fuels, and engine idle reduction policies. Although a mandatory retrofit program may achieve increased health protection sooner, such a requirement from the Federal level can only come through a change in the Clean Air Act. Concerned with nonroad emissions, some States have implemented their own mandatory programs.

[4] EPA outlined three priorities for OTAQ: (1) to successfully implement the diesel programs; (2) focus on locomotives, marine diesel engines, mobile source air toxics rule, and programs for small engines; and (3) focus on addressing existing diesel engines.

EPA has worked to encourage emissions reductions through voluntary initiatives, grants, and technical guidance. Although some funding is currently available to reduce emissions from existing engines, the Acting Director, Compliance and Innovative Strategies Division, OTAQ, said additional resources are needed. OTAQ has also focused on guidance and technical support to encourage emissions reductions.

Data Not Yet Available to Measure Actual Emissions Reductions and Health Benefits

The Clean Air Act provides EPA with the authority to establish emissions standards only for new engines; therefore, nonroad engine emissions standards phase in over time as older engines undergo turnover and replacement. Twelve of the standards have already taken effect, seven are in the process of being phased-in, and one will not begin to phase-in until 2008. Table 2-1 shows the emissions reductions estimates for some nonroad standards; for a complete list, see Appendix B.

Table 2-1: Emissions Reductions Estimates for Existing nonroad regulations

Regulation	Implementation Date	Estimated Results
Tier 1 standards for land-based diesel engines	1996-2000	By 2025, 30% reduction in NO_X emissions
Phase 1 standards for small spark-ignition engines	1997	By 2020, 32% reduction in hydrocarbon emissions
Gasoline outboard & personal watercraft Phase 1	1998-2006	By 2025, 75% lower hydrocarbon emissions on average
Tier 2 standards for land based diesel engines	2001-2006	By 2020 50% NO_X and 40% PM reduction from Tier 1 levels
Tier 2 standards for Category 1 and 2 marine diesel engines	2004-2007	By 2030, 24% reduction in NO_X, 12% reduction in PM
Tier 4 standards for land based diesel engines	2008-2015	By 2030, 95% reduction PM and 90% reduction in NO_X, and 99% reduction SOx levels

Source: EPA, *Federal Register Environmental Documents* and EPA OTAQ

The full benefits of EPA's regulations may not be realized until 2020-2030, when the standards are expected to be fully implemented. These benefits assume engine turnover and replacement, behavior which may be influenced by cost and lead time, and overall feasibility. For example, EPA estimates that the full emissions reductions from the Phase 1 standards (small spark-ignition engines) will be achieved by 2020, at which time the existing fleet of engines is expected to have turned over. An OTAQ official noted that "even during the phase-in of new standards, emission reductions are being seen, since the engines complying with the newer standards are being introduced into commerce." OTAQ provided the OIG with projected near-term emission reductions, presented in Table 2-2.

Table 2-2: Projected Near-Term Emissions Reductions Resulting from All EPA Nonroad Standards, Except Aircraft[a]

	2006		2010	
Pollutant	Tons Reduced	Percent Reduced	Tons Reduced	Percent Reduced
THC	1,590,089	33%	2,449,807	47%
NO_x	913,055	21%	1,558,322	33%
PM_{10}	73,143	21%	117,147	33%
CO	3,145,113	10%	4,718,399	14%

THC: Total hydrocarbons

PM_{10}: Particulate matter up to 10 micrometers in diameter

CO: Carbon monoxide

[a] If the aircraft category was included in Table 2-2, slightly greater emission reductions would result, in particular for NO_x.

Source: EPA OTAQ

The 2004 Nonroad Diesel Engines rule is viewed by environmental, industry, and State and local stakeholders as a successful EPA rulemaking. Similar to other nonroad regulations, emissions reductions and the resultant health benefits continue to phase-in until 2030. EPA has projected that $PM_{2.5}$ emissions will be reduced by 95 percent and NO_x emissions by 90 percent for the land-based diesel engine category of nonroad engines by 2030.

According to OTAQ's 2004 Final Regulatory Analysis, the Nonroad Diesel Engines rule[5] will ultimately yield the public health benefits shown in Table 2-3 by 2030. The timeframe for EPA's analysis reflects engine turnover (existing engines being replaced by new, cleaner ones) beginning in 2007 and extending through 2030.

Table 2-3: Projected Public Health Benefits When the Fleet of Older Nonroad Engines Has Fully Turned Over (by 2030)

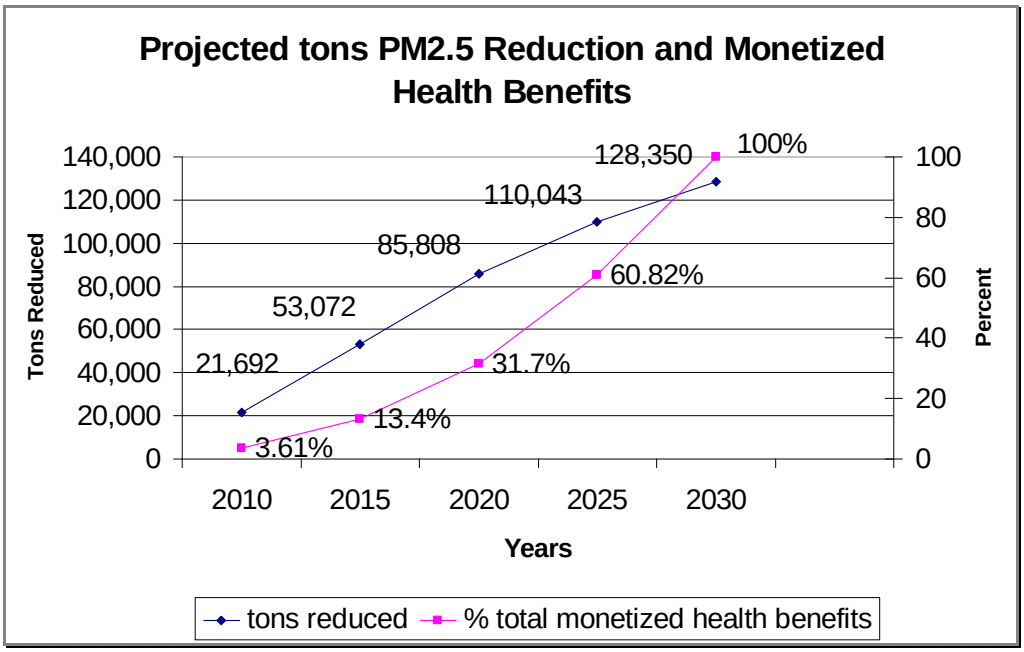
Full Implementation of Rule Will Annually Prevent	Projected Amount
Premature deaths	12,000
Hospitalizations	8,900
Heart attacks	15,000
Children's asthma-related emergency room visits	6,000
Cases of respiratory problems in children	280,000
Work days lost	1,000,000
Cases of asthma symptoms in children	200,000

Source: EPA, *Clean Air Nonroad Diesel Rule – Facts and Figures*

[5] EPA (2004a), *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines*, EPA420-R-04-007 (May 2004), Table 9-16.

As shown in Figure 2-1, both the monetized health benefits (shown by the pink line) and the tons of $PM_{2.5}$ emissions reduced (shown by the blue line) are projected to appear gradually. EPA projects that health benefits will begin to appear in 2007, when the first phase of the low-sulfur diesel fuel requirements takes effect for nonroad engines.

Figure 2-1: Projected PM-2.5 Emissions Reductions and Public Health Benefits Resulting from the 2004 Nonroad Diesel Rule



Source: EPA, *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines*

For the nonroad diesel engine standards, implementation will occur in stages: reductions in sulfur content of nonroad diesel fuel will occur first, and then adoption of controls on most new nonroad engines. Because full turnover of the fleet of nonroad diesel engines will not occur for many years, the emission reduction benefits of the standards will not be fully realized until many years after the reduction in fuel sulfur content. According to EPA, the overall quantifiable benefits will total over $83 billion annually by 2030, with a 30-year net present value of $805 billion.

EPA's "NONROAD" emission inventory model has limitations that could affect the validity of emission reduction projections. The NONROAD model is used to estimate emissions from nonroad equipment. This model calculates past, present, and future emissions inventories for all nonroad categories, but does not currently have the capability to estimate emissions from aircraft, commercial marine vessels, and locomotive engines. Also, the emissions data are based on laboratory testing instead of actual field testing of in-use applications. In the future, the aircraft, locomotive, and commercial marine source categories will be included in EPA's new emissions model – Motor Vehicle Emission Simulator (MOVES) – which is currently under development.

According to an OTAQ official, because the regulations are phased in and projections are long term, it is difficult to capture emissions reductions data in the short term. Unlike highway vehicles, nonroad engines are not registered, and the difficulty in measuring the activity of nonroad vehicles creates a challenge for the Agency and the States to collect sufficient reliable data for the NONROAD model.

Further Controls Needed In Nonattainment Areas and for Certain Nonroad Categories

EPA's deadlines to meet ozone and $PM_{2.5}$ standards by 2010 are critical to meeting human health goals in nonattainment areas. Also, OTAQ officials and outside stakeholders identified locomotive, marine, and aircraft engines as sources of significantly increasing emissions that will require additional emissions controls.

Nonattainment Areas

Emissions from nonroad diesel engines are significant contributors to the pollution in areas that do not meet National Ambient Air Quality Standards (nonattainment areas). EPA's Green Book of nonattainment areas for criteria pollutants identifies areas of the country where air pollution levels exceed the national ambient air quality standard and are designated as nonattainment. Recent data from EPA's Green Book show that about 159 million Americans live in 126 ozone nonattainment areas. Additionally, about 88 million Americans live in 208 counties not meeting EPA's $PM_{2.5}$ standards, and EPA's deadlines to meet $PM_{2.5}$ standards by 2010[6] are critical in these areas.

Nonattainment areas are required to reduce ozone and $PM_{2.5}$ emissions as part of State Implementation Plans. The 2004 Nonroad Diesel Engines rule is expected to begin providing emissions results by 2008, but will not be fully implemented until 2015. Therefore, these States will need to look elsewhere for additional ozone-forming NO_x and $PM_{2.5}$ reductions.

Category 1 and 2 Marine Diesel and Locomotive Engine Emissions

EPA estimates that by 2030, without new controls, locomotive and marine (Category 1 and 2) diesel engines will contribute about 27 percent of mobile source NO_x and 45 percent of mobile source diesel PM emissions. Currently, marine diesel engines contribute about 8 percent of mobile source NO_x and 9 percent of mobile source diesel PM emissions, although their relative contribution is greater around commercial ports.

[6] With appropriate justification, States are allowed an extension of up to 5 years, or until February 2015, to reach full attainment for $PM_{2.5}$.

A representative from OTAQ's marine and locomotive group said that because the first standards for marine diesel engines did not take effect until January 2004, large projected emissions reductions have not yet been achieved. Additionally, this representative said that emissions certification data from engine manufacturers indicate they are producing and distributing cleaner engines to meet the new standards. However, according to EPA documents, the Tier 1 marine standards are equivalent to the international emissions standards, which are considered less stringent regulations by key OTAQ officials.

EPA estimates that locomotives currently contribute about 7 percent of NO_x and 5 percent of PM mobile source emissions. Typically, a locomotive engine will remain in service 40 years or more before it is scrapped. During that time an engine may be remanufactured every 5 to 7 years to restore it to an "as new" condition and may travel a million miles between remanufactures. According to EPA, locomotive engines have relatively modest emissions standards, and continue to emit large amounts of NO_x and PM. Emissions requirements issued in 1997 were considered adequate at the time, but EPA is now considering more protective regulations. EPA included sulfur fuel requirements for locomotives in the 2004 Nonroad Diesel Engines rule to reduce emissions from these engines and improve the ability to use advanced aftertreatment systems.

OTAQ reported that they are talking with locomotive and marine engine manufacturers to develop a strategy to implement more stringent regulations for both locomotive and marine engines based on advanced aftertreatment technologies. OTAQ expects to issue a notice of proposed rulemaking by December 2006 and a final rule in 2007.

Aircraft Engine Emissions

Aircraft engine emissions are increasing at a time when other mobile source categories are being reduced. Aircraft emissions contribute 0.7 percent of NO_x emissions from mobile sources nationwide, but some cities with greater airport traffic see a larger contribution of NO_x emissions from these engines, and these emissions are expected to grow. For example, EPA estimates that NO_x emissions from commercial aircraft in the Atlanta, Georgia area are expected to double by 2010 and contribute as much as 10 percent of mobile source NO_x emissions in that area. Nationally, the Federal Aviation Administration projects that commercial air travel is expected to increase 45 percent from 2002 to 2020.

Conclusions

EPA has issued several nonroad mobile source emissions control regulations that will require significant reductions in nonroad source emissions. The full benefits of EPA's regulations may not be realized until 2020-2030 when the standards are expected to be fully implemented. However, these regulations have already achieved reductions in emissions from some emission source categories. These

benefits assume engine turnover and replacement – activities which may be influenced by cost, lead time, and overall feasibility.

According to EPA there are approximately 5 million existing nonroad diesel engines in the United States, many of which are not subject to EPA diesel engine emission standards. EPA has acknowledged the need to reduce emissions from existing engines and has introduced voluntary programs and grants to encourage emissions reductions from these engines. Although a mandatory retrofit program may achieve increased health protection sooner, such a requirement from the Federal level can only come through a change in the Clean Air Act.

This report provides information on the progress of EPA's efforts to address nonroad emissions and makes no recommendations. We plan to perform additional reviews of mobile source issues in the future, including an in-depth review related to existing engines.

Agency Response and OIG Evaluation

In addition to the memorandum sent to the OIG with Agency comments to the draft report, the Agency also submitted more specific comments on the draft report. These comments were documented in the margins of the draft. A summary of the key additional comments follows:

(1) The draft report should include information on the substantial reductions that have already occurred as a result of EPA's nonroad emissions standards. To demonstrate projected emissions reductions in the near-term, OTAQ prepared data for the OIG using the NONROAD model to show projected emissions for the years 2006 and 2010.

(2) Tier 4 standards incorporated a great deal of flexibility to allow manufacturers the lead time necessary to develop and apply aftertreatment device technology.

We agree with the Agency's key comments, and revisions to the draft report were made accordingly. The Agency also provided technical comments to the draft report; we made changes based on these comments as appropriate. In both its memorandum as well as the comments it provided within the margins of the draft, the Agency asked that the OIG include information regarding near-term projected emissions reductions to demonstrate the progress that has already been made due to EPA's nonroad emissions standards. To address this comment, the OIG incorporated data on projected emissions reductions for 2006 and 2010 in "Table 2-2: Projected Near-Term Emissions Reductions Resulting from All EPA Nonroad Standards, Except Aircraft" of the report.

The Agency's comments are in Appendix C. Appendix D contains a separate memo with information that EPA provided to supplement Table 2-2.

Chapter 3
Challenges Remain to Achieve Emissions Reductions

Although EPA has made substantial progress in developing regulations to reduce nonroad mobile source emissions, challenges remain in regulating the aircraft, marine, and small gasoline engine categories. These challenges may hinder EPA's progress in achieving emissions reductions from nonroad engines and in protecting public health. In particular:

- EPA faces significant challenges in issuing regulations for aircraft and large ocean-going marine vessels because other government entities and international organizations play significant roles in regulating those categories of nonroad sources.

- Small gasoline engines are the largest contributor of nonroad gasoline NO_x emissions, and while EPA is required to issue new regulations for small gasoline engines, technical challenges exist related to lawn and garden equipment that must be addressed first.

- Technical challenges also exist related to the diversity of nonroad engines and the wide range of applications of those engines.

Challenges Exist to Controlling Emissions from Certain Categories

Large Ocean-going (Category 3) Marine Diesel Engine Emission Challenges

The commercial marine engine sector is particularly challenging because marine diesel engines have a long service life (as long as 20 to 30 years), and there are limited Federal incentives for retrofitting these engines prior to the end of their useful life. Also, most large ocean-going vessels (category 3 diesel engines) are subject to international standards rather than U.S. standards. EPA estimates that commercial marine diesel vessels annually emit about 1,000,000 tons of ozone-forming NO_x, 40,000 tons of $PM_{2.5}$, and 160,000 tons of sulfur dioxide.

EPA has set engine emissions (Tier 1) standards for large ocean-going marine (Category 3) vessels flagged in the United States. The International Maritime Organization sets the engine emissions standards for foreign-flagged ocean-going vessels. As noted in Chapter 2, Tier 1 marine standards are equivalent to the international emissions standards and considered less stringent. However, OTAQ staff said that the standards are based on the technology available at the time the standards were adopted, and there have been technological advancements within

the nonroad diesel sector since then that OTAQ hopes to apply to the marine sector.

EPA must continue to work with the international community to regulate emissions from these engines. The International Maritime Organization was established under the United Nations to address safety, navigation, and pollution prevention for ships involved in international trade. According to EPA documents, foreign-flagged vessels account for about 97 percent of calls on U.S. ports, and it is likely that the contribution of U.S. vessels with Category 3 engines to local air pollution is small compared to foreign vessels. Because most of these ships are subject to International Maritime Organization standards rather than U.S. standards, EPA faces significant legal issues regarding its authority to regulate these vessels under the Clean Air Act.

From an environmental perspective, International Maritime Organization standards that are particularly useful are the 1997 Amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL - Annex VI), which address air emissions such as ozone-depleting substances, onboard incinerators, emissions from tanker operations, and NO_x and SO_X emissions from ship engines. MARPOL-Annex VI went into effect in May 2005, and 28 countries have signed it. In April 2006, the United States Senate gave its advice and consent to the ratification of MARPOL-Annex VI, but has not yet ratified the treaty. According to OTAQ staff, some of the potential benefits of the United States joining the MARPOL-Annex VI agreement are related to the designation of SO_X Emission Control Areas, since it would help prevent, reduce, and control air pollution from SO_X emissions. Additionally, MARPOL-Annex VI would give the United States authority to inspect foreign ships entering U.S. ports for compliance with MARPOL-Annex VI standards.

OTAQ staff also noted they are working with the international community and other stakeholders to develop a second tier of more stringent marine diesel standards. In July of 2005, the International Maritime Organization formally agreed to begin deliberations regarding a potential second tier of emission standards for ocean-going marine vessels. OTAQ and EPA's Office of International Affairs staff are actively working with the International Maritime Organization to establish aggressive future standards for ocean-going vessels, according to OTAQ representatives.

Aircraft Engine Emissions Challenges

Similar to marine diesel and locomotive engines, the long service life of aircraft engines is a substantial challenge to reducing these emissions, and there are no Federal incentives for retrofitting these engines prior to the end of their useful life. As mentioned in Chapter 2, emissions from commercial aircraft are a growing segment of mobile source emissions. Some aircraft engines have a life span of about 30 years and account for about 45 percent of total emissions among all

airport operations. Further, shared authority for regulating aircraft emissions, both internationally and within the Federal Government, add additional challenges.

EPA and the Federal Aviation Administration have joint authority for regulating aircraft emissions. An OTAQ official told us that sharing joint authority has been challenging because the two agencies have different missions and approaches. OTAQ officials said the Federal Aviation Administration focuses on aircraft safety, and their emissions agenda is more consistent with that of the airline industry than EPA's emissions agenda.

In addition, the International Civil Aviation Organization is the international governing body for the aviation industry, seeking to ensure safety, equality, and consistency among the international aircraft community through the development of standards and procedures for aircraft engines. A final rule for the control of pollution from aircraft was issued last year to adopt the Organization's current standards, but an OTAQ official told us that these standards are essentially a codification of the existing EPA aircraft standards, and are not technology-forcing. Currently, about 90 percent of aircraft engines in use already meet these standards. Further, the official said EPA has tried on numerous occasions to adopt more stringent aircraft emissions regulations but has not been successful.

Small Gasoline Engine Challenges

Small gasoline engines such as lawn and garden equipment are the largest contributor of nonroad gasoline NO_x emissions (44 percent), and the second largest contributor of $PM_{2.5}$ emissions (31 percent) among nonroad gasoline sources nationwide. Thus, small gasoline engines are another nonroad engine emissions source in need of emissions reductions. One specific challenge, described next, exists with respect to reducing emissions from small gasoline engines less than 50 horsepower.

A rider enacted in the 2004 VA-HUD[7] appropriations bill preempts any State (with the exception of California[8]) from adopting or enforcing standards relating to the control of emissions from new nonroad spark-ignition engines smaller than 50 horsepower. Section 209(e)(B) of the Clean Air Act Amendments of 1990 provided States flexibility in choosing between Federal emission standards or

[7] Appropriations Bill for the Department of Veterans Affairs and the Department of Housing and Urban Development

[8] There appears to be a typographical error in the VA-HUD Appropriation language which states that "[t]he prohibition in subsection (e) does not apply to or restrict in any way the authority granted to California under Section 209(e) of the Clean Air Act (42 U.S.C. 7543(e))." Subsection (e) does not expressly contain any prohibition, but rather contains language regarding the effect of these provisions on the enforcement by States of California standards enacted prior to September 1, 2003. We conclude that in referring to "the prohibition in subsection (e)," the drafters intended to reference subsection (c), which includes the following prohibition: "[n]o state or political subdivision thereof may adopt or attempt to enforce any standard or other requirement applicable to spark ignition engines smaller than 50 horsepower."

California's more protective standards. Now, because of the 2004 VA-HUD rider, States are prohibited from adopting (under section 209(e) of the Clean Air Act Amendments) the stricter California standards for this subset of small nonroad vehicles or engines.

EPA had previously issued two sets of regulations – *Phase 1 and 2 Emissions Standards Engines at or Below 19 kW* – to control emissions from new small spark-ignition (small gasoline) engines less than 25 horsepower in 1997 and 2000, and did not intend to issue additional regulations for these engines in the near future. Since States are preempted from adopting California's regulations for small engines less than 50 horsepower, Congress directed EPA to issue revised small gasoline engine emissions regulations by December 2004. EPA did not meet the 2004 deadline, which an OTAQ official said was unrealistic. In June 2005, the Senate approved a provision requiring EPA to conduct a safety study on the effects of installing new emission controls on lawnmowers (a small gasoline engine) and their potential to cause fires and burns, which could have impacted the development of the revised rule. Congress required EPA to complete the study by February 2, 2006, and prohibited the Agency from publishing proposed or final regulations until after the study was complete. EPA completed the study in March 2006, and concluded that adding emission control technologies would not increase the risk of fire and burns to consumers. Now EPA can begin the rulemaking process for the Phase 3 emission standards.

Nonroad Diesel Engines Rule Presents Technical Challenges

The diversity of nonroad engines presents several technical challenges to the successful implementation of the most recent rule. The 2004 Nonroad Diesel Engines rule is based on a systems approach in which emissions reductions will be accomplished through a combination of engine modifications, reduced content of sulfur in diesel fuel, and exhaust aftertreatment devices. EPA and other key stakeholders described this systems-based approach as technology-forcing, requiring technological advancements or new applications, and combinations of existing technology to meet required emissions standards. To meet these challenges, EPA will need to address: (1) diversity of nonroad engine applications, (2) integration of aftertreatment technology, and (3) availability of low sulfur fuel. Details on each follow.

Diversity of Nonroad Engine Applications

The nonroad diesel engine sector covers a diverse range of equipment and engine applications, from tractors to generators. EPA believes the emissions reduction technology currently used for the onroad sector can be transferred to the nonroad sector, but transferring this technology to the diverse engine types and sizes in the nonroad sector, in some cases, may be challenging. While onroad engines operate under a narrow range of sizes and designs, each nonroad diesel engine application

involves different mechanical and duty cycle demands, resulting in a variety of engine designs and configurations.

Integration of Aftertreatment Technology

Exhaust aftertreatment technology or retrofit devices are used to control engine emissions, such as PM and NO_x, before they leave the tailpipe. Examples of these devices include oxidation catalysts, selective catalytic reduction devices, particulate filters, and NO_x catalysts. The integration of aftertreatment devices in nonroad equipment presents a challenge due to the variation in operating temperatures and space constraints. For example, PM aftertreatment devices must be operated above a certain temperature, while NO_x aftertreatment devices have both a low and high temperature requirement. Further, the technology for controlling PM emissions is more mature than that for controlling NO_x.

Nonroad equipment also has safety and visibility requirements that must be taken into account when designing aftertreatment devices. For example, nonroad equipment operators must have a clear view of the operating area for equipment attachments, such as shovels and buckets, without being blocked by the engine compartment. While some equipment using a particular engine may have sufficient space to accommodate aftertreatment devices, the same engine used on another piece of equipment may not have enough room.

To help address these challenges, EPA incorporated flexibilities into the Tier 4 nonroad diesel rule to allow manufacturers the lead time necessary to develop and apply aftertreatment device technology. In certain cases, this flexibility extends for some manufacturers until 2020.

Availability of Low Sulfur Fuel

The use of aftertreatment devices to control NO_x and PM emissions will depend on the availability of ultra low sulfur diesel fuel. Currently, diesel fuel contains sulfur levels of about 3,400 ppm. EPA's sulfur fuel standards in the 2004 Nonroad Diesel Engines rule should enable the use of new technology to reduce PM and NO_x emissions and, more importantly, address health and environmental risks associated with these pollutants. These standards require refineries to reduce the sulfur content of diesel fuel to 500 ppm by 2007 and to 15 ppm by 2010. Thus, the availability of 15 ppm ultra low sulfur diesel fuel is critical.

Conclusions

EPA emissions control regulations exist for almost all nonroad engine categories, but challenges to reducing emissions from these engines remain. These challenges involve the development of regulations with other Federal Government entities and international organizations, as well as other issues generally outside of EPA's control. These challenges may hinder EPA's progress in achieving

emissions reductions from nonroad engines and protecting public health. Technical challenges exist related to the diversity of nonroad engines and the wide range of applications of those engines, and will require creating a wide variety of engine designs and sizes to accommodate emissions controls. Further, operating constraints, varying temperature ranges, and equipment sizes create a challenge regarding the placement of aftertreatment devices.

Agency Response and OIG Evaluation

See *Agency Response and OIG Evaluation* section at the end of Chapter 2, along with Appendices C and D.

Status of Recommendations and Potential Monetary Benefits

RECOMMENDATIONS						POTENTIAL MONETARY BENEFITS (in $000s)	
Rec. No.	Page No.	Subject	Status[1]	Action Official	Planned Completion Date	Claimed Amount	Agreed To Amount
No recommendations							

Appendix A

Details on Scope and Methodology

We conducted our work from April 2005 through February 2006 in accordance with *Government Auditing Standards* issued by the Comptroller General of the United States. This report presents information based on results from preliminary research; field work was not conducted because a follow-on evaluation is planned in the near future. This report focused on EPA's efforts to reduce emissions from nonroad sources, and not those of States or environmental and industry groups. Nonetheless, we interviewed officials from associations representing air pollution control agencies across the United States, as well as officials from selected State and local agencies, and environmental and industry groups, to ascertain their views on EPA's nonroad emissions reduction efforts. We selected these stakeholders based on their involvement in EPA's nonroad rulemaking efforts and involvement in the nonroad sector.

To review EPA's approach to reducing nonroad mobile source emissions, the progress made, and what opportunities and challenges exist in implementing actions that could lead to greater emissions reductions, we reviewed several documents. These documents included applicable Agency rulemakings, policies, guidance, and other documentation regarding planning, implementation, and oversight of programs to reduce emissions from nonroad mobile sources. We also examined external stakeholder reports, including the following:

Policies, Guidance, and Reports Reviewed

- Clean Air Act Amendments of 1977 and 1990, Sections 110 , 209, 213, and 231
- 1991 Nonroad Mobile Sources Study
- 2004 Control of Emissions of Air Pollution From Nonroad Diesel Engines and Fuel Rule
- Agency Strategic Plans
- Regulatory announcements for various nonroad diesel engine categories
- Various State and local environmental group reports pertaining to nonroad diesel engine emissions
- NONROAD emissions inventory model
- EPA National Emissions Inventory Air Pollutant Emissions Trends Data, 2005
- Clean Air Act Advisory Committee, Mobile Sources Technical Review Subcommittee meeting notes and presentations
- Clean Air Act Advisory Committee, Mobile Sources Technical Review Subcommittee – Clean Diesel and Retrofit Working Group
- National Clean Diesel Campaign
- EPA Voluntary Diesel Retrofit Program
- 2005 Diesels Emissions Reduction Act
- Congestion, Mitigation, and Air Quality Program
- State and local incentive and grant emission reduction programs
- EPA marine and locomotive regulations
- International Maritime Organization regulations
- EPA aircraft regulations
- Outdoor Power Equipment Institute

We also interviewed key air program officials and representatives at OTAQ, which is part of EPA's Office of Air and Radiation. We also interviewed the following external stakeholders

from State and local environmental organizations, environmental groups and associations, and industry:

Key Stakeholders Contacted

EPA	• Clean Air Act Advisory Committee – Clean Diesel and Retrofit Working Group • Clean Air Act Advisory Committee – Mobile Sources Technical Review Subcommittee, Ports Sector Working Group staff • OTAQ Officials ✓ Marine Diesel Engine staff ✓ NONROAD Model Staff ✓ Voluntary Diesel Retrofit Program
External	• Association of Equipment Manufacturers • Association of Local Air Pollution Control Officials • California Air Resources Board • Diesel Technology Forum • Engine Manufacturers Association • Environmental Defense • Manufacturers of Emission Controls Association • Natural Resources Defense Council • Northeast States for Coordinated Air Use Management • Puget Sound Clean Air Agency • Resources for the Future • State and Territorial Air Pollution Program Administrators / Association of Local Air Pollution Control Officials

To determine EPA's approach to reduce nonroad mobile source emissions and progress made, we identified EPA's goals and strategies for controlling nonroad emissions from 1994 to the present. We identified EPA's rulemaking status for all nonroad engine categories, including effective dates and the expected emission reductions. We reviewed EPA's regulatory authority to address emissions from new and existing engines. To identify EPA's efforts to address emissions from new and existing engines, we reviewed EPA regulations and programs to address emissions from nonroad engines, interviewed Agency staff and interested stakeholders, and analyzed supporting documentation. We reviewed PM and NO_x emission trends.

To answer the question of what additional opportunities exist for nonroad ozone precursor and PM emission reductions, we interviewed OTAQ staff, State officials, local environmental groups and associations, and industry stakeholders. This included discussing whether additional regulations were needed to address nonroad emissions. We reviewed EPA and other reports on the health and air quality impacts of nonroad sectors identified in need of additional emission reductions. We reviewed EPA and external documentation to identify nonroad categories with projected emissions growth. We identified external stakeholder reports on State and local emission reduction programs. We reviewed several Bills/Laws/Acts, such as:

- The Federal Highway Administration's Congestion, Mitigation, and Air Quality program, signed into law on August 10, 2005, as part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act.
- Diesel Emissions Reduction Act of 2005, signed into law August 2, 2005, as part of the Energy Policy Act of 2005.

To answer the question of what challenges EPA faces in effectively addressing nonroad emissions, we interviewed key EPA officials and external stakeholders to ascertain their perspective on the regulations for foreign-flagged (Category 3) marine vessels as well as aircraft, and the roles of the International Maritime Organization and International Civil Aviation Organization in addressing harmful emissions. We reviewed documentation on foreign-flagged marine vessels and aircraft emissions. We interviewed EPA and external stakeholders to understand EPA's progress in revising rules for small gasoline engines. We reviewed Congressional reports and documentation regarding small gasoline engines.

This report provides information on the progress of EPA's efforts to address nonroad emissions and makes no recommendations. We plan to perform additional reviews of mobile source issues in the future, including an in-depth review related to existing engines.

Management Controls

This report provides information on the status of EPA's efforts to address nonroad emissions, and makes no recommendations for Agency action due to the limited scope discussed above. As such, a review of EPA management control systems was not conducted. To fully assess EPA's nonroad emission reduction strategies related to existing nonroad engines, the Office of Inspector General plans further work regarding EPA's programs to reduce emissions from nonroad diesel sources.

Data Quality

We reviewed EPA's 2005 National Emissions Inventory Air Pollutants Emissions Trends Data for $PM_{2.5}$, NO_x, and VOCs, but did not conduct a data reliability assessment of the inventory as this was not the focus of our objectives.

Prior Reports

The EPA Office of Inspector General has not issued any reports specific to nonroad emissions reductions efforts. During the course of our evaluation, we reviewed the following Government Accountability Office reports related to airport emissions:

- Aviation and the Environment: Airport Operations and Future Growth Present Environmental Challenges (GAO/RCED-00-153), August 2000
- Aviation and the Environment: Strategic Framework Needed to Address Challenges Posed by Aircraft Emissions (GAO-03-252), February 2003

Appendix B

EPA's Regulatory Schedule for Nonroad Engines

Equipment Category	Rule Making and Date Final Rule Established	Phases/Tiers of Emissions Standards	Implementation Date of Emissions Standards	Actual/ Planned Emissions Reductions
Land-Based Diesel Engines				
	Control of Air Pollution; Amendments to Emission Requirements Applicable to New Nonroad Compression-Ignition Engines at or Above 37 kW: Provisions for Replacement Compression-Ignition Engines and the Use of On-Highway Compression-Ignition Engines in Nonroad Vehicles (published November 12, 1996)	Tier 1	1996-2000	Tier 1: 30% reduction in NO_X and 37% reduction by 2025
	Control of Emissions of Air Pollution from Nonroad Diesel Engines (published October 23, 1998)	Tier 2 Tier 3	2001-2006 2006-2008	Tiers 2 and 3: By 2020 exceed 50% NO_X and 40% PM reduction
	Control of Emissions of Air Pollution From Nonroad Diesel Engines (published June 29, 2004)	Tier 4	2008-2015	By 2030 , 95% reduction in PM and 90% reduction in NO_X And 99 % reduction sulfur fuel levels
Land-Based Spark-Ignition Engines				
Small Spark-Ignition				
	Control of Pollution; Emission Standards for New Nonroad Spark-Ignition Engines At or Below 19kW (published July 3, 1995)	Phase 1: <25 hp	1997	Phase 1: 32% reduction in HC by 2020
	Phase 2 Emission Standards for new Nonroad Spark-Ignition Nonhandheld Engines At or Below 19kW (published March 30, 1999)	Phase 2: <25 hp non-handheld engines	2001-2007	Phase 2: 60% reduction in HC and NO_X from Phase 1 level
	Phase 2 Emission Standards for New Nonroad Spark-Ignition Handheld engines At or Below 19kW and Minor Amendments to Emission Requirements Applicable to Small Spark-Ignition Engines and Marine Spark-Ignition Engines (published April 25, 2000)	Phase 2: <25 hp handheld engines	2002-2007	Phase 2: 70% reduction in HC and NO_X from Phase 1 level

Equipment Category	Rule Making and Date Final Rule Established	Phases/Tiers of Emissions Standards	Implementation Date of Emissions Standards	Actual/ Planned Emissions Reductions
Large Spark-Ignition				
	Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land Based) (published November 8, 2002)	> 25 hp	2004-2007	By 2030, 75% reduction in HC, 82% reduction in NO_X. 61% reduction CO, 60% reduction in PM
Recreational Vehicles				
ATVs & Motorcycles Snowmobiles	Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land Based) (published November 8, 2002)	The regulation does not include tiers of standards	2006-2007 (ATVs & Motorcycles) 2006-2012 (Snow Mobiles)	67% reduction in HC 28% reduction in CO
Marine Engines and Vessels				
Marine Spark-Ignition				
	Control of Air pollution for New Gasoline Spark-Ignition Engines: Exemptions for New Nonroad Compression Ignition Engines at or Above 37 Kilowatts and New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts (published October 4,1996)	Tier 1: Outboard & personal water craft	1998-2006	By 2025 ,75% lower HC emissions on average
Marine Diesel Engines				
Small Engines	Control of Emissions of Air Pollution from Nonroad Diesel Engines (published October 23, 1998)	Tier 1 Tier 2	1999 or 2000[a] 2004 or 2005[a]	Tier 1 and Tier 2: exceed 50% NO_X and 40% PM reduction These are the same as the Tier 2 and 3 Land Based Diesel Engine standards
Commercial diesel marine engines, Categories 1 and 2	Control of Emission from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003)[b] Control of Emission of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW (published December 29, 1999)	Tier 1 Tier 2	2004 2004-2007[a]	*Not available* 24% reduction in NO_X, 12% reduction in PM in 2030
Commercial marine diesel engines, Category 3 vessels flagged or registered in the U.S.	Control of Emission from New Marine Compression – Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003)	Tier 1	2004	Not available

Equipment Category	Rule Making and Date Final Rule Established	Phases/Tiers of Emissions Standards	Implementation Date of Emissions Standards	Actual/ Planned Emissions Reductions
Category 3 vessels – foreign flagged vessels	MARPOL-Annex VI (international marine standards)	The regulation does not include tiers of standards	2000	20% NO_X reduction
Recreational				
	Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003)	Tier 1	2004	Not available
	Control of Emission from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and land-Based) (published November 8, 2002)	Tier 2	2006-2009	Not available
Locomotives				
	Emission Standards for Locomotives and Locomotive Engines (published April 19,1998)	Tier 0: engines originally manufactured 1973-2001 Tier 1: engines originally manufactured and thereafter, 2002-2004 Tier 2: engines originally manufactured 2005 or later	2001-2005	By 2040, 59% reduction in NO_X and (41% reduction by 2010) 46% reduction in PM, 43% reduction in HC
Aircraft				
	Control of Air Pollution from Aircraft and Aircraft Engines; Emission Standards and Test Procedures, (published November 17, 2005)	The regulation does not include tiers of standards	December 19, 2005	Approximately 16% reduction in NO_X emissions

CO: Carbon Monoxide
HC: Hydrocarbons
[a] Effective dates depend on Engine Size.
[b] This rule also applies the Tier 1 standards to Category 1 and Category 2 engines with a displacement of 2.5 liters/cylinder and greater. The Tier 1 standards are equivalent to the MARPOL-Annex VI NO_x and began in 2004. Beginning in 2007, Category 1 and Category 2 engines must comply with the Tier 2 standards.

Source: EPA, *Program Update: Reducing Air Pollution from Nonroad Engines, April 2003*

Appendix C

Agency Response to Draft Report

September 8, 2006

MEMORANDUM

SUBJECT: Comments on OIG's "Progress Report on EPA's Nonroad Mobile Source Emissions Reduction Strategies"

FROM: William L. Wehrum
Acting Assistant Administrator

TO: J. Rick Beusse, Director
Office of Inspector General

I am writing to provide you with the Office of Air and Radiation's comments on the draft Inspector General Report, "Progress Report on EPA's Nonroad Mobile Source Emissions Reduction Strategies," (No. 2005-001206, May 16, 2006). Thank you for the extended opportunity to review and comment on this report.

The report has identified a number of important challenges for EPA as we try to reduce air pollution from the few remaining categories of nonroad equipment where we have yet to effect meaningful control. I am very concerned, however, as I discussed with Acting Inspector General Bill Roderick on July 31, that the report does not reflect the important progress that we have achieved thus far.

The first task OIG set out for this report was to determine "the effectiveness of EPA's efforts to reduce nonroad mobile source emissions, particularly ozone precursor emissions." The draft report, however, provides little evaluation or analysis of the enormous progress EPA has made in reducing ozone precursors (and other pollutants) from nonroad sources. Since the Clean Air Act Amendments of 1990, EPA has implemented standards for nearly every nonroad source category. Millions of engines, vehicles and equipment have been introduced into commerce in the past decade that are cleaner because of these standards, resulting in substantial reductions in air pollution. This has helped states meet the National Ambient Air Quality Standards for ozone, particulate matter and carbon monoxide, in addition to providing meaningful public health and welfare benefits. The report does not quantify these reductions, but instead indicates that EPA's efforts to date will not have any impact for 20 to 30 years. This is an important issue which should be addressed.

Please see the attached mark-up of the draft report for additional detailed comments.

I trust these comments will be helpful in completing your work on this report. Please feel free to contact me or Bill Charmley (734-214-4466) if you have any questions about our comments or if we can provide additional information.

Attachments

Appendix D

Agency Memo on Projected Near-Term Nonroad Emissions Reductions

August 25, 2006

MEMORANDUM

SUBJECT: Impact of EPA Nonroad Rules on Emissions for 2006 and 2010.

FROM: Craig Harvey and Penny Carey
Assessment and Standards division

TO: John Koupal, Director, Air Quality and Modeling Center
Assessment and Standards Division

This memorandum documents the emission reductions for calendar years 2006 and 2010 projected to occur from all existing EPA nonroad emission standards, except aircraft standards.

The NONROAD emission inventory model was used for all nonroad source categories except aircraft, commercial marine, and locomotive engines. For the two years selected, 2006 and 2010, NONROAD was used to estimate the national emissions inventory for total hydrocarbons (THC), oxides of nitrogen (NO_x), particulate matter less than 10 micrograms (PM10) and carbon monoxide (CO). For each year, annual emission inventories were estimated for two scenarios. First, inventories were estimated with no EPA emission standards in place. Second, emission inventories were estimated with the current status quo, that is, with all EPA emission standards which have been finalized as of August, 2006 assumed.

NONROAD does not currently have the capability to estimate emissions from aircraft, commercial marine and locomotive engines. Emission estimates for these categories have historically been done using spread-sheet models. For locomotive engines, the uncontrolled fuel-specific emission factors contained in the 1997 locomotive final rule were used together with the 2006 and 2010 locomotive fuel use estimates in the 2004 Clean Air Nonroad Diesel Rule to calculate the locomotive inventories with no EPA emission standards in place. The control inventories in the 2004 Clean Air Nonroad Diesel Rule incorporate all EPA locomotive standards which have been finalized to date, so these were used directly for the second scenario.

For commercial marine engines, the inventories with no EPA emission standards in place were taken from the 1999 final rule affecting Category 1 and 2 engines, and the 2003 final rule affecting Category 3 engines. The control inventories in the 2004 Clean Air Nonroad Diesel Rule incorporate all EPA commercial marine standards which have been finalized to date, so these were used directly for the second scenario.

The inventories for the source categories were then combined for each scenario. The outputs of these two scenarios were then compared and are summarized in Table 1.

Table 1: Emission reductions from all EPA nonroad standards, except aircraft

	2006		2010	
Pollutant	Tons Reduced	Percent Reduced	Tons Reduced	Percent Reduced
THC	1,590,089	33%	2,449,807	47%
NOx	913,055	21%	1,558,322	33%
PM10	73,143	21%	117,147	33%
CO	3,145,113	10%	4,718,399	14%

The results of this analysis show, for example, that in 2006, EPA's existing emission standards for nonroad sources are projected to have resulted in a 33% reduction in total hydrocarbons, a reduction of 1.5 million tons, excluding the aircraft category.

In the future, the aircraft, locomotive, and commercial marine source categories will be included in EPA's new emissions model, MOVES. If the aircraft category was included in Table 1, it would show slightly greater emission reductions, in particular for NO_x.

Appendix E

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