NATIONAL ARCHIVES AND RECORDS ADMINISTRATION
1985

Federal Register

Friday,
December 7, 2007

Part IV

Environmental Protection Agency

40 CFR Parts 9 and 94

Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 9 and 94

[EPA–HQ–OAR–2007–0121; FRL–8502–5]

RIN 2060–AO38

Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder

AGENCY: Environmental Protection Agency (EPA).

ACTION: Advance notice of proposed rulemaking.

SUMMARY: EPA is issuing this Advance Notice of Proposed Rulemaking (ANPRM) to invite comment from all interested parties on our plan to propose new emission standards and other related provisions for new compression-ignition marine engines with per cylinder displacement at or above 30 liters per cylinder. We refer to these engines as Category 3 marine engines. We are considering standards for achieving large reductions in oxides of nitrogen (NO_X) and particulate matter (PM) through the use of technologies such as in-cylinder controls, aftertreatment, and low sulfur fuel, starting as early as 2011.

Category 3 marine engines are important contributors to our nation's air pollution today and these engines are projected to continue generating large amounts of NO_X, PM, and sulfur oxides (SO_X) that contribute to nonattainment of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and ozone across the United States. Ozone and $PM_{2.5}$ are associated with serious public health problems including premature mortality, aggravation of respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function. Category 3 marine engines are of concern as a source of diesel exhaust, which has been classified by EPA as a likely human carcinogen. A program such as the one under consideration would significantly reduce the contribution of Category 3 marine engines to national inventories of NO_X, PM, and SO_X, as well as air toxics, and would reduce public exposure to those pollutants.

DATES: Comments must be received on or before March 6, 2008.

ADDRESSES: Submit your comments, identified by Docket ID No. EPA–HQ–OAR–2007–0121, by one of the following methods:

- *www.regulations.gov:* Follow the on-line instructions for submitting comments.
- *E-mail: a-and-r-docket@epa.gov*
- *Fax:* (202) 566–9744
- *Mail:* Environmental Protection Agency, Mail Code: 6102T, 1200 Pennsylvania Ave., NW., Washington, DC, 20460. Please include two copies.
- *Hand Delivery:* EPA Docket Center (Air Docket), U.S. Environmental Protection Agency, EPA West Building, 1301 Constitution Avenue, NW., Room: 3334 Mail Code: 2822T, Washington, DC. Such deliveries are only accepted during the Docket's normal hours of operation, and special arrangements should be made for deliveries of boxed information.

Instructions: Direct your comments to Docket ID No. EPA–HQ–OAR–2007–0121. EPA's policy is that all comments received will be included in the public docket without change and may be made available online at *www.regulations.gov,* including any personal information provided, unless the comment includes information claimed to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Do not submit information that you consider to be CBI or otherwise protected through *www.regulations.gov* or e-mail. The *www.regulations.gov* Web site is an ''anonymous access'' system, which means EPA will not know your identity or contact information unless you provide it in the body of your comment. If you send an e-mail comment directly to EPA without going through *www.regulations.gov* your e-mail address will be automatically captured and included as part of the comment that is placed in the public docket and made available on the Internet. If you submit an electronic comment, EPA recommends that you include your name and other contact information in the body of your comment and with any disk or CD–ROM you submit. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment. Electronic files should avoid the use of special characters, any form of encryption, and be free of any defects or viruses. For additional information about EPA's public docket visit the EPA Docket Center homepage at *http://www.epa.gov/epahome/dockets.htm.*

Docket: All documents in the docket are listed in the *www.regulations.gov* index. Although listed in the index, some information is not publicly available, e.g., CBI or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, will be publicly available only in hard copy. Publicly available docket materials are available either electronically in *www.regulations.gov* or in hard copy at the EPA Docket Center, EPA/DC, EPA West, Room 3334, 1301 Constitution Avenue, NW., Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566–1744, and the telephone number for the Air Docket is (202) 566–1742.

FOR FURTHER INFORMATION CONTACT: Michael Samulski, Assessment and Standards Division, Office of Transportation and Air Quality, 2000 Traverwood Drive, Ann Arbor, MI, 48105; telephone number: (734) 214–4532; fax number: (734) 214–4050; e-mail address: *samulski.michael@epa.gov.*

SUPPLEMENTARY INFORMATION:

I. General Information

A. Does This Action Apply to Me?

This action will affect companies that manufacture, sell, or import into the United States new marine compression-ignition engines for use on vessels flagged or registered in the United States; companies and persons that make vessels that will be flagged or registered in the United States and that use such engines; and the owners or operators of such U.S. vessels. Owners and operators of vessels flagged elsewhere may also be affected, to the extent they use U.S. shipyards or maintenance and repair facilities; see also Section VII.E regarding potential application of the standards to foreign vessels that enter U.S. ports. Finally, this action may also affect companies and persons that rebuild or maintain these engines. Affected categories and entities include the following:

Category	NAICS code[a]	Examples of potentially affected entities
Industry	333618	Manufacturers of new marine diesel engines.
Industry	336611	Manufacturers of marine vessels.
Industry	811310	Engine repair and maintenance.

Category	NAICS code[a]	Examples of potentially affected entities
Industry	483	Water transportation, freight and passenger.
Industry	324110	Petroleum Refineries.
Industry	422710, 422720	Petroleum Bulk Stations and Terminals; Petroleum and Petroleum Products Wholesalers.

[a] North American Industry Classification System (NAICS).

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by this action. To determine whether particular activities may be affected by this action, you should carefully examine the regulations. You may direct questions regarding the applicability of this action as noted in **FOR FURTHER INFORMATION CONTACT**.

B. What Should I Consider as I Prepare My Comments for EPA?

1. *Submitting CBI.* Do not submit this information to EPA through *www.regulations.gov* or e-mail. Clearly mark the part or all of the information that you claim to be CBI. For CBI information in a disk or CD–ROM that you mail to EPA, mark the outside of the disk or CD–ROM as CBI and then identify electronically within the disk or CD–ROM the specific information that is claimed as CBI. In addition to one complete version of the comment that includes information claimed as CBI, a copy of the comment that does not contain the information claimed as CBI must be submitted for inclusion in the public docket. Information so marked will not be disclosed except in accordance with procedures set forth in 40 CFR part 2.

2. *Tips for Preparing Your Comments.* When submitting comments, remember to:

- Identify the rulemaking by docket number and other identifying information (subject heading, **Federal Register** date and page number).
- Follow directions—The agency may ask you to respond to specific questions or organize comments by referencing a Code of Federal Regulations (CFR) part or section number.
- Explain why you agree or disagree, suggest alternatives, and substitute language for your requested changes.
- Describe any assumptions and provide any technical information and/or data that you used.
- If you estimate potential costs or burdens, explain how you arrived at your estimate in sufficient detail to allow for it to be reproduced.
- Provide specific examples to illustrate your concerns, and suggest alternatives.
- Explain your views as clearly as possible, avoiding the use of profanity or personal threats.
- Make sure to submit your comments by the comment period deadline identified.

II. Additional Information About This Rulemaking

The current emission standards for new compression-ignition marine engines with per cylinder displacement at or above 30 liters per cylinder were adopted in 2003 (see 68 FR 9746, February 28, 2003). This ANPRM relies in part on information that was obtained for that rule, which can be found in Public Docket EPA–HQ–OAR–2003–0045. This docket is incorporated into the docket for this action, EPA–HQ–OAR–2007–0121.

Table of Contents

I. Overview

In recent years, EPA has adopted major new programs designed to reduce emissions from diesel engines. When fully phased in, these new programs for highway[1] and land-based nonroad[2] diesel engines will lead to the elimination of over 90 percent of harmful regulated pollutants from these sources. The public health and welfare benefits of these actions are very significant, projected at over $70 billion and $83 billion for our highway and land-based nonroad diesel programs, respectively. In contrast, the corresponding cost of these programs will be a small fraction of this amount. We have estimated the annual cost at $4.2 billion and $2 billion, respectively in 2030. These programs are being implemented over the next decade.

We have also recently proposed a new emission control program for locomotives and marine diesel engines.[3] The proposed standards would address all types of diesel locomotives (line-haul, switch, and passenger rail) and all types of marine diesel engines below 30 liters per cylinder displacement (including propulsion engines used on vessels from recreational and small fishing boats to super-yachts, tugs and Great Lakes freighters, and auxiliary engines ranging from small generator sets to large generators on ocean-going

---

[1] 66 FR 5001, January 18, 2001.

[2] 69 FR 38957, June 29, 2004.

[3] 72 FR 15937, April 3, 2007.

vessels).[4] The proposal consists of a three-part program. First, we are proposing more stringent standards for existing locomotives that would apply when they are remanufactured; we are also requesting comment on a program that would apply a similar requirement to existing marine diesel engines up to 30 liters per cylinder displacement when they are remanufactured. Second, we are proposing a set of near-term emission standards, referred to as Tier 3, for newly-built locomotives and marine engines up to 30 liters per cylinder displacement that reflect the application of in-cylinder technologies to reduce engine-out NO_X and PM. Third, we are proposing longer-term standards for locomotive engines and certain marine diesel engines, referred to as Tier 4 standards, that reflect the application of high-efficiency catalytic aftertreatment technology enabled by the availability of ultra-low sulfur diesel (ULSD) fuel.

Marine diesel engines above 30 liters per cylinder, called Category 3 marine diesel engines, are significant contributors to our national mobile source emission inventory. Category 3 marine engines are predominantly used in ocean-going vessels (OGV). The contribution of these engines to national inventories is described in section VIII.A of this preamble. These inventories are expected to grow significantly due to expected increases in foreign trade. Without new controls, we anticipate that their overall contribution to mobile source oxides of nitrogen (NO_X) and fine diesel particulate matter ($PM_{2.5}$) emissions will increase to about 34 and 45 percent respectively by 2030. Their contribution to emissions in port areas on a percentage basis would be expected to be significantly higher.

Reducing emissions from these engines can lead to improvements in public health and would help states and localities attain and maintain the PM and ozone national ambient air quality standards. Both ozone and $PM_{2.5}$ are associated with serious public health problems, including premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, lost work days, and restricted activity days), changes in lung function and increased respiratory symptoms, altered respiratory defense mechanisms, and chronic bronchitis. In addition, diesel exhaust is of special public health concern. Since 2002 EPA has classified diesel exhaust as likely to be carcinogenic to humans by inhalation at environmental exposures.[5] Recent studies are showing that populations living near large diesel emission sources such as major roadways,[6] rail yards, and marine ports [7] are likely to experience greater diesel exhaust exposure levels than the overall U.S. population, putting them at greater health risks. We are currently studying the size of the U.S. population living near a sample of approximately 50 marine ports and will place this information in the docket for this ANPRM upon completion.

Category 3 marine engines are currently subject to emission standards that rely on engine-based technologies to reduce emissions. These standards, which were adopted in 2003 and went into effect in 2004, are equivalent to the NO_X limits in Annex VI to the MARPOL Convention, adopted by a Conference of the Parties to the Convention in 1997. The opportunity to gain large additional public health benefits through the application of advanced emission control technologies, including aftertreatment, lead us to consider more stringent standards for these engines. In order to achieve these emission reductions on the ship, however, it may be necessary to control the sulfur content of the fuel used in these engines. Finally, because of the international nature of ocean-going marine transportation, and the very large inventory contribution from foreign-flagged vessels, we may also consider the applicability of federal standards to foreign vessels that enter U.S. ports (see Section VII.E).

In this ANPRM, we describe the emission program we are considering for Category 3 marine diesel engines and technologies we believe can be used to achieve those standards. The remainder of this section provides background on our current emission control program and gives an overview of the program we are considering. Section II provides a brief discussion of the health and human impacts of emissions from Category 3 marine diesel engines. Section III identifies relevant Clean Air Act provisions and Section IV summarizes our interactions with the International Maritime Organization (IMO). In Sections V and VI, we describe the potential emission limits and the emission control technologies that can be used to meet them. Section VII discusses several compliance issues. In Section VIII, we summarize the contribution of these engines to current mobile source NO_X and PM inventories in the United States and describe our plans for our future cost analysis. Finally, Section IX contains information on statutory and executive order reviews covering this action. We are interested in comments covering all aspects of this ANPRM.

A. Background: EPA's Current Category 3 Standards

EPA currently has emission standards for Category 3 marine diesel engines. The standards, adopted in 2003, are equivalent to the MARPOL Annex VI NO_X limits. They apply to any Category 3 engine installed on a vessel flagged or registered in the United States, beginning in 2004.

In our 2003 final rule, we considered adopting standards that would achieve greater emission reductions through expanding the use and optimization of in-cylinder controls as well as through the use of advanced emission control technologies including water technologies (water injection, emulsification, humidification) and selective catalytic reduction (SCR). However, we determined that it was appropriate to defer a final decision on the longer-term Tier 2 standards to a future rulemaking. While there was a certain amount of information available at the time about the advanced technologies, there were several outstanding technical issues concerning the widespread commercial use of those technologies. Deferring the Tier 2 standards to a second rulemaking allowed us the opportunity to obtain important additional information on the use of these advanced technologies that we expected to become available over the next few years. This new information was expected to include: (1) New developments as manufacturers continue to make various improvements to the technology and address any remaining concerns, (2) data or experience from recently initiated in-use installations using the advanced technologies, and (3) information from

---

[4] Marine diesel engines at or above 30 l/cyl displacement are not included in this program.

[5] U.S. EPA (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/600/8–90/057F. Office of Research and Development, Washington DC. This document is available electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.* This document is available in Docket EPA–HQ–OAR–2007–0121.

[6] Kinnee, E.J.; Touman, J.S.; Mason, R.; Thurman, J.; Beidler, A.; Bailey, C.; Cook, R. (2004) Allocation of onroad mobile emissions to road segments for air toxics modeling in an urban area. Transport. Res. Part D 9: 139–150.

[7] State of California Air Resources Board. Roseville Rail Yard Study. Stationary Source Division, October 14, 2004. This document is available electronically at: *http://www.arb.ca.gov/diesel/documents/rrstudy.htm* and State of California Air Resources Board. Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, April 2006. This document is available electronically at: *http://www.arb.ca.gov/regact/marine2005/portstudy0406.pdf.* This document is available in Docket EPA–HQ–OAR–2007–0121.

longer-term in-use experience with the advanced technologies that would be helpful for evaluating the long-term durability of emission controls. An additional reason to defer the adoption of long-term standards for Category 3 engines was to allow the United States to pursue further negotiations in the international arena to achieve more stringent global emission standards for marine diesel engines.[8]

Finally, because the standards adopted in our 2003 rulemaking were equivalent to the international standards, we determined that it was appropriate to defer a decision on the application of federal standards to engines on foreign-flagged vessels that enter U.S. ports. We indicated that we would consider this issue again in our future rulemaking, and we intend to evaluate how best to address emissions from foreign vessels in this action. We expect our proposal to reflect an approach similar to the emission program recently proposed by the United States in the current discussions at the IMO to amend the MARPOL Annex VI standards to a level that achieves significant reductions in NO_X, PM, and SO_X emissions from Category 3 marine diesel engines.[9] We will evaluate progress at the IMO and, as appropriate, consider the application of new EPA national standards to engines on foreign-flagged vessels that enter U.S. ports under our Clean Air Act authority.

B. Program Under Consideration

As described in Section VI, continuing advancements in diesel engine control technology support the adoption of long-term technology-forcing standards for Category 3 engines. With regard to NO_X control, SCR has been applied to many land-based applications, and the technology continues to be refined and improved. More propulsion engines have been fitted with the technology, especially on vessels operating in the Baltic Sea, and it is being found to be very effective and durable in-use. These improvements, in addition to better optimization of engine-based controls, have the potential for significant NO_X reductions. PM and SO_X emissions from Category 3 engines are primarily due to the sulfur content of the fuel they use. In the short term, these emissions can be decreased by using fuel with a reduced sulfur content or through the use of exhaust gas cleaning technology; this is the idea behind the SO_X Emission Control Areas (SECAs) provided for in Annex VI. More significant reductions can be obtained by using distillate fuel, and at least one company has been voluntarily switching from residual fuel to distillate fuel while their ships are operating within 24 nautical miles of certain California ports.[10] Their experience demonstrates that this type of fuel switching can be done safely and efficiently, although the higher price of distillate fuel may limit this approach to near-coast and port areas. In addition, emission scrubbing techniques are improving, which have the potential for significant PM reductions from Category 3 engines.

We are currently considering an emission control program for new Category 3 marine diesel engines that takes advantage of these new emission reduction approaches. The program we are considering, described in more detail in Section V, would focus on NO_X, PM, and SO_X control from new and existing engines. This program is similar to the one recently proposed at the IMO by the U.S. government.

For NO_X control for new engines, we are considering a two-phase approach. In the first phase, called Tier 2, we are considering a NO_X emission limit for new engines that would be 15 to 25 percent below the current NO_X limits as defined by the NO_X curve in the current Tier 1 standards. These standards would apply at all times. In the second phase, called Tier 3, we are considering a NO_X emission limit that would achieve an additional 80 percent reduction from the Tier 2 limits. We are considering the Tier 2 limits as early as 2011 and Tier 3 limits in the 2016 time frame. Because Tier 3 standards are likely to be achieved using aftertreatment technologies, the application of the standards could be geographically-based thereby allowing operators to turn the system off while they are outside of a specified geographic area. That area could be the same as the compliance area for PM and SO_X reductions (see below). This two-part approach would permit near-term emission reductions while achieving deeper reductions through long-term standards.

We believe a two-phase approach under consideration is an effective way to maximize NO_X emission reductions from these engines. While we continue to believe that the focus of the emission control program should be on meaningful long-term standards that would apply high-efficiency catalytic aftertreatment to these engines, short-term emission reductions could be achieved through incremental improvements to existing engine designs. These design improvements can be consistent with a long-term, after treatment-based Tier 3 program. The recent experience of engine manufacturers in applying advanced control technologies to other mobile sources suggests that incremental changes of the type that would be used to achieve the Tier 2 standards may also be used in strategies to achieve the Tier 3 standards. For example, Tier 2 technologies may allow engine manufacturers to size their aftertreatment control systems smaller. A more stringent Tier 2 control program, however, may risk diverting resources away from Tier 3 and may result in the application of emission reduction strategies that are not consistent with high-efficiency catalytic aftertreatment-based controls.

For PM and SO_X control, we are considering a performance standard that would reflect the use of low-sulfur distillate fuels or the use of exhaust gas cleaning technology (e.g., scrubbers), or a combination of both. These standards would apply as early as 2011 and would potentially achieve SO_X reductions as high as 95 percent and substantial PM reductions as well. We believe a performance standard would be a cost-effective approach for PM emission reductions since it allows ship owners to choose from a variety of mechanisms to achieve the standard, including fuel switching or the use of emission scrubbers. Compliance with the PM and SO_X emissions could be limited to operation in a defined geographical area. For example, ships operating in the defined coastal areas (i.e., within a specified distance from shore) would be required to meet the requirements while operating within the area, but could ''turn off'' the control mechanism while on the open sea. This type of performance standard could apply to all vessels, new or existing, that operate within the designated area. An important advantage of a geographic approach for PM and SO_X control, as well as the Tier 3 standards, is that it would result in emission reductions that are important for health and human welfare while reducing the costs of the program since ships will not be required to comply with the limits while they are operating across large areas of the open sea.

---

[8] 68 FR 9748, February 28, 2003.

[9] ''Revision of the MARPOL Annex VI, the NO_X Technical Code and Related Guidelines; Development of Standards for NO_X, PM, and SO_X,'' submitted by the United States, BLG 11/5, Sub-Committee on Bulk Liquids and Gases, 11th Session, Agenda Item 5, February 9, 2007, Docket ID EPA–HQ–OAR–2007–0121–0034. This document is also available on our Web site: *http://www.epa.gov/otaq/oceanvessels.com.*

[10] See ''Maersk Line Announces Fuel Switch for Vessels Calling California'' at *http://www.maerskline.com/globalfile/?path=/pdf/environment_fuel_initiative.*

We are also considering NO_X emission controls for existing Category 3 engines that would begin in 2012. There are at least two approaches that could be used for setting NO_X emission limits for existing engines. The first would be to set a performance standard, for example a reduction of about 20 percent from the Tier 1 NO_X limits; how this reduction is achieved would be left up to the ship owner. Alternatively, the second approach would be to express the requirement as a specified action, for example an injector change known to achieve a particular reduction; this approach would simplify verification, but the emission reduction results may vary across engines. We will be exploring both of these alternative approaches and seek comment on the relative merits of each.

II. Why Is EPA Considering New Controls?

Category 3 marine engines subject to today's ANPRM generate significant emissions of fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_X) and sulfur oxides (SO_X) that contribute to nonattainment of the National Ambient Air Quality Standards for $PM_{2.5}$ and ozone. NO_X is a key precursor to ozone and secondary PM formation while SO_X is a significant contributor to ambient $PM_{2.5}$. These engines also emit volatile organic compounds (VOCs), carbon monoxide (CO), and hazardous air pollutants or air toxics, which are associated with adverse health effects. Diesel exhaust is of special public health concern, and since 2002 EPA has classified it as likely to be carcinogenic to humans by inhalation at environmental exposures. In addition, emissions from these engines also cause harm to public welfare, contributing to visibility impairment, and other detrimental environmental impacts across the U.S.

A. Ozone and PM Attainment

Many of our nation's most serious ozone and $PM_{2.5}$ nonattainment areas are located along our coastlines where vessels using Category 3 marine engine emissions contribute to air pollution in or near urban areas where significant numbers of people are exposed to these emissions. The contribution of these engines to air pollution is substantial and is expected to grow in the future. Currently more than 40 major U.S. ports [11] along our Atlantic, Great Lakes, Gulf of Mexico, and Pacific coast lines are located in nonattainment areas for ozone and/or $PM_{2.5}$ (See Figure II–1).

The health and environmental effects associated with these emissions are a classic example of a negative externality (an activity that imposes uncompensated costs on others). With a negative externality, an activity's social cost (the cost borne by society imposed as a result of the activity taking place) exceeds its private cost (the cost to those directly engaged in the activity). In this case, emissions from Category 3 marine engines impose public health and environmental costs on society. However, these added costs to society are not reflected in the costs of those using these engines and equipment. The market system itself cannot correct this negative externality because firms in the market are rewarded for minimizing their operating costs, including the costs of pollution control. In addition, firms that may take steps to use equipment that reduces air pollution may find themselves at a competitive economic disadvantage compared to firms that do not. The emission standards that EPA is considering for Category 3 marine diesel engines would help address this market failure and reduce the negative externality from these emissions by providing a positive incentive for engine manufacturers to produce engines that emit fewer harmful pollutants and for vessel builders and owners to use those cleaner engines.

When considering vessel operations in the United States' Exclusive Economic Zone (EEZ), emissions from Category 3 marine engines account for a substantial portion of the United States' ambient $PM_{2.5}$ and NO_X mobile source emissions.[12] We estimate that annual emissions in 2007 from these engines totaled more than 870,000 tons of NO_X emissions and 66,000 tons of $PM_{2.5}$. This represents more than 8 percent of U.S. mobile source NO_X and 15 percent of U.S. mobile source $PM_{2.5}$ emissions. These numbers are projected to increase significantly through 2030 due to growth in the use of Category 3 marine engines to transport overseas goods to U.S. markets and U.S. produced goods overseas. Furthermore, their proportion of the emission inventory is projected to increase significantly as regulatory controls on other major emission categories take effect. By 2030, NO_X emissions from these ships are projected to more than double, growing to 2.1 million tons a year or 34 percent of U.S. mobile source NO_X emissions while $PM_{2.5}$ emissions are expected to almost triple to 170,000 tons annually comprising 45 percent of U.S. mobile source $PM_{2.5}$ emissions.[13] In 2007 annual emission of SO_X from Category 3 engines totaled almost 530,000 tons or more than half of mobile source SO_X and by 2030 these emissions are expected to increase to 1.3 million tons or 94 percent of mobile source emissions.

Both ozone and $PM_{2.5}$ are associated with serious public health problems, including premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, lost work days, and restricted activity days), increased respiratory symptoms, altered respiratory defense mechanisms, and chronic bronchitis. Diesel exhaust is of special public health concern, and since 2002 EPA has classified it as likely to be carcinogenic to humans by inhalation at environmental exposures.[14]

Recent studies are showing that populations living near large diesel emission sources such as major roadways [15], railyards, and marine ports [16] are likely to experience greater diesel exhaust exposure levels than the overall U.S. population, putting them at greater health risks. As part of our current locomotive and marine diesel engine rulemaking (72 FR 15938, April 3, 2007), we are studying the U.S. population living near a sample of 47 marine ports which are located along the entire east and west coasts of the U.S. as well as the Gulf of Mexico and the Great Lakes region. This information

---

[11] American Association of Port Authorities (AAPA), Industry Statistics, 2005 port rankings by cargo tonnage.

[12] In general, the United States Exclusive Economic Zone (EEZ) extends to 200 nautical miles from the U.S. coast. Exceptions include geographic regions near Canada, Mexico and the Bahamas where the EEZ extends less than 200 nautical miles from the U.S. coast. See map in Figure VIII–1, below.

[13] These projections are based on growth rates ranging from 1.7 to 5.0 percent per year, depending on the geographic region. The growth rates are described in Section VIII.A.

[14] U.S. EPA (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/600/8–90/057F. Office of Research and Development, Washington DC. This document is available electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060*. This document is available in Docket EPA–HQ–OAR–2007–0121.

[15] Kinnee, E.J.; Touman, J.S.; Mason, R.; Thurman,J.; Beidler, A.; Bailey, C.; Cook, R. (2004) Allocation of onroad mobile emissions to road segments for air toxics modeling in an urban area. Transport. Res. Part D 9: 139–150.

[16] State of California Air Resources Board. Roseville Rail Yard Study. Stationary Source Division, October 14, 2004. This document is available electronically at: *http://www.arb.ca.gov/diesel/documents/rrstudy.htm* and State of California Air Resources Board. Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, April 2006. This document is available electronically at: *http://www.arb.ca.gov/regact/marine2005/portstudy0406.pdf*. These documents are available in Docket EPA–HQ–OAR–2007–0121.

will be placed in the docket for this rulemaking when the study is completed. The $PM_{2.5}$ and NO_X reductions which would occur as a result of applying advanced emissions control strategies to Category 3 marine engines could both reduce the amount of emissions that populations near these sources are exposed to and assist state and local governments as they work to reduce NO_X and $PM_{2.5}$ inventories.

Today millions of Americans continue to live in areas that do not meet existing air quality standards. As of June 2007 there are approximately 88 million people living in 39 designated areas (which include all or part of 208 counties) that either do not meet the current $PM_{2.5}$ NAAQS or contribute to violations in other counties, and 149 million people living in 94 areas (which include all or part of 391 counties) designated as not in attainment for the 8-hour ozone NAAQS. These numbers do not include the people living in areas where there is a significant future risk of failing to maintain or achieve either the $PM_{2.5}$ or ozone NAAQS.

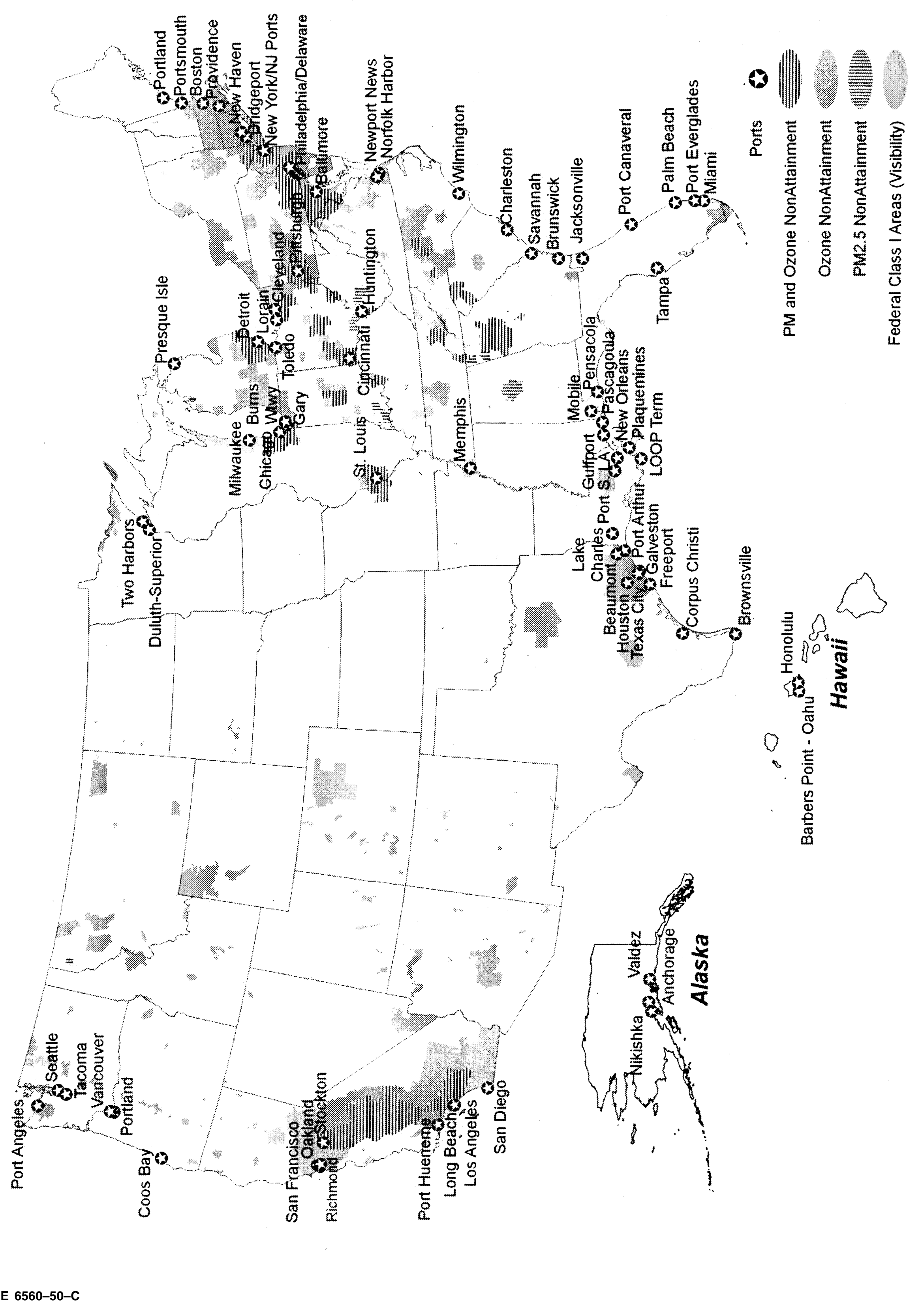
Figure II–1 illustrates the widespread nature of these problems and depicts counties which are currently (as of March 2007) designated nonattainment for either or both the 8-hour ozone NAAQS and $PM_{2.5}$ NAAQS. It also shows the location of mandatory class I federal areas for visibility. Superimposed on this map are top U.S. ports many of which receive significant port stops from ocean going vessels operating with Category 3 marine engines. Currently more than 40 major U.S. deep sea ports are located in these nonattainment areas. Many ports are located in areas rated as class I federal areas for visibility impairment and regional haze. It should be noted that emissions from ocean-going vessels are not simply a localized problem related only to cities that have commercial ports. Virtually all U.S. coastal areas are affected by emissions from ships that transit between those ports, using shipping lanes that are close to land. Many of these coastal areas also have high population densities. For example, Santa Barbara, which has no commercial port, estimates that engines on ocean-going marine vessels currently contribute about 37 percent of total NO_X in their area.[17] These emissions are from ships that transit the area, and ''are comparable to (even slightly larger than) the amount of NO_X produced onshore by cars and truck.'' By 2015 these emissions are expected to increase 67 percent, contributing 61 percent of Santa Barbara's total NO_X emissions. This mix of emission sources led Santa Barbara to point out that they will be unable to meet air quality standards for ozone without significant emission reductions from these vessels, even if they completely eliminate all other sources of pollution. Interport emissions from OGV also contribute to other environmental problems, affecting sensitive marine and land ecosystems. As discussed above, EPA recently completed estimates of the contribution of Category 3 engines to emission inventories. We recognize that air quality effects may vary from one port/coastal area to another with differences in meteorology, because of spatial differences in emissions with ship movements within regional areas. In addition, these emissions may also affect adjacent coastal areas. For these reasons, we plan to study several different port areas to better assess the air quality effects of emissions from Category 3 engines. We believe that there are additional port and adjacent coastal areas affected by emissions from Category 3 marine engines. We will be performing air quality modeling specific to this issue to better assess these impacts.

BILLING CODE 6560–50–P

---

[17] Memorandum to Docket A–2001–11 from Jean-Marie Revelt, Santa Barbara County Air Quality News, Issue 62, July–August 2001 and other materials provided to EPA by Santa Barbara County,'' March 14, 2002.

Figure II-1 Air Quality Problems are Widespread Especially in U.S. Port Areas



BILLING CODE 6560–50–C

Emissions from Category 3 marine engines account for a substantial and growing portion of the U.S.'s coastal ambient $PM_{2.5}$ and NO_X levels. The emission reductions from tightened Category 3 marine engine standards could play an important part in states' efforts to attain and maintain the NAAQS in the coming decades, especially in coastal nonattainment areas, where these engines comprise a large portion of the remaining NO_X and $PM_{2.5}$ emissions inventories. For example, 2001 emission inventories for California's South Coast ozone and PM nonattainment areas[18] indicate that ocean-going vessels (OGVs) contribute about 30 tons per day (tpd) of NO_X and 2½ tpd of $PM_{2.5}$ to regional inventories—and absent additional emission controls, this number would almost triple in 2020 to 86 tpd of NO_X and 8 tpd of $PM_{2.5}$ as port-related activities continue to grow. The Houston-Galveston-Beaumont area is also faced with growing OGV inventories which continue to hamper their area's effort to achieve and maintain clean air. Today, OGVs in the Houston nonattainment area annually contribute about 27 tpd of NO_X emissions and this is projected to climb to 30 tpd by 2009.[19] In the Corpus Christi area, OGVs in 2001 were responsible for about 16 tpd of NO_X.[20] Finally, in the New York/Northern New Jersey nonattainment area, 2000 inventories[21] indicated that OGVs contributed 12 tpd of NO_X emissions and about 0.75 tpd of $PM_{2.5}$ emissions to PM inventories. We request comment on the impact Category 3 marine engines have on state and local emission inventories as well as their efforts to meet the ozone and $PM_{2.5}$ NAAQS.

Recently, new studies[22] from the State of California provide evidence that $PM_{2.5}$ emissions within marine ports contribute significantly to elevated ambient concentrations near these sources. A substantial number of people experience exposure to Category 3 marine engine emissions, raising potential health concerns. Additional information on marine port emissions and ambient exposures can be found in section II.B.3 of this ANPRM.

In addition to public health impacts, there are serious public welfare and environmental impacts associated with ozone and $PM_{2.5}$. Specifically, ozone causes damage to vegetation which leads to crop and forestry economic losses, as well as harm to national parks, wilderness areas, and other natural systems. NO_X, SO_X and $PM_{2.5}$ can contribute to the substantial impairment of visibility in many parts of the U.S., where people live, work, and recreate, including national parks, wilderness areas, and mandatory class I federal areas. The deposition of airborne particles can also reduce the aesthetic appeal of buildings and culturally important articles through soiling, and can contribute directly (or in conjunction with other pollutants) to structural damage by means of corrosion or erosion. Finally, NO_X and SO_X emissions from diesel engines contribute to the acidification, nitrification, and eutrophication of water bodies.

While EPA has already adopted many emission control programs that are expected to reduce ambient ozone and $PM_{2.5}$ levels, including the Clean Air Interstate Rule (CAIR) (70 FR 25162, May 12, 2005), the Clean Air Nonroad Diesel Rule (69 FR 38957, June 29, 2004), the Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements (66 FR 5002, Jan. 18, 2001), and the Tier 2 Vehicle and Gasoline Sulfur Program (65 FR 6698, Feb. 10, 2000), the $PM_{2.5}$ and NO_X emission reductions resulting from tightened standards for Category 3 marine diesel engines would greatly assist nonattainment areas, especially along our nation's coasts, in attaining and maintaining the ozone and the $PM_{2.5}$ NAAQS in the near term and in the decades to come.

In September 2006, EPA finalized revised $PM_{2.5}$ NAAQS. Nonattainment areas will be designated with respect to the revised $PM_{2.5}$ NAAQS in early 2010. EPA modeling, conducted as part of finalizing the revised NAAQS, projects that in 2015 up to 52 counties with 53 million people may violate the daily, annual, or both standards for $PM_{2.5}$ while an additional 27 million people in 54 counties may live in areas that have air quality measurements within 10 percent of the revised NAAQS. Even in 2020 up to 48 counties, with 54 million people, may still not be able to meet the revised $PM_{2.5}$ NAAQS and an additional 25 million people, living in 50 counties, are projected to have air quality measurements within 10 percent of the revised standards. The $PM_{2.5}$ inventory reductions that would be achieved from applying advanced emissions control strategies to Category 3 engines could be useful in helping coastal nonattainment areas, to both attain and maintain the revised $PM_{2.5}$ NAAQS.

State and local governments are working to protect the health of their citizens and comply with requirements of the Clean Air Act (CAA or "the Act"). As part of this effort they recognize the need to secure additional major reductions in both $PM_{2.5}$ and NO_X emissions by undertaking state level action.[23] However, they also seek further Agency action for national standards, including the setting of stringent new Category 3 marine engine standards since states are preempted from setting new engine emissions standards for this class of engines.[24]

B. Public Health Impacts

1. Particulate Matter

The emission control program for Category 3 marine engines has the potential to significantly reduce their contribution to $PM_{2.5}$ inventories. In addition, these engines emit high levels of NO_X which react in the atmosphere to form secondary $PM_{2.5}$, ammonium nitrate. Category 3 marine engines also emit large amounts of SO_2 and HC which react in the atmosphere to form secondary $PM_{2.5}$ composed of sulfates and organic carbonaceous $PM_{2.5}$. The emission control program being considered would reduce the contribution of Category 3 engines to both directly emitted diesel PM and secondary PM emissions.

---

[18] California Air Resources Board (2006). Emission Reduction Plan for Ports and Goods Movements, (April 2006) Appendix B–3, Available electronically at *http://www.arb.ca.gov/gmp/docs/finalgmpplan090905.pdf.*

[19] Texas Commission On Environmental Quality (2006) Houston-Galveston-Brazoria 8-Hour Ozone State Implemental Plan & Rules, Informational Meeting Presentation, Kelly Keel, Air Quality Planning Section.

[20] Air Consulting and Engineering Solutions, Final Report Phase II Corpus Christi Regional Airshed, (August 2001) Project Number 21–01–0006.

[21] The Port Authority of New York & New Jersey, (2003), The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine Vessel Emissions Inventory, Prepared by Starcrest Consulting Group, LLC.

[22] State of California Air Resources Board. Roseville Rail Yard Study. Stationary Source Division, October 14, 2004. This document is available electronically at: *http://www.arb.ca.gov/diesel/documents/rrstudy.htm* and State of California Air Resources Board. Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, April 2006. This document is available electronically at: *ftp://ftp.arb.ca.gov/carbis/msprog/offroad/marineves s/documents/portstudy0406.pdf.* These documents are available in Docket EPA–HQ–OAR–2007–0121.

[23] For example, see: California Air Resources Board (2006). Emission Reduction Plan for Ports and Goods Movements, (April 2006), Available electronically at *http://www.arb.ca.gov/gmp/docs/finalgmpplan090905.pdf.*

[24] For example, see letter dated November 29, 2006 from California Environmental Protection Agency to Administrator Stephen L. Johnson and January 20, 2006 letter from Executive Director, Puget Sound Clean Air Agency to Administrator Stephen L. Johnson.

(a) Background

Particulate matter (PM) represents a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. PM is further described by breaking it down into size fractions. PM_{10} refers to particles generally less than or equal to 10 micrometers (µm). $PM_{2.5}$ refers to fine particles, those particles generally less than or equal to 2.5 µm in diameter. Inhalable (or ''thoracic'') coarse particles refer to those particles generally greater than 2.5 µm but less than or equal to 10 µm in diameter. Ultrafine PM refers to particles less than 100 nanometers (0.1 µm). Larger particles tend to be removed by the respiratory clearance mechanisms (e.g. coughing), whereas smaller particles are deposited deeper in the lungs.

Fine particles are produced primarily by combustion processes and by transformations of gaseous emissions (e.g., SO_X, NO_X and VOCs) in the atmosphere. The chemical and physical properties of $PM_{2.5}$ may vary greatly with time, region, meteorology, and source category. Thus, $PM_{2.5}$, may include a complex mixture of different pollutants including sulfates, nitrates, organic compounds, elemental carbon and metal compounds. These particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometers.

The primary $PM_{2.5}$ NAAQS includes a short-term (24-hour) and a long-term (annual) standard. The 1997 $PM_{2.5}$ NAAQS established by EPA set the 24-hour standard at a level of $65 \mu g/m^3$ based on the 98th percentile concentration averaged over three years. (This air quality statistic compared to the standard is referred to as the ''design value.'') The annual standard specifies an expected annual arithmetic mean not to exceed $15 \mu g/m^3$ averaged over three years. EPA has recently finalized $PM_{2.5}$ nonattainment designations for the 1997 standard (70 FR 943, Jan 5, 2005).[25] All areas currently in nonattainment for $PM_{2.5}$ will be required to meet these 1997 standards between 2009 and 2014.

EPA has recently amended the NAAQS for $PM_{2.5}$ (71 FR 61144, October 17, 2006). The final rule, signed on September 21, 2006 and published in the **Federal Register** on October 17, 2006, addressed revisions to the primary and secondary NAAQS for PM to provide increased protection of public health and welfare, respectively. The level of the 24-hour $PM_{2.5}$ NAAQS was revised from $65 \mu g/m^3$ to $35 \mu g/m^3$ to provide increased protection against health effects associated with short-term exposures to fine particles. The current form of the 24-hour $PM_{2.5}$ standard was retained (e.g., based on the 98th percentile concentration averaged over three years). The level of the annual $PM_{2.5}$ NAAQS was retained at $15 \mu g/m^3$, continuing protection against health effects associated with long-term exposures. The current form of the annual $PM_{2.5}$ standard was retained as an annual arithmetic mean averaged over three years, however, the following two aspects of the spatial averaging criteria were narrowed: (1) The annual mean concentration at each site shall be within 10 percent of the spatially averaged annual mean, and (2) the daily values for each monitoring site pair shall yield a correlation coefficient of at least 0.9 for each calendar quarter.

With regard to the secondary $PM_{2.5}$ standards, EPA has revised these standards to be identical in all respects to the revised primary standards. Specifically, EPA has revised the current 24-hour $PM_{2.5}$ secondary standard by making it identical to the revised 24-hour $PM_{2.5}$ primary standard and retained the annual $PM_{2.5}$ secondary standard. This suite of secondary $PM_{2.5}$ standards is intended to provide protection against PM-related public welfare effects, including visibility impairment, effects on vegetation and ecosystems, and material damage and soiling.

The 2006 standards became effective on December 18, 2006. As a result of the 2006 $PM_{2.5}$ standard, EPA will designate new nonattainment areas in early 2010. The timeframe for areas attaining the 2006 PM NAAQS will likely extend from 2015 to 2020.

(b) Health Effects of $PM_{2.5}$

Scientific studies show ambient PM is associated with a series of adverse health effects. These health effects are discussed in detail in the 2004 EPA Particulate Matter Air Quality Criteria Document (PM AQCD), and the 2005 PM Staff Paper.[26] [27] [28]

Health effects associated with short-term exposures (hours to days) to ambient PM include premature mortality, increased hospital admissions, heart and lung diseases, increased cough, adverse lower-respiratory symptoms, decrements in lung function and changes in heart rate rhythm and other cardiac effects. Studies examining populations exposed to different levels of air pollution over a number of years, including the Harvard Six Cities Study and the American Cancer Society Study, show associations between long-term exposure to ambient $PM_{2.5}$ and both total and cardiovascular and respiratory mortality.[29] In addition, a reanalysis of the American Cancer Society Study shows an association between fine particle and sulfate concentrations and lung cancer mortality.[30] The Category 3 marine engines covered in this proposal contribute to both acute and chronic $PM_{2.5}$ exposures.

The health effects of $PM_{2.5}$ have been further documented in local impact studies which have focused on health effects due to $PM_{2.5}$ exposures measured on or near roadways.[31] Taking account of all air pollution sources, including both spark-ignition (gasoline) and diesel powered vehicles, these latter studies indicate that exposure to $PM_{2.5}$ emissions near roadways, dominated by mobile sources, are associated with potentially serious health effects. For instance, a recent study found associations between concentrations of cardiac risk factors in the blood of healthy young police officers and $PM_{2.5}$ concentrations measured in vehicles.[32] Also, a number of studies have shown associations between residential or school outdoor concentrations of some

---

[25] U.S. EPA, Air Quality Designations and Classifications for the Fine Particles ($PM_{2.5}$) National Ambient Air Quality Standards, December 17, 2004. (70 FR 943, Jan 5, 2005) This document is available in Docket EPA–HQ–OAR–2007–0121. This document is also available on the Web at: *http://www.epa.gov/pmdesignations/.*

[26] U.S. EPA (1996) Air Quality Criteria for Particulate Matter, EPA 600–P–95–001aF, EPA 600–P–95–001bF. This document is available in Docket EPA–HQ–OAR–2007–0121.

[27] U.S. EPA (2004) Air Quality Criteria for Particulate Matter (Oct 2004), Volume I Document No. EPA600/P–99/002aF and Volume II Document No. EPA600/P–99/002bF. This document is available in Docket EPA–HQ–OAR–2007–0121.

[28] U.S. EPA (2005) Review of the National Ambient Air Quality Standard for Particulate Matter: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper. EPA–452/R–05–005. This document is available in Docket EPA–HQ–OAR–2007–0121.

[29] Dockery, DW; Pope, CA III: Xu, X; *et al.* 1993. An association between air pollution and mortality in six U.S. cities. N Engl J Med 329:1753–1759.

[30] Pope Ca, III; Thun, MJ; Namboodiri, MM; Docery, DW; Evans, JS; Speizer, FE; Heath, CW. 1995. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. Am J Respir Crit Care Med 151:669–674.

[31] Riekider, M.; Cascio, W.E.; Griggs, T.R.; Herbst, M.C.; Bromberg, P.A.; Neas, L.; Williams, R.W.; Devlin, R.B. (2003) Particulate Matter Exposures in Cars is Associated with Cardiovascular Effects in Healthy Young Men. Am. J. Respir. Crit. Care Med. 169: 934–940.

[32] Riediker, M.; Cascio, W.E.; Griggs, T.R.; et al. (2004) Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men. Am J Respir Crit Care Med 169: 934–940.

constituents of fine particles found in motor vehicle exhaust and adverse respiratory outcomes, including asthma prevalence in children who live near major roadways.[33] [34] [35] Although the engines considered in this proposal differ with those in these studies with respect to their applications and fuel qualities, these studies provide an indication of the types of health effects that might be expected to be associated with personal exposure to $PM_{2.5}$ emissions from Category 3 marine engines. By reducing their contribution to $PM_{2.5}$ inventories, the emissions controls under consideration also would reduce exposure to these emissions, specifically exposure near marine ports and shipping routes.

2. Ozone

The emissions reduction program under consideration for Category 3 marine engines would reduce the contribution of these engines NO_X inventories. These engines currently have high NO_X emissions due to the size of the engine and because they are relatively uncontrolled. NO_X contributes to the formation of ground-level ozone pollution or smog. People in many areas across the U.S. continue to be exposed to unhealthy levels of ambient ozone.

(a) Background

Ground-level ozone pollution is formed by the reaction of VOCs and NO_X in the atmosphere in the presence of heat and sunlight. These two pollutants, often referred to as ozone precursors, are emitted by many types of pollution sources, such as highway and nonroad motor vehicles and engines, power plants, chemical plants, refineries, makers of consumer and commercial products, industrial facilities, and smaller ''area'' sources.

The science of ozone formation, transport, and accumulation is complex.[36] Ground-level ozone is produced and destroyed in a cyclical set of chemical reactions, many of which are sensitive to temperature and sunlight. When ambient temperatures and sunlight levels remain high for several days and the air is relatively stagnant, ozone and its precursors can build up and result in more ozone than typically would occur on a single high-temperature day. Ozone also can be transported from pollution sources into areas hundreds of miles downwind, resulting in elevated ozone levels even in areas with low local VOC or NO_X emissions.

The highest levels of ozone are produced when both VOC and NO_X emissions are present in significant quantities on clear summer days. Relatively small amounts of NO_X enable ozone to form rapidly when VOC levels are relatively high, but ozone production is quickly limited by removal of the NO_X. Under these conditions NO_X reductions are highly effective in reducing ozone while VOC reductions have little effect. Such conditions are called ''NO_X-limited''. Because the contribution of VOC emissions from biogenic (natural) sources to local ambient ozone concentrations can be significant, even some areas where man-made VOC emissions are relatively low can be NO_X limited.

When NO_X levels are relatively high and VOC levels relatively low, NO_X forms inorganic nitrates (i.e., particles) but relatively little ozone. Such conditions are called ''VOC-limited.'' Under these conditions, VOC reductions are effective in reducing ozone, but NO_X reductions can actually increase local ozone under certain circumstances. Even in VOC-limited urban areas, NO_X reductions are not expected to increase ozone levels if the NO_X reductions are sufficiently large.

Rural areas are usually NO_X-limited, due to the relatively large amounts of biogenic VOC emissions in many rural areas. Urban areas can be either VOC- or NO_X-limited, or a mixture of both, in which ozone levels exhibit moderate sensitivity to changes in either pollutant. Ozone concentrations in an area also can be lowered by the reaction of nitric oxide with ozone, forming nitrogen dioxide (NO_2); as the air moves downwind and the cycle continues, the NO_2 forms additional ozone. The importance of this reaction depends, in part, on the relative concentrations of NO_X, VOC, and ozone, all of which change with time and location.

The current ozone NAAQS has an 8-hour averaging time. The 8-hour ozone NAAQS is met at an ambient air quality monitoring site when the average of the annual fourth-highest daily maximum 8-hour average ozone concentration over three years is less than or equal to 0.084 ppm. On June 20, 2007 EPA proposed to strengthen the ozone NAAQS. The proposed revisions reflect new scientific evidence about ozone and its effects on public health and welfare.[37] The final ozone NAAQS rule is scheduled for March 2008.

(b) Health Effects of Ozone

The health and welfare effects of ozone are well documented and are assessed in EPA's 2006 ozone Air Quality Criteria Document (ozone AQCD) and EPA staff papers.[38] [39] Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or uncomfortable sensation in the chest. Ozone can reduce lung function and make it more difficult to breathe deeply, and breathing may become more rapid and shallow than normal, thereby limiting a person's activity. Ozone can also aggravate asthma, leading to more asthma attacks that require a doctor's attention and/or the use of additional medication. Animal toxicological evidence indicates that with repeated exposure, ozone can inflame and damage the lining of the lungs, which may lead to permanent changes in lung tissue and irreversible reductions in lung function. People who are more susceptible to effects associated with

---

[33] Van Vliet, P.; Knape, M.; de Hartog, J.; Janssen, N.; Harssema, H.; Brunekreef, B. (1997). Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. Env. Research 74: 122–132.

[34] Brunekreef, B., Janssen, N.A.H.; de Hartog, J.; Harssema, H.; Knape, M.; van Vliet, P. (1997). Air pollution from truck traffic and lung function in children living near roadways. Epidemiology 8:298–303.

[35] Kim, J.J.; Smorodinsky, S.; Lipsett, M.; Singer, B.C.; Hodgson, A.T.; Ostro, B (2004). Traffic-related air pollution near busy roads: The East Bay children's respiratory health study. Am. J. Respir. Crit. Care Med. 170: 520–526.

[36] U.S. EPA Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). U.S. Environmental Protection Agency, Washington, D.C., EPA 600/R–05/004aF–cF, 2006. This document may be accessed electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_cd.html.* This document is available in Docket EPA–HQ–OAR–2007–0121.

[37] EPA proposes to set the 8-hour primary ozone standard to a level within the range of 0.070–0.075 ppm. The agency also requests comments on alternative levels of the 8-hour primary ozone standard, within a range from 0.060 ppm up to and including retention of the current standard (0.084 ppm). EPA also proposes two options for the secondary ozone standard. One option would establish a new form of standard designed specifically to protect sensitive plants from damage caused by repeated ozone exposure throughout the growing season. This cumulative standard would add daily ozone concentrations across a three month period. EPA is proposing to set the level of the cumulative standard within the range of 7 to 21 ppm-hours. The other option would follow the current practice of making the secondary standard equal to the proposed 8-hour primary standard.

[38] U.S. EPA Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). U.S. Environmental Protection Agency, Washington, D.C., EPA 600/R–05/004aF–cF, 2006. This document is available in Docket EPA–HQ–OAR–2007–0121. This document may be accessed electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_cd.html.*

[39] U.S. EPA (2006) Review of the National Ambient Air Quality Standards for Ozone, Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper Second Draft.EPA–452/D–05–002. This document is available in Docket EPA–HQ–OAR–2007–0121. This document is available electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_sp.html.*

exposure to ozone include children, the elderly, and individuals with respiratory disease such as asthma. As of the 2006 review, there was suggestive evidence that certain people may have greater genetic susceptibility. Those with greater exposures to ozone, for instance due to time spent outdoors (e.g., children and outdoor workers), are also of concern.

The recent ozone AQCD also examined relevant new scientific information which has emerged in the past decade, including the impact of ozone exposure on such health effect indicators as changes in lung structure and biochemistry, inflammation of the lungs, exacerbation and causation of asthma, respiratory illness-related school absence, hospital admissions and premature mortality. Animal toxicological studies have suggested potential interactions between ozone and PM with increased responses observed to mixtures of the two pollutants compared to either ozone or PM alone. The respiratory morbidity observed in animal studies along with the evidence from epidemiologic studies supports a causal relationship between acute ambient ozone exposures and increased respiratory-related emergency room visits and hospitalizations in the warm season. In addition, there is suggestive evidence of a contribution of ozone to cardiovascular-related morbidity and non-accidental and cardiopulmonary mortality.

3. Air Toxics

People experience elevated risk of cancer and other noncancer health effects from exposure to air toxics. Mobile sources are responsible for a significant portion of this exposure. According to the National Air Toxic Assessment (NATA) for 1999, mobile sources, including Category 3 marine engines, were responsible for 44 percent of outdoor toxic emissions and almost 50 percent of the cancer risk among the 133 pollutants quantitatively assessed in the 1999 NATA. Benzene is the largest contributor to cancer risk of all the assessed pollutants and mobile sources were responsible for about 68 percent of all benzene emissions in 1999. Although the 1999 NATA did not quantify cancer risks associated with exposure to diesel exhaust, EPA has concluded that diesel exhaust ranks with the other air toxic substances that the national-scale assessment suggests pose the greatest relative risk.

According to the 1999 NATA, nearly the entire U.S. population was exposed to an average level of air toxics that has the potential for adverse respiratory noncancer health effects. This potential was indicated by a hazard index (HI) greater than 1.[40] Mobile sources were responsible for 74 percent of the potential noncancer hazard from outdoor air toxics in 1999. About 91 percent of this potential noncancer hazard was from acrolein;[41] however, the confidence in the RfC for acrolein is medium[42] and confidence in NATA estimates of population noncancer hazard from ambient exposure to this pollutant is low.[43] It is important to note that NATA estimates of noncancer hazard do not include the adverse health effects associated with particulate matter identified in EPA's Particulate Matter Air Quality Criteria Document. Gasoline and diesel engine emissions contribute significantly to with particulate matter concentration.

It should be noted that the NATA modeling framework has a number of limitations which prevent its use as the sole basis for setting regulatory standards. These limitations and uncertainties are discussed on the 1999 NATA Web site.[44] Even so, this modeling framework is very useful in identifying air toxic pollutants and sources of greatest concern, setting regulatory priorities, and informing the decision making process.

The following section provides a brief overview of air toxics which are associated with nonroad engines, including Category 3 marine engines, and provides a discussion of the health risks associated with each air toxic.

(a) Diesel Exhaust (DE)

Category 3 marine engines emit diesel exhaust (DE), a complex mixture comprised of carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, nitrogen compounds, sulfur compounds and numerous low-molecular-weight hydrocarbons. A number of these gaseous hydrocarbon components are individually known to be toxic including aldehydes, benzene and 1,3-butadiene. The diesel particulate matter (DPM) present in diesel exhaust consists of fine particles (< 2.5 μm), including a subgroup with a large number of ultrafine particles (< 0.1 μm). These particles have large surface area which makes them an excellent medium for adsorbing organics and their small size makes them highly respirable and able to reach the deep lung. Many of the organic compounds present on the particles and in the gases are individually known to have mutagenic and carcinogenic properties. Diesel exhaust varies significantly in chemical composition and particle sizes between different engine types (heavy-duty, light-duty), engine operating conditions (idle, accelerate, decelerate), and fuel formulations (high/low sulfur fuel).[45] After being emitted in the engine exhaust, diesel exhaust undergoes dilution as well as chemical and physical changes in the atmosphere. The lifetime for some of the compounds present in diesel exhaust ranges from hours to days.

(1) Diesel Exhaust: Potential Cancer Effect of Diesel Exhaust

In EPA's 2002 Diesel Health Assessment Document (Diesel HAD),[46] diesel exhaust was classified as likely to be carcinogenic to humans by inhalation at environmental exposures, in accordance with the revised draft 1996/1999 EPA cancer guidelines. A number of other agencies (National Institute for Occupational Safety and Health, the International Agency for Research on

---

[40] To express chronic noncancer hazards, we used the RfC as part of a calculation called the hazard quotient (HQ), which is the ratio between the concentration to which a person is exposed and the RfC. (RfC is defined by EPA as, "an estimate of a continuous inhalation exposure to the human population, including sensitive subgroups, with uncertainty spanning perhaps an order of magnitude, that is likely to be without appreciable risks of deleterious noncancer effects during a lifetime.") A value of the HQ less than one indicates that the exposure is lower than the RfC and that no adverse health effects would be expected. Combined noncancer hazards were calculated using the hazard index (HI), defined as the sum of hazard quotients for individual air toxic compounds that affect the same target organ or system. As with the hazard quotient, a value of the HI at or below 1.0 will likely not result in adverse effects over a lifetime of exposure. However, a value of the HI greater than 1.0 does not necessarily suggest a likelihood of adverse effects. Furthermore, the HI cannot be translated into a probability that adverse effects will occur and is not likely to be proportional to risk.

[41] U.S. EPA. U.S. EPA (2006) National-Scale Air Toxics Assessment for 1999. This material is available electronically at *http://www.epa.gov/ttn/atw/nata1999/risksum.html.*

[42] U.S. EPA (2003) Integrated Risk Information System File of Acrolein. National Center for Environmental Assessment, Office of Research and Development, Washington, DC 2003. This material is available electronically at *http://www.epa.gov/iris/subst/0364.htm.*

[43] U.S. EPA (2006) National-Scale Air Toxics Assessment for 1999. This material is available electronically at *http://www.epa.gov/ttn/atw/nata1999/risksum.html.*

[44] U.S. EPA (2006) National-Scale Air Toxics Assessment for 1999. *http://www.epa.gov/ttn/atw/nata1999.*

[45] U.S. EPA (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/600/8–90/057F Office of Research and Development, Washington DC. Pp1–1 1–2. This document is available in Docket EPA–HQ–OAR–2007–0121. This document is available electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.*

[46] U.S. EPA (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/600/8–90/057F Office of Research and Development, Washington DC. This document is available in Docket EPA–HQ–OAR–2007–0121.

This document is available electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.*

Cancer, the World Health Organization, California EPA, and the U.S. Department of Health and Human Services) have made similar classifications. However, EPA also concluded in the Diesel HAD that it is not possible currently to calculate a cancer unit risk for diesel exhaust due to a variety of factors that limit the current studies, such as limited quantitative exposure histories in occupational groups investigated for lung cancer.

For the Diesel HAD, EPA reviewed 22 epidemiologic studies on the subject of the carcinogenicity of workers exposed to diesel exhaust in various occupations, finding increased lung cancer risk, although not always statistically significant, in 8 out of 10 cohort studies and 10 out of 12 case-control studies within several industries, including railroad workers. Relative risk for lung cancer associated with exposure ranged from 1.2 to 1.5, although a few studies show relative risks as high as 2.6. Additionally, the Diesel HAD also relied on two independent meta-analyses, which examined 23 and 30 occupational studies respectively, which found statistically significant increases in smoking-adjusted relative lung cancer risk associated with diesel exhaust, of 1.33 to 1.47. These meta-analyses demonstrate the effect of pooling many studies and in this case show the positive relationship between diesel exhaust exposure and lung cancer across a variety of diesel exhaust-exposed occupations.[47] [48] [49]

In the absence of a cancer unit risk, the Diesel HAD sought to provide additional insight into the significance of the diesel exhaust-cancer hazard by estimating possible ranges of risk that might be present in the population. An exploratory analysis was used to characterize a possible risk range by comparing a typical environmental exposure level for highway diesel sources to a selected range of occupational exposure levels. The occupationally observed risks were then proportionally scaled according to the exposure ratios to obtain an estimate of the possible environmental risk. A number of calculations are needed to accomplish this, and these can be seen in the EPA Diesel HAD. The outcome was that environmental risks from diesel exhaust exposure could range from a low of 10 − 4 to 10 − 5 to as high as 10 − 3, reflecting the range of occupational exposures that could be associated with the relative and absolute risk levels observed in the occupational studies. Because of uncertainties, the analysis acknowledged that the risks could be lower than 10 − or 10 − 5, and a zero risk from diesel exhaust exposure was not ruled out.

Retrospective health studies of railroad workers have played an important part in determining that diesel exhaust is a likely human carcinogen. Key evidence of the diesel exhaust exposure linkage to lung cancer comes from two retrospective case-control studies of railroad workers which are discussed at length in the Diesel HAD.

(2) Diesel Exhaust: Other Health Effects

Noncancer health effects of acute and chronic exposure to diesel exhaust emissions are also of concern to the Agency. EPA derived an RfC from consideration of four well-conducted chronic rat inhalation studies showing adverse pulmonary effects.[50] [51] [52] [53] The RfC is 5 $\mu g/m^3$ for diesel exhaust as measured by diesel PM. This RfC does not consider allergenic effects such as those associated with asthma or immunologic effects. There is growing evidence, discussed in the Diesel HAD, that exposure to diesel exhaust can exacerbate these effects, but the exposure-response data were found to be lacking to derive an RfC. The EPA Diesel HAD states, ''With DPM [diesel particulate matter] being a ubiquitous component of ambient PM, there is an uncertainty about the adequacy of the existing DE [diesel exhaust] noncancer database to identify all of the pertinent DE-caused noncancer health hazards. (p. 9–19).

(3) Ambient $PM_{2.5}$ Levels and Exposure to Diesel Exhaust PM

The Diesel HAD briefly summarizes health effects associated with ambient PM and discusses the EPA's annual NAAQS of 15 $\mu g/m^3$. In addition, both the 2004 AQCD and the 2005 Staff Paper for $PM_{2.5}$ have more recent information. There is a much more extensive body of human data showing a wide spectrum of adverse health effects associated with exposure to ambient PM, of which diesel exhaust is an important component. The $PM_{2.5}$ NAAQS is designed to provide protection from the noncancer and premature mortality effects of $PM_{2.5}$ as a whole, of which diesel PM is a constituent.

(4) Diesel Exhaust PM Exposures

Exposure of people to diesel exhaust depends on their various activities, the time spent in those activities, the locations where these activities occur, and the levels of diesel exhaust pollutants in those locations. The major difference between ambient levels of diesel particulate and exposure levels for diesel particulate is that exposure accounts for a person moving from location to location, proximity to the emission source, and whether the exposure occurs in an enclosed environment.

Occupational Exposures

Occupational exposures to diesel exhaust from mobile sources, including Category 3 marine engines, can be several orders of magnitude greater than typical exposures in the non-occupationally exposed population.

Over the years, diesel particulate exposures have been measured for a number of occupational groups resulting in a wide range of exposures from 2 to 1,280 $\mu g/m^3$ for a variety of occupations. Studies have shown that miners and railroad workers typically have higher diesel exposure levels than other occupational groups studied, including firefighters, truck dock workers, and truck drivers (both short and long haul).[54] As discussed in the Diesel HAD, the National Institute of Occupational Safety and Health (NIOSH) has estimated a total of 1,400,000 workers are occupationally exposed to diesel exhaust from on-road and nonroad vehicles.

---

[47] U.S. EPA (2002) Health Assessment Document for Diesel Engine Exhaust. EPA/6008–90/057F Office of Research and Development, Washington DC. This document is available in Docket EPA–HQ–OAR–2007–0121.

[48] Bhatia, R., Lopipero, P., Smith, A. (1998) Diesel exposure and lung cancer. Epidemiology 9(1):84–91.

[49] Lipsett, M: Campleman, S; (1999) Occupational exposure to diesel exhaust and lung cancer: a meta-analysis. Am J Public Health 80(7): 1009–1017.

[50] Ishinishi, N; Kuwabara, N; Takaki, Y; et al. (1988) Long-term inhalation experiments on diesel exhaust. In: Diesel exhaust and health risks. Results of the HERP studies. Ibaraki, Japan: Research Committee for HERP Studies; pp. 11–84.

[51] Heinrich, U; Fuhst, R; Rittinghausen, S; et al. (1995) Chronic inhalation exposure of Wistar rats and two different strains of mice to diesel engine exhaust, carbon black, and titanium dioxide. Inhal. Toxicol. 7:553–556.

[52] Mauderly, JL; Jones, RK; Griffith, WC; et al. (1987) Diesel exhaust is a pulmonary carcinogen in rats exposed chronically by inhalation. Fundam. Appl. Toxicol. 9:208–221.

[53] Nikula, KJ; Snipes, MB; Barr, EB; et al. (1995) Comparative pulmonary toxicities and carcinogenicities of chronically inhaled diesel exhaust and carbon black in F344 rats. Fundam. Appl. Toxicol. 25:80–94.

[54] Diesel HAD Page 2–110, 8–12; Woskie, SR; Smith, TJ; Hammond, SK: et al. (1988a) Estimation of the DE exposures of railroad workers: II. National and historical exposures. Am J Ind Med 12:381–394.

Elevated Concentrations and Ambient Exposures in Mobile Source-Impacted Areas

Regions immediately downwind of marine ports and shipping channels experience elevated ambient concentrations of directly-emitted $PM_{2.5}$ from Category 3 marine engines. Due to the unique nature of marine ports, emissions from a large number of Category 3 marine engines are concentrated in a relatively small area.

A recent study conducted by the California Air Resources Board (CARB) examined the air quality impacts of railroad operations at the J.R. Davis Rail Yard, the largest service and maintenance rail facility in the western United States.[55] This is relevant in that locomotives use diesel engines similar to those used in marine vessels. The yard occupies 950 acres along a one-quarter mile wide and four mile long section of land in Roseville, CA. The study developed an emissions inventory for the facility for the year 2000 and modeled ambient concentrations of diesel PM using a well-accepted dispersion model (ISCST3). The study estimated substantially elevated concentrations in an area 5,000 meters from the facility, with higher concentrations closer to the rail yard. Using local meteorological data, annual average contributions from the rail yard to ambient diesel PM concentrations under prevailing wind conditions were 1.74, 1.18, 0.80, and 0.25 $\mu g/m^3$ at receptors located 200, 500, 1000, and 5000 meters from the yard, respectively. Several tens of thousands of people live within the area estimated to experience substantial increases in annual average ambient $PM_{2.5}$ as a result of rail yard emissions.

Another study from CARB evaluated air quality impacts of diesel engine emissions within the Ports of Long Beach and Los Angeles in California, one of the largest ports in the U.S.[56] The study found that ocean going vessels comprised 53% of the diesel PM emissions while ship auxiliary engines' hoteling comprised another 20% of PM emissions for the marine ports. Like the earlier rail yard study, the port study employed the ISCST3 dispersion model. Also using local meteorological data, annual average concentrations were substantially elevated over an area exceeding 200,000 acres. Because the ports are located near heavily-populated areas, the modeling indicated that over 700,000 people lived in areas with at least 0.3 $\mu g/m^3$ of port-related diesel PM in ambient air, about 360,000 people lived in areas with at least 0.6 $\mu g/m^3$ of diesel PM, and about 50,000 people lived in areas with at least 1.5 ug/m^3 of ambient diesel PM directly from the port. The study found that impacts could be discerned up to 15 miles from the marine port.

Overall, while these studies focus on only two large marine port and railroad facilities, they highlight the substantial contribution these facilities make to elevated ambient concentrations in populated areas.

We initiated a study in 2006 to better understand the populations that are living near rail yards and marine ports nationally. As part of this effort, a computer geographic information system (GIS) is being used to identify the locations and property boundaries of these facilities nationally, and to determine the size and demographic characteristics of the population living near these facilities. We anticipate that the results of this study will be completed in late 2007 and we intend to add this report to the public docket.

(b) Other Air Toxics-Benzene, 1,3-butadiene, Formaldehyde, Acetaldehyde, Acrolein, POM, Naphthalene

Category 3 marine engine emissions contribute to ambient levels of other air toxics known or suspected as human or animal carcinogens, or that have non-cancer health effects. These other compounds include benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic organic matter (POM), and naphthalene. All of these compounds, except acetaldehyde, were identified as national or regional risk drivers in the 1999 National-Scale Air Toxics Assessment (NATA). That is, for a significant portion of the population, these compounds pose a significant portion of the total cancer and noncancer risk from breathing outdoor air toxics. Furthermore, a significant portion of total nationwide emissions of these pollutants result from mobile sources. However, EPA does not have high confidence in the NATA data for all these compounds. Reducing the emissions from Category 3 marine engines would help reduce exposure to these harmful substances.

Air toxics can cause a variety of cancer and noncancer health effects. A number of the mobile source air toxic pollutants described in this section are known or likely to pose a cancer hazard in humans. Many of these compounds also cause adverse noncancer health effects resulting from inhalation exposures. These include neurological, cardiovascular, liver, kidney, and respiratory effects as well as effects on the immune and reproductive systems.

C. Other Environmental Effects

There are a number of public welfare effects associated with the presence of ozone and $PM_{2.5}$ in the ambient air including the impact of $PM_{2.5}$ on visibility and materials and the impact of ozone on plants, including trees, agronomic crops and urban ornamentals.

1. Visibility

Visibility can be defined as the degree to which the atmosphere is transparent to visible light. Visibility impairment manifests in two principal ways: as local visibility impairment and as regional haze.[57] Local visibility impairment may take the form of a localized plume, a band or layer of discoloration appearing well above the terrain as a result of complex local meteorological conditions. Alternatively, local visibility impairment may manifest as an urban haze, sometimes referred to as a ''brown cloud.'' This urban haze is largely caused by emissions from multiple sources in the urban areas and is not typically attributable to only one nearby source or to long-range transport. The second type of visibility impairment, regional haze, usually results from multiple pollution sources spread over a large geographic region. Regional haze can impair visibility in large regions and across states.

Visibility is important because it has direct significance to people's enjoyment of daily activities in all parts of the country. Individuals value good visibility for the well-being it provides them directly, where they live and work, and in places where they enjoy recreational opportunities. Visibility is also highly valued in significant natural areas such as national parks and wilderness areas and special emphasis is given to protecting visibility in these areas. For more information on visibility

---

[55] Hand, R.; Pingkuan, D.; Servin, A.; Hunsaker, L.; Suer, C. (2004) Roseville rail yard study. California Air Resources Board. [Online at *http://www.arb.ca.gov/diesel/documents/rrstudy.htm*]

[56] Di, P.; Servin, A.; Rosenkranz, K.; Schwehr, B.; Tran, H. (2006) Diesel particulate matter exposure assessment study for the Ports of Los Angeles and Long Beach. California Air Resources Board. [Online at *http://www.arb.ca.gov/msprog/offroad/marinevess/marinevess.htm*]

[57] See discussion in U.S. EPA , National Ambient Air Quality Standards for Particulate Matter; Proposed Rule; January 17, 2006, Vol71 p 2676. This document is available in Docket EPA–HQ–OAR–2007–0121. This information is available electronically at *http://epa.gov/fedrgstr/EPA-AIR/2006/January/Day-17/a177.pdf.*

see the final 2004 PM AQCD[58] as well as the 2005 PM Staff Paper.[59]

Fine particles are the major cause of reduced visibility in parts of the United States. EPA is pursuing a two-part strategy to address visibility. First, to address the welfare effects of PM on visibility, EPA set secondary $PM_{2.5}$ standards which would act in conjunction with the establishment of a regional haze program. In setting this secondary standard EPA concluded that $PM_{2.5}$ causes adverse effects on visibility in various locations, depending on PM concentrations and factors such as chemical composition and average relative humidity. Second, section 169 of the Clean Air Act provides additional authority to address existing visibility impairment and prevent future visibility impairment in the 156 national parks, forests and wilderness areas categorized as mandatory class I federal areas (62 FR 38680–38681, July 18, 1997).[60] In July 1999 the regional haze rule (64 FR 35714) was put in place to protect the visibility in mandatory class I federal areas. Visibility can be said to be impaired in both $PM_{2.5}$ nonattainment areas and mandatory class I federal areas.

Category 3 marine engines contribute to visibility concerns in these areas through their primary $PM_{2.5}$ emissions and their NO_X and SO_2 emissions which contribute to the formation of secondary $PM_{2.5}$.

Recently designated $PM_{2.5}$ nonattainment areas indicate that, as of June 20, 2007, almost 90 million people live in nonattainment areas for the 1997 $PM_{2.5}$ NAAQS. Thus, at least these populations would likely be experiencing visibility impairment, as well as many thousands of individuals who travel to these areas. In addition, while visibility trends have improved in mandatory Class I federal areas the most recent data show that these areas continue to suffer from visibility impairment. In summary, visibility impairment is experienced throughout the U.S., in multi-state regions, urban areas, and remote mandatory class I federal areas.[61] [62]

2. Plant and Ecosystem Effects of Ozone

Ozone contributes to many environmental effects, with impacts to plants and ecosystems being of most concern. Ozone can produce both acute and chronic injury in sensitive species depending on the concentration level and the duration of the exposure. Ozone effects also tend to accumulate over the growing season of the plant, so that even lower concentrations experienced for a longer duration have the potential to create chronic stress on vegetation. Ozone damage to plants includes visible injury to leaves and a reduction in food production through impaired photosynthesis, both of which can lead to reduced crop yields, forestry production, and use of sensitive ornamentals in landscaping. In addition, the reduced food production in plants and subsequent reduced root growth and storage below ground, can result in other, more subtle plant and ecosystems impacts. These include increased susceptibility of plants to insect attack, disease, harsh weather, interspecies competition and overall decreased plant vigor. The adverse effects of ozone on forest and other natural vegetation can potentially lead to species shifts and loss from the affected ecosystems, resulting in a loss or reduction in associated ecosystem goods and services. Lastly, visible ozone injury to leaves can result in a loss of aesthetic value in areas of special scenic significance like national parks and wilderness areas. The final 2006 ozone Air Quality Criteria Document (ozone AQCD)[63] presents more detailed information on ozone effects on vegetation and ecosystems.

As discussed above, Category 3 marine engine emissions of NO_X contribute to ozone and therefore the NO_X standards discussed in this action would help reduce crop damage and stress on vegetation from ozone.

3. Acid Deposition

Acid deposition, or acid rain as it is commonly known, occurs when NO_X and SO_2 react in the atmosphere with water, oxygen and oxidants to form various acidic compounds that later fall to earth in the form of precipitation or dry deposition of acidic particles. It contributes to damage of trees at high elevations and in extreme cases may cause lakes and streams to become so acidic that they cannot support aquatic life. In addition, acid deposition accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.

The proposed NO_X and SO_X standards would help reduce acid deposition, thereby helping to reduce acidity levels in lakes and streams throughout the coastal areas of our country and help accelerate the recovery of acidified lakes and streams and the revival of ecosystems adversely affected by acid deposition. Reduced acid deposition levels will also help reduce stress on forests, thereby accelerating reforestation efforts and improving timber production. Deterioration of historic buildings and monuments, vehicles, and other structures exposed to acid rain and dry acid deposition also will be reduced, and the costs borne to prevent acid-related damage may also decline. While the reduction in nitrogen acid deposition will be roughly proportional to the reduction in NO_X emissions, the precise impact of new standards would differ across different areas.

4. Eutrophication and Nitrification

The NO_X standards discussed in this action would help reduce the airborne nitrogen deposition that contributes to eutrophication of watersheds, particularly in aquatic systems where atmospheric deposition of nitrogen represents a significant portion of total nitrogen loadings. Eutrophication is the accelerated production of organic matter, particularly algae, in a water body. This increased growth can cause numerous adverse ecological effects and economic impacts, including nuisance algal blooms, dieback of underwater plants due to reduced light penetration, and toxic plankton blooms. Algal and plankton blooms can also reduce the level of dissolved oxygen, which can adversely affect fish and shellfish populations. In recent decades, human activities have greatly accelerated nutrient impacts, such as nitrogen and phosphorus, causing excessive growth of algae and leading to degraded water

---

[58] U.S. EPA (2004) Air Quality Criteria for Particulate Matter (Oct 2004), Volume I Document No. EPA600/P–99/002aF and Volume II Document No. EPA600/P–99/002bF. This document is available in Docket EPA–HQ–OAR–2007–0121.

[59] U.S. EPA (2005) Review of the National Ambient Air Quality Standard for Particulate Matter: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper. EPA–452/R–05–005. This document is available in Docket EPA–HQ–OAR–2007–0121.

[60] These areas are defined in section 162 of the Act as those national parks exceeding 6,000 acres, wilderness areas and memorial parks exceeding 5,000 acres, and all international parks which were in existence on August 7, 1977.

[61] U.S. EPA, Air Quality Designations and Classifications for the Fine Particles ($PM_{2.5}$) National Ambient Air Quality Standards, December 17, 2004. (70 FR 943, Jan 5. 2005) This document is available in Docket EPA–HQ–OAR–2007–0121. This document is also available on the web at: *http://www.epa.gov/pmdesignations/.*

[62] U.S. EPA. Regional Haze Regulations, July 1, 1999. (64 FR 35714, July 1, 1999) This document is available in Docket EPA–HQ–OAR–2007–0121.

[63] U.S. EPA Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). U.S. Environmental Protection Agency, Washington, DC, EPA 600/R–05/004aF–cF, 2006. This document is available in Docket EPA–HQ–OAR–2007–0121. This document may be accessed electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_cd.html.*

quality and associated impairment of freshwater and estuarine resources for human uses.[64]

Severe and persistent eutrophication often directly impacts human activities. For example, losses in the nation's fishery resources may be directly caused by fishkills associated with low dissolved oxygen and toxic blooms. Declines in tourism occur when low dissolved oxygen causes noxious smells and floating mats of algal blooms create unfavorable aesthetic conditions. Risks to human health increase when the toxins from algal blooms accumulate in edible fish and shellfish, and when toxins become airborne, causing respiratory problems due to inhalation. According to the NOAA report, more than half of the nation's estuaries have moderate to high expressions of at least one of these symptoms—an indication that eutrophication is well developed in more than half of U.S. estuaries.[65]

5. Materials Damage and Soiling

The deposition of airborne particles can reduce the aesthetic appeal of buildings and culturally important articles through soiling, and can contribute directly (or in conjunction with other pollutants) to structural damage by means of corrosion or erosion.[66] Particles affect materials principally by promoting and accelerating the corrosion of metals, by degrading paints, and by deteriorating building materials such as concrete and limestone. Particles contribute to these effects because of their electrolytic, hygroscopic, and acidic properties, and their ability to adsorb corrosive gases (principally sulfur dioxide). The rate of metal corrosion depends on a number of factors, including the deposition rate and nature of the pollutant; the influence of the metal protective corrosion film; the amount of moisture present; variability in the electrochemical reactions; the presence and concentration of other surface electrolytes; and the orientation of the metal surface. The PM standards discussed in this action would help reduce the airborne particles that contribute to materials damage and soiling.

III. Relevant Clean Air Act Provisions

Section 213 of the Clean Air Act (the Act) gives us the authority to establish emission standards for nonroad engines and vehicles. Section 213(a)(3) requires the Administrator to set (and from time to time revise) standards for NO_X, VOCs, or carbon monoxide emissions from new nonroad engines, to reduce ambient levels of ozone and carbon monoxide. That section specifies that the ''standards shall achieve the greatest degree of emission reductions achievable through the application of technology which the Administrator determines will be available for the engines or vehicles.'' As part of this determination, the Administrator must give appropriate consideration to lead time, noise, energy, and safety factors associated with the application of such technology. Section 213(a)(4) authorizes the Administrator to establish standards on new engines to control emissions of pollutants, such as PM, which ''may reasonably be anticipated to endanger public health and welfare.'' In setting appropriate standards, EPA is instructed to take into account costs, noise, safety, and energy factors.

Section 211(c) of the CAA allows us to regulate fuels where emission products of the fuel either: (1) Cause or contribute to air pollution that reasonably may be anticipated to endanger public health or welfare, or (2) will impair to a significant degree the performance of any emission control device or system which is in general use, or which the Administrator finds has been developed to a point where in a reasonable time it will be in general use were such a regulation to be promulgated.

IV. International Regulation of Air Pollution From Ships

Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL) addresses air pollution from ships. Annex VI was adopted by the Parties to MARPOL at a Diplomatic Conference on September 26, 1997, and it went into force May 20, 2005. As of July 31, 2007, the Annex has been ratified by 44 countries, representing 74.1 percent of the world's merchant shipping tonnage.[67]

Globally harmonized regulation of ship emissions is generally recognized to be the preferred approach for addressing air emissions from ocean-going vessels. It reduces costs for ship owners, since they would not be required to comply with a patchwork of different standards that could occur if each country was setting its own standards, and it can simplify environmental protection for port and coastal states.

The significance of international shipping to the United States can be illustrated by port entrance statistics. In 1999, according to U.S. Maritime Administration (MARAD) data, about 90 percent of annual entrances to U.S. ports were made by foreign-flagged vessels (75,700 total entrances; 67,500 entrances by foreign vessels; entrances are for vessels engaged in foreign trade and do not include Jones Act[68] vessels). At the same time, however, only a small portion of those vessels account for most of the visits. In 1999, of the 7,800 foreign vessels that visited U.S. ports, about 12 percent accounted for about 50 percent of total vessel entrances; about 30 percent accounted for about 75 percent of the vessel entrances.[69]

The emission control program contained in Annex VI was the first step for the international control of air pollution from ships. However, as early as the 1997 conference, many countries ''already recognized that the NO_X emission limits established in Regulation 13 were very modest when compared with current technology developments.''[70] Consequently, a Conference Resolution was adopted at the 1997 conference that invited the Marine Environment Protection Committee (MEPC) to review the NO_X emission limits at a minimum of five-year intervals after entry into force of the protocol and, if appropriate, amend

---

[64] Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June 2000, EPA–453/R–00–005. This document is available in Docket EPA–HQ–OAR–2007–0121. It is also available at *http://www.epa.gov/oar/oaqps/gr8water/3rdrpt/obtain.html*.

[65] Bricker, Suzanne B., *et al.*, National Estuarine Eutrophication Assessment, Effects of Nutrient Enrichment in the Nation's Estuaries, National Ocean Service, National Oceanic and Atmospheric Administration, September, 1999.

[66] U.S. EPA (2005) Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information, OAQPS Staff Paper. This document is available in Docket EPA–HQ–OAR–2007–0121.

[67] See *http://www.imo.org* Go to Conventions, Status of Conventions—Summary.

[68] 46 USCS Appx § 688.

[69] Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder. EPA420–R–03–004, January 2003, pg. 3–50. This document is available at *http://www.epa.gov/otaq/regs/nonroad/marine/ci/r03004.pdf.* We will update these statistics for more recent years; however, these results are not expected to change significantly given the U.S. share of the ownership of ocean-going vessels. MARAD data from 2005 indicates that while about 4.7 percent of all ocean-going vessels are owned by citizens of the United States (5th largest fleet) only about 1.9 percent of all ocean-going vessels are flagged here. Also according to that data, while Greece, Japan, China, and Germany account for the largest fleets in terms of ownership (15.3, 13.0, 11, and 8.9 percent, respectively), Panama and Liberia account for the largest fleets by flag (21.6 and 8.9 percent, respectively).

[70] Proposal to Initiate a Revision Process, Submitted by Finland, Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom. MEPC 53/4/4, 15 April 2005. Marine Environment Protection Committee, 53rd Session, Agenda Item 4.

the NO_X limits to reflect more stringent controls.

The United States began advocating a review of the NO_X emission limits in 1999.[71] However, MEPC did not formally consider the issue until 2005, after the Annex went into effect. Negotiations for amendments to the Annex VI standards, including NO_X and SO_X emission limits, officially began in April 2006, with the most recent round of negotiations taking place in April 2007. The United States submitted a paper to that meeting (April 2007 Bulk Liquids and Gases Sub-Committee meeting, referred to as BLG–11) setting out an approach for new international engine and fuel standards. That approach forms the basis of the program outlined in this ANPRM.[72] Discussions are expected to continue through Summer 2008 and are expected to conclude at the October 2008 MEPC meeting. We will continue to coordinate our national rule for Category 3 emission limits with our activities at IMO.

V. Potential Standards and Effective Dates

Over the past several years, remarkable progress has been made for land-based highway and nonroad diesel engines in reducing NO_X and PM emissions. Current EPA standards for those land-based sources are anticipated to achieve emission reductions of more than 90 percent relative to uncontrolled NO_X and PM levels. In contrast, Category 3 marine engines are subject to modest NO_X standards only. In this rulemaking, we are considering a comprehensive program that would set long-term standards based on the use of high-efficiency catalytic aftertreatment. These standards would achieve substantial reductions in NO_X, PM, and SO_X exhaust emissions.

The program we are considering is based on the the U.S. Government proposal to IMO, which consists of near- and long-term NO_X limits for new engines based on engine controls and aftertreatment technology; NO_X limits for certain existing engines based on engine controls; and PM/SO_X limits that can be achieved through the use of exhaust gas cleaning or low sulfur fuel. To reduce the costs of the international program, the long-term new engine NO_X limits and the PM/SO_X limits would not apply while ships are operating on the open ocean; instead, they would in specified geographic areas to be defined under the treaty.

This section describes in greater detail how we are considering that emission control program for our federal action under the Clean Air Act.

A. NO_X Standards

Tier 2 NO_X limits: We are considering new NO_X emission standards for Category 3 marine diesel engines. As discussed in Section VI, emission control technology for Category 3 marine engines has progressed substantially in recent years. Significant reductions can be achieved in the near term through in-cylinder controls with little or no impact on overall vessel performance. These technologies include traditional engine-out controls such as electronically controlled high pressure common-rail fuel systems, turbocharger optimization, compression-ratio changes, and electronically controlled exhaust valves. Further emission reductions could be achieved through the use of water-based technologies such as water emulsification, direct water injection, or intake-air humidification or through exhaust gas recirculation. We request comment on setting a near term NO_X emission standard requiring a reduction of 15 to 25 percent below the current Tier 1 standard. We are considering applying this near term standard to new engines as early as 2011.

Tier 3 NO_X limits: In the longer term, we believe that much greater emission reductions could be achieved through the use of selective catalytic reduction (SCR). More than 300 SCR systems have been installed on marine vessels, some of which have been in operation for more than 10 years and have accumulated 80,000 hours of operation. While many of these applications have been limited to certain vessel classes, we believe that the technology is feasible for application to most engines given adequate lead time. As discussed in Section VI, SCR systems are capable of reducing NO_X on the order of 90 to 95 percent compared to current emission levels. We further believe that an 80 percent reduction from the Tier 2 levels discussed above is achievable throughout the life of the vessel. We are requesting comment on setting a NO_X standard 80 percent below the Tier 2 standards in the 2016 timeframe. Low sulfur distillate fuel would help in achieving these limits due to the impact of sulfur on catalyst operation; however, we do not believe low sulfur fuel is necessary to achieve these reductions. SCR systems have been used on residual fuel, with sulfur levels as high as 2.5 to 3 percent. However low sulfur distillate fuel would allow SCR systems to be smaller, more efficient, less costly, and simpler to operate.

NO_X limits for existing engines: Due to the very long life of ocean-going vessels and the availability of known in-cylinder technical modifications that provide significant and cost-effective NO_X reductions, the U.S. proposal to IMO presents potential NO_X emission limits for engines on vessels built prior to the Tier 1 limits. We are requesting comment on requiring engines on these vessels to be retrofitted to meet the Tier 1 standard. The U.S. submittal proposed that this requirement would start in 2012. Although the Tier 1 standards went into effect in the United States in 2004, manufacturers have been building engines with emissions that meet this limit since 2000 due to the MARPOL Annex VI NO_X standard. Although the Annex VI standards did not go into force until 2005, they apply to engines installed on vessels built on or after January 1, 2000.

Engines may be retrofitted to achieve meaningful emission reduction by applying technology used by manufacturers to meet the Tier 1 limits. These technologies include slide-valve fuel injectors and injection timing retard. Manufacturers have indicated that they can reduce NO_X emissions by approximately 20 percent using this technology. However, some engines have higher baseline emissions than average and would require more than a 20 percent emission reduction to meet Tier 1 standards. Manufacturers have expressed concerns that they would not necessarily be able to reduce emissions to the Tier 1 standards for such engines through a simple retrofit. Therefore, the U.S. proposal to IMO considers a standard based on percent reduction rather than an absolute numerical limit. Specifically, these engines would need to be modified to reduce NO_X emissions by 20 percent from their existing baseline emission rate. Alternatively, we request comment on requiring vessel operators to perform a specific action, such as a valve or injector change, that would be known to achieve a particular NO_X reduction. In this case, the certification and compliance provisions would be based on the completion of this action rather than achieving a specified emission reduction.

Over time, engine manufacturers have changed their engine platforms as new

---

[71] Revision of the NO_X Technical Code, Tier 2 Emission Limits for Diesel Marine Engines At or Above 130 kW, submitted by the United States. MEPC 44/11/7, 24 December 1999. Marine Environment Protection Committee, 44th Session, Agenda Item 11.

[72] ''Revision of the MARPOL Annex VI, the NO_X Technical Code and Related Guidelines; Development of Standards for NO_X, PM, and SO_X,'' submitted by the United States, BLG 11/5, Sub-Committee on Bulk Liquids and Gases, 11th Session, Agenda Item 5, February 9, 2007, Docket ID EPA–HQ–OAR–2007–0121–0034. This document is also available on our Web site: *http://www.epa.gov/otaq/oceanvessels.com.*

technologies have become available. Many of the technologies that can be used to reduce NO_X emissions on modern engines may not be easily applied to older engine designs. Based on conversations with engine manufacturers we believe that engines built in the mid-1980s and later are compatible with the lower NO_X components. Therefore we are requesting comment on excluding engines installed on a vessel prior to 1985 from this requirement. We request comment on what generation of engines can be retrofitted to achieve NO_X reductions. Also, we request comment on the feasibility, costs, and other business impacts that would result from retrofitting existing engines to meet a NO_X standard as discussed above.

B. PM and SO_X Standards

For PM and SO_X emission control, we are considering emission performance standards that would reflect the use of low-sulfur distillate fuels or the use of exhaust gas cleaning technology, or a combination of both. As discussed in Section VI, SO_X emissions and the majority of the direct PM emissions from Category 3 marine engines operated on residual fuels are a direct result of fuel quality, most notably the sulfur in the fuel. In addition, SO_X emissions form secondary PM in the atmosphere. Other components of residual fuel, such as ash and heavy metals, also contribute directly to PM. Significant PM and SO_X reductions could be achieved by using low sulfur fuel residual fuel or distillate fuel. Alternatively, direct and indirect sulfur-based PM can be reduced through the use of a seawater scrubber in the exhaust system. Recent demonstration projects have shown that scrubbers are capable of reducing SO_X emissions on the order of 95 percent and can achieve substantial reductions in PM as well.

We request comment on setting a PM standard on the order of 0.5 g/kW-hr and a SO_X standard on the order of 0.4 g/kW-hr. We believe that the combination of these two performance-based standards would be a cost-effective way to approach both primary and secondary PM emission reductions because ship owners would have a variety of mechanisms to achieve the standard, including fuel switching or the use of emission scrubbers. This standard would apply as early as 2011 and would result in more than a 90 percent reduction in SO_X and approximately a 50–70 percent reduction in PM. We request comment on performance based PM and SO_X standards for Category 3 marine engines, what the standards should be, and an appropriate implementation date. We also request comment on allowing vessel operators the option to comply with the standards by simply using a distillate fuel with a maximum allowable sulfur level, such as 1,000 ppm. Under this option, no exhaust emission testing would be required to demonstrate compliance with the standard.

VI. Emission Control Technology

A. Engine-Based NO_X Control

1. Traditional In-Cylinder Controls

Engine manufacturers are meeting the Tier 1 NO_X standards [73] for Category 3 marine engines today through traditional in-cylinder fuel and air management approaches. These in-cylinder emission control technologies include electronic controls, optimizing the turbocharger, higher compression ratio, valve timing, and optimized fuel injection which may include common rail systems, timing retard, increased injection pressure, rate shaping, and changes to the number and size of injector holes to increase fuel atomization. Although U.S. standards became effective in 2004, most manufacturers began selling marine engines in 2000 that met the MARPOL Annex VI NO_X standard in anticipation of its ratification.

Manufacturers have indicated that they would be able to use in-cylinder engine control strategies to achieve further NO_X emission reductions beyond the Tier 1 standards. EUROMOT, which is an association of engine manufacturers, submitted a proposal to the International Maritime Organization for new Category 3 marine engine NO_X standards 2 g/kW-hr below the Tier 1 NO_X standard.[74] In this submission, they pointed to the following technologies for Category 3 marine engines operating on residual fuel: Fuel injection timing, high compression ratio, modified valve timing on 4-stroke engines, late exhaust valve closing on 2-stroke engines, and optimized fuel injection system and combustion chamber. EUROMOT stated that the limiting factors for NO_X design and optimization are increases in low load smoke and thermal load, PM and CO_2 emissions, fuel consumption, and concerns about engine reliability and load acceptance. We request comment on potential emission reductions beyond the Tier 1 NO_X standards that may be achieved through traditional in-cylinder technology and what the impact of the low NO_X designs would be on fuel consumption, maintenance, and on PM exhaust emissions.

Many of the same in-cylinder control technologies used to meet the Tier 1 NO_X standards can be used as retrofit technology on existing engines built prior to the Tier 1 standards. An example of this is retrofitting older fuel injectors with new injectors using slide-valve nozzle tips. The slide-valve in the nozzle tip limits fuel ‘‘dripping’’ which leads to higher HC, PM, and smoke emissions and engine fouling. This fuel nozzle can be combined with low-NO_X engine calibration to achieve about a 20 percent reduction in NO_X emissions through an engine retrofit.[75] This retrofit is relatively simple on engine platforms similar to those used for the Tier 1 compliant engines, but the slide-valve injectors may not be compatible with older engines. We request comment on the costs and other business impacts of retrofitting Category 3 marine engines built before 2000 to meet the Tier 1 NO_X standard.

2. Water-Based Technologies

NO_X emissions from Category 3 marine engines can be reduced by introducing water into the combustion process in combination with appropriate in-cylinder controls. Water can be used in the combustion process to lower the maximum combustion temperature, and therefore lower NO_X formation without a significant increase in fuel consumption. Water has a high heat capacity which allows it to absorb enough of the energy in the cylinder to reduce peak combustion temperatures. Data from engine manufacturers suggest that, depending on the amount of water and how it is introduced into the combustion chamber, a 30 to 80 percent reduction in NO_X can be achieved from Category 3 marine engines.[76] [77] [78]

---

[73] This NO_X standard is the same as the internationally negotiated NO_X standards established by the International Maritime Organization (IMO) in Annex VI to the International Convention on the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto (MARPOL).

[74] ‘‘MARPOL Annex VI Revision—Proposals Related to Future Emission Limits and Issues for Clarification,’’ Submitted by EUROMOT to the IMO Subcommittee on Bulk Liquids and Gases, BLG 10/14/12, January 26, 2006, Docket ID EPA–HQ–OAR–2007–0121–0014.

[75] Henningsen, S., ‘‘2007 Panel Discussion on Emission Reduction Solutions for Marine Vessels; Engine Technologies’’ presentation by MAN B&W at the Clean Ships: Advanced Technology for Clean Air Conference, February 8, 2007, Docket ID EPA–HQ–OAR–2007–0121–0031.

[76] Heim, K., ‘‘Future Emission Legislation and Reduction Possibilities,’’ presentation by Wartsila at the CIMAC Circle 2006, September 28, 2006, Docket ID EPA–HQ–OAR–2007–0121–0017.

[77] Aabo, K., Kjemtrup, N., ‘‘Latest on Emission Control Water Emulsion and Exhaust Gas Re-Circulation,’’ MAN B&W, CIMAC paper number 126, presented at International Council on

However, some increase in PM may result due to the lower combustion temperatures, depending on the water introduction strategy.[79] We request comment on the potential NO_X reductions achievable from water-based technologies and what the impact on other pollutants or fuel consumption may be.

Water may be introduced into the combustion process through emulsification with the fuel, direct injection into the combustion chamber, or saturating the intake air with water vapor. Water emulsification refers to mixing the fuel and water prior to injection. This strategy is limited by the instability of the water in the fuel, but can be improved by mixing the water into the fuel just prior to injection into the cylinder. More effective control can be achieved through the use of an independent injection nozzle in the cylinder for the water. Using a separate injector nozzle for water allows larger amounts of water to be added to the combustion process because the water is injected simultaneously with the fuel, and larger injection pumps and nozzles can be used for the water injection. In addition, the fuel injection timing and water flow rates can be better optimized at different engine speeds and loads. Even higher water-to-fuel ratios can be achieved through the use of combustion air humidification and steam injection. With combustion air humidification, a water nozzle is placed in the engine intake and an air heater is used to offset condensation. With steam injection, waste heat is used to vaporize water, which is then injected into the combustion chamber during the compression stroke.

Depending on the targeted NO_X emission reduction, the amount of water used can range from half as much as the fuel volume to more than three times as much. Fresh water is necessary for the water-based NO_X reduction techniques. Introducing saltwater into the engine could result in serious deterioration due to corrosion and fouling. For this reason, a ship using water strategies would need either to produce fresh water through the use of a desalination or distillation system or to store fresh water on-board. Often, waste heat in the exhaust is used to generate fresh water for on-board use. We request comment on the capabilities of marine vessels, especially ocean-going ships, to generate sufficient fresh water on-board to support the use of water-based NO_X control technologies. For vessels making shorter trips, we request comment on the costs associated with storing fresh water on board and replenishing the water supply when at port. We also request comment on the hardware and operating costs associated with this emission control technology.

3. Exhaust Gas Recirculation

Exhaust gas recirculation (EGR) is a strategy similar to water-based NO_X reduction approaches in that a non-combustible fluid (in this case exhaust gas) is added to the combustion process. The exhaust gas is inert and reduces peak combustion temperatures, where NO_X is formed, by slowing reaction rates and absorbing some of the heat generated during combustion. One study concluded that EGR could be used to achieve similar NO_X emission reductions as water emulsion.[80] However, due to the risk of carbon deposits and deterioration due to sulfuric acid in the exhaust gas when high sulfur fuel is used, any exhaust gases recirculated to the cylinder intake would have to be cleaned before being routed back into the cylinder. One method of cleaning the exhaust would be to use a seawater scrubber.[81] Another alternative is to use internal EGR where a portion of the exhaust gases is held in the cylinder after combustion based on the cylinder scavenging design.[82]

B. NO_X Aftertreatment

NO_X emissions can be reduced substantially using selective catalytic reduction (SCR), which is a commonly-used technology reducing NO_X emissions standards in diesel applications worldwide. Stationary power plants fueled with coal, diesel, and natural gas have used SCR for three decades as a means of controlling NO_X emissions. European heavy-duty truck manufacturers are using this technology to meet Euro 5 emissions limits and several heavy-duty truck engine manufacturers have indicated that they will use SCR technology to meet stringent U.S. NO_X limits beginning in 2010. Collaborative research and development activities between diesel engine manufacturers and SCR catalyst suppliers suggest that SCR is a mature, cost-effective solution for NO_X reduction on diesel engines.

SCR has also been demonstrated for use with marine diesel engines. More than 300 SCR systems have been installed on marine vessels, some of which have been in operation for more than 10 years and have accumulated 80,000 hours of operation.[83] [84] [85] [86] These systems are used in a wide range of ship types including ferries, supply ships, ro ros (roll-on roll-off), tankers, container ships, icebreakers, cargo ships, workboats, cruise ships, and foreign navy vessels for both propulsion and auxiliary engines. These SCR units are being used successfully on slow and medium speed Category 3 propulsion engines and on Category 2 propulsion and auxiliary engines. The fuel used on ships with SCR systems ranges from low sulfur distillate fuel to high sulfur residual fuel. SCR is capable of reducing NO_X emissions in marine diesel exhaust by more than 90 percent and can have other benefits as well.[87] [88] [89] Fuel consumption improvements may also be gained with the use of an SCR system. By relying on the SCR unit for NO_X emissions control, the engine can be optimized for better fuel consumption, rather than for low NO_X emissions. When an oxidation catalyst is used in conjunction with the SCR unit, significant reductions in HC, CO, and

---

Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0005.

[78] Hagstrm, U., ''Humid Air Motor (HAM) and Selective Catalytic Reduction (SCR) Viking Line,'' presented by Viking Line at Swedish Maritime Administration Conference on Emission Abatement Technology on Ships, May 24–26, 2005, Docket ID EPA–HQ–OAR–2007–0121–0027.

[79] Koehler, H., ''Field Experience with Considerably Reduced NO_X and Smoke Emissions,'' MAN B&W, 2004, Docket ID EPA–HQ–OAR–2007–0121–0019.

[80] Aabo, K., Kjemtrup, N., ''Latest on Emission Control Water Emulsion and Exhaust Gas Re-Circulation,'' MAN B&W, CIMAC paper number 126, presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0005.

[81] Henningsen, S., ''2007 Panel Discussion on Emission Reduction Solutions for Marine Vessels; Engine Technologies'' presentation by MAN B&W at the Clean Ships: Advanced Technology for Clean Air Conference, February 8, 2007, Docket ID EPA–HQ–OAR–2007–0121–0031.

[82] Weisser, G., ''Emission Reduction Solutions for Marine Vessels—Wartsila Perspective'' presentation by Wartsila at the Clean Ships: Advanced Technology for Clean Air Conference, February 8, 2007, Docket ID EPA–HQ–OAR–2007–0121–0032.

[83] ''DEC SCR Convertor System,'' Muenters, May 1, 2006, Docket ID EPA–HQ–OAR–2007–0121–0013.

[84] Hagström, U., ''Humid Air Motor (HAM) and Selective Catalytic Reduction (SCR),'' Viking Line, presented at Air Pollution from Ships, May 24–26, 2005, Docket ID EPA–HQ–OAR–2007–0121–0027.

[85] ''Reference List—$SINO_X$® Systems,'' Argillon, December 2006, Docket ID EPA–HQ–OAR–2007–0121–0035.

[86] ''Reference List January 2005 Marine Applications,'' Hug Engineering, January 2005, Docket ID EPA–HQ–OAR–2007–0121–0036.

[87] Heim, K., ''Future Emission Legislation and Reduction Possibilities,'' Wärtsilä, presented at CIMAC Circle 2006, September 28, 2006, Docket ID EPA–HQ–OAR–2007–0121–0017.

[88] Argillon, ''Exhaust Gas Aftertreatment Systems; SCR—The Most Effective Technology for NO_X Reduction,'' presented at Motor Ship Marine Propulsion Conference, May 7–8, 2003, Docket ID EPA–HQ–OAR–2007–0121–0010.

[89] Holmström, Per, ''Selective Catalytic Reduction,'' presentation by Munters at Clean Ships: Advanced Technology for Clean Air, February 7–9, 2007, Docket ID EPA–HQ–OAR–2007–0121–0013.

PM may also be achieved. The SCR unit attenuates sound, so it may use the space on the vessel that would normally hold a large muffler generally referred to as an exhaust gas silencer. To the extent that SCR has been used in additional marine applications, we request further information on the emission reductions that have been achieved. We also request comment on the durability, packaging, and cost of these systems.

An SCR catalyst reduces nitrogen oxides to elemental nitrogen (N_2) and water by using a small amount of ammonia (NH_3) as the reducing agent. The most-common method for supplying ammonia to the SCR catalyst is to inject an aqueous urea-water solution into the exhaust stream. In the presence of high-temperature exhaust gases (>200 °C), the urea in the injected solution hydrolyzes to form NH_3. The NH_3 is stored on the surface of the SCR catalyst where it is used to complete the NO_X reduction reaction. In theory, it is possible to achieve 100 percent NO_X conversion if the exhaust temperature is high enough and the catalyst is large enough. Low temperature NO_X conversion efficiency can be improved through use of an oxidation catalyst upstream of the SCR catalyst to promote the conversion of NO to NO_2. Because the reduction of NO_X can be rate limited by NO reductions, converting some of the NO to NO_2 also allows manufacturers to use a smaller reactor.

Manufacturers report minimum exhaust temperatures for SCR units to be in the range of 250 to 300 °C, depending on the catalyst system design and fuel sulfur level.[90] [91] [92] Below this temperature, the vanadium-oxide catalyst in the SCR unit would not be hot enough to efficiently reduce NO_X. With very low sulfur fuels, a highly reactive oxidation catalyst can be used upstream of the SCR reactor to convert NO to NO_2. NO_2 reacts in the SCR catalyst at lower temperatures than NO; therefore, the oxidation catalyst lowers the exhaust temperature at which the SCR unit is effective. However, as the sulfur concentration increases, a less reactive oxidation catalyst must be used to prevent excessive formation of sulfates and poisoning of the oxidation catalyst. When operating on marine distillate fuel with a sulfur level of 1,000 ppm, the minimum exhaust temperature for effective reductions through a current SCR system would be on the order of 270 °C. On typical heavy fuel oils, which have sulfur concentrations on the order of 2.5 percent, the exhaust temperature would need to be about 300°C due to high sulfur concentrations. We request comment on the relationship between SCR operating temperatures and the quality of the fuel used.

SCR can be operated in exhaust streams at or above 500 °C before heat-related degradation of the catalyst becomes significant. This maximum exhaust temperature is sufficient for use with Category 3 marine engines. Exhaust valve temperatures are generally maintained below 450°C to minimize high temperature corrosion and fouling caused by vanadium and sodium present in residual fuel.

Modern SCR systems should be able to achieve very high NO_X conversion for all operation covered by the E3 test cycle, which includes power levels from 25 to 100 percent. A properly designed system can generally maintain exhaust temperatures high enough at these power levels to ensure proper functioning of the improved SCR catalysts. However, exhaust temperatures at lower power levels on current vessels may be below the minimum temperature threshold for SCR systems, especially when operated on high sulfur fuels. We believe that it is important that NO_X emission control is achieved even at low power due to the concern that much of the engine operation that occurs near the shore may be at less than 25 percent power. As described in Section VII.A.2, we are considering the need for changes to the test cycle or other supplemental requirements to account for the fact that the current test cycle does not include any operation below 25 percent power. We request comment on engine power levels, and corresponding exhaust temperature profiles, when maneuvering, operating at low speeds, or during other operation near shore.

We believe there are several approaches that can be used to ensure that the exhaust temperature during low power operation is sufficiently high for the SCR unit to function properly. By positioning the SCR system ahead of the turbocharger, the heat to the SCR system can be maximized. This approach was used with vessels equipped with slow-speed engines that operated at low loads near the coast.[93] Exhaust temperatures could be increased by adjusting engine parameters, such as reduced charge air cooling and modified injection timing. In one case, SCR was used on a short passage car ferry which originally had exhaust temperatures below 200 °C when the engine was operated at low load.[94] When the SCR unit was installed, controls were placed on the intercooler in the air intake system. By reducing the cooling on the intake air, the exhaust temperature was increased to be within the operating range of the SCR unit, even during low power operation. In a ship using multiple propulsion engines, one or more engines could be shut down such that the remaining engine or engines are operating at higher power. Another approach to increase the exhaust temperature could be to use burner systems during low power operation. If commenters have additional information on using SCR at low power operation, we request that this information be submitted for our consideration as we continue developing proposed standards for Category 3 marine engines.

SCR grade urea is a widely used industrial chemical around the world. Although an infrastructure for widespread transportation, storage, and dispensing of SCR-grade urea does not currently exist in most places, we believe that it would develop as needed based on market forces. Concerning urea production capacity, the U.S. has more-than-sufficient capacity to meet the additional needs of the marine engines. Currently, the U.S. consumes 14.7 million tons of ammonia resources per year, and relies on imports for 41 percent of that total (of which, urea is the principal derivative). In 2005, domestic ammonia producers operated their plants at 66 percent of rated capacity, resulting in 4.5 million tons of reserve production capacity.[95] Thus we do not project that urea cost or supply will be an issue. As an alternative, one study looked at using hydrocarbons distilled from the marine fuel oil as a reductant for an SCR unit.[96] We request

---

[90] Rasmussen, K., Ellegasrd, L., Hanafusa, M., Shimada, K., ''Large Scale SCR Application on Diesel Power Plant,'' CIMAC paper number 179, presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0007.

[91] ''Munters SCR Converter™ System,'' downloaded from *www.munters.com*, November 21, 2006, Docket ID EPA–HQ–OAR–2007–0121–0023.

[92] Argillon, ''Exhaust Gas Aftertreatment Systems; SCR—The Most Effective Technology for NO_X Reduction,'' presented at Motor Ship Marine Propulsion Conference, May 7–8, 2003, Docket ID EPA–HQ–OAR–2007–0121–0010.

[93] MAN B&W, ''Emission Control Two-Stroke Low-Speed Diesel Engines,'' December 1996, Docket ID EPA–HQ–OAR–2007–0121–0020.

[94] ''NO_X Emissions from M/V Hamlet,'' Data provided to W. Charmley, U.S. EPA. by P. Holmström, DEC Marine, February 5, 2007, Docket ID EPA–HQ–OAR–2007–0121–0015.

[95] U.S. Department of the Interior, ''Mineral Commodity Summaries 2006,'' page 118, U.S. Geological Survey, January 13, 2006, Docket ID EPA–HQ–OAR–2007–0121–0022.

[96] Tokunaga, Y., Kiyotaki, G., ''Development of NO_X Reduction System for Marine Diesel Engines by SCR using Liquid Hydrocarbon Distilled from Fuel Oil as Reductant,'' CIMAC paper number 63,

comment on any issues related using urea, or any other reductant, on ships such as costs, on-board storage requirements, and supply infrastructure.

C. PM and SO_X Control

As discussed above, we are considering PM and SO_X emission control approaches based on both fuel sulfur limits and performance based requirements. This section discusses traditional in-cylinder emission controls, fuel quality, and exhaust gas scrubbing technology.

1. In-Cylinder Controls

For typical diesel engines operating on distillate fuel, particulate matter formation is primarily the result of incomplete combustion of the fuel and lube oil. The traditional in-cylinder technologies discussed above for NO_X emission control can be optimized for PM control while simultaneously reducing NO_X emissions. If aftertreatment, such as SCR, is used to control NO_X, then the in-cylinder technologies can be used primarily for PM reductions. However, the PM reduction through in-cylinder technologies is limited for engines operating on high-sulfur fuel because the majority of the PM emissions in this case are due to compounds in the fuel rather than due to incomplete combustion, as discussed below.

2. Fuel Quality

The majority of Category 3 engines are designed to run on residual fuel which has the highest viscosity and lowest price of the petroleum fuel grades. Residual fuels are known by several names including heavy fuel oil (HFO), bunker C fuel, and marine fuel oil. This fuel is made from the very end products of the oil refining process, formulated from residues remaining in the primary distilling stages of the refining process. It has high content of ash, metals, nitrogen, and sulfur that increase emissions of exhaust PM pollutants. Typical residual fuel contains about 2.7 percent sulfur, but may have a sulfur content as high as 4.5 percent.

When a diesel engine is operating on very low sulfur distillate fuel, 80 to 90 percent of the PM in the exhaust is unburned hydrocarbons from the fuel and lubricating oil and carbon soot. When residual fuel is used, only about 25 to 35 percent of the PM from the engine is made up of unburned hydrocarbon compounds.[97] [98] [99] In this case, the majority of the PM from the engine is made up of sulfur, metal, and ash components originating from the fuel itself. On a mass basis, the vast majority of this fuel-based PM is due to the sulfur which oxidizes in the combustion process and associates with water to form an aqueous solution of sulfuric acid, known as sulfate PM. Data suggest that about two percent of the sulfur in the fuel is converted directly to sulfate PM.[100] [101] The rest of the sulfur in the fuel forms SO_X emissions. These SO_X emissions lead to indirect PM formation in the atmosphere.

We believe that substantial PM and SO_X reductions could be achieved through the use of lower sulfur fuel. Using a residual fuel with a lower sulfur content would reduce the fraction of PM from sulfate formation. One study showed a decrease of PM emissions from more than 1.0 g/kW-hr on 2.4 percent sulfur fuel to less than 0.5 g/kW-hr with 0.8 percent sulfur fuel for a medium-speed generator engine on a ship.[102] Using distillate fuel would likely have further reduced sulfur-based emissions and PM emissions from ash and metals. Another study compared PM emissions from a large 2-stroke marine engine on both low sulfur residual fuel oil and marine distillate oil and reported about a 70 percent reduction in PM.[103] The simpler molecular structure of distillate fuel may result in more complete combustion and reduced levels of carbonaceous PM (soot and heavy hydrocarbons). Because SO_X emissions are directly related to the concentration of sulfur in the fuel, a given percent reduction in sulfur in the fuel would be expected to result in about the same percent reduction in SO_X emissions from the engine. We request comment on the potential PM and SO_X emission reductions that could be achieved through the use of lower sulfur residual fuel or through the use of distillate fuel in Category 3 marine engines.

In general, engines that are designed to operate on residual fuel are capable of operating on distillate fuel. For example, if the engine is to be shut down for maintenance, distillate fuel is typically used to flush out the fuel system. There are some issues that would need to be addressed for operating engines on distillate fuel that were designed primarily for use on residual fuel. Switching to distillate fuel requires 20 to 60 minutes, depending on how slowly the operator wants to cool the fuel temperatures. According to engine manufacturers, switching from a heated residual fuel to an unheated distillate too quickly could cause damage to fuel pumps. These fuel pumps would need to be designed to operate on both fuels if a fuel-switching strategy were employed. Separate fuel tanks would be needed for distillate fuel with sufficient capacity for potentially extended operation on this fuel. It is common for ships to have several fuel tanks today to accommodate the variety in different grades of residual fuel which may be incompatible with each other and, therefore, require segregation. Also, different lubricating oil is used with each fuel type. We believe that properly designed ships would be able to operate on distillate fuel either under a fuel-switching strategy or for extended use. We request comment on the practical implications of operating ships on either lower sulfur residual or distillate fuel for extended use.

Fuel quality may also affect NO_X emissions. Residual fuels have nitrogen bound into the fuel at a concentration on the order of 0.3 to 0.4 weight percent. In contrast, marine distillate fuel has about a 0.02 to 0.06 weight percent concentration of nitrogen in the fuel. Approximately half of nitrogen in the fuel will oxidize to form NO_X in a marine diesel engine.[104] In addition, the ignition quality of the fuel may be worse for residual fuel than for distillate fuel which can affect NO_X emissions. These effects are reflected in the MARPOL NO_X technical code which allows an

---

presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0002.

[97] Paro, D., ''Effective, Evolving, and Envisaged Emission Control Technologies for Marine Propulsion Engines,'' presentation from Wartsila to EPA on September 6, 2001, Docket ID EPA–HQ–OAR–2007–0121–0028.

[98] Koehler, H., ''Field Experience with Considerably Reduced NO_X and Smoke Emissions,'' MAN B&W, 2004, Docket ID EPA–HQ–OAR–2007–0121–0019.

[99] Heim, K., ''Future Emission Legislation and Reduction Possibilities,'' presentation by Wartsila at the CIMAC Circle 2006, September 28, 2006, Docket ID EPA–HQ–OAR–2007–0121–0017.

[100] ''Emission Factors for Compression Ignition Nonroad Engines Operated on No. 2 Highway and Nonroad Diesel Fuel,'' U.S. EPA, EPA420–R–98–001, March 1998, Docket ID EPA–HQ–OAR–2007–0121–0025.

[101] Lyyranen, J., Jokiniemi, J., Kauppinen, E., Joutsensaari, J., ''Aerosol Characterization in Medium-Speed Diesel Engines Operating with Heavy Fuel Oils,'' Aerosol Science Vol. 30, No. 6, pp. 771–784, 1999, Docket ID EPA–HQ–OAR–2007–0121–0009.

[102] Maeda, K., Takasaki, K., Masuda, K., Tsuda, M., Yasunari, M., ''Measurement of PM Emission from Marine Diesel Engines,'' CIMAC paper number 107 presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0004.

[103] Kasper, A., Aufdenblatten, S., Forss, A., Mohr, M., Burtscher, H., ''Particulate Emissions from a Low-Speed Marine Diesel Engine,'' Aerosol Science and Technology, 41:24–32, 2007.

[104] Takasaki, K., Tayama, K., Tanaka, H., Baba, S., Tajima, H., Strom, A., ''NO_X Emission from Bunker Fuel Combustion,'' CIMAC paper number 87, presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0003.

upward adjustment of 10 percent for NO_X, under certain circumstances, when the engine is tested on residual fuel. We request comment on the effect of using residual fuel on NO_X emissions, both due to nitrogen in the fuel and any impacts of fuel quality on ignition-delay or other combustion characteristics.

There are several types of processes refineries use to remove sulfur from fuels. Traditional sulfur removal technologies include installing a hydrocracker upstream, or a hydrotreater upstream or downstream, of the fluidized catalytic cracker (FCC) unit. Due to high refinery production costs, it is not likely that much new volume of residual fuel will be desulfurized to create 1,000 ppm heavy fuel oil. It is more likely that additional distillate fuel may be produced by cracking existing residual fuels or that blends of high and low sulfur fuels will be used. Some existing low sulfur residual fuel is already produced, though the volume is probably insufficient to fully meet fuel volume requirements for both ships and land-based applications subject to local sulfur emission requirements. We request comment on the availability of low sulfur marine fuels.

3. Exhaust Gas Scrubbers

Another approach to reduce PM and SO_X emissions is to use seawater scrubbers. Seawater scrubbers are an aftertreatment technology that uses the seawater's ability to absorb SO_2. In the scrubber, the exhaust gases are brought into contact with seawater. The SO_2 in the exhaust reacts with oxygen to produce sulfur trioxide that subsequently reacts with water to yield sulfuric acid. The sulfuric acid in the water then reacts with carbonate (and other salts) in the seawater to form sulfates which may be removed from the exhaust. The carbonate also directionally neutralizes the pH of the sulfuric acid.

A scrubber system does not necessarily need to use sea water. An alternative approach is to circulate fresh water through the scrubber system. In this design, the pH of the wash water is monitored and additional caustic solution is added as necessary. If the pH becomes too low, the water will not absorb any further sulfur. During typical operation, a small amount of wash water is bled out of the system and fresh water is added to maintain volume. This prevents excessive build-up of contaminants in the wash water.

Water may be sprayed into the exhaust stream, or the exhaust gasses may be routed through a water bath. As the cooled exhaust gas rises out the stack, demisters are used to separate water droplets that may be entrained in the exhaust. The cleaned exhaust passes out of the scrubber through the top while the water, containing sulfates, is drained out through the bottom. Recent demonstration projects have shown scrubbers are capable of reducing SO_X emissions on the order of 95 percent.[105] Today, exhaust gas silencers are used on ships to muffle noise from the exhaust. Seawater scrubbers would act as mufflers making the exhaust gas silencers unnecessary. New seawater scrubber designs are not much larger than exhaust gas silencers already used on ships, and could be packaged in the space formerly used by an exhaust gas silencer.[106] We request comment on further experience with seawater scrubbers and on the practical issues related to installing scrubbers on ships, including space constraints and costs.

Exhaust gas scrubbers can achieve reductions in particulate matter as well. By removing sulfur from the exhaust, the scrubber removes most of the direct sulfate PM. As discussed above, sulfates are a large portion of the PM from ships operating on high sulfur fuels. By reducing the SO_X emissions, the scrubber will also control much of the secondary PM formed in the atmosphere from SO_X emissions.

Simply mixing alkaline water in the exhaust does not necessarily remove much of the carbonaceous PM, ash, or metals in the exhaust. While SO_2 associates with the wash water, particles can only be washed out of the exhaust through direct contact with the water. In simple scrubber designs, much of the mass of particles can hide in gas bubbles and escape out the exhaust. Manufacturers have been improving their scrubber designs to address carbonaceous soot and other fine particles. Finer water sprays, longer mixing times, and turbulent action would be expected to directionally reduce PM emissions through contact impactions. One scrubber design uses an electric charge on the water to attract particles in the exhaust to the water. Two chambers are used so that both a positive and a negative charge can be used to attract both negatively-charged and positively-charged particles. The manufacturer reports an efficiency of more than 99 percent for the removal for particulate matter and condensable organics in diesel exhaust.[107] Although exhaust gas scrubbers are only used in a few demonstration vessels today, this technology is widely used in land-based applications. We request comment on how scrubber design impacts the amount of PM that is removed from the exhaust.

It may be possible to achieve NO_X reductions through the use of seawater scrubbers. In a typical scrubber, the water-soluble fraction of NO_X (NO_2) can combine with the water to form nitrates which are scrubbed out of the exhaust. However, because NO_2 makes up only a small fraction of total NO_X, this results in less than a 10 percent reduction in NO_X emissions exhausted to atmosphere.[108] Seawater electrolysis systems have been developed which increase the adsorption rate of NO_X in the water by oxidizing NO to NO_2, which is water-soluble.[109] One study used electrolysis in an experimental scrubbing system to remove 90 percent of the NO and nearly all of the NO_2 in the feed gas.[110] We request comment on the feasibility of achieving significant NO_X reductions from Category 3 marine engines through the use of seawater scrubbers. We also request comment on the impact of this technology on nitrate loading and eutrophication of surrounding waters.

Water-soluble components of the exhaust gas such as SO_2, SO_3, and NO_2 form sulfates and nitrates that are dumped overboard in the discharge water. Scrubber wash water also includes suspended solids, heavy metals, hydrocarbons and PAHs. Before the scrubber water is discharged, it may be processed to remove solid particles through several approaches. Heavier particles may be trapped in a settling or sludge tank for disposal. The removal process may include cyclone technology similar to that used to separate water from residual fuel prior to delivery to the engine. However, depending on

---

[105] Skawinski, C., ''Seawater Scrubbing Advantage,'' Presentation by Marine Exhaust Solutions at the Conference for Emission Abatement Technology on Ships held by the Swedish Maritime Administration, May 24–26, 2005, Docket ID EPA–HQ–OAR–2007–0121–0021.

[106] ''Krystallon Seawater Scrubber,'' downloaded from *http://www.krystallon.com* on February 14, 2007, Docket ID EPA–HQ–OAR–2007–0121–0018.

[107] ''Cloud Chamber Scrubber Performance Results for Diesel Exhaust,'' Tri-Mer Corporation, April 14, 2005, Docket ID EPA–HQ–OAR–2007–0121–0026.

[108] Skawinski, C., ''Seawater Scrubbing Advantage,'' Presentation by Marine Exhaust Solutions at the Conference for Emission Abatement Technology on Ships held by the Swedish Maritime Administration, May 24–26, 2005, Docket ID EPA–HQ–OAR–2007–0121–0021.

[109] An, S., Nishida, O., ''Marine Air Pollution Control System Development Applying Seawater and Electrolyte,'' SAE Paper 2002–01–2295, July 2002, Docket ID EPA–HQ–OAR–2007–0121–0024.

[110] Houng-Soo, K., ''Development of Diesel Engine Emission Control System on NO_X and SO_X by Seawater Electrolysis,'' CIMAC paper number 25 presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0001.

particle size distribution and particle density, settling tanks and hydrodynamic separation may not effectively remove all suspended solids. Other approaches include filtration and flocculation techniques. Flocculation, which is used in many waste water treatment plants, refers to adding a chemical agent to the water that will cause the fine particles to aggregate so that they may be filtered out. Sludge separated from the scrubber water would be stored on board until it is disposed of at proper facilities. We request comment on appropriate waste discharge limits for scrubber water and how these limits should be defined. We are concerned that if limits are based on the concentration of the pollutants in the water, then the standards could be met simply by diluting the effluent before it is discharged. Although diluting the discharge water may have some local benefits near the vessel, it would not change the total pollutant load on a given body of water. We request comment on basing limits for waste water pollutants on engine load, similar to exhaust emission standards.

VII. Certification and Compliance

In general, we expect to retain the certification and compliance provisions finalized with the Tier 1 standards. These include testing, durability, labeling, maintenance, prohibited acts, etc. However, we believe additional testing and compliance provisions will be necessary for new standards requiring more advanced technology and more challenging calibrations. These changes, as well as other modifications to our certification and compliance provisions, are discussed below.

A. Testing

1. PM Sampling

In the past, there has been some concern regarding the use of older PM measurement procedures with high sulfur residual fuels. The primary issue of concern was variability of the PM measurement, which was strongly influenced by the amount of water bound to sulfur. However, we believe improvements in PM measurement procedures, such as those specified in 40 CFR 1065, have addressed these issues of measurement variability. The U.S. government recently submitted proposed procedures for PM measurement to IMO.[111] We request comment on these procedures for accurately measuring PM emissions from Category 3 marine engines operating on residual fuel.

2. Low Power Operation

We are concerned about emission control performance when the engine is operated at low power. Category 3 engines operate at relatively low power levels when they are operating in port areas. Ship pilots generally operate engines at reduced power for several miles to approach a port, with even lower power levels very close to shore. The ISO E3 and E2 test cycles are used for emission testing of propulsion marine engines. These test cycles are heavily weighted towards high power. Therefore, it is very possible that manufacturers could meet the cycle-weighted average emission standards without significantly reducing emissions at low-power modes. Because low power operation is more prevalent for propulsion engines when they operate close to commercial ports, it is important that the emission control strategy be effective at low power operation to maximize on-shore emission benefits. This issue would generally not apply to vessels that rely on multiple engines providing electric-drive propulsion, because these engines can be shut down as needed to maintain the desired engine loading and therefore may not operate at low power settings. We request comment on the need for addressing emissions at low power operation and whether and how the test procedure should be changed to accommodate this operation. See section VI.B for additional discussion of low power NO_X emissions for engines equipped with exhaust aftertreatment.

3. Test Fuel

Appropriate test procedures need to represent in-use operating conditions as much as possible, including specification of test fuels consistent with the fuels that compliant engines will use over their lifetimes. For the Tier 1 standards, we allow engine testing using distillate fuel, even though vessels with Category 3 marine engines primarily use the significantly less expensive residual fuel. This provision is consistent with the specifications of the NO_X Technical Code. Also, most manufacturers have test facilities designed to test engines using distillate fuel. Distillate fuel is easier to test with because it does not need to be heated to remain a liquid and manufacturers have indicated that it is difficult to obtain local permits for testing with residual fuel. However, we believe it is important to specify a test fuel that is consistent with the in-use fuel with which engines will operate in service. This is especially true for PM measurements. We request comment on the appropriate test fuel for emission testing and if this fuel should be representative on the fuel on which a specific engine is designed to operate.

For any NO_X measurements from engines operating on residual fuel we recognize that there may be emission-related effects due to fuel quality, specifically fuel-bound nitrogen. If the standards were based on distillate fuel, we would consider a NO_X correction factor to account for the impact of fuel quality when testing on residual fuel. This correction would be useful because of the high levels of nitrogen contained in residual fuel. Such a correction factor would likely involve measuring fuel-bound nitrogen and correcting measured values to what would occur with a nitrogen concentration of 0.4 weight percent. This corrected value would be used to determine whether the engine meets emission standards or not. We request comment on the need for corrections and, if so, how the appropriate corrections would be developed.

B. On-Off Technologies

One of the features of the emission control technologies that could be used to achieve significant NO_X and PM reductions from C3 engines is that they are not integral to the engine and the engine can be operated without them. Aftertreatment systems such as SCR or emission scrubbing, or the use of lower sulfur fuel, require a positive action on the part of the ship owner to make sure the emission control system is in operation or that the appropriate fuel is used. These types of technologies are often called ''on-off'' technologies.

The increased operating costs of such controls associated with urea or other catalysts or with distillate usage suggest that it may be reasonable to allow these systems to be turned off while a ship is operated on the open ocean, far away from sensitive areas that are affected by ship emissions. In other words, EPA could elect to set geographically-based NO_X and PM standards, with one limit that would apply when ships are operated within a specified distance from U.S. coasts, and another that would apply when ships are operated outside those limits.

If EPA were to adopt such an approach, we would need to determine the areas in which ships would have to comply with the standards. We are currently exploring this issue through the air quality modeling for our proposed standards. There are other

---

[111] Measurement Method for Particulate Matter Emitted from Marine Engines, submitted by the United States. BLG–WGAP 2, October 2007. Intersessional Meeting of the BLG Working Group on Air Pollution, 2nd Session.

issues associated with such an approach, including: The technological feasibility of by-pass systems and their impacts on the emission control systems when they are not in use; the level of the standard that would apply when the system is turned off; and how compliance would be demonstrated. There may also be additional certification requirements for ships equipped with such systems.

We request comment on all aspects of this alternative, especially with regard to how such systems could be designed to ensure no loss of emission reductions.

C. Parameter Adjustment

Given the broad range of ignition properties for in-use residual fuels, we expect that our in-use adjustment allowance for Category 3 engines would result in a broad range of adjustment. We are therefore considering a requirement for operators to perform a simple field measurement test to confirm emissions after parameter adjustments or maintenance operations, using onboard emission measurement systems with electronic-logging equipment. We expect this issue will be equally important for more advanced engines that rely on water injection or aftertreatment for emission reductions. Onboard verification systems could add significant assurance that engines have properly operating emission controls.

We envision a simpler measurement system than the type specified in Chapter 6 of the NO_X Technical Code. As we described in the 2003 final rule, we believe that onboard emission equipment that is relatively inexpensive and easy to use could verify that an engine is properly adjusted and is operating within the engine manufacturer's specifications. Note that Annex VI includes specifications allowing operators to choose to verify emissions through onboard testing, which suggests that Annex VI also envisioned that onboard measurement systems could be of value to operators. We request comment on requiring onboard verification systems on ships with Category 3 marine engines and on a description of such a system.

D. Certification of Existing Engines

While we normally require certification only for newly built engines, we are considering emission standards that would apply to remanufactured engines in the existing fleet. This leads to questions about how one would certify the modified engines. We are considering adoption of one or more of the following simplified certification procedures for in-use engines:

- Basing certification for any engine on a pre-existing certificate if the engine is modified to be the same as a later engine that is already certified to the Tier 1 NO_X standard.
- Testing in-use engines using portable emission measurement equipment, with appropriate consideration for any necessary deviations in the engine test cycle.
- Broadening the engine family concept for in-use engines to reduce the amount of testing necessary to certify a range of engines. This would require the same or similar hardware and calibration requirements to ensure that a single test engine can properly represent all the engines in the broader engine family.
- Developing alternatives to the NO_X Technical File[112] to simplify the certification burdens for existing vessels while ensuring that the modified engines and emission components may be appropriately surveyed and inspected.

We request comment on the best approach for ensuring compliance from existing engines. We also request comment on the simplified certification procedures listed above.

E. Other Compliance Issues

We intend to apply the same exemptions to any new tier of Category 3 marine diesel engine standards as currently apply under our Tier 1 program. These exemptions, including the national security exemption, are set out in 40 CFR part 94, subpart J. We will also consider whether to include engines on foreign vessels in the program and whether we should also adopt standards for non-diesel engines such as gas turbine engines.

1. Engines on Foreign-Flagged Vessels

Our current federal marine diesel engine standards do not apply to Category 1, 2, and 3 marine diesel engines installed on foreign-flagged vessels. In our 2003 Final Rule we acknowledged the contribution of engines on foreign-flagged vessels to U.S. air pollution but did not apply federal standards to foreign vessels (see 68 FR 9759, February 28, 2003). This section summarizes the discussion from that 2003 Final Rule. We will continue to evaluate this issue as we develop the proposal for this rule.

Section 213 of the Clean Air Act (42 U.S.C. 7547), authorizes regulation of ''new nonroad engine'' and ''new nonroad vehicle.'' However, Title II of the Clean Air Act does not define either ''new nonroad engine'' or ''new nonroad vehicle.'' Section 216 defines a ''new motor vehicle engine'' to include an engine that has been ''imported.'' EPA modeled the current regulatory definitions of ''new nonroad engine'' and ''new marine engine'' at 40 CFR 89.2 and 40 CFR 94.2, respectively, after the statutory definitions of ''new motor vehicle engine'' and ''new motor vehicle.'' This was a reasonable exercise of the discretion provided to EPA by the Clean Air Act to interpret ''new nonroad engine'' or ''new nonroad vehicle.'' See *Engine Manufacturers Assoc.* v. *EPA,* 88 F.3d 1075, 1087 (DC Cir. 1996).

The 1999 marine diesel engine rule did not apply to marine engines on foreign vessels. 40 CFR 94.1(b)(3). At that time, we concluded that engines installed on vessels flagged or registered in another country, that come into the United States temporarily, will not be subject to the emission standards. At that time, we believed that they were not considered imported under the U.S. customs law. As a result, we did not apply the standards adopted in that rule to those vessels (64 FR 73300, Dec. 29, 1999).

The May 29, 2002 proposed rule for Category 3 marine diesel engines solicited comment on whether to exercise our discretion and modify the definition of a ''new marine engine'' to find that engine emission standards apply to foreign vessels that enter U.S. ports. However, in the February 28, 2003 final rule we determined that we did not need to determine whether we have the discretion to interpret ''new'' nonroad engine or vessel in such a manner.

Foreign vessels were expected to comply with the MARPOL standards whether or not they were also subject to the equivalent Clean Air Act standards being adopted in that final rule. Consequently, we concluded that no significant emission reductions would be achieved by treating foreign vessels as ''new'' for purposes of the Tier 1 standards and there would be no significant loss in emission reductions by not including them. Therefore, we did not include foreign engines and vessels in our 2003 rulemaking and we did not revise the definition of ''new marine engine'' at that time.

---

[112] The NO_X Technical File, required pursuant to Section 2.4 of the Technical Code on Control of Emissions of Nitrogen Oxides from Marine Diesel Engines, is a record containing details of engine parameters, including components and settings, which may influence the NO_X emissions of the engine. The NO_X Technical File also contains a description of onboard NO_X verification procedures required for engine surveys. The NO_X Technical File is developed by the engine manufacturer and must be approved by the authority issuing the engine certificate.

In this rule we will evaluate under what circumstances we may and should define new nonroad engine and vessel to include foreign engines and vessels. As part of that evaluation, we will also assess the progress made by the international community toward the adoption of new more stringent international consensus standards that reflect advanced emission-control technologies.

2. Non-Diesel Engines

Gas turbine engines are internal combustion engines that can operate using diesel fuel, residual fuel, or natural gas, but do not operate on a compression-ignition or other reciprocating engine cycle. Power is extracted from the combustion gas using a rotating turbine rather than reciprocating pistons. While gas turbine engines are used primarily in naval ships, a small number are being used in commercial ships. In addition, we have received indication that their use is growing in some applications such as cruise ships and liquid natural gas carriers. As we develop the proposal for this rule we will consider whether it is appropriate to regulate emissions from gas turbine engines and, if so, whether special provisions would be needed for testing and certifying turbine engines. For example, since turbine engines have no cylinders, we may need to address how to apply any regulatory provisions that depend on a specified value for per-cylinder displacement. We would welcome any emissions information that is available for turbine engines.

Marine engines have been developed that can operate either on natural gas or a dual-fuel.[113] In a dual-fuel application, a mixture of marine diesel oil and natural gas is used for the main engine that provides a means to comply with the low-sulfur fuel requirement. Natural gas engines are especially attractive to vessels that carry a cargo of liquefied petroleum gas due to the readily available fuel supply. Natural gas powered engines are similar to Category 3 marine engines operating on traditional diesel fuels, and we would consider including these engines in this rulemaking.

We request comment on fuels and engine types that we should consider in the scope of this rulemaking. We also request comments on test procedure or other compliance issues that would need to be considered for these fuels and engines.

VIII. Potential Regulatory Impacts

A. Emission Inventory

The inventory contribution of Category 3 engines consists of two parts: emissions that occur in port areas and emissions that occur at various distances from the coast while vessels are underway. Although the issue of emissions transport is common to all of our air pollution control programs, these underway emissions suggest that Category 3 emissions are different from emissions from other mobile sources and result in at least two implications for the analysis we will perform for our proposal. First, the definition of the inventory modeling domain becomes important. In the inventory analysis described below we use a distance of 200 nautical miles from shore (see Figure VIII–1 below and associated text). This distance is reasonable based on both particle dynamics[114] and results from air quality modeling for other programs which has shown that PM and NO_X emissions can be transported significant distances.[115] Second, it will be important to analyze the air quality impacts of these emissions at various distances to determine how offshore emissions affect air quality both along the coasts and inland. We will use the CMAQ model, modified to accommodate at-sea emissions, to track the impacts of underway emissions and estimate the air quality benefits of the proposal.

This section contains our updated inventory estimates for Category 3 marine engines in the 200 nautical mile domain and a brief discussion of our inventory estimation methodology.

1. Estimated Inventory Contribution

Category 3 marine engines contribute to the formation of ground level ozone and concentrations of fine particles in the ambient atmosphere. Based on our current emission inventory analysis of U.S. and foreign-flag vessels, we estimate that these engines contributed nearly 6 percent of mobile source NO_X, over 10 percent of mobile source $PM_{2.5}$, and about 40 percent of mobile source SO_2 in 2001. We estimate that their contribution will increase to about 34 percent of mobile source NO_X, 45 percent of mobile source $PM_{2.5}$, and 94 percent of mobile source SO_2 by 2030 without further controls on these engines. Our current estimates for NO_X, $PM_{2.5}$, SO_2 inventories are set out in Tables VIII–1 through VIII–3. The inventory projections for 2020 and 2030 include the impact of existing emission mobile source and stationary source control programs previously adopted by EPA (excluding the recently adopted MSAT regulations, signed on February 9, 2007 which will have an impact on future highway non-diesel $PM_{2.5}$ levels).

TABLE VIII–1.—50-STATE ANNUAL NO_X BASELINE EMISSION LEVELS FOR MOBILE AND OTHER SOURCE CATEGORIES

Category	2001[a]			2020			2030		
	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total
Commercial Marine (C3)[b]	745,224	5.7	3.3	1,368,420	22.8	11.3	2,023,974	33.7	16.7
Locomotive	1,118,786	8.6	5.0	860,474	14.3	7.1	854,226	14.1	7.0
Recreational Marine Diesel	40,437	0.3	0.2	45,477	0.8	0.4	48,102	0.8	0.4
Commercial Marine (C1 & C2)	834,025	6.4	3.7	676,154	11.3	5.6	680,025	11.3	5.6
Land-Based Nonroad Diesel	1,548,236	11.9	6.9	678,377	11.3	5.6	434,466	7.2	3.6
Small Nonroad SI	114,319	0.9	0.5	114,881	1.9	0.9	133,197	2.2	1.1
Recreational Marine SI	44,732	0.3	0.2	86,908	1.4	0.7	96,143	1.6	0.8
SI Recreational Vehicles	5,488	0.0	0.0	17,496	0.3	0.1	20,136	0.3	0.2
Large Nonroad SI (25hp)	321,098	2.5	1.4	46,319	0.8	0.4	46,253	0.8	0.4
Aircraft	83,764	0.6	0.4	105,133	1.7	0.9	118,740	2.0	1.0
Total Off Highway	4,856,109	37.5	21.8	3,999,640	66.6	33.0	4,455,262	74.2	36.8
Highway Diesel	3,750,886	28.9	16.8	646,961	10.8	5.3	260,915	4.3	2.2
Highway non-diesel	4,354,430	33.6	19.5	1,361,276	22.7	11.2	1,289,780	21.5	10.6
Total Highway	8,105,316	62.5	36.3	2,008,237	33.4	16.6	1,550,695	25.8	12.8

---

[113] Nylund, I., ''Status and Potentials of the Gas Engines,'' Wartsila, CIMAC paper number 163, presented at International Council on Combustion Engines Congress, 2004, Docket ID EPA–HQ–OAR–2007–0121–0006.

[114] U.S. EPA. Air Quality Criteria for Particulate Matter (October 2004). U.S. Environmental Protection Agency, Washington, DC, EPA 600/P–99/002aF-bF, 2004.

[115] U.S. EPA Technical Support Document for the Final Clean Air Interstate Rule Air Quality Modeling (March 2005) U.S. Environmental Protection Agency, Washington, DC.

TABLE VIII–1.—50-STATE ANNUAL NO_X BASELINE EMISSION LEVELS FOR MOBILE AND OTHER SOURCE CATEGORIES—Continued

Category	2001[a]			2020			2030		
	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total
Total Mobile Sources	12,961,425	100	58.1	6,007,877	100	49.6	6,005,957	100	49.6
Stationary Point & Area Sources	9,355,659	....	41.9	6,111,866	....	50.4	6,111,866	....	50.4
Total Man-Made Sources	22,317,084	....	100	12,119,743	....	100	12,117,823	....	100

[a] The locomotive, commercial marine (C1 & C2), and recreational marine diesel estimates are for calendar year 2002.
[b] This category includes emissions from Category 3 (C3) propulsion engines and C2/3 auxiliary engines used on ocean-going vessels.

TABLE VIII–2.—50-STATE ANNUAL $PM_{2.5}$ BASELINE EMISSION LEVELS FOR MOBILE AND OTHER SOURCE CATEGORIES

Category	2001[a]			2020			2030		
	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total
Commercial Marine (C3)[b]	54,667	10.9	2.2	110,993	33.6	5.2	166,161	45.4	7.6
Locomotive	29,660	5.9	1.2	26,301	8.0	1.2	25,109	6.8	1.1
Recreational Marine Diesel	1,096	0.2	0.0	1,006	0.3	0.0	1,140	0.3	0.1
Commercial Marine (C1 & C2)	28,730	5.7	1.2	22,236	6.7	1.0	23,760	6.5	1.1
Land-Based Nonroad Diesel	164,180	32.8	6.7	46,075	13.9	2.1	17,934	4.9	0.8
Small Nonroad SI	25,466	5.1	1.0	32,904	10.0	1.5	37,878	10.3	1.7
Recreational Marine SI	16,837	3.4	0.7	6,367	1.9	0.3	6,163	1.7	0.3
SI Recreational Vehicles	12,301	2.5	0.5	11,773	3.6	0.5	9,953	2.7	0.5
Large Nonroad SI (>25hp)	1,610	0.3	0.1	2,421	0.7	0.1	2,844	0.8	0.1
Aircraft	5,664	1.1	0.2	7,044	2.1	0.3	8,569	2.3	0.4
Total Off Highway	340,211	68.0	13.8	267,120	80.9	12.4	299,511	81.8	13.7
Highway Diesel	109,952	22.0	4.5	15,800	4.8	0.7	10,072	2.7	0.5
Highway non-diesel	50,277	10.0	2.0	47,354	14.3	2.2	56,734	15.5	2.6
Total Highway	160,229	32.0	6.5	63,154	19.1	2.9	66,806	18.2	3.1
Total Mobile Sources	500,440	100	20.3	330,274	100	15.4	366,317	100	16.8
Stationary Point & Area Sources	1,963,264	....	79.7	1,817,722	....	84.6	1,817,722	....	83.2
Total Man-Made Sources	2,463,704	....	100	2,147,996	....	100	2,184,039	....	100

[a] The locomotive, commercial marine (C1 & C2), and recreational marine diesel estimates are for calendar year 2002.
[b] This category includes emissions from Category 3 (C3) propulsion engines and C2/3 auxiliary engines used on ocean-going vessels.

TABLE VIII–3.—50-STATE ANNUAL SO_2 BASELINE EMISSION LEVELS FOR MOBILE AND OTHER SOURCE CATEGORIES

Category	2001[a]			2020			2030		
	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total	Short tons	Percent of mobile source	Percent of total
Commercial Marine (C3)[b]	457,948	42.4	2.8	932,820	93.2	10.1	1,398,598	94.5	14.4
Locomotive	76,727	7.1	0.5	400	0.0	0.0	468	0.0	0.0
Recreational Marine Diesel	5,145	0.5	0.0	162	0.0	0.0	192	0.0	0.0
Commercial Marine (C1 & C2)	80,353	7.4	0.5	3,104	0.3	0.0	3,586	0.3	0.0
Land-Based Nonroad Diesel	167,615	15.5	1.0	999	0.1	0.0	1,078	0.1	0.0
Small Nonroad SI	6,710	0.6	0.0	8,797	0.9	0.1	10,196	0.7	0.1
Recreational Marine SI	2,739	0.3	0.0	2,963	0.3	0.0	3,142	0.2	0.0
SI Recreational Vehicles	1,241	0.1	0.0	2,643	0.3	0.0	2,784	0.2	0.0
Large Nonroad SI (25hp)	925	0.1	0.0	905	0.1	0.0	1,020	0.1	0.0
Aircraft	7,890	0.7	0.0	9,907	1.0	0.1	11,137	0.8	0.1
Total Off Highway	807,293	74.7	5.0	962,700	96.1	10.4	1,432,202	96.8	14.8
Highway Diesel	103,632	9.6	0.6	3,443	0.3	0.0	4,453	0.3	0.0
Highway non-diesel	169,125	15.7	1.0	35,195	3.5	0.4	42,709	2.9	0.4
Total Highway	272,757	25.3	1.7	38,638	3.9	0.4	47,162	3.2	0.5
Total Mobile Sources	1,080,050	100	6.7	1,001,338	100	10.9	1,479,364	100	15.3
Stationary Point & Area Sources	15,057,420	....	93.3	8,215,016	....	89.1	8,215,016	....	84.7
Total Man-Made Sources	16,137,470	....	100	9,216,354	....	100	9,694,380	....	100

[a] The locomotive, commercial marine (C1 & C2), and recreational marine diesel estimates are for calendar year 2002.
[b] This category includes emissions from Category 3 (C3) propulsion engines and C2/3 auxiliary engines used on ocean-going vessels.

The United States is actively engaged in international trade and is frequently visited by ocean-going marine vessels. As shown in Figure II–1, the ports which accommodate these vessels are located along the entire coastline of the United States. Commercial marine vessels, powered by Category 3 marine engines, contribute significantly to the emissions inventory for many U.S. ports. This is illustrated in Table VIII–4 which presents the mobile source inventory contributions of these vessels for several ports. The ports in this table were selected to present a sampling over a wide geographic area along the U.S. coasts. In 2005, these twenty ports received approximately 60 percent of the vessel calls to the U.S. from ships of 10,000 DWT or greater.[116]

TABLE VIII–4.—CONTRIBUTION OF COMMERCIAL MARINE VESSELS[a] TO MOBILE SOURCE INVENTORIES FOR SELECTED PORTS IN 2002

Port area	NO_X percent	$PM_{2.5}$ percent	SO_X percent
Valdez, AK	4	10	43
Seattle, WA	10	20	56
Tacoma, WA	20	38	74
San Francisco, CA	1	1	31
Oakland, CA	8	14	80
LA/Long Beach, CA	5	10	71
Beaumont, TX	6	20	55
Galveston, TX	5	12	47
Houston, TX	3	10	41
New Orleans, LA	14	24	59
South Louisiana, LA	12	24	58
Miami, FL	13	25	66
Port Everglades, FL	9	20	56
Jacksonville, FL	5	11	52
Savannah, GA	24	39	80
Charleston, SC	22	33	87
Wilmington, NC	7	16	73
Baltimore, MD	12	27	69
New York/New Jersey	4	9	39
Boston, MA	4	5	30

[a] This category includes emissions from Category 3 (C3) propulsion engines and C2/3 auxiliary engines used on ocean-going vessels.

2. Inventory Calculation Methodology

The exhaust emission inventories presented above for commercial marine vessels, with Category 3 marine engines, include emissions from vessels in-port and from vessels engaged in interport transit. This section gives a general overview of the methodology used to estimate the emission contribution of these vessels. A more detailed description of this inventory analysis is available in the public docket.[117]

For the purposes of this analysis, in-port operation includes cruising, reduced speed zone, maneuvering, and hotelling. The in-port analysis includes operation out to a 25 nautical mile radius from the entrance to the port. Interport operation includes ship traffic, within the U.S. Exclusive Economic Zone (EEZ), not included as part of the port emissions analysis. In general, the EEZ extends to 200 nautical miles from the U.S. coast. Exceptions include geographic regions near Canada, Mexico and the Bahamas where the EEZ extends less than 200 nautical miles from the U.S. coast.

The port inventories are based on detailed emission estimates for eleven specific ports. The port inventories were estimated using activity data for that port (number of port calls, vessel types and typical times in different operating modes) and an emission factor for each mode. Emission estimates for all other commercial ports were developed by matching each of the other commercial ports to one of the eleven specific ports. Matching was based on characteristics of port activity, such as predominant vessel types, harbor craft and region of the country. The detailed port emissions were then scaled for the other commercial ports based on relative port activity.[118] An exception to this is that detailed port inventories for fourteen California ports were provided by the California Air Resources Board (ARB).

To calculate the mobile fractions in Table VIII–4, we compared commercial marine port inventory estimates described above to county-level mobile source emission estimates developed in support of the recent rulemaking for national PM ambient air quality standards.[119] Both propulsion engines and auxiliary engines are included in these estimates. The county-level inventories were adjusted to include the updated emissions estimates for commercial marine vessels.

Recently, the California Air Resources Board (ARB) sponsored the development of new national inventory estimates for Category 3 marine engines.[120] The new approach captures actual interport activity, by using information on ship movements, ship attributes, and the distances of routes. We believe that this methodology is an improvement over past evaluations of interport shipping emissions which were based on estimates of ton-miles of

---

[116] ''Vessel Calls at U.S. & World Ports; 2005,'' U.S. Maritime Administration, Office of Statistical and Economic Analysis, April 2006, Docket ID EPA–HQ–OAR–2007–0121–0040.

[117] ''Development of Inventories for Commercial Marine Vessels with Category 3 Engines,'' U.S. EPA, October 2007.

[118] Browning, L., Hartley, S., Lindhjem, C., Hoats, A., ''Commercial Marine Port Inventory Development; Baseline Inventories,'' prepared by ICF International and Environ for the U.S. Environmental Protection Agency, September 2006, Docket ID EPA–HQ–OAR–2007–0121–0037.

[119] Regulatory Impact Analysis for the Review of the Particulate Matter National Ambient Air Quality Standards, EPA Docket: EPA–HQ–OAR–2006–0834–0048.3.

[120] Corbett, J., PhD, Wang, C., PhD, Firestone, J., PhD., ''Estimation, Validation, and Forecasts of Regional Commercial Marine Vessel Inventories, Tasks 1 and 2: Baseline Inventory and Ports Comparison; Final Report,'' University of Delaware, May 3, 2006, Available electronically at *http://www.arb.ca.gov/research/seca/jctask12.pdf,* Docket ID EPA–HQ–OAR–2007–0121–0038.

cargo moved. The new methodology captures ship traffic more completely which results in much higher estimates of total emissions from commercial marine vessels engaged in interport traffic within the U.S. EEZ.

Our emission inventory estimates for interport traffic are based on the ARB-sponsored study with four primary modifications.[121] [122] First, we use only the interport traffic estimates from the study and rely on our own, more detailed, analysis of in-port emissions. Second, we modified the geographic boundaries of the inventory to align with the U.S. EEZ. Third, we use adjusted emission factors for PM emissions to better reflect the sum of available PM emissions data from engines on marine vessels.

The detailed inventory studies described above were performed for 2002. To calculate emission inventories for future years, we applied separate growth rates for the West Coast, Gulf Coast, East Coast, and Great Lakes. These emission inventory growth estimates were determined based on economic growth projections of trade between the United States and other regions of the world.[123] In contrast, the ARB-sponsored study looks at a range of growth rates based on extrapolations of historical growth in installed power.[124] The approach used by EPA is more conservative in that it uses lower growth rate projections.

The inventory estimates include emissions from both U.S. flagged vessels and foreign flagged vessels. The majority of the ship operation near the U.S. coast is from ships that are not registered in the United States. According to the U.S. Maritime Administration, in 2005, approximately 87 percent of the calls by ocean-going vessels (10,000 dead weight tons or greater) at U.S. ports were made by foreign vessels.[125]

This inventory analysis includes emissions from Category 3 propulsion engines and the Category 2 and 3 auxiliary engines used on these vessels. Based on our emissions inventory analysis, auxiliary engines contribute approximately half of the exhaust emissions from vessels in port. In contrast, auxiliary engines only represent about 4 percent of the exhaust emissions from ships engaged in interport traffic.

The exhaust emission inventory for commercial marine vessels with Category 3 marine engines includes operation that extends out to 200 nautical miles from shore. Considering all emissions from ships operating in the U.S. EEZ, emissions in ports contribute to less than 20 percent of the total inventory. However, we recognize that emissions closer to shore are more likely to impact human health and welfare because of their proximity to human populations. We have initiated efforts to perform air quality modeling to quantify these impacts. The air quality modeling will consider transport of emissions over the ocean, meteorological data, population densities, emissions from other sources, and other relevant information. We request comment on the methodology used to develop exhaust inventory estimates for ships with Category 3 engines operating near the U.S. coast.

As discussed above, the national inventories presented here are for the Exclusive Economic Zone around the 50 states. Note that the ship traffic in the EEZ includes not only direct movements to and from U.S. ports but also movements up and down the coast. The boundaries for the EEZ are presented in Figure VIII–1.

BILLING CODE 6560–50–P

---

[121] ''Recalculation of Baseline and 2005 Emissions and Fuel Consumption,'' memorandum from Lou Browning, ICF and Chris Lindhjem and Lyndsey Parker, Environ, to Penny Carey, Mike Samulski, and Russ Smith, U.S. EPA, July 19, 2007.

[122] ''U.S. and Regional Totals of Marine Vessel Emissions and Fuel Consumption under WA 0–2 Tasks 6 and 7,'' draft memorandum from Abby Hoats and Chris Lindhjem, Environ, to Lou Browning, ICF International, April 23, 2007.

[123] ''RTI Estimates of Growth in Bunker Fuel Consumption,'' memorandum from Michael Gallaher and Martin Ross, RTI International, to Barry Garelick and Russ Smith, U.S. EPA, April 24, 2006, Docket ID EPA–HQ–OAR–2007–0121–0039.

[124] Corbett, J., PhD, Wang, C., PhD, ''Estimation, Validation, and Forecasts of Regional Commercial Marine Vessel Inventories, Tasks 3 and 4: Forecast Inventories for 2010 and 2020; Final Report,'' University of Delaware, May 3, 2006, Docket ID EPA–HQ–OAR–2007–0121–0012.

[125] ''Vessel Calls at U.S. & World Ports; 2005,'' U.S. Maritime Administration, Office of Statistical and Economic Analysis, April 2006, Docket ID EPA–HQ–OAR–2007–0121–0040.

Figure VIII-1: Regions of U.S. EEZ used for Category 3 Inventory Analysis

BILLING CODE 6560–50–C

Table VIII–5 presents the 2002 national exhaust emission inventory for commercial marine vessels, with Category 3 marine engines, subdivided into the seven regions shown in the above figure. The Alaska and Hawaii regions contribute to roughly one-fifth of the national emissions inventory. The inventory for the Alaska EEZ includes emissions from ships on a great circle route, along the Aleutian Islands, between Asia and the U.S. West Coast. Therefore, eastern Alaska, which includes most of the state population, is presented separately in the table below. The Hawaii EEZ includes major shipping lanes across the Pacific that pass near the Hawaiian isles.

TABLE VIII–5.—2002 REGIONAL U.S. EMISSIONS FROM COMMERCIAL MARINE VESSELS [a]

[Tons/yr]

Region	NO_X [short tons]	$PM_{2.5}$ [short tons]	SO_X [short tons]
South Pacific	116,057	8,283	62,944
North Pacific	28,941	2,205	16,469
East Coast	243,261	17,901	153,597
Gulf Coast	192,130	14,374	110,382
Alaska (east)	20,078	1,458	11,037
Alaska (west)	66,768	4,799	35,998
Hawaii	60,501	4,372	32,970
Great Lakes (U.S. only)	16,708	1,207	9,098
Great Lakes (Canada only)	5,621	405	3,043
Total (using U.S. only Great Lakes)	744,444	54,599	432,496

[a] This category includes emissions from Category 3 (C3) propulsion engines and C2/3 auxiliary engines used on ocean-going vessels.

B. Potential Costs

The emission-control technologies we are considering for Category 3 marine engines are already in development or in commercial use in some marine applications. The draft Regulatory Impact Analysis [126] for the May 29, 2002 proposed rulemaking for Category 3 marine engines (67 FR 37548) included an analysis of regulatory alternatives which included advanced technologies. To estimate costs of this prospective emissions control program, we expect to start with cost estimates that were developed as part of that regulatory analysis. We will modify these costs as needed to take into account advances in technology, changes in cost structure, and comments received on this ANPRM. We encourage commenters to review the information covering all aspects of engine costs in the regulatory impact documents for the earlier Category 3 rulemaking and to provide comments on cost-related issues. In addition, we are interested in cost information associated with potential retrofitting concepts and in information about any unique costs associated with equipment redesign for the marine market.

We will also consider the economics of desulfurizing residual fuel, using of distillate fuel, and blending high and low sulfur fuels. Due to high refinery production costs, it is not likely that much new volume of residual fuel will be desulfurized. We expect to employ a worldwide refinery modeling analysis to estimate the cost for desulfurizing residual fuel and to estimate the cost for the production of additional distillate fuel in our analysis for different fuel volume scenarios. Additionally, we will estimate scrubbing costs and potential scrubber penetration rates for ships, as the use of scrubbers is another method that ships may use to comply, in lieu of using low sulfur fuel. The resulting fuel cost from our refinery analysis will be compared to the costs from scrubbing and fuel blending to determine the most economical method for complying with the standards for Category 3 marine engines. We request comment on the potential costs of low sulfur marine fuels.

IX. Statutory and Executive Order Reviews

A. Executive Order 12866: Regulatory Planning and Review

Under section (3)(f)(1) Executive Order 12866 (58 FR 51735, October 4, 1993), the Agency must determine whether the regulatory action is ''significant'' and therefore subject to review by the Office of Management and Budget (OMB) and the requirements of this Executive Order. This Advance Notice has been sent to the Office of Management and Budget (OMB) for review under Executive Order 12866 and any changes made in response to OMB recommendations have been documented in the docket for this action.

B. Paperwork Reduction Act

We will prepare information collection requirements as part of our proposed rule and submit them for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*

C. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), requires agencies to endeavor, consistent with the objectives of the rule and applicable statutes, to fit regulatory and information requirements to the scale of businesses, organizations, and governmental jurisdictions subject to their regulations. SBREFA amended the RFA to strengthen its analytical and procedural requirements and to ensure that small entities are adequately considered during rule development. The Agency accordingly requests comment on the potential impacts on a small entity of the program described in this notice. These comments will help the Agency meet its obligations under SBREFA and will suggest how EPA can minimize the impacts of this rule for small entities that may be adversely impacted.

Depending on the number of small entities identified prior to the proposal and the level of any contemplated regulatory action, we may convene a Small Business Advocacy Review Panel under section 609(b) of the Regulatory Flexibility Act as amended by SBREFA. The purpose of the Panel would be to collect the advice and recommendations of representatives of small entities that could be impacted by the eventual rule. If we determine that a panel is not warranted, we would intend to work on a less formal basis with those small entities identified.

Although we do not believe that this rule will have a significant economic impact on a substantial number of small entities, we are requesting information on small entities potentially impacted by this rulemaking. Information on company size, number of employees, annual revenues and product lines would be especially useful. Confidential business information may be submitted as described under **SUPPLEMENTARY INFORMATION.**

D. Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private

---

[126] ''Draft Regulatory Support Document: Control of Emissions from Compression-Ignition Marine Diesel Engines at or Above 30 Liters per Cylinder,'' U.S. Environmental Protection Agency, April, 2002.

sector. Under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with ''Federal mandates'' that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is needed, section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed under section 203 of the UMRA a small government agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant Federal intergovernmental mandates, and informing, educating, and advising small governments on compliance with the regulatory requirements.

As part of the development of our Notice of Proposed Rulemaking, we will examine the impacts of our proposal with respect to expected expenditures by State, local, and tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year.

E. Executive Order 13132: Federalism

Executive Order 13132, entitled ''Federalism'' (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' ''Policies that have federalism implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.''

Under Section 6 of Executive Order 13132, EPA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, or EPA consults with State and local officials early in the process of developing the proposed regulation. EPA also may not issue a regulation that has federalism implications and that preempts State law, unless the Agency consults with State and local officials early in the process of developing the proposed regulation.

Section 4 of the Executive Order contains additional requirements for rules that preempt State or local law, even if those rules do not have federalism implications (*i.e.*, the rules will not have substantial direct effects on the States, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government). Those requirements include providing all affected State and local officials notice and an opportunity for appropriate participation in the development of the regulation. If the preemption is not based on express or implied statutory authority, EPA also must consult, to the extent practicable, with appropriate State and local officials regarding the conflict between State law and Federally protected interests within the agency's area of regulatory responsibility.

As part of the development of our Notice of Proposed Rulemaking, we will examine the impacts of our proposal with respect to the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132.

In the spirit of Executive Order 13132, and consistent with EPA policy to promote communications between EPA and State and local governments, EPA specifically solicits comment on this proposed rule from State and local officials.

F. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

Executive Order 13175, entitled ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, November 9, 2000), requires EPA to develop an accountable process to ensure ''meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.'' ''Policies that have tribal implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on one or more Indian tribes, on the relationship between the Federal government and the Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes.''

As part of the development of our Notice of Proposed Rulemaking, we will examine the impacts of our proposal with respect to tribal implications.

G. Executive Order 13045: Protection of Children From Environmental Health and Safety Risks

Executive Order 13045, ''Protection of Children From Environmental Health Risks and Safety Risks'' (62 FR 19885, April 23, 1997) applies to any rule that: (1) Is determined to be ''economically significant'' as defined under Executive Order 12866, and (2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the Agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency.

This rule is not subject to the Executive Order because it does not involve decisions on environmental health or safety risks that may disproportionately affect children. The EPA believes that the emissions reductions from the strategies proposed in this rulemaking will further improve air quality and will further improve children's health.

H. Executive Order 13211: Actions That Significantly Affect Energy Supply, Distribution, or Use

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' (66 FR 28355 (May 22, 2001)) requires that we determine whether or not there is a significant impact on the supply of energy caused by our rulemaking. These impacts include: Reductions in supply, reductions in production, increases in energy usage, increases in the cost of energy production and distribution, or other similarly adverse outcomes. We anticipate that our proposal will not be a ''significant energy action'' as defined by this order because we are not reducing the supply or production of any fuels or electricity, nor are we increasing the use or cost of energy by more than the stated thresholds. The proposed standards will have for their aim the reduction of emissions from certain marine engines using either exhaust gas cleaning technology or an alternative grade of marine fuel, and will have no effect on fuel formulation.

I. National Technology Transfer Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (''NTTAA''), Public Law 104 113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (*e.g.*, materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

As part of the development of our Notice of Proposed Rulemaking, we will examine the availability and use of voluntary consensus standards.

J. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order 12898 (59 FR 7629 (Feb. 16, 1994)) establishes federal executive policy on environmental justice. Its main provision directs federal agencies, to the greatest extent practicable and permitted by law, to make environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations in the United States.

EPA has determined that this proposed rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations because it increases the level of environmental protection for all affected populations without having any disproportionately high and adverse human health or environmental effects on any population, including any minority or low-income population. Rather the opposite as more low-income individuals tend to live closer to marine ports, and it is these areas that will receive the most benefits in this rule that will reduce emissions of large marine engines.

List of Subjects

40 CFR Part 9

Reporting and recordkeeping requirements.

40 CFR Part 94

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Imports, Incorporation by reference, Penalties, Reporting and recordkeeping requirements, Vessels, Warranties.

Dated: November 29, 2007.

Stephen L. Johnson,

Administrator.

[FR Doc. E7–23556 Filed 12–6–07; 8:45 am]

BILLING CODE 6560–50–P