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Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 9, 85, 86, 89, 92, 94, 1033, 1039, 1042, 1065, and 1068

[EPA–HQ–OAR–2003–0190; FRL–8545–3]

RIN 2060–AM06

Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: EPA is adopting a comprehensive program to dramatically reduce pollution from locomotives and marine diesel engines. The controls will apply to all types of locomotives, including line-haul, switch, and passenger, and all types of marine diesel engines below 30 liters per cylinder displacement, including commercial and recreational, propulsion and auxiliary. The near-term emission standards for newly-built engines will phase in starting in 2009. The near-term program also includes new emission limits for existing locomotives and marine diesel engines that apply when they are remanufactured, and take effect as soon as certified remanufacture systems are available, as early as 2008. The long-term emissions standards for newly-built locomotives and marine diesel engines are based on the application of high-efficiency catalytic aftertreatment technology. These standards begin to take effect in 2015 for locomotives and in 2014 for marine diesel engines. We estimate particulate matter (PM) reductions of 90 percent and nitrogen oxides (NO_X≤) reductions of 80 percent from engines meeting these standards, compared to engines meeting the current standards.

We project that by 2030, this program will reduce annual emissions of NO_X≤ and PM by 800,000 and 27,000 tons, respectively. EPA projects these reductions will annually prevent up to 1,100 PM-related premature deaths, 280 ozone-related premature deaths, 120,000 lost work days, 120,000 school day absences, and 1.1 million minor restricted-activity days. The annual monetized health benefits of this rule in 2030 will range from $9.2 billion to $11 billion, assuming a 3 percent discount rate, or between $8.4 billion to $10 billion, assuming a 7% discount rate. The estimated annual social cost of the program in 2030 is projected to be $740 million, significantly less than the estimated benefits.

DATES: This rule is effective on July 7, 2008. The incorporation by reference of certain publications listed in this regulation is approved by the Director of the Federal Register as of July 7, 2008.

ADDRESSES: EPA has established a docket for this action under Docket ID No. EPA–HQ–2003–0190. All documents in the docket are listed on the *www.regulations.gov*≤ web site. 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, is not placed on the Internet and will be publicly available only in hard copy form. Publicly available docket materials are available either electronically through *www.regulations.gov*≤ or in hard copy at the Air Docket, EPA/DC, EPA West, Room 3334, 1301 Constitution Ave., 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: John Mueller, U.S. EPA, Office of Transportation and Air Quality, Assessment and Standards Division (ASD), Environmental Protection Agency, 2000 Traverwood Drive, Ann Arbor, MI 48105; telephone number: (734) 214–4275; fax number: (734) 214–4816; e-mail address: *Mueller.John@epa.gov,*≤ or Assessment and Standards Division Hotline; telephone number: (734) 214–4636.

SUPPLEMENTARY INFORMATION:

Does This Action Apply to Me?

• *Locomotives*

Entities potentially affected by this action are those that manufacture, remanufacture or import locomotives or locomotive engines; and those that own or operate locomotives. Regulated categories and entities include:

Category	NAICS code [1]	Examples of potentially affected entities
Industry	333618, 336510	Manufacturers, remanufacturers and importers of locomotives and locomotive engines.
Industry	482110, 482111, 482112	Railroad owners and operators.
Industry	488210	Engine repair and maintenance.

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by this action. This table lists the types of entities that EPA is now aware could potentially be regulated by this action. Other types of entities not listed in the table could also be regulated. To determine whether your company is regulated by this action, you should carefully examine the applicability criteria in 40 CFR 92.1, 1033.1, 1065.1, and 1068.1. If you have questions, consult the person listed in the preceding **FOR FURTHER INFORMATION CONTACT**≤ section.

• *Marine Engines and Vessels*

Entities potentially affected by this action are companies and persons that manufacture, sell, or import into the United States new marine compression-ignition engines, companies and persons that rebuild or maintain these engines, companies and persons that make vessels that use such engines, and the owners/operators of such vessels. Affected categories and entities include:

Category	NAICS code [1]	Examples of potentially affected entities
Industry	333618	Manufacturers of new marine diesel engines.
Industry	33661 and 346611	Ship and boat building; ship building and repairing.

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

Category	NAICS code [1]	Examples of potentially affected entities
Industry	811310	Engine repair, remanufacture, and maintenance.
Industry	483	Water transportation, freight and passenger.
Industry	487210	and Sightseeing Transportation, Water.
Industry	4883	Support Activities for Water Transportation.
Industry	1141	Fishing.
Industry	336612	Boat building (watercraft not built in shipyards and typically of the type suitable or intended for personal use).

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by this action. This table lists the types of entities that EPA is now aware could potentially be regulated by this action. Other types of entities not listed in the table could also be regulated. To determine whether your company is regulated by this action, you should carefully examine the applicability criteria in 40 CFR 94.1, 1042.1, 1065.1, and 1068.1. If you have questions, consult the person listed in the preceding **FOR FURTHER INFORMATION CONTACT**≤ section.

Outline of This Preamble

I. Overview

This final rule completes an important step in EPA's ongoing National Clean Diesel Campaign (NCDC) by adding new programs for locomotives and marine diesel engines to the clean diesel initiatives we have already undertaken for highway, other nonroad, and stationary diesel engines. As detailed below, it significantly strengthens the locomotive and marine diesel programs we proposed last year (72 FR 15938, April 3, 2007), especially in controlling emissions during the critical early years through the early introduction of advanced technologies and the more complete coverage of existing engines. When fully implemented, this coordinated set of new programs will reduce harmful diesel engine emissions to a small fraction of their previous levels.

The new programs 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 (hereafter referred to as ''marine diesel engines'').[2] These engines are used to power a wide variety of vessels, from small fishing and recreational boats to large tugs and Great Lakes freighters. They are also used to generate auxiliary vessel power, including on ocean-going ships.

Emissions of fine particulate matter ($PM_{2.5}$≤) and nitrogen oxides (NO_X≤) from these diesel engines contribute to nonattainment of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$≤ and ozone. Today, locomotives and marine diesel engines account for about 20 percent of mobile source NO_X≤ emissions and 25 percent of mobile source diesel $PM_{2.5}$≤ emissions in the U.S. Absent this final action, by 2030 the relative contributions of NO_X≤ and $PM_{2.5}$≤ from these engines would have grown to 35 and 65 percent, respectively.

We are finalizing a comprehensive three-part program to address this problem. First, we are adopting stringent emission standards for existing locomotives and for existing commercial marine diesel engines above 600 kilowatt (kW) (800 horsepower (hp)). These standards apply when the engines are remanufactured. This part of the program will take effect as soon as certified remanufacture systems are available, for some engines as early as a few months from now. Under our existing program, locomotives have been certified to one of three tiers of standards: Tier 0 for locomotives originally built between 1973 and 2001, Tier 1 for those built between 2002 and 2004, and Tier 2 for those built in or after 2005. Under this new program, certified locomotive remanufacture systems must be made available by 2010 for Tier 0 and Tier 1 locomotives, and by 2013 for Tier 2 locomotives. Remanufacture systems that are certified for use in marine engine remanufactures are likewise required to be used. We are not, however, setting a specific compliance date for certified marine diesel remanufacture systems because we expect that engine manufacturers will be well motivated by the market opportunity to certify emissions-compliant systems.

Second, we are adopting a set of near-term emission standards, referred to as Tier 3, for newly-built locomotives and marine engines. The Tier 3 standards reflect the application of technologies to reduce engine-out particulate matter (PM) and NO_X≤.

Third, we are adopting longer-term standards, referred to as Tier 4, for newly-built locomotives and marine

[2] Marine diesel engines at or above 30 liters per cylinder, called Category 3 engines, are typically used for propulsion power on ocean-going ships. EPA is addressing Category 3 engines through separate actions, including a planned rulemaking for a new tier of federal standards (see Advance Notice of Proposed Rulemaking published December 7, 2007 at 72 FR 69522) and participation on the U.S. delegation to the International Maritime Organization for negotiations of new international standards (see *http://www.epa.gov/otaq/oceanvessels.com*≤ for information on both of those actions), as well as EPA's Clean Ports USA Initiative (see *http://www.epa.gov/cleandiesel/ports/index.htm*≤).

engines. Tier 4 standards reflect the application of high-efficiency catalytic aftertreatment technology enabled by the availability of ultra-low sulfur diesel fuel (ULSD). These standards take effect in 2015 for locomotives, and phase in over time for marine engines, beginning in 2014. Finally, we are adopting provisions in all three parts of the program to eliminate emissions from unnecessary locomotive idling.

Locomotives and marine diesel engines designed to these Tier 4 standards will achieve PM reductions of 90 percent and NO_X≤ reductions of 80 percent, compared to engines meeting the current Tier 2 standards. The new standards will also yield sizeable reductions in emissions of nonmethane hydrocarbons (NMHC), carbon monoxide (CO), and hazardous compounds known as air toxics. Table I–1 summarizes the PM and NO_X≤ emission reductions for the new standards compared to today's (Tier 2) emission standards; for remanufactured engines, the comparison is to the current standards for each tier of locomotives covered, and to typical unregulated levels for marine engines.

TABLE I–1.—REDUCTIONS FROM LEVELS OF EXISTING STANDARDS

Sector	Standards tier	PM (percent)	NO_X≤ (percent)
Locomotives	Remanufactured Tier 0	60	15–20.
	Remanufactured Tier 1	50	
	Remanufactured Tier 2	50	
	Tier 3	50	
	Tier 4	90	80.
	All tiers—idle emissions	50	50.
Marine Diesel Engines [a]	Remanufactured Engines	25–60	Up to 20.
	Tier 3	50	20.
	Tier 4	90	80.

Note:≤ (a) Standards vary by displacement and within power categories. Reductions indicated are typical.

On a nationwide annual basis, these reductions will amount to 800,000 tons of NO_X≤ and 27,000 tons of PM by 2030, resulting annually in the prevention of up to 1,100 PM-related premature deaths, 280 ozone-related premature deaths, 120,000 lost work days, 120,000 school day absences, and 1.1 million minor restricted-activity days. We estimate the annual monetized health benefits of this rule in 2030 will range from $9.2 billion to $11 billion, assuming a 3 percent discount rate, or between $8.4 billion to $10 billion, assuming a 7% discount rate.[3] The estimated annual social cost of the program in 2030 is projected to be $740 million, significantly less than the estimated benefits.

A. What Is EPA Finalizing and How Does it Differ From the Proposal?

This final rule makes a number of important changes to the program set out in our Notice of Proposed Rulemaking (NPRM). Among these are changes that will yield significantly greater overall NO_X and PM reductions, especially in the critical early years of the program: The adoption of standards for remanufactured marine engines and a 2-year pull-ahead of the Tier 4 NO_X requirements for line-haul locomotives and for 2000–3700 kW (2760–4900 hp) marine engines.

The major elements of the final program are summarized below. We are also revising existing testing, certification, and compliance provisions to better ensure emissions control in use. Detailed provisions and our justifications for them are discussed in sections III and IV. Section VII of this preamble describes a number of alternatives that we considered in developing the rule. After evaluating the alternatives, we believe that our new program provides the best opportunity for achieving timely and very substantial emissions reductions from locomotive and marine diesel engines. It balances a number of key factors: (1) Achieving very significant emissions reductions as early as possible, (2) providing appropriate lead time to develop and apply advanced control technologies, and (3) coordinating requirements in this final rule with existing highway and nonroad diesel engine programs. The provisions we are finalizing that are different from the proposed program are:

- The adoption of standards for remanufactured marine diesel engines to address emissions from the existing fleet (this was presented as one of the proposal alternatives),
- Inclusion of Tier 4 NO_X controls on 2015–2016 model year locomotives at initial build rather than at first remanufacture,
- A two-year pull-ahead of the Tier 4 NO_X standard for 2000–3700 kW marine engines to 2014,
- Inclusion of Class II railroads in the remanufactured locomotives program,
- No Tier 4 standards for the small fleet of large recreational vessels at this time,
- A revised approach to migratory vessels that spend part of their time overseas,
- Credit for locomotive design measures that reduce emissions as part of efforts to improve efficiency,
- A number of changes to test and compliance requirements detailed in sections III and IV.

Overall, our comprehensive three-part approach to setting standards for locomotives and marine diesel engines will provide very large reductions in PM, NO_X, and toxic compounds, both in the near-term (as early as 2008), and in the long-term. These reductions will be achieved in a manner that: (1) Leverages technology developments in other diesel sectors, (2) aligns well with the clean diesel fuel requirements already being implemented, and (3) provides the lead time needed to deal with the significant engineering design workload that is involved.

(1) Locomotive Emission Standards

We are setting stringent exhaust emission standards for newly-built and remanufactured locomotives, furthering the initiative for cleaner locomotives started in 2004 with the establishment of the ULSD locomotive fuel program, and adding this important category of engines to the highway and nonroad diesel applications already covered

[3] Low and high benefits estimates are derived from a range of ozone-related premature mortality studies (including an assumption of no causality) and $PM_{2.5}$-related premature mortality based on the ACS study (Pope et al., 2002). Benefits also include $PM_{2.5}$- and ozone-related morbidity benefits. See section VI for a complete discussion and analysis of benefits associated with the final rule.

under EPA's National Clean Diesel Campaign.

Briefly, for newly-built line-haul locomotives we are setting a new Tier 3 PM standard of 0.10 grams per brake horsepower-hour (g/bhp-hr), based on improvements to existing engine designs. This standard will take effect in 2012. We are also setting new Tier 4 standards of 0.03 g/bhp-hr for PM and 1.3 g/bhp-hr for NO_X, based on the evolution of high-efficiency catalytic aftertreatment technologies now being developed and introduced in the highway diesel sector. The Tier 4 standards will take effect in 2015. We are requiring that remanufactured Tier 2 locomotives meet a PM standard of 0.10 g/bhp-hr, based on the same engine design improvements as Tier 3 locomotives, and that remanufactured Tier 0 and Tier 1 locomotives meet a 0.22 g/bhp-hr PM standard. We are also requiring that remanufactured Tier 0 locomotives meet a NO_X standard of 7.4 g/bhp-hr, the same level as current Tier 1 locomotives, or 8.0 g/bhp-hr if the locomotive is not equipped with a separate loop intake air cooling system. Section III provides a detailed discussion of these new standards, and section IV details improvements being made to the applicable test, certification, and compliance programs.

In setting our original locomotive emission standards in 1998, the historic pattern of transitioning older line-haul locomotives to road- and yard-switcher service resulted in our making little distinction between line-haul and switch locomotives. Because of the increase in the size of new locomotives in recent years, that pattern cannot be sustained by the railroad industry, as today's 4000+ hp (3000+ kW) locomotives are poorly suited for switcher duty. Furthermore, although there is still a fairly sizeable legacy fleet of older smaller line-haul locomotives that could find their way into the switcher fleet, essentially the only newly-built switchers put into service over the last two decades have been of radically different design, employing one to three smaller high-speed diesel engines designed for use in nonroad applications. We are establishing new standards and special certification provisions for newly-built and remanufactured switch locomotives that take these factors into account.

Locomotives spend a substantial amount of time idling, during which they emit harmful pollutants, consume fuel, create noise, and increase maintenance costs. We are requiring that idle controls, such as Automatic Engine Stop/Start Systems (AESS), be included on all newly-built Tier 3 and Tier 4 locomotives. We also are requiring that they be installed on all existing locomotives that are subject to the new remanufactured engine standards, at the point of first remanufacture under the standards, unless already equipped with idle controls. Additional idle emissions control beyond AESS is encouraged in our program by factoring it into the certification test program.

(2) Marine Engine Emission Standards

We are setting emissions standards for newly-built and remanufactured marine diesel engines with displacements up to 30 liters per cylinder (referred to as Category 1 and 2, or C1 and C2, engines). Newly-built engines subject to the new standards include those used in commercial, recreational, and auxiliary power applications, and those below 37 kW (50 hp) that were previously regulated in our nonroad diesel program.

The new marine diesel engine standards include stringent engine-based Tier 3 standards for newly-built marine diesel engines that phase in beginning in 2009. These are followed by aftertreatment-based Tier 4 standards for engines above 600 kW (800 hp) that phase in beginning in 2014. The specific levels and implementation dates for the Tier 3 and Tier 4 standards vary by engine size and power. This yields an array of emission standards levels and start dates that help ensure the most stringent standards feasible at the earliest possible time for each group of newly-built marine engines, while helping engine and vessel manufacturers implement the program in a manner that minimizes their costs for emission reductions. The new standards and implementation schedules, as well as their technological feasibility, are described in detail in section III of this preamble.

We are also adopting standards to address the considerable impact of emissions from large marine diesel engines installed in vessels in the existing fleet. These standards apply to commercial marine diesel engines above 600 kW when these engines are remanufactured, and take effect as soon as certified remanufacture systems are available. The final requirements are different from the programmatic alternative on which we sought comment in that there is no mandatory date by which marine remanufacture systems must be made available. However, systems for the larger Category 2 marine diesel engines are expected to become available at the same time as the locomotive remanufacture systems for similar engines, as early as 2008, because Category 2 marine diesel engines are often derived from locomotive engines. This new marine remanufacture program is described in more detail in section III.B(2)(b). We intend to revisit this program in the future to evaluate the extent to which remanufacture systems are being introduced into the market without a mandatory requirement, and to determine if the program should be extended to small commercial and recreational engines as well.

Taken together, the program elements described above constitute a comprehensive program that addresses the problems caused by locomotive and marine diesel emissions from both a near-term and long-term perspective. It does this while providing for an orderly and cost-effective implementation schedule for the railroads, vessel owners, manufacturers, and remanufacturers.

B. Why Is EPA Taking This Action?

(1) Locomotives and Marine Diesels Contribute to Serious Air Pollution Problems

As we discuss extensively in both the proposal and today's action, EPA strongly believes it is appropriate to take steps now to reduce future emissions from locomotive and marine diesel engines. Emissions from these engines generate significant emissions of $PM_{2.5}$ and NO_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. These engines also emit hazardous air pollutants or air toxics, which are associated with serious adverse health effects. Finally, emissions from locomotive and marine diesel engines cause harm to public welfare, including contributing to visibility impairment and other harmful environmental impacts across the U.S.

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 to 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, as described below and in section II, emissions from locomotives and marine diesel engines and vessels impose public health and environmental costs on society. However, these added costs are not reflected in the costs of those using these engines and equipment. The current market and regulatory scheme do not correct this externality because firms in the market are rewarded for minimizing their production costs, including the costs of pollution control, and do not benefit from reductions in emissions. In addition, firms that may take steps to use equipment that reduces air pollution may find themselves at a competitive disadvantage compared to firms that do not. The emission standards that EPA is finalizing help address this market failure and reduce the negative externality from these emissions by providing a regulatory incentive for engine and locomotive manufacturers to produce engines and locomotives that emit fewer harmful pollutants and for railroads and vessel builders and owners to use those cleaner engines.

Emissions from locomotive and marine diesel engines account for substantial portions of the country's current ambient $PM_{2.5}$ and NO_X levels. We estimate that today these engines account for about 20 percent of mobile source NO_X emissions and about 25 percent of mobile source diesel $PM_{2.5}$ emissions. Under this rulemaking, by 2030, NO_X emissions from these diesel engines will be reduced annually by 800,000 tons and $PM_{2.5}$ emissions by 27,000 tons, and these reductions will grow beyond 2030 as fleet turnover to the cleanest engines continues.

EPA has already taken steps to bring emissions levels from highway and nonroad diesel vehicles and engines to very low levels over the next decade, while the per horsepower-hour emission levels for locomotive and marine diesel engines remain at much higher levels—comparable to the emissions for highway trucks in the early 1990s.

Both ozone and $PM_{2.5}$ contribute to 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, loss work days, and restricted activity days), changes in lung function and increased respiratory symptoms, altered respiratory defense mechanisms, and chronic bronchitis. Diesel exhaust is of special public health concern, and since 2002 EPA has classified exposure to diesel exhaust as likely to be carcinogenic to humans by inhalation from environmental exposures.[4] Recent studies are showing that populations living near large diesel emission sources such as major roadways, rail yards, and marine ports are likely to experience greater diesel exhaust exposure levels than the overall U.S. population, putting them at greater health risks.[5 thnsp;6]

EPA recently conducted an initial screening-level analysis [7] of selected marine port areas and rail yards to better understand the populations that are exposed to diesel particulate matter (DPM) emissions from these facilities.[8 9] This screening-level analysis focused on a representative selection of national marine ports and rail yards.[10] Of the 47 marine ports and 37 rail yards selected, the results indicate that at least 13 million people, including a disproportionate number of low-income households, African-Americans, and Hispanics, living in the vicinity of these facilities, are being exposed to ambient DPM levels that are 2.0 μg/m³ and 0.2 μg/m³ above levels found in areas further from these facilities. Because those populations exposed to DPM emissions from marine ports and rail yards are more likely to be low-income and minority residents, these populations will benefit from the controls being finalized in this action. The detailed findings of this study are available in the public docket for this rulemaking.

Today, millions of Americans continue to live in areas that do not meet existing air quality standards. Currently, ozone concentrations exceeding the 8-hour ozone NAAQS occur over wide geographic areas, including most of the nation's major population centers. As of October 10, 2007, approximately 88 million people live 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 144 million people live in 81 areas (which include all or part of 368 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 current or future $PM_{2.5}$ or ozone NAAQS.

In addition to public health impacts, there are public welfare and environmental impacts associated with ozone and $PM_{2.5}$ emissions. 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 and direct emissions of $PM_{2.5}$ can contribute to the 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 objects through soiling and can contribute directly (or in conjunction with other pollutants) to structural damage by means of corrosion or erosion. Finally, NO_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) and 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

[4] 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.*

[5] 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.

[6] 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.*

[7] This type of screening-level analysis is an inexact tool and not appropriate for regulatory decisionmaking; it is useful in beginning to understand potential impacts and for illustrative purposes. Additionally, the emissions inventories used as inputs for the analyses are not official estimates and likely underestimate overall emissions because they are not inclusive of all emission sources at the individual ports in the sample. For example, most inventories included emissions from ocean-going vessels (powered by Category 3 engines), as well as some commercial vessel categories, including harbor crafts, (powered by Category 1 and 2 engines), cargo handling equipment, locomotives, and heavy-duty vehicles. This final rule will not address emissions from ocean-going vessels, cargo handling equipment or heavy-duty vehicles.

[8] ICF International. September 28, 2007. Estimation of diesel particulate matter concentration isopleths for marine harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[9] ICF International. September 28, 2007. Estimation of diesel particulate matter population exposure near selected harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[10] The Agency selected a representative sample of the top 150 U.S. ports including coastal, inland, and Great Lake ports. In selecting a sample of rail yards the Agency identified a subset from the hundreds of rail yards operated by Class I Railroads.

(65 FR 6698, Feb. 10, 2000), the additional $PM_{2.5}$ and NO_X emission reductions resulting from this rule will assist states in attaining and maintaining the Ozone and the $PM_{2.5}$ NAAQS both near term and in the decades to come.

In September 2006, EPA finalized revised $PM_{2.5}$ NAAQS standards and over the next few years the EPA will undergo the process of designating areas that do not meet this new standard. EPA modeling, conducted as part of finalizing the revised NAAQS, projects that in 2015 up to 52 counties with 53 million people may violate either the daily or annual standards for $PM_{2.5}$ (or both), 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 locomotive and marine diesel $PM_{2.5}$ reductions resulting from this rulemaking are needed by a number of states to both attain and maintain the revised $PM_{2.5}$ NAAQS.

State and local governments continue 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 diesel $PM_{2.5}$ and NO_X emissions by undertaking numerous state-level actions.[11] However, they have also urged Agency action to finalize a strong locomotive and marine diesel engine program that will provide crucial emission reductions both in the near and longterm.

The federal program finalized today results in earlier and significantly greater NO_X and PM reductions from the locomotive and marine sector than the proposed program because of the first-ever national standards for remanufactured marine engines and the starting of Tier 4 NO_X requirements for line-haul locomotives and for 2000–3700 kW (2760–4900 hp) marine engines two years earlier than proposed. These changes reflect important cooperative efforts by the regulated industry to implement cleaner technology as early as possible. While the program finalized today will help many states and communities achieve cleaner air, for some areas, such as the South Coast of California, the reductions achieved through this rule will not alone enable them to meet their near-term ozone and PM air quality goals. This was also the case for our 1998 locomotive rulemaking, where the State of California worked with Class I railroads operating in southern California to develop a Memoranda of Understanding (MOU) ensuring that the cleanest technologies enabled by federal rules were expeditiously introduced in areas of California with greatest air quality improvement needs. EPA continues to support California's efforts to reconcile likely future growth in the locomotive and marine sector with the public health protection needs of the area, and today's final rule includes provisions which are well-suited to encouraging early deployment of cleaner technologies through the development of similar programs.

In addition to these new standards, EPA has a number of voluntary programs that help enable government, industry, and local communities to address challenging air quality problems. The EPA SmartWay program has worked with railroads to encourage them to reduce unnecessary locomotive idling and will continue to promote the use of innovative idle reduction technologies that can substantially reduce locomotive emissions while reducing fuel consumption. EPA's National Clean Diesel Campaign, through its Clean Ports USA program is working with port authorities, terminal operators, and trucking and rail companies to promote cleaner diesel technologies and emission reduction strategies through education, incentives, and financial assistance. Part of these efforts involves voluntary retrofit programs that can further reduce emissions from the existing fleet of diesel engines. Finally, EPA is implementing a new Sustainable Ports Strategy which will allow EPA to partner with ports, business partners, communities and other stakeholders to become world leaders in sustainability, including achieving cleaner air. This new strategy builds on the success of collaborative work EPA has been doing in partnership with the American Association of Port Authorities (AAPA), and through port related efforts of Clean Ports USA, SmartWay, EPA's Regional Diesel Collaboratives and other programs. Together these approaches augment the regulations being finalized today, helping states and communities achieve larger reductions sooner in the areas of our country that need them the most.

(2) Advanced Technologies Can Be Applied

Air pollution from locomotive and marine diesel exhaust is a challenging problem. However, we believe it can be addressed effectively through a combination of engine-out emission reduction technologies and high-efficiency catalytic aftertreatment technologies. As discussed in greater detail in section III.C, the development of these aftertreatment technologies for highway and nonroad diesel applications has advanced rapidly in recent years, so that new engines can achieve very large emission reductions in PM and NO_X (in excess of 90 and 80 percent, respectively).

High-efficiency PM control technologies are being broadly used in many parts of the world and are being used domestically to comply with EPA's heavy-duty truck standards that started taking effect in the 2007 model year. These technologies are highly durable and robust in use and have proved extremely effective in reducing exhaust hydrocarbon (HC) and carbon monoxide emissions.

Control of NO_X emissions from locomotive and marine diesel engines can also be achieved with high-efficiency exhaust emission control technologies. Such technologies are expected to be used to meet the stringent NO_X standards included in EPA's heavy-duty highway diesel and nonroad Tier 4 programs and have been in production for heavy-duty trucks in Europe since 2005 and in many stationary source applications throughout the world.

Section III.C discusses additional engineering challenges in applying these technologies to newly-built locomotive and marine engines, as well as the development steps that we expect to be taken to resolve the challenges. With the lead time available and the assurance of ULSD for the locomotive and marine sectors in 2012, as provided by our 2004 final rule for nonroad engines and fuel, we are confident the application of advanced technology to locomotives and marine diesel engines will proceed at a reasonable rate of progress and will result in systems capable of achieving the new standards on time.

(3) Basis for Action Under the Clean Air Act

Authority for the actions promulgated in this document is granted to the EPA

[11] Two examples of state and local actions are: California Air Resources Board (2006). Emission Reduction Plan for Ports and Goods Movements (April 2006), Available electronically at *www.arb.ca.gov/gmp/docs/finalgmpplan090905.pdf*; Connecticut Department of Environmental Protection (2006). Connecticut's Clean Diesel Plan (January 2006). See *http://www.dep.state.ct.us/air2/diesel/index.htm* for description of initiative.

by sections 114, 203, 205, 206, 207, 208, 213, 216, and 301(a) of the Clean Air Act as amended in 1990 (42 U.S.C. 7414, 7522, 7524, 7525, 7541, 7542, 7547, 7550 and 7601(a)).

Authority to Set Standards. EPA is promulgating emissions standards for new marine diesel engines pursuant to its authority under section 213(a)(3) and (4) of the CAA. EPA is promulgating emission standards for new locomotives and new engines used in locomotives pursuant to its authority under section 213(a)(5) of the CAA.

EPA has previously determined that certain existing locomotive engines, when they are remanufactured, are returned to as-new condition and are expected to have the same performance, durability, and reliability as freshly-manufactured locomotive engines. Consequently we set emission standards for these remanufactured engines that apply at the time of remanufacture (defined as ''to replace, or inspect and qualify, each and every power assembly of a locomotive or locomotive engine, whether during a single maintenance event or cumulatively within a five-year period * * *'' (see 61 FR 53102, October 4, 1996; 40 CFR 92.2). In this action we are adopting new tiers of standards for both freshly manufactured and remanufactured locomotives and locomotive engines.

In the proposal for this rulemaking we also discussed applying a similar approach to marine diesel engines. Many marine diesel engines, particularly those above 600 kW (800 hp), periodically undergo a maintenance process that returns them to as-new condition. A full rebuild that brings an engine back to as-new condition includes a complete overhaul of the engine, including piston, rings, liners, turbocharger, heads, bearings, and geartrain/camshaft removal and replacement. Engine manufacturers typically provide instructions for such a full rebuild. Marine diesel engine owners complete this process to maintain engine reliability, durability, and performance over the life of their vessel, and to avoid the need to repower (replace the engine) before their vessel wears out. A commercial marine vessel can be in operation in excess of 40 years, which means that a marine diesel engine may be remanufactured to as-new condition three or more times before the vessel is scrapped.

Because these remanufactured engines are returned to as-new condition, section 213(a)(3) and (4) give EPA the authority to set emission standards for those engines. We are adopting requirements for remanufactured marine diesel engines, described in section III.B(2)(b) of this action. For the purpose of this program, we are defining remanufacture as the replacement of all cylinder liners, either in one maintenance event or over the course of five years (for the purpose of this program, ''replacement'' includes the removing, inspecting and requalifying a liner). While replacement of cylinder liners is only one element of a full rebuild, it is common to all rebuilds. Marine diesel engines that do not have their cylinder liners replaced all at once or within a five-year period, or that do not perform cylinder liner replacement at all, are not considered to be returned to as-new condition and therefore are not considered to be remanufactured. Those engines will not be subject to the marine remanufacture requirements.

Pollutants That Can Be Regulated. CAA section 213(a)(3) directs the Administrator to set NO_X, volatile organic compounds (VOCs), or carbon monoxide standards for classes or categories of engines such as marine diesel engines that contribute to ozone or carbon monoxide concentrations in more than one nonattainment area. These (''standards shall achieve the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines or vehicles, giving appropriate consideration to cost, lead time, noise, energy, and safety factors associated with the application of such technology.''

CAA section 213(a)(4) authorizes the Administrator to establish standards to control emissions of pollutants which ''may reasonably be anticipated to endanger public health and welfare'' where the Administrator determines, as it has done for emissions of PM, that nonroad engines as a whole contribute significantly to such air pollution. The Administrator may promulgate regulations that are deemed appropriate, taking into account costs, noise, safety, and energy factors, for classes or categories of new nonroad vehicles and engines which cause or contribute to such air pollution.

Level of the Standards. CAA section 213(a)(5) directs EPA to adopt emission standards for new locomotives and new engines used in locomotives that achieve the ''greatest degree of emissions reductions achievable through the use of technology that the Administrator determines will be available for such vehicles and engines, taking into account the cost of applying such technology within the available time period, the noise, energy, and safety factors associated with the applications of such technology.'' Section 213(a)(5) does not require any review of the contribution of locomotive emissions to pollution, though EPA does provide such information in this rulemaking. As described in section III of this preamble and in chapter 4 of the final Regulatory Impact Analysis (RIA), EPA has evaluated the available information to determine the technology that will be available for locomotives and engines subject to EPA standards.

Certification and Implementation. EPA is also acting under its authority to implement and enforce both the marine diesel emission standards and the locomotive emission standards. Section 213(d) provides that the standards EPA adopts for both new locomotive and marine diesel engines ''shall be subject to sections 206, 207, 208, and 209'' of the Clean Air Act, with such modifications that the Administrator deems appropriate to the regulations implementing these sections. In addition, the locomotive and marine standards ''shall be enforced in the same manner as [motor vehicle] standards prescribed under section 202'' of the Act. Section 213(d) also grants EPA authority to promulgate or revise regulations as necessary to determine compliance with, and enforce, standards adopted under section 213.

Technological Feasibility and Cost of Standards. The evidence provided in section III.C of this Preamble and in chapter 4 of the RIA indicates that the stringent emission standards we are setting today for newly-built and remanufactured locomotive and marine diesel engines are feasible and reflect the greatest degree of emission reduction achievable through the use of technology that will be available in the model years to which they apply. We have given appropriate consideration to costs in setting these standards. Our review of the costs and cost-effectiveness of these standards indicate that they will be reasonable and comparable to the cost-effectiveness of other emission reduction strategies that EPA has required in prior rulemakings. We have also reviewed and given appropriate consideration to the energy factors of this rule in terms of fuel efficiency as well as any safety and noise factors associated with these standards.

Health and Environmental Need for the Standards. The information in section II of this Preamble and chapter 2 of the RIA regarding air quality and public health impacts provides strong evidence that emissions from marine diesel engines and locomotives significantly and adversely impact public health or welfare. EPA has already found in previous rules that emissions from new marine diesel engines contribute to ozone and carbon monoxide concentrations in more than one area which has failed to attain the ozone and carbon monoxide NAAQS (64 FR 73300, December 29, 1999). EPA has also previously determined that it is appropriate to establish PM standards for marine diesel engines under section 213(a)(4), and the additional information on the carcinogenicity of exposure to diesel exhaust noted above reinforces this finding. In addition, we have already found that emissions from nonroad engines as a whole significantly contribute to air pollution that may reasonably be anticipated to endanger public welfare due to regional haze and visibility impairment (67 FR 68241, Nov. 8, 2002). We find here, based on the information in the NPRM and in section II of this preamble and Chapters 2 and 3 of the final RIA, that emissions from the new marine diesel engines likewise contribute to regional haze and to visibility impairment.

The PM and NO_X emission reductions resulting from these standards are important to states' efforts in attaining and maintaining the ozone and the $PM_{2.5}$ NAAQS in the near term and in the decades to come. As noted above, the risk to human health and welfare will be significantly reduced by the standards finalized in today's action.

II. Air Quality and Health Impacts

The locomotive and marine diesel engines subject to this final rule generate significant emissions of particulate matter (PM) and nitrogen oxides (NO_X) that contribute to nonattainment of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and ozone. These engines also emit hazardous air pollutants or air toxics that are associated with serious adverse health effects and contribute to visibility impairment and other harmful environmental impacts across the U.S.

By 2030, these standards are expected to reduce annual locomotive and marine diesel engine $PM_{2.5}$ emissions by 27,000 tons; NO_X emissions by 800,000 tons; and volatile organic compound (VOC) emissions by 43,000 tons as well as reducing carbon monoxide (CO) and toxic compounds known as air toxics.[12]

We project that reductions of $PM_{2.5}$, NO_X, and VOC emissions from locomotive and marine diesel engines will produce nationwide air quality improvements. According to air quality modeling performed in conjunction with this rule, all 39 current $PM_{2.5}$ nonattainment areas will experience a decrease in their projected 2030 design values. Likewise the 133 mandatory class I federal areas that EPA modeled will all see improvements in their visibility. This rule will also result in nationwide ozone benefits. In 2030, 573 counties (of 579 that have monitored data) experience at least a 0.1 ppb decrease in their ozone design values.

A. Overview

From a public health perspective, we are concerned with locomotive and marine diesel engines' contributions to atmospheric levels of particulate matter in general, diesel $PM_{2.5}$ in particular, various gaseous air toxics, and ozone. Today, locomotive and marine diesel engine emissions represent a substantial portion of the U.S. mobile source diesel $PM_{2.5}$ and NO_X inventories, approximately 20 percent of mobile source NO_X and 25 percent of mobile source diesel $PM_{2.5}$. Over time, the relative contribution of these diesel engines to air quality problems is expected to increase as the emission contribution from other mobile sources decreases and the usage of locomotives and marine vessels increases. By 2030, without the additional emissions controls finalized in today's rule, locomotive and marine diesel engines will emit about 65 percent of the total mobile source diesel $PM_{2.5}$ emissions and 35 percent of the total mobile source NO_X emissions.

Based on the most recent data available for this rule, air quality problems continue to persist over a wide geographic area of the United States. As of October 10, 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 144 million people living in 81 areas (which include all or part of 366 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 current or future $PM_{2.5}$ or ozone NAAQS. Figure II–1 illustrates the widespread nature of these problems. This figure depicts counties which are currently 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.

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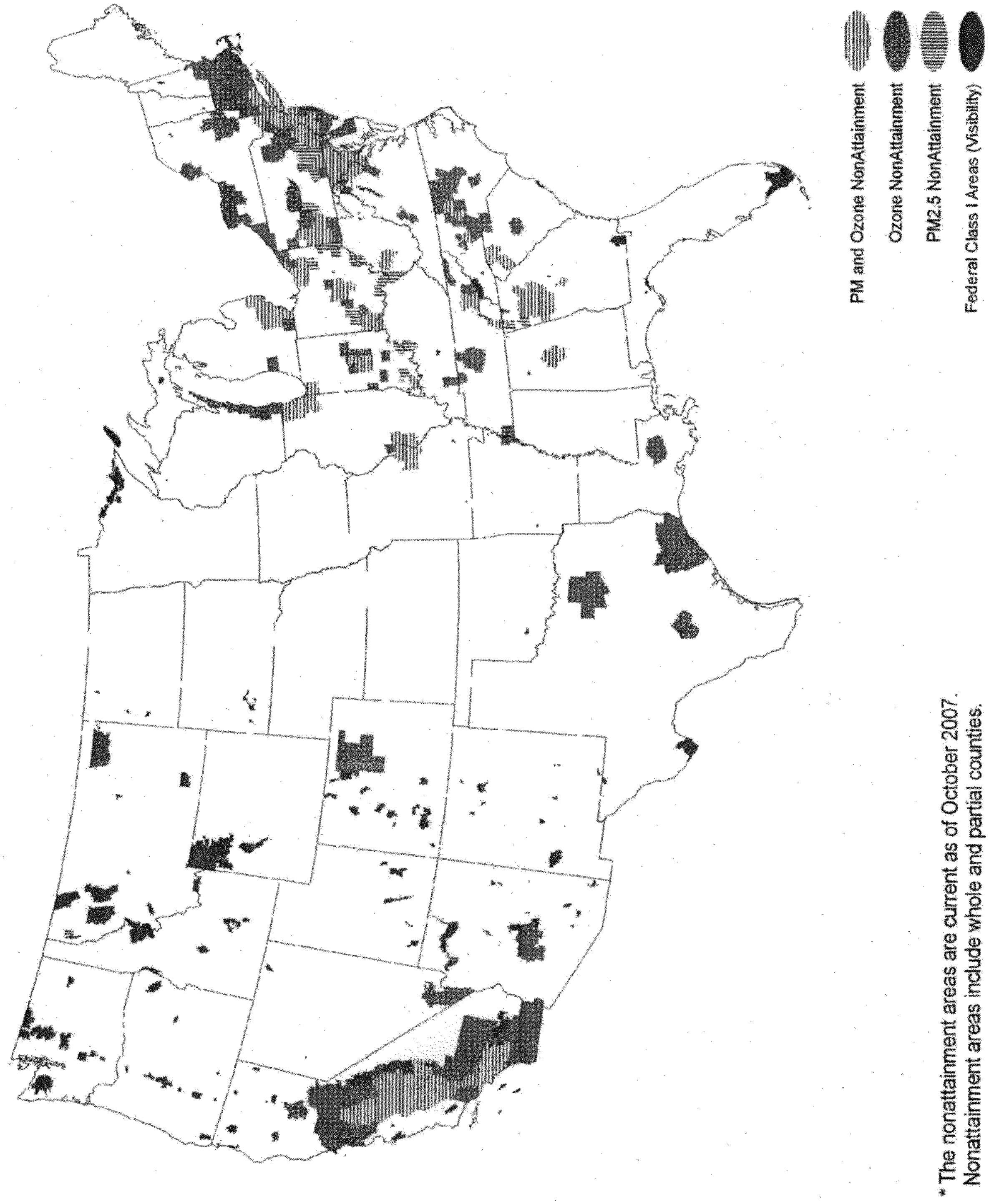
[12] Nationwide locomotive and marine diesel engines comprise approximately 3 percent of the nonroad mobile sources hydrocarbon inventory. EPA National Air Quality and Emissions Trends Report 1999. March 2001, Document Number: EPA 454/R–0–004. This document is available in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at: *http://www.epa.gov/air/airtrends/aqtrnd99/*.

Figure II-1 Air Quality Problems are Widespread



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The engine standards finalized in this rule will help reduce emissions of PM, NO_X, VOCs, CO, and air toxics and their associated health and environmental effects. Emissions from locomotives and diesel marine engines contribute to PM and ozone concentrations in many, if not all, of these nonattainment areas.[13] The engine standards being finalized today will become effective as early as 2008, making the expected $PM_{2.5}$, NO_X, and VOC inventory reductions from this rulemaking critical to a number of states as they seek to either attain or maintain the current $PM_{2.5}$ or ozone NAAQS.

Beyond the impact locomotive and marine diesel engines have on our nation's ambient air quality the diesel

[13] See section II.B.(1)(c) and II.B.(2)(c) for a summary of the impact emission reductions from locomotive and marine diesel engines will have on air quality in current $PM_{2.5}$ and ozone nonattainment areas.

exhaust emissions from these engines are also of particular concern since exposure to diesel exhaust is classified as likely to be carcinogenic to humans by inhalation from environmental levels of exposure.[14] Many people spend a large portion of time in or near areas of concentrated locomotive or marine diesel emissions, near rail yards, marine ports, railways, and waterways. Recent studies show that populations living near large diesel emission sources such as major roadways,[15] rail yards [16] and marine ports [17] are likely to experience greater diesel exhaust exposure levels than the overall U.S. population, putting them at a greater health risk.

EPA recently conducted an initial screening-level analysis [18] of selected marine port areas and rail yards to better understand the populations that are exposed to diesel particulate matter (DPM) emissions from these facilities.[19] [20] This screening-level analysis focused on a representative selection of national marine ports and rail yards.[21] Of the 47 marine ports and 37 rail yards selected, the results indicate that at least 13 million people, including a disproportionate number of low-income households, African-Americans, and Hispanics, living in the vicinity of these facilities, are being exposed to ambient DPM levels that are 2.0 μg/m^3 and 0.2 μg/m^3 above levels found in areas further from these facilities. Because those populations exposed to DPM emissions from marine ports and rail yards are more likely to be low-income and minority residents, these populations will benefit from the controls being finalized in this action. The detailed findings of this study are available in the public docket for this rulemaking.

In the following sections we review important public health effects linked to pollutants emitted from locomotive and marine diesel engines. First, the human health effects caused by the pollutants and their current and projected ambient levels are discussed. Following the discussion of health effects, the modeled air quality benefits resulting from this action and the welfare effects associated with emissions from diesel engines are presented. Finally, the locomotive and marine engine emission inventories for the primary pollutants affected by this rule are provided. In summary, the emission reductions from this rule will contribute to controlling the health and welfare problems associated with ambient PM and ozone levels and with diesel-related air toxics.

Taken together, the materials in this section and in the proposal describe the need for tightened emission standards for both locomotive and marine diesel engines and the air quality and public health benefits resulting from this program. This section is not an exhaustive treatment of these issues. For a fuller understanding of the topics treated here, you should refer to the extended presentations in Chapter 2, 3 and 5 of the Regulatory Impact Analysis (RIA) accompanying this final rule.

B. Public Health Impacts

(1) Particulate Matter

The locomotive and marine engine standards detailed in this action will result in significant reductions in primary (directly emitted) $PM_{2.5}$ emissions. In addition, the standards finalized today will reduce emissions of NO_X and VOCs, which contribute to the formation of secondary $PM_{2.5}$. Locomotive and marine diesel engines emit high levels of NO_X, which react in the atmosphere to form secondary $PM_{2.5}$ (namely ammonium nitrate). These engines also emit SO_2 and VOC, which react in the atmosphere to form secondary $PM_{2.5}$ composed of sulfates and organic carbonaceous $PM_{2.5}$. This rule will reduce both primary and secondary PM.

(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) in diameter. $PM_{2.5}$ refers to fine 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) in diameter. 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 VOC) 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 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 μg/m^3 based on the 98th percentile concentration averaged over three years. The annual standard specifies an

[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 in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060*.

[15] Kinnee, E.J.; Touma, 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; also see Cohen, J.; Cook, R; Bailey, C.R.; Carr, E. (2005) Relationship between motor vehicle emissions of hazardous pollutants, roadway proximity, and ambient concentrations in Portland, Oregon. Environ. Modeling & Software 20: 7–12.

[16] Hand, R.; Di, P; Servin, A.; Hunsaker, L.; Suer, C. (2004) Roseville Rail Yard Study. California Air Resources Board. This document is available in Docket EPA–HQ–OAR–2003–0190. [Online at *http://www.arb.ca.gov/diesel/documents/rrstudy.htm*].

[17] Di P.; Servin, A.; Rosenkranz, K.; Schwehr, B.; Tran, H. (April 2006); Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach. State of California Air Resources Board.

[18] This type of screening-level analysis is an inexact tool and not appropriate for regulatory decision-making; it is useful in beginning to understand potential impacts and for illustrative purposes. Additionally, the emissions inventories used as inputs for the analyses are not official estimates and likely underestimate overall emissions because they are not inclusive of all emission sources at the individual ports in the sample. For example, most inventories included emissions from ocean-going vessels (powered by Category 3 engines), as well as some commercial vessel categories, including harbor crafts (powered by Category 1 and 2 engines), cargo handling equipment, locomotives, and heavy-duty vehicles. This final rule will not address emissions from ocean-going vessels, cargo handling equipment or heavy-duty vehicles.

[19] ICF International. September 28, 2007. Estimation of diesel particulate matter concentration isopleths for marine harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[20] ICF International. September 28, 2007. Estimation of diesel particulate matter population exposure near selected harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[21] The Agency selected a representative sample of the top 150 U.S. ports including coastal, inland and Great Lake ports. In selecting a sample of rail yards the Agency identified a subset from the hundreds of rail yards operated by Class I Railroads.

expected annual arithmetic mean not to exceed 15 μg/m^3 averaged over three years.

EPA has recently amended the NAAQS for $PM_{2.5}$ (71 FR 61144, October 17, 2006). The final rule, signed on September 21, 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 μg/m^3 to 35 μg/m^3 and the level of the annual $PM_{2.5}$ NAAQS was retained at 15 μg/m^3. With regard to the secondary standards for $PM_{2.5}$, EPA has revised these standards to be identical in all respects to the revised primary standards.

(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.[22] [23] Further discussion of health effects associated with PM can also be found in the RIA for this rule.

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.[24] In addition, a reanalysis of the American Cancer Society Study shows an association between fine particle and sulfate concentrations and lung cancer mortality.[25]

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. These studies take into account all air pollution sources, including both spark-ignition (gasoline) and diesel powered vehicles, and indicate that exposure to $PM_{2.5}$ emissions near roadways, which are 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.[26] Also, a number of studies have shown associations between residential or school outdoor concentrations of some fine particle constituents that are found in motor vehicle exhaust, and adverse respiratory outcomes, including asthma prevalence in children who live near major roadways.[27] [28] [29] Although the engines considered in this rule differ from 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 large marine diesel and locomotive engines.

Recent new studies from the State of California provide evidence that $PM_{2.5}$ emissions within marine ports and rail yards can contribute significantly to elevated ambient concentrations near these sources.[30] [31] A substantial number of people experience exposure to locomotive and marine diesel engine emissions, raising potential health concerns. The controls finalized in this action will help reduce exposure to $PM_{2.5}$, specifically exposure to marine port and rail yard related diesel $PM_{2.5}$ sources. Additional information on marine port and rail yard emissions and ambient exposures can be found in Chapter 2 of the RIA.

(c) Current and Projected $PM_{2.5}$ Levels

$PM_{2.5}$ concentrations exceeding the level of the $PM_{2.5}$ NAAQS occur in many parts of the country.[32] In 2005 EPA designated 39 nonattainment areas for the 1997 $PM_{2.5}$ NAAQS (70 FR 943, January 5, 2005). These areas are comprised of 208 full or partial counties with a total population exceeding 88 million. The 1997 $PM_{2.5}$ NAAQS was recently revised and the 2006 $PM_{2.5}$ NAAQS became effective on December 18, 2006. Table II–1 presents the number of counties in areas currently designated as nonattainment for the 1997 $PM_{2.5}$ NAAQS as well as the number of additional counties that have monitored data that is violating the 2006 $PM_{2.5}$ NAAQS.

[22] 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–2003–0190.

[23] 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–2003–0190.

[24] 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.

[25] Pope, C. A., III; Burnett, R. T.; Thun, M. J.; Calle, E. E.; Krewski, D.; Ito, K.; Thurston, G. D. (2002) Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. J. Am. Med. Assoc. 287:1132–1141.

[26] 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.

[27] 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.

[28] 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.

[29] 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.

[30] State of California Air Resources Board. Roseville Rail Yard Study. Stationary Source Division, October 14, 2004. This document is available in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at: *http://www.arb.ca.gov/diesel/documents/rrstudy.htm*.

[31] 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 in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at: *ftp://ftp.arb.ca.gov/carbis/msprog/offroad/marinevess/documents/portstudy0406.pdf*.

[32] A listing of the $PM_{2.5}$ nonattainment areas is included in the RIA for this rule.

TABLE II–1.—FINE PARTICLE STANDARDS: CURRENT NONATTAINMENT AREAS AND OTHER VIOLATING COUNTIES

Nonattainment areas/other violating counties	Number of counties	Population [a]
1997 $PM_{2.5}$ Standards: 39 areas currently designated	208	88,394,000
2006 $PM_{2.5}$ Standards: counties with violating monitors [b]	49	18,198,676
Total	257	106,595,676

Notes:

(a) Population numbers are from 2000 census data.

(b) This table provides an estimate of the counties violating the 2006 $PM_{2.5}$ NAAQS based on 2003–05 air quality data. The areas designated as nonattainment for the 2006 $PM_{2.5}$ NAAQS will be based on 3 years of air quality data from later years. Also, the county numbers in the summary table includes only the counties with monitors violating the 2006 $PM_{2.5}$ NAAQS. The monitored county violations may be an underestimate of the number of counties and populations that will eventually be included in areas with multiple counties designated nonattainment.

A number of state governments have told EPA that they need the reductions this rule will provide in order to meet and maintain the $PM_{2.5}$ NAAQS. Areas designated as not attaining the 1997 $PM_{2.5}$ NAAQS will need to attain the 1997 standards in the 2010 to 2015 time frame, and then maintain them thereafter. The attainment dates associated with the potential new 2006 $PM_{2.5}$ nonattainment areas are likely to be in the 2015 to 2020 timeframe. The emission standards finalized in this action become effective as early as 2008 making the NO_X, PM, and VOC inventory reductions from this rulemaking useful to states in attaining or maintaining the $PM_{2.5}$ NAAQS.

EPA has already adopted many emission control programs that are expected to reduce ambient $PM_{2.5}$ levels and which will assist in reducing the number of areas that fail to achieve the $PM_{2.5}$ NAAQS. Even so, our air quality modeling for this final rule projects that in 2020, with all current controls but excluding the reductions achieved through this rule, up to 11 counties with a population of 24 million may not attain the current annual $PM_{2.5}$ standard of 15 μg/m³. These numbers do not account for additional areas that have air quality measurements within 10 percent of the annual $PM_{2.5}$ standard. These areas, although not violating the standards, will also benefit from the additional reductions from this rule ensuring long-term maintenance of the $PM_{2.5}$ NAAQS.

Air quality modeling performed for this final rule shows that in 2020 and 2030 all 39 current $PM_{2.5}$ nonattainment areas will experience decreases in their $PM_{2.5}$ design values. For areas with current $PM_{2.5}$ design values greater than 15 μg/m³ the modeled future-year population weighted $PM_{2.5}$ design values are expected to decrease on average by 0.08 μg/m³ in 2020 and by 0.16 μg/m³ in 2030. The maximum decrease for future-year $PM_{2.5}$ design values will be 0.38 μg/m³ in 2020 and 0.81 μg/m³ in 2030. The air quality modeling methodology and the projected reductions are discussed in more detail in Chapter 2 of the RIA.

(2) Ozone

The locomotive and marine engine standards finalized in this action are expected to result in significant reductions of NO_X and VOC emissions. NO_X and VOC contribute 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 typically formed by the reaction of volatile organic compounds (VOC) and nitrogen oxides (NO_X) in the lower atmosphere in the presence of heat and sunlight. These 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.[33] 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 occurs on a single high-temperature day. Ozone can also be transported into an area from pollution sources found hundreds of miles upwind, resulting in elevated ozone levels even in areas with low local VOC or NO_X emissions.

The current ozone NAAQS, established by EPA in 1997, 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 people and public welfare.[34] 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 Paper.[35, 36] Ozone

[33] 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–2003–0190. This document may be accessed electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_cd.html.*

[34] EPA proposed to set the 8-hour primary ozone standard to a level within the range of 0.070–0.075 ppm. The agency also requested 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 proposed 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 proposed 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.

[35] 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–2003–0190. This document may be accessed electronically at: *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_cd.html.*

[36] U.S. EPA (2007) Review of the National Ambient Air Quality Standards for Ozone, Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper.EPA–452/R–07–003. This document is available in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at: *http:www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_sp.html.*

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; breathing may also 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 medical attention and/or the use of additional medication. There is evidence of an elevated risk of mortality associated with acute exposure to ozone, especially in the summer or warm season when ozone levels are typically high. 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 exposure to ozone can include children, the elderly, and individuals with respiratory disease such as asthma. Those with greater exposures to ozone, for instance due to time spent outdoors (e.g., children and outdoor workers), are also of particular concern.

The recent ozone AQCD also examined relevant new scientific information that has emerged in the past decade, including the impact of ozone exposure on such health effects 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.

(c) Current and Projected Ozone Levels

Ozone concentrations exceeding the level of the 8-hour ozone NAAQS occur over wide geographic areas, including most of the nation's major population centers.[37] As of October 10, 2007, there were approximately 144 million people living in 81 areas (which include all or part of 366 counties) designated as not in attainment with the 8-hour ozone NAAQS. These numbers do not include the people living in areas where there is a future risk of failing to maintain or attain the 8-hour ozone NAAQS.

States with 8-hour ozone nonattainment areas are required to take action to bring those areas into compliance in the future. Based on the final rule designating and classifying 8-hour ozone nonattainment areas (69 FR 23951, April 30, 2004), most 8-hour ozone nonattainment areas will be required to attain the ozone NAAQS in the 2007 to 2013 time frame and then maintain the NAAQS thereafter.[38] Many of these nonattainment areas will need to adopt additional emission reduction programs and the NO_X and VOC reductions from this final action are particularly important for these states. In addition, EPA's review of the ozone NAAQS is currently underway with a final rule scheduled for March 2008. If the ozone NAAQS is revised then new nonattainment areas will be designated. While EPA is not relying on it for purposes of justifying this rule, the emission reductions from this rulemaking will also be helpful to states if EPA revises the ozone NAAQS to be more stringent.

EPA has already adopted many emission control programs that are expected to reduce ambient ozone levels. These control programs are described in section I.B.1 of this preamble. As a result of these programs, the number of areas that fail to meet the 8-hour ozone NAAQS in the future is expected to decrease. Based on the air quality modeling performed for this rule, which does not include any additional local controls, we estimate nine counties (where 22 million people are projected to live) will exceed the 8-hour ozone NAAQS in 2020.[39] An additional 39 counties (where 29 million people are projected to live) are expected to be within 10 percent of violating the 8-hour ozone NAAQS in 2020.

This rule results in reductions in nationwide ozone levels. The air quality modeling projects that in 2030, 573 counties (of 579 that have monitored data) experience at least a 0.1 ppb decrease in their ozone design values. There are three nonattainment areas in southern California, the Los Angeles-South Coast Air Basin nonattainment area, the Riverside Co. (Coachella Valley) nonattainment area and the Los Angeles—San Bernardino (W. Mojave) nonattainment area, which will experience 8-hour ozone design value increases due to the NO_X disbenefits which occur in these VOC-limited ozone nonattainment areas. Briefly, NO_X reductions at certain times and in some areas can lead to increased ozone levels. The air quality modeling methodology (Section 2.3), the projected reductions (Section 2.2.4), and the limited NO_X disbenefits (Section 2.2.4.2.1), are discussed in more detail in Chapter 2 of the RIA.

Results from the air quality modeling conducted for this final rule indicate that the locomotive and marine diesel engine emission reductions in 2020 and 2030 will improve both the average and population-weighted average ozone concentrations for the U.S. In addition, the air quality modeling shows that on average this final rule will help bring counties closer to ozone attainment as well as assist counties whose ozone concentrations are within ten percent below the standard. For example, in projected nonattainment counties, on a population-weighted basis, the 8-hour ozone design value will on average decrease by 0.13 ppb in 2020 and 0.62 ppb in 2030.[40]

The impact of the reductions has also been analyzed with respect to those areas that have the highest design values, at or above 85 ppb, in 2020. We project there will be nine U.S. counties with design values at or above 85 ppb in 2020. After implementation of this rule, we project that one of these nine counties will drop below 85 ppb. Further, two of the nine counties will be at least 10 percent closer to a design value of less than 85 ppb, and on average all nine counties will be about 18 percent closer to a design value of less than 85 ppb.

(3) Air Toxics

People experience elevated risk of cancer and other noncancer health effects from exposure to the class of pollutants known collectively as ''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 locomotive and marine diesel marine engines, were

[37] A listing of the 8-hour ozone nonattainment areas is included in the RIA for this rule.

[38] The Los Angeles South Coast Air Basin 8-hour ozone nonattainment area will have to attain before June 15, 2021.

[39] We expect many of the 8-hour ozone nonattainment areas to adopt additional emission reduction programs but we are unable to quantify or rely upon future reductions from additional state and local programs that have not yet been adopted.

[40] Ozone design values are reported in parts per million (ppm) as specified in 40 CFR part 50. Due to the scale of the design value changes in this action, results have been presented in parts per billion (ppb) format.

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 other emissions 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.[41] 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;[42] however, the confidence in the RfC for acrolein is medium[43] and confidence in NATA estimates of population noncancer hazard from ambient exposure to this pollutant is low.[44] 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 particulate matter concentration.

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 website.[45] 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 locomotive and marine diesel engines, and provides a discussion of the health risks associated with each air toxic.

(a) Diesel Exhaust (DE)

Locomotive and marine diesel 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 a 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). Also, there are emissions differences between on-road and nonroad engines because the nonroad engines are generally of older technology. This is especially true for locomotive and marine diesel engines.[46]

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.

(i) Diesel Exhaust: Potential Cancer Effects

In EPA's 2002 Diesel Health Assessment Document (Diesel HAD),[47] exposure to diesel exhaust was classified as likely to be carcinogenic to humans by inhalation from 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 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 exposure to 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

[41] 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, which 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.

[42] 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*.

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

[44] 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*.

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

[46] 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 electronically at *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060*. This document can be found in Docket EPA–HQ–OAR–2003–0190.

[47] 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 can be found in Docket EPA–HQ–OAR–2003–0190.

across a variety of diesel exhaust-exposed occupations.[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^{-4} 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 exposure to diesel exhaust is likely to be carcinogenic to humans by inhalation from environmental exposures. 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 and summarized in Chapter 2 of the RIA.

(ii) Diesel Exhaust: Other Health Effects

Noncancer health effects of acute and chronic exposure to diesel exhaust emissions are also of concern to the EPA. EPA derived a diesel exhaust reference concentration (RfC) from consideration of four well-conducted chronic rat inhalation studies showing adverse pulmonary effects.[50 51 52 53] The RfC is 5 µg/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 are presently 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). The Diesel HAD concludes ''that acute exposure to DE [diesel exhaust] has been associated with irritation of the eye, nose, and throat, respiratory symptoms (cough and phlegm), and neurophysiological symptoms such as headache, lightheadedness, nausea, vomiting, and numbness or tingling of the extremities.'' [54]

Exposure to diesel exhaust has also been shown to cause serious noncancer effects in occupational exposure studies. One study of railroad workers and electricians, cited in the Diesel HAD,[55] found that exposure to diesel exhaust resulted in neurobehavioral impairments in one or more areas including reaction time, balance, blink reflex latency, verbal recall, and color vision confusion indices. Pulmonary function tests also showed that 10 of the 16 workers had airway obstruction and another group of 10 of 16 workers had chronic bronchitis, chest pain, tightness, and hyperactive airways. Finally, a variety of studies have been published subsequent to the completion of the Diesel HAD. One such study, published in 2006,[56] found that railroad engineers and conductors with diesel exhaust exposure from operating trains had an increased incidence of chronic obstructive pulmonary disease (COPD) mortality. The odds of COPD mortality increased with years on the job so that those who had worked more than 16 years as an engineer or conductor after 1959 had an increased risk of 1.61 (95% confidence interval, 1.12–2.30). EPA is assessing the significance of this study within the context of the broader literature.

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

The Diesel HAD also briefly summarizes health effects associated with ambient PM and discusses the EPA's annual $PM_{2.5}$ NAAQS of 15 µg/m^3. 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.

(iv) 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 locomotive engines and marine diesel 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. A wide range of exposures have been reported, from 2 µg/m^3 to 1,280 µg/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).[57] As discussed in the Diesel HAD, the National Institute of Occupational Safety and Health

[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] ''Health Assessment Document for Diesel Engine Exhaust,'' U.S. Environmental Protection Agency, 600/8–90/057F, *http://www.epa.gov/ttn/atw/dieselfinal.pdf*, May 2002, p. 9–9.

[55] Kilburn (2000) See HAD Chapter 5–7.

[56] Hart, JE; Laden F; Schenker, M.B.; and Garshick, E. Chronic Obstructive Pulmonary Disease Mortality in Diesel-Exposed Railroad Workers; Environmental Health Perspective July 2006: 1013–1016.

[57] 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.

(NIOSH) has estimated a total of 1,400,000 workers are occupationally exposed to diesel exhaust from on-road and nonroad vehicles including locomotive and marine diesel engines.

Elevated Concentrations and Ambient Exposures in Mobile Source-Impacted Areas

Regions immediately downwind of rail yards and marine ports may experience elevated ambient concentrations of directly-emitted $PM_{2.5}$ from diesel engines. Due to the unique nature of rail yards and marine ports, emissions from a large number of diesel engines are concentrated in a small area. Furthermore, emissions occur at or near ground level, allowing emissions of diesel engines to reach nearby receptors without fully mixing with background air.

A 2004 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.[58] 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 diesel PM 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 μg/m³ 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 these 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.[59] Like the earlier rail yard study, the port study employed the ISCST3 dispersion model. 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 μg/m³ of port-related diesel PM in ambient air, about 360,000 people lived in areas with at least 0.6 μg/m³ of diesel PM, and about 50,000 people lived in areas with at least 1.5 ug/m³ of ambient diesel PM directly from the port. Most recently, CARB released several additional Railyard Health Risk Assessments which all show that diesel PM emissions result in significantly higher pollution risks in nearby communities.[60] Together these studies highlight the substantial contribution these facilities make to elevated ambient concentrations in populated areas.

As mentioned in section II.A of this preamble, EPA recently conducted an initial screening-level analysis of a representative selection of national marine port areas and rail yards to begin to better understand the populations that are exposed to DPM emissions from these facilities.[61] [62] As part of this study, a computer geographic information system (GIS) was used to identify the locations and property boundaries of 47 marine ports and 37 rail yard facilities.[63] Census information was used to estimate the size and demographic characteristics of the population living in the vicinity of the ports and rail yards. The results indicate that at least 13 million people, including a disproportionate number of low-income, African-Americans, and Hispanics, live in the vicinity of these facilities and are being exposed to ambient DPM levels that are 2.0 μg/m³ and 0.2 μg/m³ above levels found in areas further from these facilities. These populations will benefit from the controls being finalized in this action. This study is discussed in greater detail in chapter 2 of the RIA and detailed findings of this study are available in the public docket for this rulemaking.

(b) Other Air Toxics—benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, POM, naphthalene

Locomotive and marine diesel engine exhaust emissions also contribute to ambient levels of other air toxics known or suspected as human or animal carcinogens, or that have noncancer health effects. These other air toxics 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 cancer risk or noncancer hazard drivers in the 1999 National-Scale Air Toxics Assessment (NATA) and have significant inventory contributions from mobile sources. That is, for a significant portion of the population, these compounds pose a significant portion of the total cancer and noncancer risk from breathing outdoor air toxics. The reductions in locomotive and marine diesel engine emissions finalized in this rulemaking will help reduce exposure to these harmful substances.

Benzene: EPA has characterized benzene as a known human carcinogen (causing leukemia) by all routes of exposure, and concludes that exposure is associated with additional health effects, including genetic changes in both humans and animals and increased proliferation of bone marrow cells in mice.[64] [65] [66] EPA states in its IRIS database that data indicate a causal relationship between benzene exposure and acute lymphocytic leukemia and suggests a relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia. The IARC has determined that benzene is a human carcinogen and the U.S. DHHS has characterized

[58] 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*] This document can be found in Docket EPA–HQ–OAR–2003–0190.

[59] 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 in Docket EPA–HQ–OAR–2003–0190. This document is available electronically at: *ftp://ftp.arb.ca.gov/carbis/msprog/offroad/marinevess/documents/portstudy0406.pdf.*

[60] These studies are available in Docket EPA–HQ–OAR–2003–0190. Studies are also available at *http://www.arb.ca.gov/railyard/hra/hra.htm.*

[61] ICF International. September 28, 2007. Estimation of diesel particulate matter concentration isopleths for marine harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[62] ICF International. September 28, 2007. Estimation of diesel particulate matter population exposure near selected harbor areas and rail yards. Memorandum to EPA under Work Assignment Number 0–3, Contract Number EP–C–06–094. This memo is available in Docket EPA–HQ–OAR–2003–0190.

[63] The Agency selected a representative sample of the top 150 U.S. ports including coastal, inland, and Great Lake ports. In selecting a sample of rail yards the Agency identified a subset from the hundreds of rail yards operated by Class I Railroads.

[64] U.S. EPA. 2000. Integrated Risk Information System File for Benzene. This material is available electronically at *http://www.epa.gov/iris/subst/0276.htm.*

[65] International Agency for Research on Cancer (IARC). 1982. Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Some industrial chemicals and dyestuffs, World Health Organization, Lyon, France, p. 345–389.

[66] Irons, R.D.; Stillman, W.S.; Colagiovanni, D.B.; Henry, V.A. 1992. Synergistic action of the benzene metabolite hydroquinone on myelopoietic stimulating activity of granulocyte/macrophage colony-stimulating factor in vitro, Proc. Natl. Acad. Sci. 89:3691–3695.

benzene as a known human carcinogen.[67] [68]

A number of adverse noncancer health effects including blood disorders, such as preleukemia and aplastic anemia, have also been associated with long-term exposure to benzene.[69] [70] The most sensitive noncancer effect observed in humans, based on current data, is the depression of the absolute lymphocyte count in blood.[71] [72] In addition, recent work, including studies sponsored by the Health Effects Institute (HEI), provides evidence that biochemical responses are occurring at lower levels of benzene exposure than previously known.[73, 74, 75, 76] EPA's IRIS program has not yet evaluated these new data.

1,3-Butadiene: EPA has characterized 1,3–butadiene as carcinogenic to humans by inhalation.[77] [78] The IARC has determined that 1, 3-butadiene is a human carcinogen and the U.S. DHHS has characterized 1,3-butadiene as a known human carcinogen.[79] [80] There are numerous studies consistently demonstrating that 1,3-butadiene is metabolized into genotoxic metabolites by experimental animals and humans. The specific mechanisms of 1,3-butadiene-induced carcinogenesis are unknown; however, the scientific evidence strongly suggests that the carcinogenic effects are mediated by genotoxic metabolites. Animal data suggest that females may be more sensitive than males for cancer effects associated with 1,3-butadiene exposure; while there are insufficient data in humans from which to draw conclusions about sensitive subpopulations.

1,3-Butadiene also causes a variety of reproductive and developmental effects in mice; no human data on these effects are available. The most sensitive effect was ovarian atrophy observed in a lifetime bioassay of female mice.[81]

Formaldehyde: Since 1987, EPA has classified formaldehyde as a probable human carcinogen based on evidence in humans and in rats, mice, hamsters, and monkeys.[82] EPA is currently reviewing recently published epidemiological data. For instance, research conducted by the National Cancer Institute (NCI) found an increased risk of nasopharyngeal cancer and lymphohematopoietic malignancies such as leukemia among workers exposed to formaldehyde.[83] [84] NCI is currently updating these studies. A recent National Institute of Occupational Safety and Health (NIOSH) study of garment workers also found increased risk of death due to leukemia among workers exposed to formaldehyde.[85] Extended follow-up of a cohort of British chemical workers did not find evidence of an increase in nasopharyngeal or lymphohematopoietic cancers, but a continuing statistically significant excess in lung cancers was reported.[86] Recently, the IARC re-classified formaldehyde as a human carcinogen (Group 1).[87]

Formaldehyde exposure also causes a range of noncancer health effects, including irritation of the eyes (burning and watering of the eyes), nose and throat. Decreased pulmonary function has been observed in humans. Effects from repeated exposure in humans include respiratory tract irritation, chronic bronchitis and nasal epithelial lesions.[88]

Acetaldehyde: EPA has characterized acetaldehyde as a probable human carcinogen, based on nasal tumors in rats.[89] Acetaldehyde is reasonably anticipated to be a human carcinogen by the U.S. Department of Health and Human Services (DHHS) in the 11th Report on Carcinogens and is classified as possibly carcinogenic to humans (Group 2B) by the International Agency for Research on Carcinogens (IARC).[90] [91] EPA is currently conducting a reassessment of cancer and noncancer risk from inhalation exposure to acetaldehyde.

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[67] International Agency for Research on Cancer (IARC). 1987. Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Supplement 7, Some industrial chemicals and dyestuffs, World Health Organization, Lyon, France.

[68] U.S. Department of Health and Human Services National Toxicology Program 11th Report on Carcinogens available at: *http://ntp.niehs.nih.gov/go/16183.*

[69] Aksoy, M. (1989). Hematotoxicity and carcinogenicity of benzene. Environ. Health Perspect. 82: 193–197.

[70] Goldstein, B.D. (1988). Benzene toxicity. Occupational medicine. State of the Art Reviews. 3: 541–554.

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[72] U.S. EPA (2002) Toxicological Review of Benzene (Noncancer Effects). Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington DC. This material is available electronically at *http://www.epa.gov/iris/subst/0276.htm.*

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[76] Turtletaub, K.W. and Mani, C. (2003) Benzene metabolism in rodents at doses relevant to human exposure from Urban Air. Research Reports Health Effect Inst. Report No.113.

[77] U.S. EPA (2002) Health Assessment of 1,3-Butadiene. Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC. Report No. EPA600–P–98–001F. This document is available electronically at *http://www.epa.gov/iris/supdocs/buta-sup.pdf.*

[78] U.S. EPA (2002) Full IRIS Summary for 1,3-butadiene (CASRN 106–99–0). Environmental Protection Agency, Integrated Risk Information System (IRIS), Research and Development, National Center for Environmental Assessment, Washington, DC *http://www.epa.gov/iris/subst/0139.htm.*

[79] International Agency for Research on Cancer (IARC) (1999) Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 71, Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide and Volume 97 (in preparation), World Health Organization, Lyon, France.

[80] U.S. Department of Health and Human Services (2005) National Toxicology Program 11th Report on Carcinogens available at: *ntp.niehs.nih.gov/index.cfm?objectid=32BA9724-F1F6-975E-7FCE50709CB4C932.*

[81] Bevan, C.; Stadler, J.C.; Elliot, G.S.; et al. (1996) Subchronic toxicity of 4-vinylcyclohexene in rats and mice by inhalation. Fundam. Appl. Toxicol. 32:1–10.

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[83] Hauptmann, M.; Lubin, J.H.; Stewart, P.A.; Hayes, R.B.; Blair, A. 2003. Mortality from lymphohematopoetic malignancies among workers in formaldehyde industries. Journal of the National Cancer Institute 95: 1615–1623.

[84] Hauptmann, M.; Lubin, J.H.; Stewart, P.A.; Hayes, R.B.; Blair, A. 2004. Mortality from solid cancers among workers in formaldehyde industries. American Journal of Epidemiology 159: 1117–1130.

[85] Pinkerton, L.E. 2004. Mortality among a cohort of garment workers exposed to formaldehyde: an update. Occup. Environ. Med. 61: 193–200.

[86] Coggon, D, EC Harris, J Poole, KT Palmer. 2003. Extended follow-up of a cohort of British chemical workers exposed to formaldehyde. J National Cancer Inst. 95:1608–1615.

[87] International Agency for Research on Cancer (IARC). 2006. Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol. Volume 88. (in preparation), World Health Organization, Lyon, France.

[88] U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry. 1999. Toxicological Profile for formaldehyde. Available at *http://www.atsdr.cdc.gov/toxprofiles/tp111.html.*

[89] U.S. EPA. 1991. Integrated Risk Information System File of Acetaldehyde. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www.epa.gov/iris/subst/0290.htm.*

[90] U.S. Department of Health and Human Services National Toxicology Program 11th Report on Carcinogens available at: *ntp.niehs.nih.gov/index.cfm?objectid=32BA9724-F1F6-975E-7FCE50709CB4C932.*

[91] International Agency for Research on Cancer (IARC). 1999. Re-evaluation of some organic chemicals, hydrazine, and hydrogen peroxide. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemical to Humans, Vol 71. Lyon, France.

The primary noncancer effects of exposure to acetaldehyde vapors include irritation of the eyes, skin, and respiratory tract.[92] In short-term (4 week) rat studies, compound-related histopathological changes were observed only in the respiratory system at various concentration levels of exposure.[93 94] Data from these studies were used by EPA to develop an inhalation reference concentration. Some asthmatics have been shown to be a sensitive subpopulation to decrements in functional expiratory volume (FEV1 test) and bronchoconstriction upon acetaldehyde inhalation.[95]

Acrolein: Acrolein is extremely acrid and irritating to humans when inhaled, with acute exposure resulting in upper respiratory tract irritation, mucus hypersecretion and congestion. Levels considerably lower than 1 ppm (2.3 mg/m^3) elicit subjective complaints of eye and nasal irritation and a decrease in the respiratory rate.[96 97] Lesions to the lungs and upper respiratory tract of rats, rabbits, and hamsters have been observed after subchronic exposure to acrolein. Based on animal data, individuals with compromised respiratory function (e.g., emphysema, asthma) are expected to be at increased risk of developing adverse responses to strong respiratory irritants such as acrolein. This was demonstrated in mice with allergic airway-disease by comparison to non-diseased mice in a study of the acute respiratory irritant effects of acrolein.[98] EPA is currently in the process of conducting an assessment of acute exposure effects for acrolein. The intense irritancy of this carbonyl has been demonstrated during controlled tests in human subjects who suffer intolerable eye and nasal mucosal sensory reactions within minutes of exposure.[99]

EPA determined in 2003 that the human carcinogenic potential of acrolein could not be determined because the available data were inadequate. No information was available on the carcinogenic effects of acrolein in humans and the animal data provided inadequate evidence of carcinogenicity.[100] The IARC determined in 1995 that acrolein was not classifiable as to its carcinogenicity in humans.[101]

Polycyclic Organic Matter (POM): POM is generally defined as a large class of organic compounds which have multiple benzene rings and a boiling point greater than 100 degrees Celsius. Many of the compounds included in the class of compounds known as POM are classified by EPA as probable human carcinogens based on animal data. One of these compounds, naphthalene, is discussed separately below. Polycyclic aromatic hydrocarbons (PAHs) are a subset of POM that contain only hydrogen and carbon atoms. A number of PAHs are known or suspected carcinogens. Recent studies have found that maternal exposures to PAHs (a subclass of POM) in a population of pregnant women were associated with several adverse birth outcomes, including low birth weight and reduced length at birth, as well as impaired cognitive development at age three.[102 103] EPA has not yet evaluated these recent studies.

Naphthalene: Naphthalene is found in small quantities in gasoline and diesel fuels but is primarily a product of combustion. EPA recently released an external review draft of a reassessment of the inhalation carcinogenicity of naphthalene.[104] The draft reassessment recently completed external peer review.[105] Based on external peer review comments received to date, additional analyses are being undertaken. This external review draft does not represent official agency opinion and was released solely for the purposes of external peer review and public comment. Once EPA evaluates public and peer reviewer comments, the document will be revised. The National Toxicology Program listed naphthalene as ''reasonably anticipated to be a human carcinogen'' in 2004 on the basis of bioassays reporting clear evidence of carcinogenicity in rats and some evidence of carcinogenicity in mice.[106] California EPA has released a new risk assessment for naphthalene, and the IARC has reevaluated naphthalene and re-classified it as Group 2B: Possibly carcinogenic to humans.[107] Naphthalene also causes a number of chronic non-cancer effects in animals, including abnormal cell changes and growth in respiratory and nasal tissues.[108]

C. Environmental Impacts

There are a number of public welfare effects associated with the presence of ozone, NO_X and $PM_{2.5}$ in the ambient air. In this section we discuss visibility, the impact of deposition on ecosystems 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. Airborne particles degrade visibility by scattering and

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92 U.S. EPA. 1991. Integrated Risk Information System File of Acetaldehyde. This material is available electronically at *http://www.epa.gov/iris/subst/0290.htm.*

93 Appleman, L.M., R.A. Woutersen, V.J. Feron, R.N. Hooftman, and W.R.F. Notten. 1986. Effects of the variable versus fixed exposure levels on the toxicity of acetaldehyde in rats. J. Appl. Toxicol. 6: 331–336.

94 Appleman, L.M., R.A. Woutersen, and V.J. Feron. 1982. Inhalation toxicity of acetaldehyde in rats. I. Acute and subacute studies. Toxicology. 23: 293–297.

95 Myou, S.; Fujimura, M.; Nishi K.; Ohka, T.; and Matsuda, T. 1993. Aerosolized acetaldehyde induces histamine-mediated bronchoconstriction in asthmatics. Am. Rev. Respir. Dis. 148(4 Pt 1): 940–3.

96 Weber-Tschopp, A; Fischer, T; Gierer, R; et al. (1977) Experimentelle reizwirkungen von Acrolein auf den Menschen. Int Arch Occup Environ Hlth. 40(2):117–130. In German.

97 Sim, VM; Pattle, RE. (1957) Effect of possible smog irritants on human subjects. J Am Med Assoc. 165(15):1908–1913.

98 Morris JB, Symanowicz PT, Olsen JE, et al. 2003. Immediate sensory nerve-mediated respiratory responses to irritants in healthy and allergic airway-diseased mice. J Appl Physiol. 94(4):1563–1571.

99 Sim VM, Pattle RE. Effect of possible smog irritants on human subjects. JAMA. 165: 1980–2010, 1957.

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

101 International Agency for Research on Cancer (IARC). 1995. Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 63, Dry cleaning, some chlorinated solvents and other industrial chemicals, World Health Organization, Lyon, France.

102 Perera, F.P.; Rauh, V.; Tsai, W–Y.; et al. (2002) Effect of transplacental exposure to environmental pollutants on birth outcomes in a multiethnic population. Environ Health Perspect. 111: 201–205.

103 Perera, F.P.; Rauh, V.; Whyatt, R.M.; Tsai, W.Y.; Tang, D.; Diaz, D.; Hoepner, L.; Barr, D.; Tu, Y.H.; Camann, D.; Kinney, P. (2006) Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children. Environ Health Perspect. 114: 1287–1292.

104 U.S. EPA (2004) Toxicological Review of Naphthalene (Reassessment of the Inhalation Cancer Risk), Environmental Protection Agency, Integrated Risk Information System, Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www.epa.gov/iris/subst/0436.htm.*

105 Oak Ridge Institute for Science and Education (2004) External Peer Review for the IRIS Reassessment of the Inhalation Carcinogenicity of Naphthalene. August 2004. *http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=84403.*

106 National Toxicology Program (NTP). (2004). 11th Report on Carcinogens. Public Health Service, U.S. Department of Health and Human Services, Research Triangle Park, NC. Available from: *http://ntp-server.niehs.nih.gov.*

107 International Agency for Research on Cancer (IARC) (2002) Monographs on the Evaluation of the Carcinogenic Risk of Chemicals for Humans. Vol. 82. Lyon, France.

108 U.S. EPA (1998) Toxicological Review of Naphthalene, Environmental Protection Agency, Integrated Risk Information System, Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at *http://www.epa.gov/iris/subst/0436.htm.*

absorbing light. 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, see the final 2004 PM AQCD as well as the 2005 PM Staff Paper.[109 110]>

EPA is pursuing a two-part strategy to address visibility. First, to address the welfare effects of PM on visibility, EPA has set secondary $PM_{2.5}$ standards which act in conjunction with the establishment of a regional haze program. In setting this secondary standard, EPA has 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 38680–81, July 18, 1997).[111] 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.

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

Current Visibility Impairment

As of October 10, 2007, almost 90 million people live in nonattainment areas for the 1997 $PM_{2.5}$ NAAQS. These populations, as well as large numbers of individuals who travel to these areas, are likely to experience visibility impairment. 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.[112] In summary, visibility impairment is experienced throughout the U.S., in multi-state regions, urban areas, and remote mandatory class I federal areas.[113 114]

Future Visibility Impairment

Air quality modeling conducted for this final rule was used to project visibility conditions in 133 mandatory class I federal areas across the U.S. in 2020 and 2030. The results indicate that improvement in visibility will occur in all mandatory class I federal areas although all areas will continue to have annual average deciview levels above background in 2020 and 2030. Chapter 2 of the RIA contains more detail on the visibility portion of the air quality modeling.

(2) Plant and Ecosystem Effects of Ozone

Elevated ozone levels contribute to 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 low 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 Criteria Document presents more detailed information on ozone effects on vegetation and ecosystems.

As discussed above, locomotive and marine diesel engine emissions of NO_X contribute to ozone and therefore the NO_X standards will help reduce crop damage and stress on vegetation from ozone.

(3) Atmospheric Deposition

Wet and dry deposition of ambient particulate matter delivers a complex mixture of metals (e.g., mercury, zinc, lead, nickel, aluminum, cadmium), organic compounds (e.g., POM, dioxins, furans) and inorganic compounds (e.g., nitrate, sulfate) to terrestrial and aquatic ecosystems. The chemical form of the compounds deposited is impacted by a variety of factors including ambient conditions (e.g., temperature, humidity, oxidant levels) and the sources of the material. Chemical and physical transformations of the particulate compounds occur in the atmosphere as well as the media onto which they deposit. These transformations in turn influence the fate, bioavailability and potential toxicity of these compounds. Atmospheric deposition has been identified as a key component of the environmental and human health hazard posed by several pollutants including mercury, dioxin and PCBs.[115]

Adverse impacts on water quality can occur when atmospheric contaminants deposit to the water surface or when material deposited on the land enters a water body through runoff. Potential impacts of atmospheric deposition to water bodies include those related to both nutrient and toxic inputs. Adverse effects to human health and welfare can occur from the addition of excess particulate nitrate nutrient enrichment, which contributes to toxic algae blooms and zones of depleted oxygen, which can lead to fish kills, frequently in coastal waters. Particles contaminated with heavy metals or other toxins may lead to the ingestion of contaminated fish, ingestion of contaminated water, damage to the marine ecology, and limited recreational uses. Several

[109] 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–2003–0190.

[110] 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–2003–0190.

[111] 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.

[112] U.S. EPA (2002). Latest Findings on National Air Quality—2002 Status and Trends. EPA 454/K–03–001.

[113] 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 also available on the Web at: *http://www.epa.gov/pmdesignations/*.

[114] U.S. EPA. Regional Haze Regulations, July 1, 1999. (64 FR 35714, July 1, 1999).

[115] U.S. EPA (2000). Deposition of Air Pollutants to the Great Waters: Third Report to Congress. Office of Air Quality Planning and Standards. EPA–453/R–00–0005. This document is available in Docket EPA–HQ–OAR–2003–0190.

studies have been conducted in U.S. coastal waters and in the Great Lakes Region in which the role of ambient PM deposition and runoff is investigated.[116 117 118 119 120]

Adverse impacts on soil chemistry and plant life have been observed for areas heavily impacted by atmospheric deposition of nutrients, metals and acid species, resulting in species shifts, loss of biodiversity, forest decline and damage to forest productivity. Potential impacts also include adverse effects to human health through ingestion of contaminated vegetation or livestock (as in the case for dioxin deposition), reduction in crop yield, and limited use of land due to contamination.

The NO_X, VOC and PM standards finalized in this action will help reduce the environmental impacts of atmospheric deposition.

(4) 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.[121] 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 $PM_{2.5}$ standards finalized in this action will help reduce the airborne particles that contribute to materials damage and soiling.

D. Other Criteria Pollutants Affected by This Final Rule

Locomotive and marine diesel engines account for about 1 percent of the mobile source carbon monoxide (CO) inventory. Carbon monoxide (CO) is a colorless, odorless gas produced through the incomplete combustion of carbon-based fuels. The current primary NAAQS for CO are 35 ppm for the 1-hour average and 9 ppm for the 8-hour average. These values are not to be exceeded more than once per year. As of October 10, 2007, there are 854 thousand people living in 4 areas (made up of 5 counties) that are designated as nonattainment for CO.

Carbon monoxide enters the bloodstream through the lungs, forming carboxyhemoglobin and reducing the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected, but only at higher CO levels. Exposure to elevated CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks. Carbon monoxide also contributes to ozone nonattainment since carbon monoxide reacts photochemically in the atmosphere to form ozone. Additional information on CO related health effects can be found in the Air Quality Criteria for Carbon Monoxide.[122]

E. Emissions from Locomotive and Marine Diesel Engines

(1) Overview

The engine standards in this final rule will affect emissions of $PM_{2.5}$, NO_X, VOCs, CO, and air toxics for locomotive and marine diesel engines. Based on our analysis for this rulemaking, we estimate that in 2001 locomotive and marine diesel engines contributed almost 60,000 tons (18 percent) to the national mobile source diesel $PM_{2.5}$ inventory and about 2.0 million tons (16 percent) to the mobile source NO_X inventory. In 2030, absent the standards finalized today, these engines will contribute about 50,000 tons (65 percent) to the mobile source diesel $PM_{2.5}$ inventory and almost 1.6 million tons (35 percent) to the mobile source NO_X inventory. Under today's final standards, by 2030, annual NO_X emissions from these engines will be reduced by 800,000 tons, $PM_{2.5}$ emissions by 27,000 tons, and VOC emissions by 43,000 tons.

Locomotive and marine diesel engine emissions are expected to continue to be a significant part of the mobile source emissions inventory, both nationally and in ozone and $PM_{2.5}$ nonattainment areas, in the coming years. Absent the standards finalized today, we expect overall emissions from these engines to decrease modestly over the next ten to fifteen years then remain relatively flat through 2025 due to existing regulations such as lower fuel sulfur requirements, the phase-in of locomotive and marine diesel Tier 1 and Tier 2 engine standards, and the current Tier 0 locomotive remanufacturing requirements. Starting after 2025, emission inventories from these engines once again begin increasing due to growth in the locomotive and marine sectors, see Table II–2.

Each sub-section below discusses one of the affected pollutants, including expected emissions reductions associated with the final standards. Table II–2 summarizes the impacts of this rule for 2012, 2015, 2020, 2030 and 2040. Further details on our inventory estimates are available in chapter 3 of the RIA.

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[116] U.S. EPA (2004). National Coastal Condition Report II. Office of Research and Development/ Office of Water. EPA–620/R–03/002. This document is available in Docket EPA–HQ–OAR–2003–0190.

[117] Gao, Y., E.D. Nelson, M.P. Field, et al. 2002. Characterization of atmospheric trace elements on $PM_{2.5}$ particulate matter over the New York-New Jersey harbor estuary. Atmos. Environ. 36: 1077–1086.

[118] Kim, G., N. Hussain, J.R. Scudlark, and T.M. Church. 2000. Factors influencing the atmospheric depositional fluxes of stable Pb, 210Pb, and 7Be into Chesapeake Bay. J. Atmos. Chem. 36: 65–79.

[119] Lu, R., R.P. Turco, K. Stolzenbach, et al. 2003. Dry deposition of airborne trace metals on the Los Angeles Basin and adjacent coastal waters. J. Geophys. Res. 108(D2, 4074): AAC 11–1 to 11–24.

[120] Marvin, C.H., M.N. Charlton, E.J. Reiner, et al. 2002. Surficial sediment contamination in Lakes Erie and Ontario: A comparative analysis. J. Great Lakes Res. 28(3): 437–450.

[121] 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–2003–0190.

[122] U.S. EPA (2000). Air Quality Criteria for Carbon Monoxide, EPA/600/P–99/001F. This document is available in Docket EPA–HQ–OAR–2003–0190.

Table II- 2 Estimated National (50 State) Reductions in Emissions from Locomotive and Marine Diesel Engines

Pollutant [short tons]	2012	2015	2020	2030	2040
Direct $PM_{2.5}$					
$PM_{2.5}$ Emissions Without Rule	53,000	48,000	46,000	46,000	49,000
$PM_{2.5}$ Emissions with Rule	49,000	41,000	32,000	20,000	13,000
$PM_{2.5}$ Reductions Resulting from Rule	4,000	7,000	14,000	27,000	37,000
NO_x					
NO_x Emissions Without Rule	1,678,000	1,635,000	1,584,000	1,584,000	1,708,000
NO_x Emissions with Rule	1,591,000	1,474,000	1,213,000	790,000	564,000
NO_x Reductions Resulting from Rule	87,000	161,000	371,000	795,000	1,144,000
VOC					
VOC Emissions Without Rule	71,000	70,000	70,000	71,000	76,000
VOC Emissions with Rule	63,000	55,000	42,000	28,000	21,000
VOC Reductions Resulting from Rule	8,000	15,000	28,000	43,000	55,000

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(2) $PM_{2.5}$ Emission Reductions

As described earlier, EPA believes that reductions of diesel $PM_{2.5}$ emissions are an important part of the nation's progress toward clean air. $PM_{2.5}$ reductions resulting from this final rule will reduce hazardous air pollutants or air toxics from these engines, reduce diesel exhaust exposure in communities near these emissions sources, and help areas address visibility and other environmental impacts associated with $PM_{2.5}$ emissions.

In 2001, annual emissions from locomotive and marine diesel engines totaled about 60,000 tons (18 percent) of the national mobile source diesel $PM_{2.5}$ inventory and by 2030 these engines, absent this final rule, contribute about 50,000 tons (65 percent) of the mobile source diesel $PM_{2.5}$ inventory. Both Table II–2 and Figure II–2 show that $PM_{2.5}$ emissions are relatively flat through 2030 before beginning to rise again due to growth in these sectors.

Table II–2 and Figure II–2 present $PM_{2.5}$ emission reductions from locomotive and marine diesel engines with the final standards required in this rule. Emissions of $PM_{2.5}$ drop in 2012 and 2015 by 4,200 and 7,300 tons respectively. By 2020, annual $PM_{2.5}$ reductions total 14,500 tons and by 2030 emissions are reduced further by 27,000 tons annually. Significant reductions from these engines continue through 2040 when approximately 37,000 tons of $PM_{2.5}$ are annually eliminated as a result of this rule.

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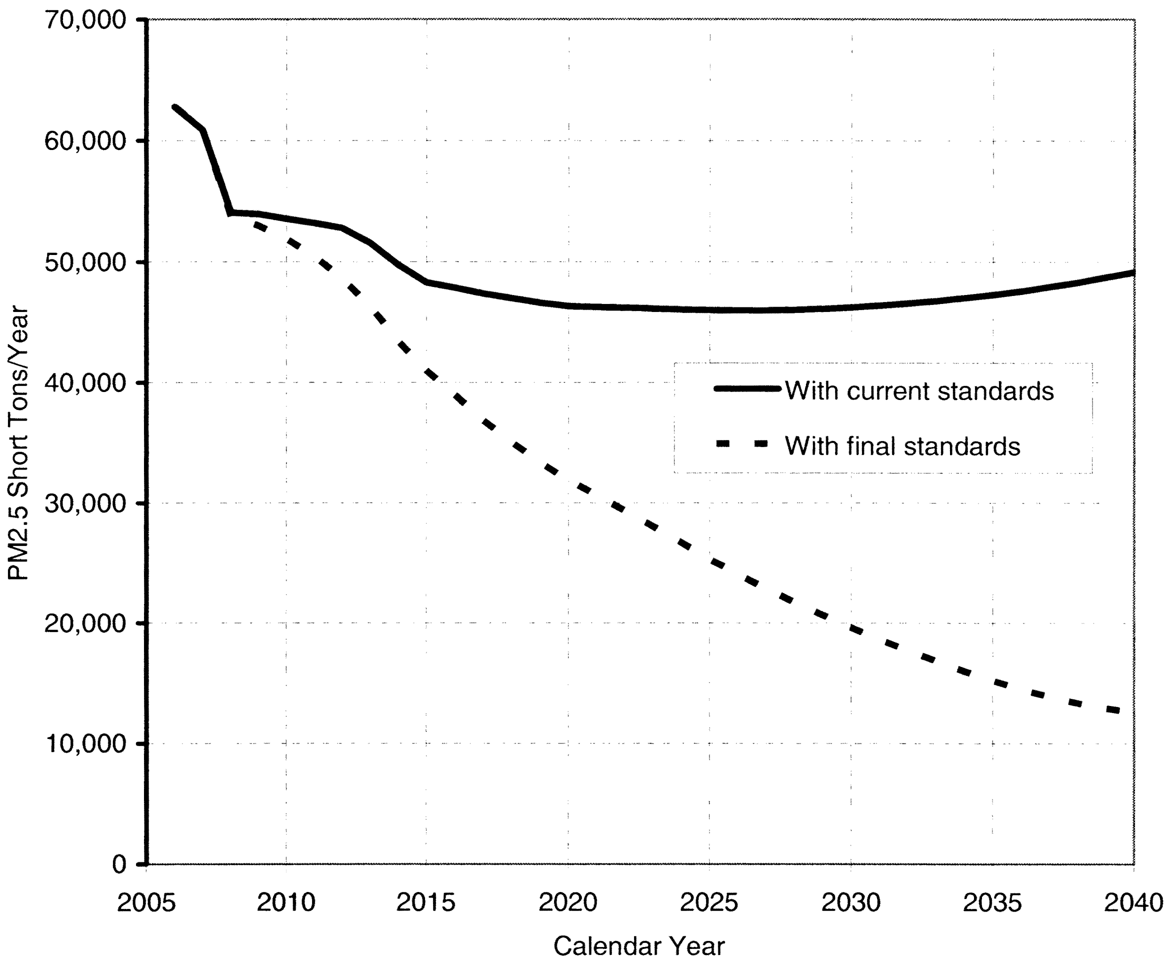
Figure II-2 $PM_{2.5}$ Reductions from Final Rule



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(3) NO_X Emissions Reductions

In 2001 annual emissions from locomotive and marine diesel engines totaled about 2.0 million tons. Due to earlier engine standards for these engines, annual NO_X emissions drop to approximately 1.6 million tons in 2030. Both Table II–2 and Figure II–3 show NO_X emissions remaining fairly flat through 2030 before beginning to rise again due to growth in these sectors.

As shown in Table II–2 and Figure II–3, in the near term this rule reduces annual NO_X emissions from the current national inventory baseline by 87,000 tons in 2012 and 161,000 tons in 2015. By 2020, annual NO_X emissions are cut by 371,000 tons and by 2030—795,000 tons are eliminated. As with $PM_{2.5}$ emissions, a yearly decline in NO_X emissions continues through 2040 when more than 1.1 million tons of NO_X are annually reduced from locomotive and marine diesel engines.

These numbers are comparable to emission reductions projected in 2030 for our already established Clean Air Nonroad Diesel (CAND) program. Table II–3 provides the 2030 NO_X emission reductions (and PM reductions) for this rule compared to the Heavy-Duty Highway rule and CAND rule. The 2030 NO_X reductions of about 738,000 tons for the CAND rule are slightly less than those from this rule.

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Figure II-3 NO_x Reductions from Rule

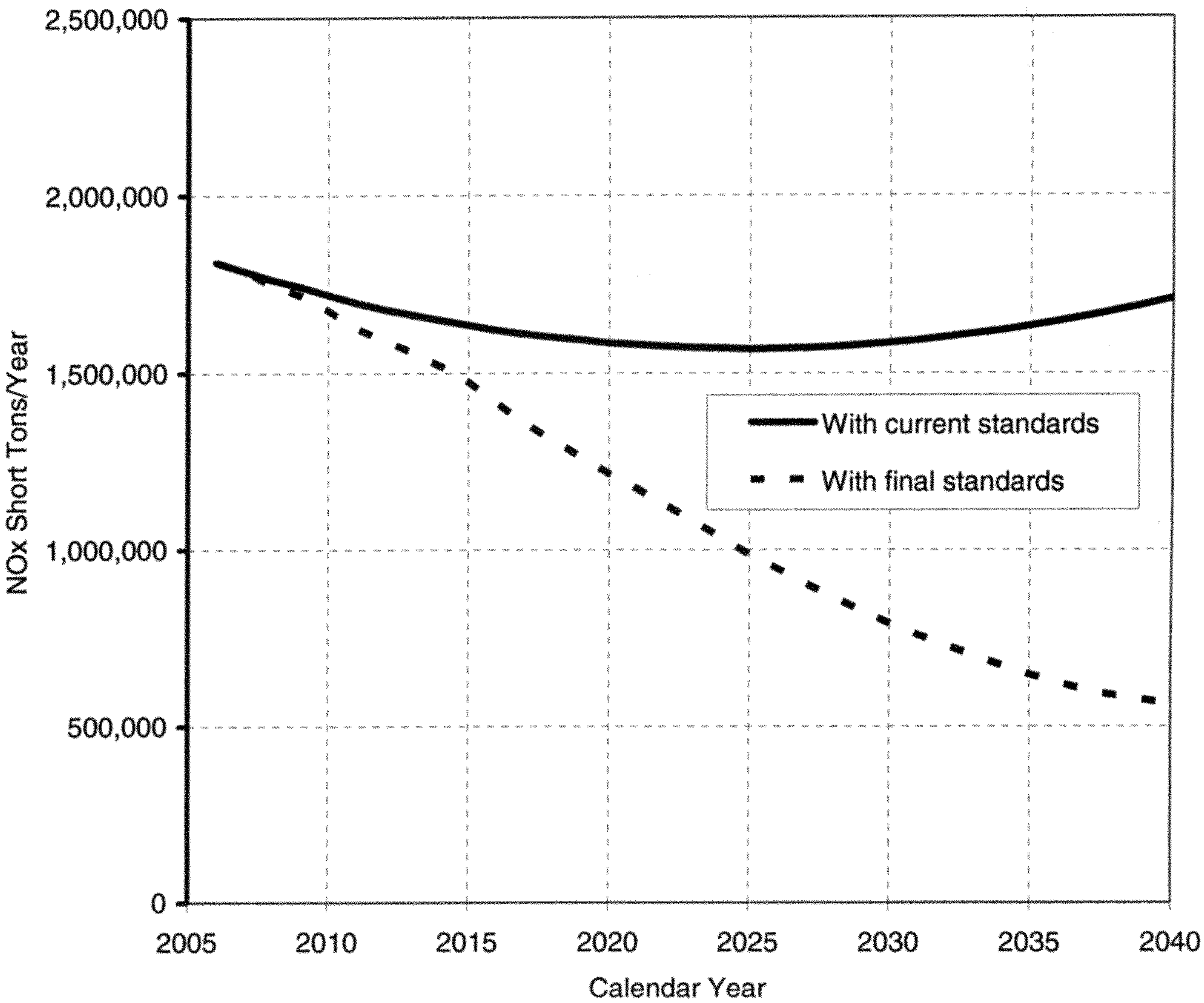

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TABLE II–3.—PROJECTED 2030 EMISSIONS REDUCTIONS FROM RECENT MOBILE SOURCE RULES

[Short tons]

Rule	NO_X	$PM_{2.5}$
Locomotive and Marine	795,000	27,000
Clean Air Nonroad Diesel	738,000	129,000
Heavy-Duty Highway	2,600,000	109,000

(4) Volatile Organic Compounds Emissions Reductions

Emissions of volatile organic compounds (VOCs) from locomotive and marine diesel engines are shown in Table II–2, along with the estimates of the reductions we expect from the HC standard in our rule in 2012, 2015, 2020, 2030 and 2040. In 2012, 8,000 tons of VOCs are reduced and in 2015 15,000 tons are annually eliminated from the inventory. By 2020, reductions will expand to 28,000 tons annually from these engines. Over the next ten years, annual reductions from controlled locomotive and marine diesel engines will produce annual VOC reductions of 43,000 tons in 2030 and 55,000 tons in 2040. Figure II–4 shows our estimate of VOC emissions between 2006 and 2040 both with and without this rule.

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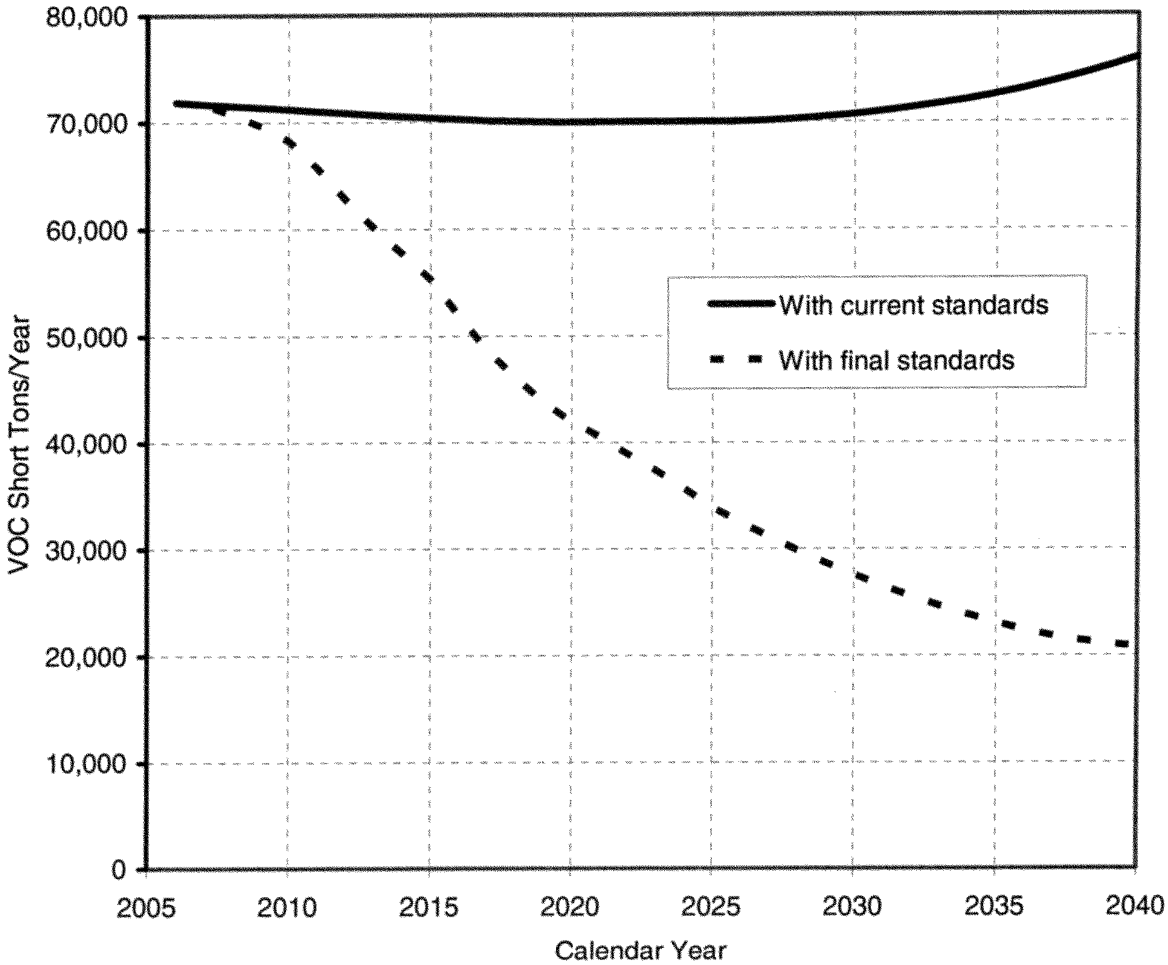
Figure II-4 VOC Reductions from Rule



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III. Emission Standards

$PM_{2.5}$This section details the emission standards, implementation dates, and other major requirements of the new program. Following brief summaries of the types of locomotives and marine engines covered, we describe the provisions for:

- Standards for remanufactured Tier 0, 1, and 2 locomotives,
- Tier 3 and Tier 4 standards for newly-built line-haul locomotives,
- Standards and other provisions for switch locomotives,
- Requirements to reduce idling locomotive emissions,
- Tier 3 and Tier 4 standards for newly-built marine diesel engines, and
- Standards for remanufactured marine diesel engines.

An assessment of the technological feasibility of the standards follows the program description. To ensure that the benefits of the standards are realized throughout the useful life of these engines, and to incorporate lessons learned over the last few years from the existing test and compliance programs, we are also revising test procedures and related certification requirements, and adding comparable provisions for remanufactured marine diesel engines. These are described in section IV.

A. What Locomotives and Marine Engines Are Covered?

The regulations being adopted affect locomotives currently regulated under part 92 and marine diesel engines and vessels currently regulated under parts 89, 1039, and 94, as described below.[123] In addition, they apply to existing marine diesel engines above 600 kW (800 hp).

With some exceptions, the locomotive regulations apply for all locomotives originally built in or after 1973 that operate extensively within the United States. See section IV.B for a discussion of the exemption for locomotives that are used only incidentally within the U.S. The exceptions include historic steam-powered locomotives and locomotives powered solely by an external source of electricity. In addition, the regulations generally do not apply to some existing locomotives owned by small businesses. Furthermore, engines used in

[123] All of the regulatory parts referenced in this preamble are parts in Title 40 of the Code of Federal Regulations, unless otherwise noted.

locomotive-type vehicles with less than 750 kW (1006 hp) total power (used primarily for railway maintenance), engines used only for hotel power (for passenger railcar equipment), and engines that are used in self-propelled passenger-carrying railcars, are excluded from these regulations. The engines used in these smaller locomotive-type vehicles are generally subject to the nonroad engine requirements of Parts 89 and 1039.

The marine diesel engine program applies to all propulsion and auxiliary engines with per cylinder displacement up to 30 liters.[124] For purposes of these standards, these marine diesel engines are categorized both by per cylinder displacement and by maximum engine power.

According to our existing definitions, a marine engine is defined as an engine that is installed or intended to be installed on a marine vessel. Engines that are on a vessel but that are not ''installed'' are generally considered to be land-based nonroad engines and are regulated under 40 CFR part 89 or part 1039. Consistent with our current marine diesel engine program, the standards adopted in this rule apply to engines manufactured for sale in the United States or imported into the United States beginning with the effective date of the standards. The standards also apply to any engine installed for the first time in a marine vessel after it has been used in another application subject to different emission standards. In other words, an existing nonroad diesel engine would become a new marine diesel engine, and subject to the marine diesel engine standards, when it is marinized for use in a marine application.

Consistent with our current program, the marine engine standards we are finalizing will not apply to marine diesel engines installed on foreign vessels. While we received many comments requesting that we extend the new standards to engines on foreign vessels operating in the United States, we have determined that it is appropriate to postpone this decision to our rulemaking for Category 3 marine diesel engines. This will allow us to consider all engines on an ocean-going vessel as a system; this may facilitate the application of advanced emission control technologies because these engines often share a common fuel and/or exhaust system. This approach is also consistent with the United States Government's proposal to amend Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) currently under consideration at the International Maritime Organization (IMO), which calls for significant emission reductions from all engines on ocean-going vessels.[125] EPA expects to finalize new Category 3 engine emission standards in late 2009.[126]

B. What Standards Are We Adopting?

(1) Locomotive Standards

(a) Line-Haul Locomotives

We are setting new emission standards for newly-built and remanufactured line-haul locomotives. Our standards for newly-built line-haul locomotives will be implemented in two tiers: Tier 3, based on engine design improvements, and Tier 4, based on the application of the high-efficiency catalytic aftertreatment technologies now being developed and introduced in the highway diesel sector. Our standards for remanufactured line-haul locomotives apply to all Tier 0, 1, and 2 locomotives and are based on engine design improvements. Table III–1 summarizes the line-haul locomotive standards and implementation dates. The feasibility of the new standards and the technologies involved are discussed in detail in section III.C.

TABLE III.—1 LINE-HAUL LOCOMOTIVE STANDARDS

[g/bhp-hr]

Standards apply to	Take effect in year	PM	NO_X	HC
Remanufactured Tier 0 without separate loop intake air cooling.	2008 as Available, 2010 Required	0.22	8.0	1.00
Remanufactured Tier 0 with separate loop intake air cooling.	2008 as Available, 2010 Required	0.22	7.4	0.55
Remanufactured Tier 1	2008 as Available, 2010 Required	0.22	7.4	0.55
Remanufactured Tier 2	2008 as Available, 2013 Required	0.10	5.5	0.30
New Tier 3	2012	0.10	5.5	0.30
New Tier 4	2015	0.03	1.3	0.14

(i) Remanufactured Locomotives

As proposed, we are setting new standards for the existing fleet of Tier 0, Tier 1, and Tier 2 locomotives, to apply at the time of remanufacture. These standards will also apply at the first remanufacture of Tier 2 locomotives added to the fleet between now and the start of Tier 3.

Commenters have suggested that EPA adopt a naming convention for the standards tiers to avoid confusion over whether, for example, the terms ''Tier 0 standards'' and ''Tier 0 locomotives'' are referring to the ''old'' Tier 0 standards adopted in 1998 or the ''new'' Tier 0 standards promulgated in this rule. A similar confusion may exist for old and new Tier 1 and Tier 2 standards, including for marine engines. The confusion is compounded by the fact that many of the locomotives previously subject to the old Tier 0 standards will now be subject to the new Tier 1 standards, and so a Tier 0 locomotive that is upgraded to meet them could fairly be called a Tier 1 locomotive, and likewise for Tier 2/Tier 3 standards.

[124] Marine diesel engines at or above 30 liters per cylinder, called Category 3 engines, are typically used for propulsion power on ocean-going ships. EPA is addressing Category 3 engines through separate actions, including a planned rulemaking for a new tier of federal standards (see Advance Notice of Proposed Rulemaking published December 7, 2007 at 72 FR 69522) and participation on the U.S. delegation to the International Maritime Organization for negotiations of new international standards (see *http://www.epa.gov/otaq/oceanvessels.com* for information on both of those actions), as well as EPA's Clean Ports USA Initiative (see *http://www.epa.gov/cleandiesel/ports/index.htm*).

[125] See ''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 11/15, 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, along with the U.S. Statement concerning the same, is also available on our Web site: *www.epa.gov/otaq/oceanvessels.com*.

[126] See 72 FR 68518, December 5, 2007 for the new regulatory deadline for the final rule for an additional tier of standards for Category 3 rulemaking (final rule by December 17, 2009).

In response, we are adopting a simple approach whereby a Tier 0 locomotive remanufactured under the more stringent Tier 0 standards we are adopting in this rule will be designated a Tier 0+ locomotive. A Tier 0 locomotive originally manufactured with a separate loop intake air cooling system that is remanufactured to the Tier 1+ standards will be designated as a Tier 1+ locomotive. We are adopting the same approach for Tier 1 and Tier 2 locomotives. That is, those remanufactured under the new standards would be called Tier 1+ and Tier 2+ locomotives, respectively. We are also suggesting that in many contexts, including a number of places in this final rule, there is really no need to make distinctions of this sort, as no ambiguity arises. In these contexts it would be perfectly acceptable to drop the ''+'' designation and simply refer to Tier 0, 1, and 2 locomotives and standards.

As described in section IV.B(3), the new Tier 0+, 1+, and 2+ standards (and corresponding switch-cycle standards) may apply when a Tier 0, 1, or 2 locomotive is remanufactured anytime after this final rule takes effect, if a certified remanufacture system is available. However, this early certification is voluntary on the part of the manufacturers, and so if no emissions control system is certified early for a locomotive, these standards will instead apply beginning January 1, 2010 for Tier 0 and 1, and no later than January 1, 2013 for Tier 2. We are also adopting the proposed reasonable cost provision, described in section IV.B(3), to protect against the unlikely event that the only certified systems made in the early program phase are exorbitantly priced.

Although under this approach, certification of new remanufacture systems in the early phase of the program is voluntary, we believe that developers will strive to certify systems to the new standards as early as possible, even in 2008, to establish these products in the market, especially for the locomotive models anticipated to have significant numbers coming due for remanufacture in the next few years. This focus on higher volume products also maximizes the potential for large emission reductions very early in this program, greatly offsetting the effect of slow turnover to new Tier 3 and Tier 4 locomotives inherent in this sector.

These remanufactured locomotive standards represent PM reductions of about 50 percent for Tier 0 and Tier 1 locomotives, and NO_X reductions of about 20 percent for Tier 0+ locomotives with separate loop aftercooling. Significantly, these reductions will be substantial in the early years. This will be important to State Implementation Plans (SIPs) being developed to achieve attainment with the NAAQS, owing to the 2008 start date and relatively rapid remanufacture schedule (roughly every 7 years, though it varies by locomotive model and age).

Some commenters argued for delaying the remanufactured locomotive standards and some argued for accelerating them. However, little technical justification was provided on either side and, after reconsideration, we believe the proposed standards and dates are appropriate. However, based on the comments, we have identified two current Tier 0 locomotive models that are not likely to meet the new standards under the full range of required test conditions, owing to limitations in the original locomotive design. These are the General Electric (GE) Dash-8 locomotives not equipped with separate loop aftercooling, and the Electro-Motive Diesel (EMD) SD70MAC locomotives that are equipped with separate loop aftercooling. As a result, we are allowing an exception in ambient temperature and altitude conditions under which these models, when remanufactured, must meet the new standards, as detailed in the Part 1033 regulations. These exceptions are limited to the extent that it is technically feasible to meet the relevant standards under most in-use conditions.

(ii) Newly-Built Locomotives

We are adopting the proposed Tier 3 and Tier 4 line-haul locomotive standards but with an earlier start date for Tier 4 NO_X, along with an additional compliance flexibility option. We requested comment in the NPRM on whether additional NO_X emission reductions would be feasible and appropriate for Tier 3 locomotives in the 2012 timeframe, based on reoptimization of existing Tier 2 NO_X control technologies, or the addition of new engine-based technologies such as exhaust gas recirculation (EGR). Manufacturers submitted detailed technical comments indicating that achieving such reductions would result in a large fuel economy penalty, a major engine redesign that would hamper Tier 4 technology development, or both. Our own review of the technical options leads us to the same conclusion and we are therefore finalizing the Tier 3 emissions standards as proposed.

We proposed to allow manufacturers to defer meeting the Tier 4 NO_X standard on newly-built locomotives until the 2017 model year, in order to work through any implementation and technological issues that might arise with advanced NO_X control technology. Even so, we expected that manufacturers would undertake a single comprehensive redesign program for Tier 4, relying on the same basic locomotive platform and overall emission control space allocations for all Tier 4 product years. With this in mind, we proposed that locomotives certified under Tier 4 in 2015 and 2016 without Tier 4 NO_X control systems should have these systems added when they undergo their first remanufacture and be subject to the Tier 4 NO_X standard thereafter.

We received many comments from state and local air quality agencies, and from environmental organizations, arguing that earlier implementation of these advanced technologies is technologically feasible and emphatically stating that they were needed to address the nation's air quality problems. Further review of the test data available for the proposed rule and of new test data available since the proposal supports the argument for earlier implementation of Tier 4 NO_X controls. This information is discussed in detail in section III.C. Consequently, after considering this data and industry comments regarding feasibility, we have concluded that the progress made in the development of NO_X aftertreatment technology has been such that this proposed allowance to defer NO_X control is not consistent with our obligation under section 213(a)(3) of the Clean Air Act to set standards that ''achieve the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines or vehicles, giving appropriate consideration to cost, lead time, noise, energy, and safety factors associated with the application of such technology.''

We are therefore not adopting this allowance for deferred NO_X control in 2015–2016 Tier 4 locomotives, effectively advancing the Tier 4 NO_X standard for locomotives by two years. Besides meeting our obligation under the Clean Air Act, this change will simplify the certification and compliance program for all stakeholders by providing a single step for Tier 4 implementation. It will also provide substantial additional NO_X reductions during years that are important to some states for NAAQS attainment, thus helping to address what was arguably the most critical comment we received from state and local air agencies and environmental organizations.

We recognize that designing locomotives to meet the stringent Tier 4 standards in 2015 with the high levels of performance and reliability demanded by the railroad industry will be challenging. As in other recent EPA mobile source programs, we proposed and are finalizing several compliance flexibility measures to aid the transition to these very clean technologies. Specifically, we are adopting two distinct compliance flexibility options for NO_X that, while ensuring the earliest possible introduction of advanced emission control, will provide locomotive manufacturers some level of risk mitigation should the technology solutions prove to be less robust than we project. The first compliance flexibility is consistent with the flexibility program described in our NPRM providing an in-use compliance margin for NO_X of 1.3 g/bhp-hr at full useful life (*i.e.*, a 2.6 g/bhp-hr emissions cap for in-use testing) for the first three Tier 4 model years. See section IV.A(8) for details on this program.

The second flexibility provision is an alternative NO_X compliance option that reduces the in-use NO_X add-on to 0.6 g/bhp-hr (*i.e.*, a 1.9 g/bhp-hr emissions cap for any in-use testing) for model years 2015–2022. While significantly tightening the in-use emissions cap, the provision provides manufacturers with significantly more time to develop advanced NO_X emission control systems using real in-use experiences from the locomotive fleet. Complementing this focus on improving technology through experience with the in-use fleet, this provision also allows manufacturers to substitute additional in-use tests on locomotives in lieu of the typical production line testing requirements of our locomotive regulations. This optional in-use testing would be in addition to the current in-use testing requirements of our locomotive certification program. See section IV.A(8) for details on this program.

For reasons explained in the NPRM, Tier 4 line-haul locomotives will not be required to meet standards on the switch cycle, but we are requiring that newly-built Tier 3 locomotives and Tier 0 through Tier 2 locomotives remanufactured under this program be subject to switch cycle standards, set at levels above the line-haul cycle standards. Section III.B(1)(b) provides details.

(b) Switch Locomotives

The NPRM discussed at some length the importance and challenges of turning over today's large switch locomotive fleet to clean diesel. In response, we proposed standards and other provisions aimed at overcoming these challenges by encouraging the replacement of old high-emitting units with newly-built or refurbished locomotives powered by very clean engines developed for the nonroad equipment market.

We are adopting the new standards for switch locomotives that we proposed. As proposed, we are also continuing the existing Part 92 policy of requiring Tier 0 switch locomotives to only meet standards on the switch cycle, while requiring Tier 1 and Tier 2 locomotives to meet the applicable standards on both the line-haul and switch cycles. This policy was adopted to ensure that manufacturers design emission controls to function broadly over all notches. The switch cycle standards shown in Table III–2 will require emission reductions equivalent to those required by our new standards that apply over the line-haul cycle. Note that these switch cycle standards also apply to the Tier 3 and earlier line-haul locomotives that are subject to compliance requirements on the switch cycle, as mentioned above and in Section III.B(1)(b).

We are also adopting the proposed Tier 3 and 4 emission standards for newly-built switch locomotives, as shown in Table III–2. These standards are slightly more stringent than the Tier 3 and Tier 4 line-haul standards. Given these more stringent switch cycle standards, it is not necessary to require to Tier 3 and 4 switchers to meet the line-haul standards over the line-haul cycle.

TABLE III.—2 EMISSION STANDARDS FOR SWITCH LOCOMOTIVES

[g/bhp-hr]

Switch locomotive standards apply to	Take effect in year	PM	NO_X	HC
Remanufactured Tier 0	2008 as available, 2010 required	0.26	11.8	2.10
Remanufactured Tier 1	2008 as available, 2010 required	0.26	11.0	1.20
Remanufactured Tier 2	2008 as available, 2013 required	0.13	8.1	0.60
Tier 3	2011	0.10	5.0	0.60
Tier 4	2015	0.03	1.3	0.14

We are also finalizing the proposed streamlined certification option to help in the early implementation of the switch locomotive program. As described in section IV.B(9), during a 10-year program start-up period aimed at encouraging the turnover of the existing switcher fleet to the new cleaner engines, switch locomotives may use nonroad-certified engines (Table III–3) without need for an additional certification under the locomotive program. In the years before the nonroad Tier 4 start dates, we are making this provision available using pre-Tier 4 nonroad engines meeting today's standards of 0.15 g/bhp-hr PM and 3.0/4.8 g/bhp-hr NO_X+NMHC (below/above 750 hp), because switchers built with these nonroad engines will still be much cleaner than those meeting the current switch locomotive Tier 2 standards of 0.24 and 8.1 g/bhp-hr PM and NO_X, respectively.

Commenters suggested that we allow the use of even earlier-tier nonroad engines under this option, as these would still be substantially cleaner than the engines being replaced. However, we feel this would defeat the purpose of the program, and would not be justifiable on a feasibility basis, as current-tier nonroad engines will be available for incorporation into new switchers in any year of the program. We are adopting other compliance and ABT provisions relevant to switch locomotives as discussed in section IV.B(1), (2), (3), and (9).

TABLE III.—3 RELEVANT LARGE NONROAD ENGINE TIER 4 STANDARDS

[g/bhp-hr]

Engine power	Model year	PM	NO_X
At or Below 750 hp	2011	0.01	3.0 (NO_X+NMHC) [a]
	2014	0.01	0.30
750–1200 hp	2011	0.075	2.6
	2015	0.02	0.50
Over 1200 hp	2011	0.075	0.50 genset; 2.6 non-genset
	2015	0.02	0.50

Note: (a) 0.30 NO_X for 50% of sales in 2011–2013, or alternatively 1.5 g NO_X for 100% of sales.

Finally, we are revising the definition of a switch locomotive to make clear that it is the total switch locomotive power rating (including power from any auxiliary engines that can operate when a main engine is operating), and not the individual engine power rating, that must be below 2300 hp to qualify, and to drop the unnecessary requirement that it be designed or used primarily for short distance operation. This clears up the ambiguity in the Part 92 definition over multi-engine switchers.

(c) Reduction of Locomotive Idling Emissions

We are adopting the proposed requirement that an Automatic Engine Stop/Start System (AESS) be used on all new Tier 3 and Tier 4 locomotives and installed on all existing locomotives that are subject to the new remanufactured engine standards, at the point of first remanufacture under the new standards. Locomotives equipped with an AESS device under this program must shut down the locomotive engine after no more than 30 continuous minutes of idling, and be able to stop and start the engine at least six times per day without causing engine damage or other serious problems. Continued idling is allowed under the following conditions: to prevent engine damage such as damage caused by coolant freezing, to maintain air pressure for brakes or starter systems, to recharge the locomotive battery, to perform necessary maintenance, or to otherwise comply with applicable government regulations.

Commenters also pointed out that it can sometimes be appropriate to allow a locomotive to idle to heat or cool the cab, and we are adopting regulations to allow it where necessary. Our implementation of this provision will rely on the strong incentive railroads have to limit idling to realize fuel cost savings after they have invested capital by installing an AESS system on a locomotive. We expect the railroads to appropriately develop policies instructing operators when it is acceptable to idle the locomotive to provide heating or cooling to the locomotive cab. We do not believe that those individuals responsible for developing railroad policies have any incentive to encourage or allow unnecessary idling. It is our intention to stay abreast of how well this combination of idle control systems and railroad policies does in fact accomplish the intended goal of reducing unnecessary idling. In general, we may consider it to be circumvention of this provision for an individual operator to use the AESS system in a manner other than that for which the system was designed and implemented per a railroad's policy directive.

A further reduction in idling emissions can be achieved through the use of onboard auxiliary power units (APUs), either as standalone systems or in conjunction with an AESS. In contrast to AESS, which works to reduce unnecessary idling, the APU goes further by also reducing the amount of time when locomotive engine idling is necessary, especially in cold weather climates. APUs are small (less than 50 hp) diesel engines that stop and start themselves as needed to provide: heat to both the engine coolant and engine oil, power to charge the batteries, and power to run accessories such as those required for cab comfort. This allows the much larger locomotive engine to be shut down while the locomotive remains in a state of readiness, thereby reducing fuel consumption without the risk of the engine being damaged in cold weather. APUs are powered by nonroad engines compliant with EPA or State of California nonroad engine standards, and emit at much lower levels than an idling locomotive under current standards.

Some commenters suggested we require both an AESS and an APU. However, the amount of idle reduction an APU can provide is dependent on a number of variables, such as the function of the locomotive (e.g., a switcher or a line-haul), where it operates (i.e., geographical area), and its operating characteristics (e.g., number of hours per day that it operates). As we stated in the NPRM, at this time we are not requiring that APUs be installed on every locomotive because it is not clear how much additional benefit they would provide outside of regions and times of the year where low temperatures or other factors that warrant the use of an APU exist and because they do involve some inherent design and operational complexities that could not be justified without such commensurate benefits. We are, however, adopting the proposed provision to encourage the additional use of APUs by providing in our test regulations, a process by which the manufacturer can appropriately account for the proven emission benefits of a more comprehensive idle reduction system.

In response to comment, we are adopting a more flexible approach that will allow the idle reduction requirement for remanufactured Tier 0+, 1+, and 2+ locomotives to be addressed in a separate certification apart from the certification of the full remanufacture system. Under this approach, remanufacturers will be allowed to obtain a certificate for a system that meets all of the requirements of part 1033 except for those of § 1033.115(g). However, since the idle controls would still need to be installed in a certified configuration before the remanufactured locomotive is returned to service, some other entity would need to obtain a certificate to cover the requirements of § 1033.115(g). (This separate certification approach is somewhat analogous to allowing a motor vehicle engine manufacturer to hold the certificate for exhaust emission standards and a motor vehicle manufacturer to hold the certificate for evaporative emission standards for a single motor vehicle.) Note that manufacturers of freshly manufactured locomotives and their customers will also have the choice as to whether the AESS is installed as part of the certified engine configuration at the factory or by an aftermarket company pursuant to a separate certification before the freshly manufactured locomotive is put into service. These provisions will allow more companies to remain in the AESS manufacturing market and thus provide more choices to the railroads.

As described in Chapter 5 of the RIA, manufacturers of AESS, and demonstrations done in partnership between government and industry have shown that for most locomotives the fuel savings that result in the first few years after installation of an AESS system will offset the cost of adding the system to the locomotive. Given these short payback times for adding idle reduction technologies to a typical locomotive, normal market forces have led many railroads to retrofit a number of their locomotives with such controls. However, as is common with pollution, market prices generally do not account for the external social costs of the idling emissions, leading to an underinvestment in idling reduction systems. This rulemaking addresses those locomotives for which the railroads judge the fuel savings insufficient to justify the cost of the retrofit. We believe that applying AESS to these locomotives is appropriate when one also considers the significant emissions reductions that will result.

(2) Marine Diesel Engine Standards

(a) Newly-Built Marine Engines

We are adopting Tier 3 and Tier 4 emission standards for newly-built marine diesel engines with displacements under 30 liters per cylinder. Our analysis of the feasibility of these standards is summarized in section III.C and detailed in the RIA.

We are retaining our existing per-cylinder displacement approach to establishing cutpoints for standards, but are revising and refining it in several places to ensure that the appropriate standards apply to every group of engines in this very diverse sector and to provide for an orderly phase-in of the program to spread out the redesign workload burden:

We are moving the C1/C2 cutpoint from 5 liters/cylinder to 7 liters/cylinder, because the latter is a more accurate cutpoint between today's high- and medium-speed diesels.

We are revising the per-cylinder displacement cutpoints within Category 1 to better define the application of standards.

An additional differentiation is made between high power density engines typically used in planing vessels and standard power density engines, with a cutpoint between them set at 35 kW/liter (47 hp/liter).

We are removing the distinction for marine diesels under 37 kW (50 hp) in Category 1, originally made because these were regulated under our nonroad engine program.

Finally, we will further group engines by maximum engine power, especially in regards to setting appropriate long-term aftertreatment-based standards.

Note that we are retaining the differentiation between recreational and non-recreational marine engines within Category 1 because there are differences in their certification programs. Also, as discussed below, we are not finalizing Tier 4 standards for recreational marine engines at this time. Section IV.C(10) clarifies the definition of recreational marine diesel engine.

The new standards and implementation schedules are shown on Tables III–4 through 7. Briefly summarized, the marine diesel standards include stringent engine-based Tier 3 standards, phasing in over 2009–2014. They also include aftertreatment-based Tier 4 standards for commercial marine engines at or above 600 kW (800 hp), phasing in over 2014–2017. For engines of power levels not included in the Tier 3 and Tier 4 tables, the previous tier of standards (Tier 2 or Tier 3, respectively) continues to apply. These standards and implementation dates are the same as those proposed except: (1) Recreational marine engines are not subject to Tier 4 standards; (2) The Tier 4 NO_X standard for 2000–3700 kW engines has been pulled forward by two years; (3) The proposed optional Tier 4 approach coordinated with locomotive Tier 4 has been modified; and (4) based on comments we received, the Tier 3 standards for high power density engines in the 3.5 to 7 liter/cylinder category (Table III–5) have been adjusted slightly to better align them with standards in other categories. The first three of these changes are discussed in more detail below. See section 3.2.1.1 of the Summary and Analysis of Comments document for discussion of the fourth.

TABLE III–4.—TIER 3 STANDARDS FOR MARINE DIESEL C1 COMMERCIAL STANDARD POWER DENSITY

Maximum engine power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X+HC [d] g/bhp-hr (g/kW-hr)	Model year
<19 kW	<0.9	0.30 (0.40)	5.6 (7.5)	2009
19 to <75 kW	<0.9 [a]	0.22 (0.30)	5.6 (7.5)	2009
		0.22 (0.30) [b]	3.5 (4.7) [b]	2014
75 to <3700 kW	<0.9	0.10 (0.14)	4.0 (5.4)	2012
	0.9–<1.2	0.09 (0.12)	4.0 (5.4)	2013
	1.2–<2.5	0.08 (0.11) [c]	4.2 (5.6)	2014
	2.5–<3.5	0.08 (0.11) [c]	4.2 (5.6)	2013
	3.5–<7.0	0.08 (0.11) [c]	4.3 (5.8)	2012

Notes:
(a) <75 kW engines at or above 0.9 L/cylinder are subject to the corresponding 75–3700 kW standards.
(b) Option: 0.15 g/bhp-hr (0.20 g/kW-hr) PM/4.3 g/bhp-hr (5.8 g/kW-hr) NO_X+HC in 2014.
(c) This standard level drops to 0.07 g/bhp-hr (0.10 g/kW-hr) in 2018 for <600 kW engines.
(d) Tier 3 NO_X+HC standards do not apply to 2000–3700 kW engines.

TABLE III–5.—TIER 3 STANDARDS FOR MARINE DIESEL C1 RECREATIONAL AND COMMERCIAL HIGH POWER DENSITY

Maximum engine power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X+HC g/bhp-hr (g/kW-hr)	Model year
<19 kW	<0.9	0.30 (0.40)	5.6 (7.5)	2009
19 to <75 kW	<0.9 [a]	0.22 (0.30)	5.6 (7.5)	2009

TABLE III–5.—TIER 3 STANDARDS FOR MARINE DIESEL C1 RECREATIONAL AND COMMERCIAL HIGH POWER DENSITY—Continued

Maximum engine power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X+HC g/bhp-hr (g/kW-hr)	Model year
		0.22 (0.30) [b]	3.5 (4.7) [b]	2014
75 to <3700 kW	<0.9	0.11 (0.15)	4.3 (5.8)	2012
	0.9–<1.2	0.10 (0.14)	4.3 (5.8)	2013
	1.2–<2.5	0.09 (0.12)	4.3 (5.8)	2014
	2.5–<3.5	0.09 (0.12)	4.3 (5.8)	2013
	3.5–<7.0	0.08 (0.11)	4.3 (5.8)	2012

Notes:
(a) <75 kW engines at or above 0.9 L/cylinder are subject to the corresponding 75–3700 kW standards.
(b) Option: 0.15 g/bhp-hr (0.20 g/kW-hr) PM/4.3 g/bhp-hr (5.8 g/kW-hr) NO_X+HC in 2014.

Table III–6.—Tier 3 Standards for Marine Diesel C2 [A]

Maximum engine power	L/cylinder	PM g/bhp-hr (g/kW-hr)	NO_X+HC [b] g/bhp-hr (g/kW-hr)	Model year
<3700 kW	7–<15	0.10 (0.14)	4.6 (6.2)	2013
	15–<20	0.20 (0.27) [c]	5.2 (7.0)	2014
	20–<25	0.20 (0.27)	7.3 (9.8)	2014
	25–<30	0.20 (0.27)	8.2 (11.0)	2014

Notes:
(a) See note (c) of Table III–7 for optional Tier 3/Tier 4 standards.
(b) Tier 3 NO_X+HC standards do not apply to 2000–3700 kW engines.
(c) For engines below 3300 kW in this group, the PM Tier 3 standard is 0.25g/bhp-hr (0.34 g/kW-hr).

TABLE III–7.—TIER 4 STANDARDS FOR MARINE DIESEL C1 AND C2

Maximum engine power	PM g/bhp-hr (g/kW-hr)	NO_X g/bhp-hr (g/kW-hr)	HC g/bhp-hr (g/kW-hr)	Model year
At or above 3700 kW	0.09 (0.12) [a]	1.3 (1.8)	0.14 (0.19)	[c] 2014
	0.04 (0.06)	1.3 (1.8)	0.14 (0.19)	[b c] 2016
2000 to <3700 kW	0.03 (0.04)	1.3 (1.8)	0.14 (0.19)	[c d] 2014
1400 to <2000 kW	0.03 (0.04)	1.3 (1.8)	0.14 (0.19)	[c] 2016
600 to <1400 kW	0.03 (0.04)	1.3 (1.8)	0.14 (0.19)	[b] 2017

Notes:
(a) This standard is 0.19 g/bhp-hr (0.25 g/kW-hr) for engines with 15–30 liter/cylinder displacement.
(b) Optional compliance start dates can be used within these model years; see discussion below.
(c) Option for C2: Tier 3 PM/NO_X+HC at 0.10 / 5.8 g/bhp-hr (0.14/7.8 g/kW-hr) in 2012, and Tier 4 in 2015.
(d) The Tier 3 PM standards continue to apply for these engines in model years 2014 and 2015 only.

Engine manufacturers argued that modifying standard power density engines between 2000 and 3700 kW for Tier 3 NO_X, and again for Tier 4 NO_X shortly after would be too difficult. They argued that these engines could meet Tier 4 NO_X in 2014, two years earlier, if the Tier 3 NO_X+HC standard, proposed to apply in 2012, 2013, or 2014, depending on displacement, did not have to be met. We have analyzed this group of engines and agree that the suggested approach would be feasible and would have very little detrimental effect on NO_X reductions in 2012–2013, while providing significant additional NO_X reductions thereafter. We are therefore leaving the Tier 3/Tier 4 PM standards as proposed but revising the NO_X implementation schedule as suggested by the industry.

The Tier 3 standards for engines with maximum engine power less than 75 kW (100 hp) are based on the nonroad diesel Tier 2 and Tier 3 standards, because these smaller marine engines are largely derived from (and often nearly identical to) the nonroad engine designs. The relatively straightforward carry-over nature of this approach also allows for an early implementation schedule, in model year 2009, providing substantial early benefits to the program. However, some of the nonroad engines less than 75 kW are also subject to aftertreatment-based Tier 4 nonroad standards, and our new program does not carry these over into the marine sector, due to vessel design and operational constraints discussed in section III.C. Because of the widespread use of both direct- and indirect-injection diesel engines in the 19 to 75 kW (25–100 hp) engine market today, we are making two options available to manufacturers for meeting Tier 3 standards on any engine in this range, as indicated in Table III–4. One option focuses on lower PM and the other on lower NO_X, though both require substantial reductions in both PM and NO_X and will take effect in 2014.

With important exceptions, we are subjecting marine diesel engines at or above 75 kW (100 hp) to new emissions standards in two steps, Tier 3 and Tier 4. The Tier 3 standards are based on the engine-out emission reduction potential (apart from the addition of exhaust aftertreatment) of the nonroad Tier 4 diesel engines that will be introduced beginning in 2011. The Tier 3 standards for C1 engines will phase in over 2012–2014. We believe it is appropriate to coordinate the marine Tier 3 standards with the nonroad Tier 4 (rather than Tier 3) engine developments in this way because marine diesel engines are largely derived from land-based nonroad counterparts, and because the advanced fuel and combustion systems that we expect the Tier 4 nonroad engines to employ will allow approximately a 50 percent reduction in PM when compared to the reduction potential of the nonroad Tier 3 engines. Inserting an additional marine engine tier based on nonroad Tier 3 engines would result in overly short lead time and stability periods and/or a delay in stringent standards.

We are applying high-efficiency aftertreatment-based Tier 4 standards to all commercial and auxiliary C1 and C2 engines over 600 kW (800 hp). These standards will phase in over 2014–2017. Marine diesels over 600 kW, though fewer in number, are the workhorses of the inland waterway and intercoastal marine industry, running at high load factors, for many hours a day, over decades of heavy use. As a result they also account for the bulk of marine diesel engine emissions.

After considering the substantial number of comments received on the feasibility of extending Tier 4 standards to engines below 600 kW, we are not at this time setting Tier 4 standards for these engines. We may do so at some point in the future if further technology developments show a path to address the issues we identify in RIA chapter 4 with the application of aftertreatment technologies to smaller vessels.

We are also not extending the Tier 4 program to recreational marine diesel engines. In our proposal we indicated that at least some recreational vessels, those with engines above 2000 kW (2760 hp), have the space and design layout conducive to aftertreatment-based controls and professional crews who oversee engine operation and maintenance. This suggested that aftertreatment-based standards would be feasible for these larger recreational engines. While commenters on the proposal did not disagree with these views, they pointed out these very large recreational vessels often travel outside the United States, and, for tax reasons, flag outside the U.S. as well. Commenters argued that applying Tier 4 standards to large recreational marine diesel engines would further discourage U.S.-flagging because vessels with those engines would be limited to using only those foreign ports that make ULSD and reductant for NO_X aftertreatment available at recreational docking facilities, limiting their use and hurting the vessel's resale value. The aftertreatment devices used to meet Tier 4 are expected to be sensitive to sulfur in the exhaust and so ULSD must be used in these engines.

In general, we expect ULSD to become widely available worldwide, which would help reduce these concerns. However, there are areas such as Latin America and parts of the Caribbean that currently do not plan to require use of this fuel. Even in countries where ULSD is available for highway vehicles but not mandated for other mobile sources, recreational marinas may choose to not make ULSD and reductant available if demand is limited to a small number of vessels, especially if the storage and dispensing costs are high. To the extent the fuel requirements for Tier 4 engines encourage vessel owners to flag outside the United States, the results would be increased emissions since the international standards for these engines are equivalent to EPA's Tier 1 standards.

After considering the above, we conclude that it is preferable at this time to hold recreational engines marine diesel engines to the Tier 3 standards. We plan to revisit this decision when we consider the broader questions of the application of our national marine diesel engine standards to engines on foreign vessels that enter U.S. ports in the context of our Category 3 marine diesel engine rulemaking.

There is a group of commercial vessels that share some of the characteristics of recreational vessels in that they also operate outside the United States. However, the concerns that lead us to exclude recreational vessels from the Tier 4 standards (flagging or registering in a foreign country and thus avoiding all U.S. emission standards; resale value) do not generally apply to commercial vessels. Unlike recreational vessels, the majority of commercial vessels with C1 or C2 main propulsion engines that operate in the United States do not have the option of flagging offshore. This is because they are engaged full-time in harbor activities in U.S. ports or in transporting freight or otherwise operating only between two U.S. ports, and cabotage laws require such vessels be flagged in the United States. In addition, most of these vessels operate at or between U.S. ports, so ULSD availability is not expected to be a problem. Finally, the resale of U.S. commercial vessels on the world market is already affected by other U.S.-specific vessel design and operation requirements, and these standards are not expected to affect that situation.

Nevertheless, some commercial vessels are used in ways that could make the use of ULSD and even urea an intractable problem. These are commercial vessels that are routinely operated outside of the United States for extended periods of time, including tug/barge cargo vessels operated on circle routes between the United States and Latin America that routinely refuel in places where ULSD is not available, and lift boats, utility boats, supply boats and crewboats that are used in the offshore drilling industry and are contracted to work in waters off Latin America or Western Africa for up to several years at a time without returning to the United States. Owners of these vessels informed us that requiring them to use Tier 4 engines will adversely impact their business in significant ways since they would have to arrange for ULSD and urea outside the United States, potentially at great additional cost, and that this is turn would affect their ability to compete with foreign transportation providers who do not face the same costs. These owners flag their vessels in the U.S. to maximize the flexibility of their business operations, but they informed us that they would consider segregating their fleets and flagging some elsewhere if they are required to use Tier 4 engines. Similar to the recreational marine case, the engines on reflagged vessels would not be subject to any U.S. emission controls or compliance requirements. In addition, there could be adverse impacts on associated industries that use these services, if there are fewer vessels available for use in the Untied States. For all of these reasons, these vessel owner/operators encouraged EPA to consider a provision that would not require these vessels to use Tier 4 engines.

We do not expect ULSD availability at foreign commercial ports to be a widespread problem. Many industrial nations already have or are expected to shift to ULSD in the near future, including Japan (by 2008), Singapore (in 2007), Mexico (in 2007 for ''Northern border areas''), the EU member states (by 2009), and Australia (by 2009). Other countries may also make ULSD available by 2016, as refineries in other countries modify their production to supply ULSD to the U.S. markets even if they do not require it domestically. However, ULSD may be difficult to obtain in some areas of the world, notably Latin America and Africa. Therefore, it is reasonable to include a limited compliance exemption from the Tier 4 standards for the narrow set of vessels that are described above.

Because the decision of whether a Tier 4 engine is required must be made at the design phase of a vessel, and not after it goes into service, it is preferable to define such an exemption based on vessel design characteristics instead of the owner's intentions for how the vessel may ultimately be used. After consulting with industry representatives, we concluded that the most obvious design feature that indicates the vessel is intended for extensive international use is compliance with international safety standards. We have concluded that the costs of obtaining and maintaining certification for the International Convention for the Safety of Life at Sea (SOLAS) are high enough to discourage owners of vessels that will not be used outside the United States to obtain certification to evade the Tier 4 standards. These costs can range from about $250,000 to $1 million in capital costs and from about $50,000 to $100,000 in annual operating costs. The Port State Information Exchange database maintained by the U.S. Coast Guard indicates that about 30 percent of offshore supply vessels built annually are SOLAS certified and that 3 percent or fewer passenger vessels and tugs built annually are SOLAS certified (based on new vessel construction, 1995–2006).[127] Therefore, to be eligible for the exemption, the owner will be required to obtain and maintain relevant international safety certification pursuant to the requirements of the United States Coast Guard and SOLAS for the vessel on which an exempted engine is installed.

Vessel owners will be required to petition EPA for an exemption for a particular vessel in order for an engine manufacturer to sell them an exempted engine; granting of the exemption will not be automatic. In evaluating a request for a Tier 4 exemption, we will consider the owner's projections of how and where the vessel will be used and the availability of ULSD in those areas, as well as the mix of SOLAS and non-SOLAS vessels in the owner's current fleet and the extent to which those vessels are being or have been operated outside the United States. In general, it is our expectation that fleets should first use existing pre-Tier 4 vessels for operations where ULSD may not be available. Therefore, we would not expect to grant an exemption for a vessel that will be part of a fleet that does not already have a significant percentage of Tier 4 vessels, since a fleet with a smaller percentage of Tier 4 vessels would likely have more pre-Tier 4 vessels that could be employed in the overseas application instead. For example, if 30 percent of an owner's current fleet has SOLAS certification, we would expect that up to 70 percent of the vessels in that fleet could be Tier 4 compliant without changes in the operation of the fleet. We may also ask the petitioner to demonstrate that other vessels in the petitioner's fleet remain in service outside the United States and have not been placed into service domestically. EPA does not expect to approve applications for the Tier 4 exemption described in this paragraph prior to 2021; we expect that the existing fleet of Tier 3 vessels can be used for overseas operations during that time. If an owner petitions EPA for an exemption prior to that year, we may request additional information on the owner's expected operation plans for that vessel and a more complete explanation as to why another vessel in the existing fleet could not be redirected to the offshore application with the Tier 4 vessel under construction taking that vessel's place. Finally, a failure to maintain SOLAS certification for the vessel on which an exempted engine is installed would result in a finding of noncompliance and the owner would be liable for applicable fines and other penalties.

To address the situation in which an owner of a vessel with Tier 4 engines wants to use that vessel in a country that does not have ULSD available, we are also including a provision that will allow the owner to petition EPA to temporarily remove or disable the Tier 4 controls on vessels that are operated solely outside the United States for a given period of time. The petitioner will need to specify where the vessel will operate, how long the vessel will operate there, and why the owner will be unable to provide ULSD for the vessel. The petitioner will also be required to describe what actions will be taken to disable or disconnect the Tier 4 controls. Permission to disable or remove the Tier 4 controls will be allowed only for the period specified by the owner and agreed to by EPA; however, the owner may re-petition EPA at the end of that period for an extension. As part of the approval of such a petition, the petitioner will be required to agree to re-install or reconnect the Tier 4 emission control devices prior to re-entry into the United States, whether this occurs only at the end of the specified period or earlier.

These provisions for migratory vessels are intended to facilitate the use of vessels certified to the U.S. federal marine diesel emission standards while they are operated for extended periods in areas that may not have ULSD available. It should be noted that vessels that receive either limited exemptions or that petition EPA to remove or disable Tier 4 controls will still be subject to the MARPOL emission limits when they are operated outside the United States. We may review these migratory vessel provisions in the context of our upcoming Category 3 marine diesel engine rulemaking. We may also revisit this program in the future if the number of exemption requests appears to be unreasonably high or if we find that significant numbers of vessels that have obtained exemptions from Tier 4 are, in fact, in use domestically.

Note that the implementation schedule in the above marine standards tables is expressed in terms of model years, consistent with past practice and the format of our regulations. However, in two cases we believe it is appropriate to provide a manufacturer the option to delay compliance somewhat, as long as the standards are implemented within the indicated model year. Specifically, we are allowing a manufacturer to delay Tier 4 compliance within the 2017 model year for 600–1000 kW (800–1300 hp) engines by up to 9 months (but no later than October 1, 2017) and, for Tier 4 PM, within the 2016 model year for engines at or above 3700 kW (4900 hp) by up to 12 months (but no later than December 31, 2016). We consider this option to delay implementation appropriate in order to give some flexibility in spreading the implementation workload and ensure a smooth transition to the long-term Tier 4 program.

The Tier 4 standards for locomotives and for C2 diesel marine engines of comparable size are at the same numerical levels but differ somewhat in implementation schedule: Locomotive Tier 4 standards start in 2015, while diesel marine Tier 4 standards start in 2016 for engines in the 1400–2000 kW (1900–2700 hp) range, and in 2014 for engines over 2000 kW (with final PM standards starting in 2016 for these engines). We consider these locomotive and marine diesel Tier 4 implementation schedules to be close enough to warrant our adopting a marine engine option based on the Tier 4 locomotive schedule, aimed at facilitating continuance of today's frequent practice of developing a common engine platform for both markets. Commenters on the proposal supported this marine engine option, but expressed concerns about competitiveness issues and argued that we should remove the proposed restriction to engines of 7–15 liter/cylinder displacement and under 3700 kW maximum engine power.

We are adopting this locomotive-based marine engine option, but with

[127] Memorandum to Docket EPA–HQ–OAR–2003–0190, Marine Vessels—SOLAS Certification, from Jean MarieRevelt, dated January 11, 2007.

some changes from the proposed approach to address potential competitiveness issues, as well as our own concern that this option be used only for the intended purpose of avoiding unnecessary dual design efforts. First, we are retaining some limits on its scope, specifically to engines above both a 7 liters per cylinder limit (Category 2 in the marine sector) and a 1400 kW (1900 hp) maximum engine power. Second, if the option is used, its standards must be met for all of a manufacturer's marine engines at or above 1400 kW (1900 hp) in the same displacement category (that is, 7–15, 15–20, 20–25, or 25–30 liters per cylinder) in all of the model years 2012 through 2016. This will help ensure the option is not gamed by artificially subdividing engine platforms. Because the switch locomotive program we are establishing already includes a similar streamlined option allowing the use of land-based nonroad engines, we are not extending this option to switchers.

We are adopting another provision to help ensure that this locomotive-based marine engine option is environmentally beneficial and is not used to gain a competitive advantage. We are requiring that marine engines under this option meet Tier 3 standards in 2012, the year Tier 3 starts for locomotives, with standards numerically corresponding to locomotive Tier 3 standards levels: 0.14 g/kW-hr (0.10 g/bhp-hr) PM and 7.8 g/kW-hr NO_X+HC (5.8 g/bhp-hr: that is, 5.5 + 0.30 g/bhp-hr combined NO_X and HC). Otherwise a manufacturer could take advantage of the later-starting marine Tier 3 schedule to generate credits or allow increased emissions from these engines until 2015 when the option requires Tier 4 compliance. This approach also deals fairly with the problem identified in the proposal regarding redesigning locomotive-based engine platforms to meet the numerically lower marine Tier 3 NO_X level.

Finally, we considered but are not adopting a provision that would set a total vessel power limit for the Tier 4 standards. The comments we received on this issue lead us to conclude that multiple-engine configurations are used in vessel designs for specific purposes and are not likely to be employed to evade the Tier 4 standards. We may consider this type of restriction in a future action, however, if multiple-engine vessels are built in applications that have typically used a different number of engines in the past.

(b) Remanufactured Marine Engines

In addition to the standards for newly-built engines, we are adopting for the first time emission standards for marine diesel engines on existing vessels. Many of these existing engines will remain in the fleet for 40 years or more, making them what would otherwise be a substantial source of air pollution. The marine remanufacture program will provide early PM reductions by reducing emissions from this legacy fleet sooner than would be the case from the retirement of old vessels in favor of new vessels with cleaner engines. Additional early NO_X reductions are expected to be achieved from the use of locomotive remanufacture systems recertified under this program for Category 2 engines.

The program we are finalizing is modified from what we described in the NPRM. In the NPRM we described a two-part program that would have applied to all commercial marine diesel engines above 600 kW when they are remanufactured. In the first part, which we considered beginning as early as 2008, vessel owners/operators and engine rebuilders who remanufacture engines would be required to use a certified remanufacture system when an engine is remanufactured (defined as replacement of all cylinder liners, either in one event or over a five-year period) if such a certified system is available. In the second part, which we considered beginning in 2013, a marine diesel engine identified by EPA as a high-sales volume engine model would have been required to meet specified emission requirements when it is remanufactured. Specifically, the remanufacturers or owners of such engines would have been required to use systems certified to meet the standard; if no certified system is available, they would have needed to either retrofit the engines with emission reduction technology that demonstrates at least a 25 percent reduction or replace the engines with new ones. For engines not identified as high-sales volume engines, Part 1 would have continued to apply.

Several commenters requested that EPA not finalize this program at this time but instead consider it in a separate rulemaking. They noted that this would allow additional time to consider the program and its requirements. Postponing the program, however, would also result in the loss of important emission reductions early in the program. Delay is also not necessary because the program we are adopting consists only of the first part of the program described in our proposal, requiring the owner of a marine diesel engine to use a certified marine remanufacture system when the engine is remanufactured if such a system is available. We are not adopting a requirement for the mandatory availability of remanufacture systems. (Under the option discussed in the proposal, in certain circumstances, if a remanufacture system was not made available the owner would have been required to retrofit an emission control technology, repower the vessel (replace its engines) or scrap the vessel.)

The marine remanufacture program we are adopting applies to all commercial marine diesel engines with maximum engine power greater than 600 kW and manufactured in 1973 or later, through Tier 2. The beginning date of 1973 is based on our existing locomotive program; many of the techniques used to achieve those standards are expected to be applicable to marine diesel engines over 600 kW.

As described in more detail below, the program draws on aspects of our locomotive remanufacture and diesel retrofit programs with regard to the basic requirements that apply and how remanufacture systems are certified. The remainder of this section describes the main features of the program. The technological feasibility of this program is described in section III.C, and the certification requirements are set out in section IV. Small manufacturer, engine dresser, vessel builder, and operator flexibilities are set out in section IV.A(13)(b).

Similar to the locomotive program, the marine program we are finalizing applies when a marine diesel engine is remanufactured. Covered engines are those that are remanufactured to as-new condition. Based on discussions with engine manufacturers, we have determined that replacing all cylinder liners is a simple and clear indicator that the servicing being done is extensive enough for the engine to be considered functionally equivalent to a freshly manufactured engine, both mechanically and in terms of how it is used. Therefore, we are defining remanufacture as the removal and replacement of all cylinder liners, either during a single maintenance event or over a five-year period. It should be noted that marine diesel engines are not considered to be remanufactured if the rebuilding process falls short of this definition (i.e., the cylinder liners are removed and replaced over more than a five-year period). As with locomotives, remanufactured marine diesel engines are new until they are sold or placed into service.

For the purpose of this program, ''replace'' includes removing, inspecting, and requalifying a liner. This addresses the situation in which an engine experiences a cylinder failure prior to a scheduled rebuild: The owner might replace the failed cylinder right away and replace the others at rebuild; then, at the time of rebuild, the installer would likely inspect the cylinder that was a few months old to make sure it qualified for continued use according to the certificate holder's instructions. We do not think that owners will fail to requalify cylinders to avoid the remanufacture requirements because requalification is done both to ensure the continued reliability and durability of the engine and as part of surveys necessary to retain vessel certification for safety and other purposes. The five-year provision was first adopted in the locomotive program to help ensure that the standards are not avoided through phased remanufacturing (i.e., not replacing the power assemblies all at once). It is reasonable to use this approach in the marine sector as most commercial engines are rebuilt all at once, although some owners may choose a rolling rebuild approach in which a certain number of cylinders are rebuilt every year. We may revisit the five-year limit after a few years of the program to evaluate whether this is the appropriate period and whether owners are adjusting their rebuild practices, particularly with respect to rolling rebuilds, to circumvent the regulations (see discussion of rolling rebuilds, below).

When an engine is remanufactured, it must be certified as meeting the emission standards for remanufactured engines (by using a certified remanufacture system) unless there is no certified remanufacturing system available for that engine. In other words, the owner/operator or installer of a covered engine would be required to use a certified marine remanufacture system when remanufacturing that engine if one is available. If there is no certified system available at that time, there is no requirement. Availability means not only that EPA has certified a system, but also that it can be obtained and installed in a timely manner consistent with normal business practices. For example, a system would generally not be considered to be available if it required that the engine be removed from the vessel and shipped to a factory to be remanufactured unless that is the normal rebuild process for that engine. Similarly, a system would not be considered to be available if the component parts are not available for purchase in the period normally associated with a scheduled rebuild. If a certified system is not available there is no requirement to comply with this program until the next remanufacture, at which time the remanufacturer would need to check again to see if a system is available. Nonavailability due to inability to obtain parts may be demonstrated by a written record that shows a good faith effort to obtain parts.

Several states and localities have voluntary retrofit programs to reduce emissions from marine diesel engines. These programs encourage vessel owners to apply emission reduction strategies in return for a financial or operational incentive. Retrofit systems range from engine adjustments to installing different cylinders, fuel injectors, turbochargers, or other engine components. To receive the incentive, the owner must demonstrate the reduction, often through emission measurements. We received state agency comments expressing concern about the potential inconsistency between state and local retrofit programs and a potential marine remanufacture program. Specifically, a situation could be created in which a vessel owner who has already applied a retrofit device pursuant to a state or local retrofit program would be required to remove the voluntary retrofit device and install a certified marine remanufacture system. We do not want to negatively impact the positive benefits that arise from state and local retrofit programs, especially in those cases in which the retrofit achieves a greater reduction (e.g., retrofit of a SCR system) than a certified marine remanufacture system. We also do not want to discourage these programs especially in early years where states and local programs may achieve reductions before certified remanufacture systems become available.

Therefore, we are adopting a provision that will allow an owner/operator of an engine that is fit with a retrofit device prior to 2017 pursuant to a state or local retrofit program to request a qualified exemption from the marine remanufacture requirements for that engine. This qualified exemption will be available only to engines equipped with retrofit device under a state or local program before 2017. The owner/operator must request the exemption prior to a remanufacturing event that would otherwise trigger the requirement to use a certified remanufacture system. The request must include documentation that the vessel has been retrofit pursuant to a state or local retrofit program and a signed statement declaring that to be true. Except for the initial request for a specific vessel and a specific retrofit, a request would be considered to be approved unless we notify the requestor otherwise within 30 days of the date that we receive the request. Note that the exemption does not apply where the sponsoring government specifies that inclusion in the retrofit program is not intended to provide an exemption from the requirements of this subpart. EPA's granting of the exemption is conditioned upon the owner/operator's continued use and maintenance of the retrofit kit that provides the basis for the exemption.

Beginning in 2017, this exemption will no longer be available for new retrofits. Engines included in state or local retrofit programs will be required to use a certified remanufacture system if one is available when the engine is remanufactured. In this case either the certified remanufacture system would be part of the retrofit or the vessel owner would use a certified remanufacture system the next time at the next remanufacture event.

At this time, we are adopting standards for remanufacture systems only for marine diesel engines over 600 kW. This 600 kW threshold is reasonable because of the long hours of use, often at high load, of engines above 600 kW, and their long services lives. These engines are also more likely to undergo regular full overhauls, returning them to as-new condition. Commercial marine diesel engines larger than 600 kW typically undergo periodic full, like-new rebuilds. These large engines are often installed on tugs, towboats, ferries, offshore supply vessels, lakers, and coasters, which require reliable power at all times. These vessels are often used for ten or more hours a day, every day of the year. As a result, these engines are typically subject to regular maintenance to ensure their dependability. In addition, many manufacturers provide guidance for a full rebuild to as-new condition. This might include replacing piston rings, heads, bearings, and gear train/camshaft as well as piston liners.[128] Rebuilding to as-new condition helps ensure smooth operation over the full maintenance interval. Owners of these vessels are also motivated to maintain their engines because it is very complicated and expensive to repower their vessels; replacing an engine may require major hull modifications. Because these vessels operate for decades, often 40 or

[128] See Note from Amy Kopin, Mechanical Engineer, to Jean Marie Revelt, EPS, Re: Marine Remanufacture Program. A copy of this Note is available in Docket OAR–2003–0190.

more years, their engines may be remanufactured to as-new condition anywhere from three to six or even more times before the vessel is scrapped.

We are not setting standards for marine remanufacture systems for engines below 600 kW because we currently do not have sufficient data to determine the extent that rebuilding of engines below 600kW qualifies as remanufacturing to an as new condition. Smaller commercial engines under 600 kW or recreational engines typically have shorter useful lives than the larger engines and do not see as much wear on an annual basis. This means it takes longer to acquire the hours between maintenance intervals. Engines on some smaller commercial or recreational marine vessels may not be rebuilt at all but, instead, are replaced or the vessel is scrapped. There may also be other technological and cost issues with applying remanufacture requirements to smaller commercial or recreational engines.

For these reasons, we are finalizing only standards for remanufactured commercial marine diesel engines above 600 kW. We may revisit this approach after implementing the program to evaluate whether other remanufactured marine diesel engines should be included in the program as well.

A certified marine remanufacture system must achieve a 25 percent reduction in PM emissions compared to the engine's measured baseline emissions level (the emission level of the engine as rebuilt according to the manufacturer's specification but before the installation of the remanufacture system) without increasing NO_X emissions (within 5 percent). We are not finalizing a 0.22 g/kW-hr PM cap, as proposed. The percent reduction is being adopted because the large range of engine platforms on existing marine diesel engines makes the selection of an effective numeric emission limit impractical. A more stringent emission limit may prevent the development of remanufacture systems for many engines, while a less stringent limit could allow manufacturers to certify remanufacture systems for engines that already meet the limit without any additional emission benefits. A percentage reduction has the advantage of allowing more engines to participate in the program while ensuring valid emission reductions.

We are not adopting the multi-step approach discussed in the proposal. This approach, based on the Urban Bus program, would have entailed setting standards based on reductions of 60 percent, 40 percent, and 20 percent, and requiring that a rebuild use the certified kit meeting the most stringent of these three standards if available. Manufacturers expressed concern that such a requirement would discourage the development of remanufacture systems since they could rapidly become obsolete. Owners were concerned that they would be subject to a moving requirement that would complicate their engine maintenance and overhaul schedules and could result in identical engine models being required to use different remanufacture systems. They also were concerned that such an approach would mean they would have to use a different system every time they remanufacture, and the impacts on engines that are remanufactured over several maintenance events. For these reasons, instead of adopting the multi-step approach, we are adopting a single emission reduction requirement. If several certified systems are available, we will allow any of them to be used. However, states may develop incentive programs to encourage the use of the certified remanufacture system with the greatest reduction. Also, we may revisit the emission level in the future to determine if it should be modified to reflect advances in applying new PM reduction technologies to existing marine diesel engines.

We expect that this PM reduction will be met by using incrementally-improved components that are replaced when an engine is remanufactured, based on reduction technologies manufacturers are already using or will be using to achieve the Tier 3 PM standards. For example, a remanufacture system could reduce PM emissions by using different fuel injectors or different piston rings to reduce oil consumption. Remanufacturing systems may not adversely affect engine reliability, durability, or power.

Some engine manufacturers expressed concern about the potential for unintended adverse effects on engine performance, reliability, or durability that could occur if another entity develops a remanufacture system for their engines. They were particularly concerned about being held responsible for an emission failure if the remanufacture system does not perform as intended, or for an engine failure if the system causes other engine components to fail. To address this concern, the program we are finalizing requires any person who wishes to certify a remanufacture system for an engine not produced by that person to notify the original engine manufacturer and request their comments on the remanufacture system. Any comments received by the certifier are required to be included in the certification application, as well as a description of how those comments were addressed.

As we described at proposal, this final rule includes a cost cap on marine diesel remanufacture systems of $45,000 per ton of PM reduced, based on the incremental cost of the remanufacture system (the cost in excess of what a rebuild would otherwise cost). This cost cap is analogous to the reasonable cost limit in the current locomotive remanufacturing program and is intended to ensure that marine remanufacture systems do not impose excessively burdensome cost requirements on vessel owners that are not justified by the benefits of the reductions. The $45,000 per ton of PM reduced is similar to the cost of a number of mobile source retrofit programs. This cap includes all costs to the vessel owner associated with the remanufacture system beyond those associated with an engine remanufactured without a certified system, such as labor for any special installation procedures and any modifications to the vessel or its operation (e.g., fuel consumption impacts).

It may not be possible for the certifier to predict the characteristics of all vessels that can use the remanufacture system and therefore provide a comprehensive estimate of the total incremental costs of installing the remanufacture system. Therefore, in addition to an estimate of the vessel-related installation costs that would apply to most vessels, the certifier must also provide an estimate of the amount of residual incremental costs that would be available for installation of the remanufacture system on a particular vessel without triggering the $45,000 per ton PM threshold (i.e., the maximum amount installation may cost for a particular vessel after the cost of the remanufacture system is deducted from the $45,000 maximum cost). This will guide vessel owners in determining if the cost of a certified remanufacture system will exceed the $45,000 threshold for a particular vessel.

We are including a provision that will allow a vessel owner to request an exemption from EPA if the vessel owner can demonstrate to EPA's satisfaction that actual installation cost for his or her vessel will exceed the $45,000 per ton PM threshold. This may be necessary, for example, if a vessel with external keel cooling cannot be modified to achieve required cooling levels required by the remanufacture system without extensive modifications to the vessel hull. We are also including a small business exemption as well as a financial hardship provision (see Section IV.A.13(b)(vi and vii)) that would allow postponing the requirements for owners who can show financial hardship.

Marine remanufacture systems can be certified as soon as this rule goes into effect. A remanufacture system will be considered to be available 120 days after we issue a certificate of conformity for it or 90 days after we include it on our list of certified remanufacture systems, whichever is later. Prior to the end of that period, a kit will not be considered to be ''available.'' This period allows time for owners to arrange for remanufacturing with a certified system once one that applies to the relevant engine has been certified. Once a marine remanufacture system is certified, as evidenced by an EPA-issued certificate of conformity, it will be considered to be available until it is withdrawn or the certificate holder fails to obtain a certificate of conformity for a subsequent year. We will maintain a list of available remanufacture systems and provide access to this list by posting it on our website. Owners should consult the list prior to any particular remanufacturing event to determine whether a certified system is available and therefore whether they are affected by the program. Uncertified systems purchased before that date can be used as long as they are consistent with the normal parts inventory practices of the owner or rebuild facility. Stockpiling of uncertified remanufacture systems to evade the requirements of the program is not allowed.

For engines on a rolling rebuild schedule (i.e., cylinder liners are not replaced all at once but are replaced in sets on a schedule of 5 or fewer years, for example 5 sets of 4 liners for a 20-cylinder engine on a 5-year schedule), the requirement is triggered at the time the remanufacture system becomes available, with the engine required to be in a certified configuration when the last set of cylinder liners is replaced. The remanufacturing requirements do not apply for cylinder-liner replacements that occurred before the remanufacture system becomes available. Any remanufacturing that occurs after the system is available needs to use the certified system, including remanufacturing that occurs on a rolling schedule over less than five years following the availability of the remanufacturing system. If the components of a certified remanufacture system are not compatible with the engine's current configuration, the program allows the owner to postpone the installation of the remanufacture system until the replacement of the last set of cylinder-liners, which would occur no later than five years after the availability of the system. At that time, all engine components must be replaced according to the certified remanufacture system requirements.

Initially, we expect marine remanufacture systems to be certified for C2 engines that are derived from certified locomotive remanufacture systems. Some of these certified locomotive systems are already used on C2 marine diesel engines, or can be used with modification. The new Tier 0+, Tier 1+ and Tier 2+ certified locomotive remanufacture systems are likely to be capable of being used on marine diesel engines without much additional development when those certified locomotive systems become available, for additional reductions. To encourage this practice, we are providing a streamlined certification process for locomotive systems certified to the new Tier 0+, Tier 1+, or Tier 2+ standards for use on C2 engines. The streamlined certification will also be allowed for existing Tier 0 locomotive remanufacture systems (certified under part 92), but those systems can be used only on pre-Tier 1 (uncertified) C2 marine engines, and the use of these existing Tier 0 systems will not be permitted after systems certified to the new Tier 0+ (or Tier 1+ if applicable) locomotive standards are made available. The streamlined certification process will require only an engineering analysis demonstrating that the system would achieve emission reductions from marine engines similar to those from locomotives. The streamlined certification process will allow modifications to the previously certified locomotive system as necessary to install the system on a C2 marine engine. If the manufacturer of a locomotive remanufacture system chooses to modify that system in a substantive way, for example to remove NO_X emission controls (because the marine remanufacture program only requires PM reductions), then the system will have to be recertified as a marine remanufacture system based on measured values and subject to all of the other certification requirements of the marine remanufacture program (see section IV). We are not providing a similar streamlined certification process for C1 marine systems because there are currently no certified remanufacture systems for C1-equivalent engines through our other mobile source programs.

The program described above is engine-based in that it assumes that remanufacture systems will consist of changes to engine components or operational settings. At least one user asked EPA to consider also allowing remanufacture systems consisting of the use of specified fuels or fuel additives. The program we are adopting will allow this type of remanufacture system, subject to the following constraints.

First, the use of a remanufacture system based on a fuel or fuel additive will not be mandatory if such a system is certified. Instead, the use of a fuel or fuel additive system will be allowed as an alternative compliance mechanism in place of an engine-based remanufacture system. In other words, if an engine-based remanufacture system is certified, owners of the affected engine models can either use that engine-based system or use a fuel or fuel additive system if one has also been certified; if there is no certified engine-based system, then there is no requirement to use the fuel or fuel additive remanufacture system. This requirement is necessary because, in contrast to an engine-based system, a fuel or fuel additive-based system requires positive action on the part of the owner to achieve the emission reductions. In the case of an engine-based system, the owner installs the replacement parts at the time of rebuild; installation of the parts will achieve the required reductions and there is little impact on the owner or the vessel's operations. In the case of a fuel or fuel additive system, however, the owner will be required to use the specified fuel or fuel additive at all times; if the owner does not take the required action, the ''system'' will not be in use. Because a fuel or fuel additive-based system will require the owner to do something on a continuous basis and require additional recording and recordkeeping, the success of the system requires a positive commitment on behalf of the owner/operator.

Second, the certifier of a remanufacture system based on a fuel or fuel additive will be required to show that use of the fuel or fuel additive meets the 25 percent PM reduction based on measured values, without increasing NO_X emissions, for all engines to which the system will apply. This will require testing an engine with and without the use of the specified fuel or fuel additive. Different engines may be combined into one engine family for the purpose of certification, based on EPA approval.

Third, any fuel or fuel additive for which certification is sought under the marine remanufacture program must first be registered under 40 CFR Part 79, Registration of Fuels and Fuel Additives. This is to ensure that the fuel or fuel additive does not contain substances that are otherwise controlled by EPA.

Fourth, as part of the certification, the certifier will be required to provide a sampling procedure that can be used by EPA or other enforcement authorities to verify owner compliance onboard and for enforcement purposes. That procedure should explain how to detect if the appropriate level of fuel additive or if the appropriate fuel type is actually being used onboard on the basis of a fuel sample taken from a fuel tank on the vessel. In addition to being provided to EPA as part of the certification process, the certifier will be required to provide a copy of this procedure to the purchaser as part of the remanufacture system package and will be required to maintain a copy of the procedure on the internet to facilitate in-field compliance verification.

Fifth, the remanufacture system will require a notification to be placed at the appropriate fill location (either on the fuel tank inlet in the case of fuels or pre-blended fuel additives, or as specified on the engine in the case of fuel additives not blended in the fuel) that indicates the engine is outfitted with a fuel or fuel additive remanufacture system and that compliant fuel or additives must be used at all times.

Finally, when an owner agrees to use a fuel or fuel additive-based remanufacture system in lieu of an engine-based system, that owner must also agree to any recordkeeping requirements specified in the certification of that system. These may include keeping a record of the purchase of the specified fuel or fuel additive and, in the case of additives, the amounts and dates of the additive use. These requirements must be set out by the certifier as part of the kit, and the owner will be deemed to have agreed to them by affixing a label to the engine or appropriate fuel or fuel additive inlet indicating that it is certified with a fuel or fuel-additive remanufacture system.

If an owner or operator chooses a certified remanufacture system based on a particular fuel or fuel additive to meet these remanufacture requirements, the failure to use the fuel or fuel additive would be a violation of 1068.101(b)(1).

Allowing the use of fuel or fuel additive-based remanufacture systems is not intended to be a mechanism to require fuel switching for marine diesel engines, either to 15 ppm fuel earlier than required or to distillate from residual fuel for auxiliary engines on vessels with Category 3 marine diesel engines or for those smaller vessels than may currently use residual fuel in their C2 main propulsion engines. It is also not intended to prevent the use of off-spec fuel in marine diesel engines. If there is no certified engine-based remanufacture system available for an engine, a fuel or fuel additive-based kit will not be required to be used even if one is certified.

EPA is committed to the development and successful operation of a marine remanufacture program. We intend to assess the effectiveness of this program as early as 2012 to ascertain the extent to which engine manufacturers are providing certified remanufacture systems. If remanufacture systems are not available or are not in the process of being developed and certified at that time for a significant number of engines, we may consider changes to the program. As part of that assessment, we may evaluate whether to include Part 2 of the program described in our proposal. Part 2 would require the owner/operator or installers of a marine diesel engine identified by EPA as a high-sales volume engine to either use a certified remanufacture system when the engine is remanufactured or, if no system is available, retrofit an emission reduction technology for the engine that meets the 25 percent PM reduction, or repower (replace the engine with a freshly manufactured engine). Part 2 was intended to create a market for marine remanufacture systems, to help ensure their development over the initial five years of the program. However, vessel owners were very concerned that a mandatory repower program would have the opposite impact, and would discourage certification of remanufacture systems in favor of mandatory repowers due to the higher value of a replacement engine compared to a remanufacture system. In evaluating the effectiveness of the remanufacture program in the future, EPA may revisit the need for Part 2, or something similar, to ensure emission reductions from the large marine legacy fleet are occurring in a timely and effective manner. We may also evaluate other aspects of the program, including the criteria that trigger a remanufacturing event (including the 5-year period for incremental remanufactures), and whether we should set remanufacture standards for engines less than 600 kW.

(3) Carbon Monoxide, Hydrocarbon, and Smoke Standards

We did not propose and are not setting new standards for CO. Emissions of CO are typically relatively low in diesel engines today compared to non-diesel pollution sources. Furthermore, among diesel application sectors, locomotives and marine diesel engines are already subject to relatively stringent CO standards in Tier 2—essentially 1.5 and 3.7 g/bhp-hr, respectively, compared to the current heavy-duty highway diesel engine CO standard of 15.5 g/bhp-hr. Therefore, the Tier 3 and Tier 4 CO standards for all locomotives and marine diesel engines will remain at current Tier 2 levels and remanufactured Tier 0, 1 and 2 locomotives will likewise continue to be subject to the existing CO standards for each of these tiers. Although we are not setting more stringent standards for CO in Tier 4, we note that aftertreatment devices using precious metal catalysts that we project will be employed to meet Tier 4 PM, NO_X and HC standards will provide meaningful reductions in CO emissions as well.

As discussed in section II, HC emissions, often characterized as VOCs, are precursors to ozone formation, and include compounds that EPA considers to be air toxics. As with CO, emissions of HC are typically relatively low in diesel engines compared to non-diesel sources. However, in contrast to CO standards, the HC standard for Tier 2 line-haul locomotives (0.30 g/bhp-hr), though comparable to HC standards from other diesel applications in Tier 2 and Tier 3, is more than twice that of the long-term 0.14 g/bhp-hr standard set for both the heavy-duty highway 2007 and nonroad Tier 4 programs. For marine diesel engines, the Tier 2 HC standard is expressed as part of a combined NO_X+HC standard varying (by engine size) between 5.4 and 8.2 g/bhp-hr, which clearly allows for high HC levels. Our more stringent Tier 3 NO_X+HC standards for marine diesel engines will likely provide some reduction in HC emissions, but we expect that the catalyzed exhaust aftertreatment devices used to meet the Tier 4 locomotive and marine NO_X and PM standards will concurrently provide very sizeable reductions in HC emissions. Therefore, in accordance with the Clean Air Act section 213 provisions outlined in section I.B(3) of this preamble, we are applying a 0.14 g/hp-hr HC standard to locomotives and marine diesel engines in Tier 4. This level is the same as that adopted for highway and nonroad diesel engines equipped with high-efficiency aftertreatment.

We are retaining the existing form of the HC standards through Tier 3. That is, locomotive and marine HC standards will remain in the form of total hydrocarbons (THC), except for gaseous- and alcohol-fueled engines (See 40CFR § 92.8 and § 94.8). Likewise, the Tier 3 marine NO_X+HC standards are based on THC, except that Tier 3 standards for less than 75 kW (100 hp) engines are based on NMHC, consistent with their basis in the nonroad engine program. Tier 4 HC standards are expressed as NMHC standards, consistent with aftertreatment-based standards adopted for highway and nonroad diesel engines.

As for other diesel mobile sources, we believe that locomotive smoke standards currently in place are of diminishing usefulness as PM emissions are reduced to very low levels, as these low-PM engines emit very little or no visible smoke. We are therefore not setting smoke standards for locomotives covered under the new 40 CFR Part 1033 created by this final rule, if the locomotives are certified to a PM family emission limit (FEL) or standard of 0.05 g/bhp-hr (0.07 g/kW-hr) or lower. Locomotives certified with PM at higher levels are subject to smoke standards equal to those established previously in Part 92. This allows manufacturers of locomotives certified to Tier 4 PM (or to an FEL slightly above Tier 4) to avoid the unnecessary expense of testing for smoke. Marine diesel engines currently have no smoke standards and we are not setting any in this rule.

Commenters suggested that smoke testing is superfluous for pre-Tier 4 engines as well, because a properly maintained engine meeting any tier of EPA emissions standards will also meet the smoke standards. Based on the available information, we remain unconvinced that this argument is valid in all cases and we are therefore retaining the smoke standards for locomotives with PM FELs above 0.05 g/bhp-hr. However, we do agree that this relationship generally holds true for engines designed to emission standards being set in this rule, and are therefore waiving the smoke test requirement from certification, production line, and in-use testing, unless there is visible evidence of excessive smoke emissions. This provides the test cost savings sought by the manufacturers but retains the EPA enforcement opportunity if smoke should become a problem in engines subject to this program.

C. Are the Standards Feasible?

In this section, we describe the feasibility of the various emission control technologies we project will be used to meet the standards we are finalizing today. Because of the range of engines and applications we cover in this rulemaking and because of the diversity in technologies that will be available for them, our standards span a range of emission levels. We have identified a number of different emission control technologies we expect will be used to meet these standards. The technologies range from incremental improvement of existing engine components to highly advanced catalytic exhaust aftertreatment systems similar to those expected to be used to control emissions from heavy-duty diesel trucks and nonroad equipment.

We first describe the feasibility of emission control technologies we project will be used to meet the standards we are finalizing for existing locomotive and marine engines that are remanufactured as new (i.e., Tier 0, 1, 2 locomotives and marine diesel engines >600 kW). We next describe how these same technologies will be applied to meet the interim standards for freshly manufactured engines (i.e., Tier 3). We conclude this section with a discussion of catalytic exhaust aftertreatment technologies projected to be used to meet our Tier 4 standards. Throughout this section, we also address many of the comments submitted by stakeholders concerning the feasibility, applicability, performance, and durability of the emission control technologies we presented in the Notice of Proposed Rulemaking (NPRM). For a more detailed analysis of these technologies, issues related to their application to locomotive and marine diesel engines, and our response to public comments, we refer you to the Regulatory Impact Analysis (RIA) and Summary & Analysis of Comments documents associated with this rulemaking.

(1) Emission Control Technologies for Remanufacture of Existing Locomotives and Marine Diesel Engines >600 kW

In the locomotive sector, emissions standards already exist for engines that are remanufactured as new. Some of these engines were originally unregulated (i.e. Tier 0), and others were originally built to earlier emissions standards (Tier 1 and Tier 2). This rulemaking now requires more stringent standards for these engines whenever the locomotives are remanufactured as new. Our remanufactured engine standards apply to locomotive engines and marine engines >600 kW that were originally built as early as 1973.

We project that incremental improvements to existing engine components will make it feasible to meet both our locomotive and marine remanufactured engine standards for PM. In many cases, these improvements have already been implemented on newly built locomotives to meet our current locomotive standards. To meet the more stringent NO_X standard for the locomotive Tier 0+ and Tier 1+ remanufacturing program, we expect that improvements in fuel system design, engine calibration and optimization of existing after-cooling systems will be used to reduce NO_X from the current 9.5 g/bhp-hr Tier 0 standard to the tightened Tier 1+ standard for NO_X of 7.4 g/bhp-hr. These are the same technologies used to meet the current Tier 1 emission standard of 7.4 g/bhp-hr. In essence, locomotive manufacturers will duplicate current Tier 1 locomotive NO_X and HC emission solutions and incorporate them into the portion of the existing Tier 0 fleet able to accommodate them (i.e. locomotives manufactured with separate-circuit cooling systems for intake air and engine coolant). For older Tier 0 locomotives without separate-circuit cooling systems, reaching the Tier 1 NO_X level will not be possible, and 8.0 g/hp-hr represents the lowest achievable NO_X emission level through the application of improved fuel system design.

To meet the more stringent PM standards for the Tier 0+, 1+, and 2+ locomotive and marine remanufacturing programs (as well as the new locomotive Tier 3 interim standards), we expect that lubricating oil consumption control technologies will be implemented. A significant fraction of the PM in today's medium-speed locomotive and locomotive-based marine engines is comprised of lubricating oil.[129] Engine design changes which reduce oil consumption also reduce the volatile organic fraction of the engine-out PM. Whether oil consumption is reduced through improvements in piston ring-pack design, improved closed crankcase ventilation systems, or a combination of both, lower PM emissions will result. We believe that use of existing low-oil-consumption piston ring-pack designs—in conjunction with improvements to closed crankcase ventilation systems—can provide the significant, near-term PM reductions required for these remanufacturing programs. These PM-reducing technologies can be applied to all medium-speed locomotive and locomotive-based marine engines—including those built as far back as 1973.

For the remanufacture of locomotive- and nonroad-based marine engines >600 kW, we believe that similar improvements to piston ring-pack designs, as well as turbocharger, fuel system, and closed crankcase ventilation system improvements can achieve the 25 percent PM reduction required in this program without the use of exhaust aftertreatment devices.

[129] Smith, B., Osborne, D., Fritz, S., ''AAR Locomotive Emissions Testing 2006 Final Report,'' Association of American Railroads, Document #LA–023.

Turbocharger designs which increase engine airflow or charge air cooling system enhancements which reduce intake air temperatures can reduce PM levels. Fuel system changes such as increased injection pressure or improved injector tip design can enhance fuel atomization, improving combustion efficiency and reducing soot PM. Any combination of these improvements—or other technologies which achieve the 25 percent PM reduction—can become part of a certified marine remanufacture kit.

We believe that some fraction of the remanufacturing systems for locomotives can be developed and certified as early as this year, so we are requiring the usage of the new Tier 0+, Tier 1+ and Tier 2+ emission control systems as soon as they are available. However, we estimate that it will take approximately 2 years to complete the development and certification process for all of the Tier 0+ and Tier 1+ emission control systems, so full implementation of the Tier 0+ and Tier 1+ remanufactured engine standards is not anticipated until it is required in 2010. We base this lead time on the types of technology that we expect to be implemented and on the amount of lead time locomotive manufacturers needed to certify similar systems for our current remanufacturing program. The lead time required to implement the design changes necessary to meet the Tier 3 and remanufactured Tier 2 locomotive PM emission standards led to an implementation date of 2012 for new Tier 3 engines and 2013 for remanufactured Tier 2 engines. These engine changes include further improvements to ring pack designs (especially for two-stroke engines) and the implementation of high efficiency crankcase ventilation systems, which are described and illustrated in detail in Chapter 4 of the RIA.

(2) Emission Control Technologies for New Tier 3 Locomotive and Marine Diesel Engines

The new Tier 3 locomotive and marine diesel engine standards require PM reductions relative to current Tier 2 levels. Based upon our on-highway and nonroad clean diesel experience, we expect that the introduction of ULSD fuel into the locomotive and marine sectors will reduce sulfate PM formation and assist in meeting the PM standards for locomotives (both remanufactured Tier 2 and new Tier 3) and new marine diesel engines. We believe that the combination of reduced sulfate PM and incremental design changes that bring oil and crankcase emission control to near Tier 3 nonroad or 2007 heavy-duty on-highway levels can provide at least a 50 percent reduction in PM emissions.

For Tier 3 marine diesel engines (which are, in almost all instances, a derivative of land-based nonroad and locomotive engines), the technologies and design changes needed to meet the more stringent NO_X and PM standards are already being developed for nonroad Tier 4 applications. In order to meet our nonroad Tier 4 emission levels, these engines, in the years before 2012, will see significant base engine improvements designed to reduce engine-out emissions. For details on the design, calibration, and hardware changes we expect will be used to meet the Tier 3 standards for lower horsepower marine engines, we refer you to our nonroad Tier 4 rulemaking.[130] For example, we expect that marine engines will utilize high-pressure, common-rail fuel injection systems or improvements in unit injector design. When such fuel system improvements are used in conjunction with engine mapping and calibration optimization, the marine Tier 3 diesel engine standards can be met. In the case of locomotive-based marine engines, we expect that manufacturers will transfer the technologies used to meet locomotive standards to the marine engine designs.

The 2009 Tier 3 start date for marine engines <75 kW constitutes a special case. We proposed this very early start date, matched with standard levels equal to the nonroad engine Tier 4 standard levels that take effect in 2008, based on our assessment that these engines are close derivatives of the nonroad engines on which they are based—in some cases, with no substantive modifications. The 2009 start date accounts for time needed to make the necessary modifications, prepare for and conduct the certification process, and deal with the large overall workload burden for diesel engine manufacturers. Although the manufacturers commented that this is a very aggressive schedule, at the limits of feasibility, they did not refute our assessment. Their objections to implementation of the not-to-exceed (NTE) standard on the same schedule, and our response, are discussed in section IV.A(3).

Because all of the aforementioned technologies to reduce NO_X and PM emissions can be developed for production, certified, and introduced into the marine engine sector without extended lead-time, we believe these technologies can be implemented for some engines as early as 2009, and for all engines by 2014, on a schedule that very closely follows the nonroad Tier 4 engine changes.

(3) Catalytic Exhaust Aftertreatment Technologies for Tier 4 Locomotive and Marine Engines

For marine diesel engines in commercial service that are greater than 600 kW and for all locomotives, we are setting stringent Tier 4 standards based on the use of advanced catalytic exhaust aftertreatment systems to control both PM and NO_X emissions. There are four main issues to address when analyzing the application of this technology to these new sources: The efficacy of the fundamental catalyst technology in terms of the percent reduction in emissions given certain engine conditions such as exhaust temperature; its appropriateness in terms of packaging; its long-term durability; and whether the technology significantly impacts an industry's supply chain infrastructure—especially with respect to supplying urea reductant for NO_X aftertreatment on locomotives and marine vessels. We have carefully examined these points, and based upon our analysis (detailed in Chapter 4 of the RIA), we have identified robust PM and NO_X catalytic exhaust aftertreatment systems that are suitable for locomotives and marine engines that also pose a manageable impact on the rail and marine industries' infrastructure.

(a) Catalytic PM Emission Control Technology

The most effective exhaust aftertreatment used for diesel PM emission control is the diesel particulate filter (DPF). In Europe, more than one million light-duty diesel passenger cars are OEM-equipped with DPF systems, and worldwide, over 200,000 DPF retrofits to diesel engines have been completed.[131] Broad application of catalyzed diesel particulate filter (CDPF) systems with greater than 90 percent PM control began with the successful introduction of 2007 model year heavy-duty diesel trucks in the United States. These systems use a combination of passive and active soot regeneration strategies. CDPF systems utilizing metal substrates are a further development that balances a degree of elemental carbon soot control with reduced

[130] ''Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines,'' EPA420–R–04–007, May 2004, Docket EPA–HQ–OAR–2003–0012. The RIA is also available online at *http://epa.gov/nonroad-diesel/2004fr/420r04007.pdf.*

[131] ''Diesel Particulate Filter Maintenance: Current Practices and Experience'', Manufacturers of Emission Controls Association, June 2005, online at *http://meca.org/galleries/default-file/Filter_Maintenance_White_Paper_605_final.pdf.*

backpressure, improved ability of the trap to clear oil ash, greater design freedom regarding filter size/shape, and greater system robustness. Metal-CDPFs were initially introduced as passive-regeneration retrofit technologies for diesel engines designed to achieve approximately 60 percent control of PM emissions. Recent data from development of these systems for Euro-4 truck applications has shown that metal-CDPF trapping efficiency for elemental carbon PM can exceed 70 percent for engines with inherently low elemental carbon emissions.[132]

Data from locomotive testing confirms a relatively low elemental carbon fraction and relatively high organic fraction for PM emissions from medium-speed Tier 2 locomotive engines.[133] The use of an oxidizing catalyst with platinum group metals (PGM) coated directly to the CPDF combined with a diesel oxidation catalyst (DOC) mounted upstream of the CDPF will provide 95 percent or greater removal of HC, including the semi-volatile organic compounds that contribute to PM. Such systems will reduce overall PM emissions from a locomotive or marine diesel engine by approximately 90 percent from today's levels.

We believe that locomotive and marine diesel engine manufacturers will benefit from the extensive development taking place to implement DPF technologies in advance of the heavy-duty truck and nonroad PM standards in Europe and the United States. Given the steady-state operating characteristics of locomotive and marine engines, DPF regeneration strategies will certainly be capable of precisely controlling PM under all conditions and passively regenerating whenever the exhaust gas temperature is >250 °C. Therefore, we believe that the Tier 4 PM standards we are adopting for locomotive and marine diesel engines are technologically feasible. And given the level of activity in the on-highway and nonroad sectors to implement DPF technology, we have concluded that our implementation dates for locomotive and marine diesel engines are appropriate and achievable.

(b) Catalytic NO_X Emission Control Technology

We have analyzed a variety of technologies available for NO_X reduction to determine their applicability to diesel engines in the locomotive and marine sectors. As described in more detail in Chapter 4 of the RIA, we expect locomotive and marine diesel engine manufacturers will choose to use Selective Catalytic Reduction (SCR) to comply with our new standards. SCR is a commonly-used aftertreatment device for meeting stricter 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, and currently European heavy-duty truck manufacturers are using this technology to meet Euro 5 emissions limits. To a lesser extent, SCR has been introduced on diesel engines in the U.S. market, but the applications have been largely limited to ferry boats and stationary electrical power generation demonstration projects in California and several of the Northeast states. However, several heavy-duty truck engine manufacturers have indicated that they will use SCR technology by 2010, when 100 percent of the heavy-duty diesel trucks are required to meet the NO_X limits of the 2007 heavy-duty highway rule.[134] [135] Providing comment on our NPRM, locomotive and marine diesel engine manufacturers confirm that they expect to use urea-SCR catalyst systems to comply with our Tier 4 standards. While other promising NO_X-reducing technologies such as lean NO_X catalysts, NO_X adsorbers, and advanced combustion control continue to be developed (and may be viable approaches to the standards we are setting today), our analysis assumes that SCR will be the Tier 4 NO_X technology of choice in the locomotive and marine diesel engine sectors.

An SCR catalyst supports the chemical reactions which reduce nitrogen oxides in the exhaust stream to elemental nitrogen (N^2) and water by using 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 gasses (>250 °C), the urea hydrolyzes to form NH^3 and CO^2. 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 NH^3-to-NO_X ratio (α) is 1:1 and the space velocity within the catalyst is not excessive. However, given the space limitations in packaging exhaust aftertreatment devices in mobile applications, an α of 0.85–1.0 is often used to balance the need for high NO_X conversion rates against the potential for NH^3 slip (where NH^3 passes through the catalyst unreacted). The urea dosing strategy and the desired α are dependent on the conditions present in the exhaust gas; namely temperature and the quantity of NO_X present (which can be determined by engine mapping, temperature sensors, and NO_X sensors). Overall NO_X conversion efficiency, especially under low-temperature exhaust gas conditions, can be improved by controlling the ratio of two NO_X species within the exhaust gas; NO^2 and NO. This can be accomplished through use of an oxidation catalyst upstream of the SCR catalyst to promote the conversion of NO to NO^2. The physical size and catalyst formulation of the oxidation catalyst are the principal factors that control the NO^2-to-NO ratio, and by extension, improve the low-temperature performance of the SCR catalyst.

Recent studies have shown that SCR systems are capable of providing well in excess of 80 percent NO_X reduction efficiency in high-power, diesel applications.[136] [137] [138] SCR catalysts can achieve significant NO_X reduction throughout much of the exhaust gas temperature operating range observed in locomotive and marine applications. Collaborative research and development activities between diesel engine manufacturers, truck manufacturers, and SCR catalyst suppliers have also shown that SCR is a mature, cost-effective solution for NO_X reduction on diesel engines in other mobile sources. While many of the published studies have focused on highway truck applications, similar trends, operational characteristics, and NO_X reduction efficiencies have been reported for marine and stationary applications as well.[139] Given the preponderance of studies and data—and our analysis summarized here and detailed in Chapter 4 of the RIA—we have

[132] Jacob, E., Laëmmerman, R., Pappenheimer, A., Rothe, D. ''Exhaust Gas Aftertreatment System for Euro 4 Heavy-duty Engines'', MTZ, June, 2006.

[133] Smith, B., Osborne, D., Fritz, S. ''AAR Locomotive Emissions Testing 2006 Final Report'' Association of American Railroads, Document #LA–023.

[134] ''Review of SCR Technologies for Diesel Emission Control: European Experience and Worldwide Perspectives,'' presented by Dr. Emmanuel Joubert, 10th DEER Conference, July 2004.

[135] Lambert, C., ''Technical Advantages of Urea SCR for Light-Duty and Heavy-Duty Diesel Vehicle Applications,'' SEA Technical Paper 2004–01–1292, 2004.

[136] Walker, A.P. et al., ''The Development and In-Field Demonstration of Highly Durable SCR Catalyst Systems,'' SAE 2004–01–1289.

[137] Conway, R. et al., ''Combined SCR and DPF Technology for Heavy Duty Diesel Retrofit,'' SAE Technical Paper 2005–01–1862, 2005.

[138] ''The Development and On-Road Performance and Durability of the Four-Way Emission Control SCRTTM System,'' presented by Andy Walker, 9th DEER Conference, August 28, 2003.

[139] Telephone conversation with Gary Keefe, Argillon, June 6, 2006.

concluded that this technology is appropriate for locomotive and marine diesel applications. Furthermore, locomotive and marine diesel engine manufacturers will benefit from the extensive development taking place to implement SCR technologies in advance of the heavy-duty truck NO_X standards in Europe and the U.S. The urea dosing systems for SCR, already in widespread use across many different diesel applications, are expected to become more refined, robust, and reliable in advance of our Tier 4 locomotive and marine standards. Given the predominately steady-state operating characteristics of locomotive and marine engines, SCR NO_X control strategies will certainly be capable of precisely controlling NO_X under all conditions whenever the exhaust gas temperature is greater than 250 °C.

To ensure that we have the most up-to-date information on urea-SCR NO_X technologies and their application to locomotive and marine engines, we have met with a number of locomotive and marine engine manufacturers, as well as manufacturers of catalytic NO_X emission control systems. Through our discussions we have learned that some engine manufacturers perceive some risk regarding urea injection accuracy and long-term catalyst durability, both of which could result in either less efficient NO_X reduction or ammonia emissions. Comments on our NPRM, submitted by the Manufacturers of Emission Controls Association (MECA), provided additional information on the issues of urea dosing accuracy, catalyst durability, and system performance and their comments are consistent with our own analysis that urea-SCR technology can provide durable control of NO_X emissions. We have carefully investigated these issues for other diesel applications and conclude that precise urea injection systems and durable catalysts already exist and have been applied to urea-SCR NO_X emission control systems which are similar to those that we expect to be implemented in locomotive and marine applications.

Urea injection systems applied to on-highway diesel trucks and diesel electric power generators already ensure the precise injection of urea, and these applications have similar—if not more dynamic—engine operation as compared to locomotive and marine engine operation. To ensure precise urea injection across all engine operating conditions, these systems utilize NO_X sensors to maintain closed-loop feedback control of urea injection. These NO_X-sensor-based feedback control systems are similar to oxygen sensor-based systems that are used with catalytic converters on virtually every gasoline vehicle on the road today. These systems, already developed for many diesel engines, are directly applicable to locomotive and marine engines as well.

(c) Durability of Catalytic PM and NO_X Emission Control Technology

Published studies indicate that SCR systems will experience very little deterioration in NO_X conversion throughout the life-cycle of a diesel engine.[140] [141] The principal mechanism of deterioration in an SCR catalyst is thermal sintering—the loss of catalyst surface area due to the melting and growth of active catalyst sites under high-temperature conditions (as the active sites melt and combine, the total number of active sites at which catalysis can occur is reduced). This effect can be minimized by design of the SCR catalyst washcoat and substrate for the exhaust gas temperature window in which it will operate. Several commenters noted that locomotives are subject to consist operation in tunnels, which results in elevated exhaust gas temperatures. Further, they speculated that these elevated exhaust temperatures could reach 700 °C—a temperature that could lead to deterioration of catalyst performance over the useful life of a locomotive. To investigate this scenario, EPA conducted a study (in cooperation with locomotive manufacturers and the railroads) in August, 2007 on Union Pacific's Norden tunnel system (between Sparks, NV and Roseville, CA).[142] We determined that the peak, post-turbine exhaust gas temperature observed in the 2 trailing units of a 4-unit lead consist was only 560 °C. In light of this new information, we are more confident that catalytic aftertreatment devices will be both effective and durable when used in locomotive service.

Another mechanism for catalyst deterioration is chemical poisoning—the plugging and/or chemical de-activation of active catalytic sites. Phosphorus from the engine oil and sulfur from diesel fuel are the primary components in the exhaust stream which can de-activate a catalytic site. The risk of catalyst deterioration due to sulfur poisoning will be all but eliminated with the 2012 implementation of ULSD fuel (<15 ppm S) for locomotive and marine applications. Locomotive and marine operators will already have several years of experience running ULSD fuel by the time NO_X aftertreatment technology is required. Catalyst deterioration due to chemical poisoning can also be reduced through the use of an engine oil with lower levels of sulfated ash, phosphorous, and sulfur (commonly referred to as ''low-SAPS'' oil). Such an oil formulation, designed for use in 2007 DPF- and DOC-equipped on-highway, heavy-duty engines was introduced in October 2006 and is specified by the American Petroleum Institute (API) as ''CJ–4.'' [143] This specification has new and/or lower limits on the amount of sulfated ash, phosphorous, and sulfur an oil may contain and was developed specifically for 2007 on-highway engines equipped with exhaust aftertreatment technologies running on ULSD fuel. Previous oil formulations for heavy-duty, on-highway engines, such as API CI–4, did not specify a limit for sulfur content, and allowed higher levels of phosphorous (0.14% vs. 0.12%) and ash (1.2∼.5% vs. 1.0%) content.[144]

The migration of low-SAPS engine oil properties to future locomotive and marine oil formulations—while beneficial and directionally helpful in regards to the durability, performance, and maintenance of the exhaust aftertreatment components we reference—does not affect our feasibility analysis. European truck and marine applications have shown that SCR is a durable technology even without using a low-SAPs oil formulation. One commenter suggested that these newer, low-SAPS oil formulations, developed for use in on-highway and nonroad diesel engines, may not be appropriate for locomotive or marine applications. While we acknowledge that the exact oil formulation for locomotive and marine applications using ULSD fuel is not known today, we do believe that there is adequate time to develop an appropriate oil formulation. For example, in the State of California, all

[140] Conway, R. et al., ''NO_X and PM Reduction Using Combined SCR and DPF Technology in Heavy Duty Diesel Applications,'' SAE Technical Paper 2005–01–3548, 2005.

[141] Searles, R.A., et al., ''Investigation of the Feasibility of Achieving EURO V Heavy-Duty Emission Limits with Advanced Emission Control Systems,'' 2007 AECC Conference—Belgium, Paper Code: F02E310.

[142] ''Locomotive Exhaust Temperatures During High Altitude Tunnel Operation In Donner Pass,'' U.S. EPA, August 29, 2007. This document is available in Docket EPA–HQ–OAR–2003–0190–0736.

[143] ''API CJ–4 Performance Specifications,'' American Petroleum Institute, online at *http://apicj-4.org/performance_spec.html*. This document is available in Docket EPA–HQ–OAR–2003–0190–0738.

[144] ''CJ–4 Performance Specification: Frequently Asked Questions,'' Lubrizol, online at *http://www.lubrizol.com/cj-4/faq.asp*. This document is available in Docket EPA–HQ–OAR–2003–0190–0741.

intra-state locomotives, marine vessels (in the SCAQMD), and nonroad engines have been operating with ULSD fuel since June, 2006—so there should already be field data/experience available today to begin developing an oil formulation for ULSD in advance of the implementation date for aftertreatment-forcing standards. In addition, the nonroad sector will have transitioned to ULSD fuel nationwide by June, 2010, followed by the locomotive sector in June, 2012—again, leaving ample time to develop an oil formulation which does not contain any more sulphated-ash than necessary to neutralize crankcase acids.

Thermal cycling, mechanical vibration, and shock loads are all factors which can affect the mechanical durability of exhaust system components. The stresses applied to the aftertreatment devices by these factors can be managed through the selection of proper materials and the design of support and mounting structures which are capable of withstanding the shock and vibration levels present in locomotive and marine applications. One commenter to our NPRM stated that shock loading for a locomotive catalyst is estimated to be 10–12 g. This level of shock loading is consistent with the levels that catalyst substrate manufacturers, catalyst canners, and exhaust system manufacturers are currently designing to (for OEM aftertreatment systems and components subject to the durability requirements of on-highway, marine, and nonroad applications). Nonroad applications such as logging equipment are subject to shock loads in excess of 10 g and on-highway applications can exceed 30 g (with some OEM applications specifying a 75 g shock load requirement).[145] In addition, the American Bureau of Shipping (ABS) specification for exhaust manifolds on diesel engines states that these parts may need to withstand vibration levels as high as ±10 g at 600 °C for 90 minutes.[146] Given these examples of shock and vibration requirements for today's nonroad, on-highway, and marine environments, we believe that appropriate support structures can be designed and developed for the aftertreatment devices we expect to be used on Tier 4 locomotives.

(d) Packaging of Catalytic PM and NO_X Emission Control Technologies

Locomotive manufacturers will need to design the exhaust system components to accommodate the aftertreatment system. Our analysis, detailed in the RIA, shows that the packaging requirements for the aftertreatment system are such that they can be accommodated within the envelope defined by the Association of American Railroads (AAR) Plate ''L'' clearance diagram for freight locomotives.[147] The typical volume required for the SCR catalyst and post-SCR ammonia slip catalyst for Euro V and U.S. 2010 heavy-duty truck applications is approximately 2 times the engine displacement, and the upstream DOC/CDPF volume is approximately 1–1.5 times the engine displacement. Due to the longer useful life and maintenance intervals required for locomotive applications, we estimate that the SCR catalyst volume will be sized at approximately 2.5 times the engine displacement, and the combined DOC/CDPF volume will be approximately 1.7 times the engine displacement. For a typical locomotive engine with 6 ft^3 of total cylinder displacement, the volume requirement for the aftertreatment components alone would be approximately 25 ft^3 (of the 80 ft^3 estimated to be available for packaging these components and their associated ducts/hardware above the engine).

EPA engineers have examined Tier 2 EMD and GE line-haul locomotives and acknowledge that packaging the necessary aftertreatment components will be a difficult task. However, this task should not be more difficult (and will quite likely less so) than the packaging challenges faced by nonroad and on-highway applications. Given the space available on today's locomotives, we feel that packaging catalytic PM and NO_X emission control technologies onboard locomotives may be less challenging than packaging similar technologies onboard other mobile sources (such as light-duty vehicles, heavy-duty trucks, and nonroad equipment). Given that similar exhaust systems are either already implemented onboard these vehicles or will be implemented on these vehicles years before similar systems would be required onboard locomotives and marine vessels, we have concluded that any packaging issues will be successfully addressed early in the locomotive and marine vessel design process. Our analysis concludes that there is adequate space to package these components, as well as their associated ducts, transitions, and urea/exhaust mixing devices. This conclusion also applies to new switcher locomotives as well, which while being shorter in length than line-haul locomotives, are also equipped with smaller, less-powerful engines—resulting in smaller volume requirements for the aftertreatment components.

For commercial vessels which use marine diesel engines greater than 600 kW, we expect these vessels will be designed to accommodate the exhaust system components engine manufacturers specify as necessary to meet the new standards. Our discussions with marine architects and engineers, along with our review of vessel characteristics, leads us to conclude that for commercial marine vessels, adequate engine room space can be made available to package aftertreatment components. Packaging of these components, and analyzing their mass/placement effect on vessel characteristics, will become part of design process undertaken by marine architecture firms.[148]

We did determine, however, that for recreational vessels and for vessels equipped with engines less than 600 kW, catalytic PM and NO_X exhaust aftertreatment systems were less practical from a packaging standpoint than for the larger, commercially operated vessels. We have identified catalytic emission control systems that would significantly reduce emissions from these smaller vessels. However, after taking into consideration costs, energy, safety, and other relevant factors, we found a number of reasons, detailed in the RIA, to not adopt any new exhaust aftertreatment-forcing standards at this time on these smaller vessels. One reason is that most of these vessels use seawater-cooled exhaust systems—and even seawater injection into their exhaust systems—to cool engine exhaust gases and prevent the overheating materials such as a fiberglass hull. This current practice of cooling and seawater injection could reduce the effectiveness of catalytic exhaust aftertreatment systems. This is significantly more challenging than for gasoline catalyst systems due to much larger relative catalyst sizes and cooler exhaust temperatures typical of diesel engines. In addition, because of these vessels' small size and their typical operation by planing high on the surface

[145] Correspondence from Adam Kotrba of Tenneco. This document is available in Docket EPA–HQ–OAR–2003–0190–0742.

[146] ''ABS Rules for Building and Classing—Steel Vessels Under 90 Meters (295 Feet) In Length,'' Part 4—Vessel Systems and Machinery, American Bureau of Shipping, 2006.

[147] ''AAR Manual of Standards and Recommended Practices,'' Standard S–5510, Association of American Railroads.

[148] Telephone conversation between Brian King, Elliot Bay Design Group, and Brian Nelson, EPA, July 24, 2006.

of the water, catalytic exhaust aftertreatment systems pose several significant packaging and weight challenges. These challenges could be addressed by the use of lightweight hull and superstructure materials. But any solution which employs new, lightweight hull and superstructure materials would have to be developed, tested and approved by classifying organizations prior to their application on vessels using catalytic exhaust aftertreatment systems. Taken together, these factors led us to conclude that it is not prudent to set aftertreatment-forcing emission standards for marine diesel engines below 600 kW at this time.

(e) Infrastructure Impacts of Catalytic PM and NO_X Emission Control Technologies

For PM trap technology the rail and marine industries will experience minimal impacts on their infrastructures. Since PM trap technology relies on no separate reductant, any infrastructure impacts will be limited to some minor changes in maintenance practices and equipment at maintenance facilities. Such maintenance will be limited to the infrequent removal of ash buildup from within a PM trap. This type of maintenance may require that maintenance facilities periodically remove PM traps for ash cleaning and may involve the use of a crane or other lifting device. We understand that much of this kind of infrastructure already exists for other locomotive and marine engine maintenance practices. We have toured shipyards and locomotive maintenance facilities at rail switchyards, and we observed that such facilities are generally already adequate for any required PM trap removal and maintenance.

We do expect some impact on the railroad and marine sectors to accommodate the use of a separate reductant for use in a NO_X SCR system. For light-duty, heavy-duty, and nonroad applications, the commonly preferred reductant in an SCR system has been a 32.5 percent urea-water solution. The 32.5 percent solution, also known as the ''eutectic'' concentration, provides the lowest freezing point (−11 °C or 12 °F) and ensures that the ratio of urea-to-water will not change when the solution begins to freeze.[149] Heated urea storage tanks and insulation of the urea dosing hardware onboard the locomotive (urea storage tank, pump, and lines) may be necessary to prevent freeze-up in northern climates. Locomotives and marine vessels are commonly refueled from large, centralized fuel storage tanks, tanker trucks, or tenders with long-term purchase agreements. Urea suppliers will be able to distribute urea to the locomotive and marine markets in a similar manner, or they may choose to employ multi-compartment diesel fuel/urea tanker trucks for delivery of both products simultaneously. The frequency that urea will need to be replenished is dependent on many factors; urea storage capacity, engine duty-cycle, and expected urea dosing rate for each application. We expect that locomotive manufacturers and marine vessel designers will size the urea storage tanks appropriate to the usage factors for each application plus some margin-of-safety (to reduce the probability that an engine will be operated without urea). Discussions concerning the urea infrastructure in North America and specifications for an emissions-grade urea solution are now under way amongst light- and heavy-duty on-highway diesel stakeholders.

Although an infrastructure for widespread transportation, storage, and dispensing of SCR-grade urea does not currently exist in the U.S., the affected stakeholders in the light- and heavy-duty on-highway and nonroad diesel sectors are expected to follow the European model, where diesel engine/truck manufacturers and fuel refiners/distributors have formed a collaborative working group known as ''AdBlue.'' The goal of the AdBlue organization is to resolve potential problems with the supply, handling, and distribution of urea and to establish standards for product purity.[150] With regard to urea production capacity, the U.S. has more-than-sufficient capacity to meet the additional needs of the rail and marine industries. For example, in 2003, the total diesel fuel consumption for Class I railroads was approximately 3.8 billion gallons.[151] If 100 percent of the Class I locomotive fleet were equipped with SCR catalysts, approximately 190 million gallons-per-year of 32.5 percent urea-water solution would be required.[152] It is estimated that 190 million gallons of urea solution would require 0.28 million tons of dry urea (1 ton dry urea is needed to produce 667 gallons of 32.5 percent urea-water solution). 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.[153] In the very long-term situation above, where 100 percent of the locomotive fleet required urea, only 6.2 percent of the reserve domestic capacity would be needed to satisfy the additional demand. A similar analysis for the marine industry, with a yearly diesel fuel consumption of 2.2 billion gallons per year, would not significantly impact the urea demand-to-reserve capacity equation. Since the rate at which urea-SCR technology is introduced to the railroad and marine markets will be gradual—and the reserve urea production capacity is more-than-adequate to meet the expected demand from all diesel markets in the 2017 timeframe—EPA does not project any urea cost or supply issues, beyond the costs estimated in the RIA, will result from implementing the Tier 4 standards.

(f) Unregulated Pollutants

There is potential for the formation of unregulated pollutants of significant concern to EPA any time engine technologies change, including when new emission control technologies are added. Some examples of these unregulated pollutants include N^2O and ammonia (NH^3). In addition, failure to dose urea in an SCR system while operating under load may cause elevated NO^2 emissions. Similarly, use of a CDPF that produces NO^2 in excess of what is needed for passive regeneration—and operated without a downstream SCR system—may lead to elevated NO^2 emissions. Such increased NO^2 emissions could be a concern for operation in enclosed environments such as locomotive operation in minimally ventilated or unventilated tunnels. Similarly, use of NO_X reduction catalysts with poor selectivity could result in elevated N^2O emissions. An aggressive urea dosing strategy within an SCR system (for high levels of NO_X control) without a properly designed/calibrated feedback control system, ammonia slip catalyst, or adequate exhaust/urea mixing could also result in elevated ammonia (NH^3) emissions.

[149] Miller, W. et al., ''The Development of Urea-SCR Technology for US Heavy Duty Trucks,'' SAE Technical Paper 2000–01–0190, 2000.

[150] ''Ensuring the Availability and Reliability of Urea Dosing for On-Road and Non-Road,'' presented by Glenn Barton, Terra Corp., 9th DEER Conference, August 28, 2003.

[151] ''National Transportation Statistics—2004,'' Table 4–5, U.S. Bureau of Transportation Statistics.

[152] Assuming the dosing rate of 32.5 percent urea-water solution is 5 percent of the total fuel consumed; 3.8 billion gallons of diesel fuel * 0.05 = 190 million gallons of urea-water solution.

[153] ''Mineral Commodity Summaries 2006,'' page 118, U.S. Geological Survey, online at *www.minerals.usgs.gov/minerals/pubs/mcs/mcs2006.pdf.*

These NH^3 emissions, which can be minimized through the use of closed-loop feedback and control of urea injection, can be all-but-eliminated through use of an oxidation catalyst downstream of the SCR catalyst. Such catalysts, commonly referred to as ''slip catalysts,'' are in use today and have been shown to be highly effective at eliminating ammonia emissions.[154]

The issue of NH^3 emissions (or ammonia slip) was raised by several commenters, with claims that excessive NH^3 emissions are ''inevitable'', and may reach 25 ppm during steady-state operation and 100 ppm during transient operation. We have assessed this issue and concluded that a properly-designed slip catalyst, with good selectivity to nitrogen (N^2), can convert most of the excess NH^3 released from the SCR catalyst into N^2 and water. Recent studies by Johnson Matthey and the Association for Emissions Control by Catalyst (AECC) have shown that an aged SCR system equipped with a slip catalyst can achieve tailpipe NH^3 levels of less of than 10 ppm when tested on the European Stationary Cycle (ESC) and European Transient Cycle (ETC).[154] [155] The SCR system in the Johnson Matthey study was aged on a cycle which included 400 hours of high-temperature operation at 650 °C (to simulate active DPF regeneration events). Our analysis of the locomotive engine operating conditions presumes a maximum, post-turbine exhaust temperature of 560 °C. This presumption is based on implementation of a ''passive'' DPF regeneration approach (in which NO^2 created by the oxidation catalyst is sufficient to oxidize trapped soot) and our own testing of locomotives during operation in non-ventilated tunnels.[142] Under these conditions, we expect slip catalysts to be durable and effective in reducing NH^3 slip.

We expect manufacturers to be conscious of these possibilities and to take appropriate action to minimize or prevent the formation of unregulated pollutants when designing emission control systems. Manufacturers must comply with the ''Prohibited Controls'' section of 40 CFR 1033.115(c), which states:

''You may not design or produce your locomotives with emission control devices, systems, or elements of design that cause or contribute to an unreasonable risk to public health, welfare, or safety while operating. For example, this would apply if the locomotive emits a noxious or toxic substance it would otherwise not emit that contributes to such an unreasonable risk.''

Emission control systems designed to meet the 2007 and 2010 heavy-duty truck and Tier 2 light-duty vehicle emission standards already take these unregulated pollutants into account through compliance with section 202(A)(4) of the Clean Air Act. CDPF systems that minimize formation of excess NO^2 while still relying primarily on passive regeneration have entered production for OEM and retrofit applications. Compact urea-SCR systems that have been developed to meet the U.S. 2010 heavy-duty truck standards use closed-loop controls that continuously monitor NO_X reduction performance. Such systems have the capability to control stack emissions of NH^3 to below 5 ppm during transient operation even without the use of an ammonia slip catalyst. We understand that such systems may still emit some very small level of uncontrolled pollutants and we would not generally consider a system that releases de minimis amounts of NH^3 or N^2O while employing technology consistent with limiting these emissions to be in violation of § 1033.115(c)—which is the same way we currently treat passenger cars and heavy-duty trucks with regard to N^2O and H_2S emissions.

(4) The New Standards Are Technologically Feasible

Our rulemaking involves a range of engines, and we have identified a range of technologically feasible emission control technologies that we project will be used to meet our new standards. Some of these technologies are incremental improvements to existing engine components, and many of these improved components have already been applied to similar engines. The other technologies we identified involve catalytic exhaust aftertreatment systems. For these technologies we carefully examined the catalyst technology, its applicability to locomotive and marine engine packaging constraints, its durability with respect to the lifetime of today's locomotive and marine engines, and its impact on the infrastructure of the rail and marine industries. From our analysis, which is presented in detail in our RIA, we conclude that incremental improvements to engine components and the implementation of catalytic PM and NO_X exhaust aftertreatment technology will be feasible to meet our new emissions standards.

IV. Certification and Compliance Program

This section describes the regulatory changes being finalized for the locomotive and marine compliance programs, beyond the standards discussed in section III. The most obvious change is that the regulations have been written in plain language. They are structured to contain the provisions that are specific to locomotives in a new part 1033 and the provisions that are specific to marine engines and vessels in a new part 1042. We also proposed to apply the general provisions of existing parts 1065 and 1068.[156] The plain language regulations, however, are not intended to significantly change the compliance program, except as specifically noted in today's notice. These plain language regulations will supersede the regulations in part 92 and 94 (for Categories 1 and 2) as early as the 2008 model year. See section III for the starting dates for different engines. The changes from the existing programs are described below briefly along with other notable aspects of the compliance program. See the regulatory text for the detailed requirements and see the Summary and Analysis of Comments document for a more complete rationale for the changes being adopted. **Note:** The term manufacturer is used in this section to include locomotive and marine manufacturers and remanufacturers.

A. Issues Common to Locomotives and Marine

For many aspects of compliance, we are adopting similar provisions for marine engines and locomotives, which are discussed in this section. Several other issues are also included in this section, where we are specifying different provisions, but where the issues are similar in nature. The remaining compliance issues are discussed in sections 00(for locomotives) and 00(for marine).

(1) Test Procedures

(a) Incorporation of Part 1065 Test Procedures for Locomotive and Marine Diesel Engines

As part of our initiative to update the content, organization and writing style

[154] Smedler, Gudmund, ''NO_X Emission Control Options'', 2007 HDD Emission Control Symposium—Gothenberg, Sweden, September 11, 2007.

[155] Searles, R.A., et al., ''Investigation of Feasibility of Achieving EURO V Heavy-Duty Emission Limits with Advanced Emission Control Systems,'' 2007 AECC Conference—Belgium, Paper Code: F02E310.

[156] We proposed modifications to the existing provisions of 40 CFR part 1068 on May 18, 2007 (72 FR 28097). Readers interested in the compliance provisions that will apply to locomotives and marine diesel engines should also read the actual regulatory changes in that will be finalized in that rulemaking.

of our regulations, we are revising our test procedures. We have grouped all of our engine dynamometer and field testing test procedures into one part entitled, ''Part 1065: Test Procedures.'' For each engine or vehicle sector for which we have recently promulgated standards (such as land-based nonroad diesel engines or recreational vehicles), we identified an individual part as the standard-setting part for that sector. These standard-setting parts then refer to one common set of test procedures in part 1065. These programs regulate land-based on-highway heavy-duty engines, land-based nonroad diesel engines, recreational vehicles, and nonroad spark-ignition engines over 19 kW. In this rule, we are applying part 1065 to all locomotive and marine diesel engines, as part of a plan to eventually have all our engine programs refer to a common set of procedures.

In the past, each engine or vehicle sector had its own set of testing procedures. There are many similarities in test procedures across the various sectors. However, as we introduced new regulations for individual sectors, the more recent regulations featured test procedure updates and improvements that the other sectors did not have. As this process continued, we recognized that a single set of test procedures allows for improvements to occur simultaneously across engine and vehicle sectors. A single set of test procedures is easier to understand than trying to understand many different sets of procedures, and it is easier to move toward international test procedure harmonization if we only have one set of test procedures. We note that procedures that are particular for different types of engines or vehicles, for example, test schedules designed to reflect the conditions expected in use for particular types of vehicles or engines, remain separate and are reflected in the standard-setting parts of the regulations.

The part 1065 test procedures are organized and written to be clearer than locomotive- and marine-specific test procedures found in parts 92 and 94. In addition, part 1065 improves the content of the respective testing specifications, including the following:

- Specifications and calculations written in the international system of units (SI)
- Procedures by which manufacturers can demonstrate that alternate test procedures are equivalent to specified procedures
- Specifications for new measurement technology that has been shown to be equivalent or more accurate than existing technology
- Procedures that improve test repeatability
- Calculations that simplify emissions determination
- New procedures for field testing engines
- More comprehensive sets of definitions, references, and symbols
- Calibration and accuracy specifications that are scaled to the applicable standard, which allows us to adopt a single specification that applies to a wide range of engine sizes and applications.

We are adopting the lab-testing and field-testing specifications in part 1065 for all locomotive and marine diesel engines. These procedures replace those currently published in parts 92 and 94. We are making a gradual transition from the part 92 and 94 procedures. In general, we specify that manufacturers use the test procedures in 1065 when certifying under part 1033 or 1042. However, we will allow manufacturers to use a combination of the old and new test procedures through 2014, provided such use is done using good engineering judgment. Moreover, manufacturers may continue to rely on carryover test data based on part 92 or 94 procedures to recertify engine families that are not changing.

In the future, we may apply the test procedures specified in part 1065 to other types of engines, so we encourage companies involved in producing or testing other engines to stay informed of developments related to these test procedures.

(b) Revisions to Part 1065

Part 1065 was originally adopted on November 8, 2002 (67 FR 68242) and was initially applicable to standards regulating large nonroad spark-ignition engines and recreational vehicles under 40 CFR parts 1048 and 1051. The test procedures initially adopted in part 1065 were sufficient to conduct testing, but on July 13, 2005 (70 FR 11534) we promulgated a final rule that reorganized these procedures and added content to make various improvements. Today, we are finalizing additional modifications, largely as proposed. The reader is referred to the NPRM, the regulatory text, and the docket for more information about the changes being made to Part 1065 in this final rule. Note that since part 1065 applies for diesel engines subject to parts 86 and 1039, we are also making some minor revisions to those parts to reflect the changes being made to part 1065. (We are also making a technical correction to an equation in § 86.117–96.)

These changes will become effective July 7, 2008. Section 1065.10(c)(6) of the existing regulations includes a provision that automatically allows manufacturers an additional 12 months beyond the effective date to revise their test procedures to comply with the new regulations. Since these changes will not affect the stringency of the standards, we also plan to use our authority under § 1065.10(c)(4) to allow the use of carryover data collected using the earlier procedures.

(2) Certification Fuel

It is well-established that measured emissions may be affected by the properties of the fuel used during the test. For this reason, we have historically specified allowable ranges for test fuel properties such as cetane and sulfur content. These specifications are intended to represent most typical fuels that are commercially available in use. This helps to ensure that the emissions reductions expected from the standards occur in use as well as during emissions testing.

In our previous regulation of in-use locomotive and marine diesel fuel, we established a 15 ppm sulfur standard at the refinery gate for locomotive and marine (LM) diesel fuel beginning June 1, 2012. However, since we intended to allow the sale, distribution, and use of higher sulfur LM diesel fuel (such as contaminated ULSD) to continue indefinitely, we did not set a ''hard and fast'' downstream requirement that only 15 ppm LM diesel may be sold and distributed in all areas of the country . Because refiners cannot intentionally produce off-specification fuel for locomotives, most in-use locomotive and marine diesel fuel will be ULSD (with a sulfur content of 15 ppm or less). Nevertheless, we expect that some fuel will be available with sulfur levels between 15 and 500 ppm, and our existing regulations require that such fuel be designated as 500 ppm sulfur diesel fuel. Note that fuel designated as 500 ppm sulfur is also known as low sulfur diesel fuel (LSD).

Because we have reduced the upper limit for locomotive and marine diesel fuel sulfur content for refiners to 15 ppm in 2012, we are establishing new ranges of allowable sulfur content for diesel test fuels. See section 0 for information about testing marine engines designed to use residual fuel. For marine diesel engines, we are specifying the use of ULSD fuel as the test fuel for Tier 3 and later standards. We believe this will correspond to the fuels that these engines will see in use over the long term. We recognize that this approach will mean that some marine engines will use a test fuel that is lower in sulfur than in-use fuel during the first few years and that other Tier 2 marine engines allowed to be produced after 2012 will use a test fuel that is higher in sulfur than fuel already available in use when they are produced. However, we believe that it is more important to align changes in marine test fuels with changes in the PM standards than strictly with changes in the in-use fuel. Nevertheless, we are allowing Tier 2 certification with fuel meeting the 7 to 15 ppm sulfur specification to simplify testing but will require that PM emissions be corrected to be equivalent to testing conducted with the specified fuel. This will ensure that the effective stringency of the Tier 2 standards will not be affected.

For locomotives, we will require that Tier 4 engines be certified based on ULSD test fuels. We are also requiring that these locomotives use ULSD in the field. We will continue to allow the use of 500 ppm LM diesel fuel, in older locomotives in the field.[157] Thus, we are requiring that remanufacture systems for Tier 0 and Tier 1 locomotives be certified on LSD test fuel. We are allowing the use of test fuels other than those specified here. Specifically, we will allow the use of ULSD during emission testing for locomotives otherwise required to use LSD, provided they do not use sulfur-sensitive technology (such as oxidation catalysts). However, as a condition of this allowance, the manufacturer will be required to add an additional amount to the measured PM emissions to make them equivalent to what would have been measured using LSD. For example, we will allow a manufacturer to test with ULSD if they adjusted the measured PM emissions upward by 0.01 g/bhp-hr (which would be a relatively conservative adjustment and would ensure that manufacturers would not gain an inappropriate advantage by testing on ULSD).

We are adopting special fuel provisions for Tier 3 locomotives and Tier 2 locomotive remanufacture systems. The final regulations specify that the test fuel for these be ULSD without sulfur correction since these locomotives will use ULSD in use for most of their service lives. However, unlike Tier 4 locomotives, we will not require them to be labeled to require the use of ULSD, unless they included sulfur sensitive technology.

We are adopting a new flexibility for locomotives and Category 2 marine engines to reduce fuel costs for testing. Because these engines can consume 200 gallons of diesel fuel per hour at full load, fuel can represent a significant fraction of the testing cost, especially if the manufacturer must use specially blended fuel rather than commercially available fuel. To reduce this cost, we will allow manufacturers to immediately begin testing of locomotives and Category 2 marine engines with commercially available diesel fuel. We do not believe that this will change the effective stringency of the standards.

For both locomotive and marine engines, all of the specifications described above will apply to emission testing conducted for certification, production-line testing, and in-use, as well as any other testing for compliance purposes for engines in the designated model years. Any compliance testing of previous model year engines will be done with the fuels designated in our regulations for those model years.

(3) Supplemental Emission Standards

We are continuing the supplemental emission standards for locomotives and marine engines. For locomotives, this means we will continue to apply notch emission caps, based on the emission rates in each notch, as measured during certification testing. We recognize that for our Tier 4 standards it will not be practical to measure very low levels of PM emissions separately for each notch during testing, and thus we are changing the calculation of the PM notch cap for Tier 4 locomotives. All other notch caps will be determined and applied as they currently are under 40 CFR 92.8(c). See § 1033.101(e) of the regulations for the detailed calculation.

Marine engines will continue to be subject to not-to-exceed (NTE) standards; however, we are making certain changes to these standards based upon our understanding of in-use marine engine operation and based upon the underlying Tier 3 and Tier 4 duty cycle emissions standards. As background, we determine NTE compliance by first applying a multiplier to the duty-cycle emission standard, and then we compare to that value an emissions result that is recorded when an engine runs within a certain range of engine operation. This range of operation is called an NTE zone (see 40 CFR 94.106). The first regulation of ours that included NTE standards was the commercial marine diesel regulation, finalized in 1999. After we finalized that regulation, we promulgated other NTE regulations for both heavy-duty on-highway and nonroad diesel engines. We also finalized a regulation that requires heavy-duty on-highway engine manufacturers to conduct field testing to demonstrate in-use compliance with the on-highway NTE standards. Throughout our development of these other regulations, we have learned many details about how best to specify NTE zones and multipliers that will ensure the greatest degree of in-use emissions control, while at the same time will avoid disproportionately stringent requirements for engine operation that has only a minor contribution to an engine's overall impact on the environment. Based upon the Tier 3 and Tier 4 standards—and our best information of in-use marine engine operation—we are making certain improvements to our marine NTE standards.

For marine engines we are broadening the NTE zones in order to better control emissions in regions of engine operation where an engine's emissions rates (i.e. grams/hour, tons/day) are greatest; namely at high engine speed and high engine load. This is especially important for commercial marine engines because they typically operate at steady-state at high-speed and high-load operation. This change also will make our marine NTE zones much more similar to our on-highway and nonroad NTE zones. Additionally, we analyzed different ways to define the marine NTE zones, and we determined a number of ways to improve and simplify the way we define and calculate the borders of these zones. We feel that these improvements will help clarify when an engine is operating within a marine NTE zone.

Note that we specify different duty cycles to which a marine engine may be certified, based upon the engine's specific application (e.g., fixed-pitch propeller, controllable-pitch propeller, constant speed, auxiliary, etc.). These duty cycles are described below in section 0. Correspondingly, we also have a unique NTE zone for each of these duty cycles. These different NTE zones are intended to best reflect an engine's real-world range of operation for that particular application. One primary change in the NTE zones, compared to the NPRM, is for controllable-pitch propeller applications. Rather than using the nonroad NTE zone, as proposed, the final NTE zone for these engines has been revised to better reflect marine engine operation. Please refer to section 1042.101(c) of the new regulations for a description of our new NTE standards. In the cases where marine auxiliary engines use the same duty cycle as their land-based nonroad counterparts, we

[157] Under our existing fuel regulations (40 CFR 80.510(g)), 500 ppm LM diesel fuel may not be sold and/or distributed in the Northeast/Mid-Atlantic (NE/MA) area beginning October 1, 2012. Such fuel may no longer be used in the NE/MA area beginning December 1, 2012.

are adopting the same NTE standards as we have already finalized for nonroad engines in 40 CFR § 1039.101. As the standards for marine diesel engines under 75 kW are based on the corresponding nonroad engine standards, we are aligning the NTE standard start dates for these engines with the nonroad engine NTE start dates in 2012 and 2013.

We are also implementing new NTE multipliers. We have analyzed how the Tier 3 and Tier 4 emissions standards affect the stringency of the marine NTE standards, especially in comparison to the stringency of the underlying duty cycle standards. We recognized that in certain sub-regions of our new NTE zones, slightly higher multipliers are necessary because of the way that our more stringent Tier 3 and Tier 4 emissions standards will affect the stringency of the NTE standards. For comparison, Tier 2 marine NTE standards contain multipliers that range in magnitude from 1.2 to 1.5 times the corresponding duty cycle standard. The new multipliers range from 1.2 to 1.9 times the standard. Even with these slightly higher NTE multipliers, we are confident that our changes to the marine NTE standards will ensure the greatest degree of in-use emissions control. We are also confident that our changes to the marine NTE standards will continue to ensure proportional emissions reductions, across the full range of marine engine operation.

We are also adopting other NTE provisions for marine engines that are similar to our existing heavy-duty on-highway and nonroad diesel NTE standards. We are making these particular changes to account for the implementation of catalytic exhaust treatment devices on marine engines. One such provision is to account for when a marine engine rarely operates within a limited region of the NTE zone (i.e. less than 5 percent of in-use operation). Another provision allows small deficiencies in NTE compliance for a limited period of time. We feel that these provisions have been effective in our on-highway and nonroad NTE programs; therefore, we are adopting them for our marine NTE standards as well.

(4) Emission Control Diagnostics

We requested comment on a requirement that all Tier 4 engines include a simple engine diagnostic system to alert operators to general emission-related malfunctions. As is described in the S&A document, we are not adopting such general requirements today. (See section 0 of this Final Rule for related requirements involving SCR systems.) We are, however, adopting special provisions for locomotives that include emission related diagnostics. First, we will require locomotive operators to respond to malfunction indicators by performing the required maintenance or inspection. Second, locomotive manufacturers will be allowed to repair such malfunctioning locomotives during in-use compliance testing (they would still be required to include a description of the malfunction in the in-use testing report.). This approach takes advantage of the unique market structure with two major manufacturers and only a few railroads buying nearly all of the freshly manufactured locomotives. These provisions create incentives for both the manufacturers and railroads to work together to develop a diagnostic system that would effectively reveal real emission malfunctions. Our current regulations already require that locomotive operators complete all manufacturer-specified emission-related maintenance, and this new requirement treats repairs indicated by diagnostic systems as such emission-related maintenance. Thus, the railroads will have a strong incentive to make sure that they only have to perform this additional maintenance when real malfunctions are occurring. On the other hand, manufacturers will want to have all emission malfunctions revealed so that when they test an in-use locomotive they can repair identified malfunctions before testing if the railroad has not yet done it.

(5) Monitoring and Reporting of Emissions Related Defects

We are applying the defect reporting requirements of § 1068.501 to replace the provisions of subparts E in parts 92 and 94. This will result in two significant changes for manufacturers. First, § 1068.501 obligates manufacturers to tell us when they learn that emission control systems are defective and to conduct investigations under certain circumstances to determine if an emission-related defect is present. Second, it changes the thresholds after which they must submit defect reports. See the text 40 CFR 1068.501 for details about this requirement.

(6) Rated Power

We are specifying in parts 1033 and 1042 how to determine maximum engine power in the regulations for both locomotives and marine engines. The term ''maximum engine power'' will be used for marine engines instead of previously undefined terms such as ''rated power'' or ''power rating'' to specify the applicability of the standards. The addition of this definition is intended to allow for more objective applicability of the standards. More specifically, for marine engines, we define maximum engine power to mean the maximum brake power output on the nominal power curve for an engine.

For locomotives, the term ''rated power'' will continue to be used, but is explicitly defined to be the brakepower of the engine at notch 8. We will continue to use the term ''rated power'' because this definition is consistent with the commercial meaning of the term.

(7) In-Use Compliance for SCR Operation

As discussed in section III.C, we are projecting that manufacturers will use urea-based SCR systems to comply with the Tier 4 emission standards.[158] These systems are very effective at controlling NO_X emissions as long as the operator continues to supply urea of acceptable quality. Thus we considered concepts put forward by manufacturers in other mobile source sectors in dealing with this issue. These include design features to prevent an engine from being operated without urea if an operator ignores repeated warnings and allows the urea level to run too low. EPA has issued a guidance document for urea SCR systems discussing the use of such features on highway diesel vehicles.

We believe that the nature of the locomotive and large commercial marine sectors supports a different in-use compliance approach. This approach focuses on requirements for operators of locomotives and marine diesel engines that depend on urea SCR to meet EPA standards, aided by onboard alarm and logging mechanisms that engine manufacturers will be required to include in their engine designs. Except in the rare instance that operation without urea may be necessary, the regulatory provisions put no burden on the end-user beyond simply filling the urea tank with appropriate quality urea. Specifically, we are specifying:

- That it is illegal to operate without acceptable quality urea when the urea is needed to keep the SCR system functioning properly;
- That manufacturers must include clear and prominent instructions to the operator on the need for, and proper steps for, maintaining urea, including a

[158] The provisions described in this section will apply equally to SCR systems using reductants other than urea, except for systems using normal diesel fuel as the reductant.

statement that it is illegal to operate the engine without urea;

• That manufacturers must include visible and audible alarms at the operator's console to warn of low urea levels or inadequate urea quality;

• That engines and locomotives must be designed to track and log, in nonvolatile computer memory, all incidents of engine operation with inadequate urea injection or urea quality; and

• That operators must report to EPA in writing any incidence of operation with inadequate urea injection or urea quality within 30 days of each incident, and

• That, when requested, locomotive and vessel operators must provide EPA with access to, and assistance in obtaining information from, the electronic onboard incident logs.

We understand that in extremely rare circumstances, such as during a temporary emergency involving risk of personal injury, it may be necessary to operate a vessel or locomotive without adequate urea. We would intend such extenuating circumstances to be taken into account when considering what penalties or other actions are appropriate as a result of such operation. The information from SCR compliance monitoring systems described above may also be useful for state and local air quality agencies and ports to assist them in any marine engine compliance programs they implement.

Our new regulations specify that what constitutes acceptable urea solution quality be specified by the manufacturers in their maintenance instructions and require that the certified emission control system must meet the emissions standards with any urea solution within stated specifications. This could be facilitated by an industry standard for urea quality, which we expect will be generated in the future as these systems move closer to market. We recognize that this will likely require automated sensing of some characteristic indicator such as urea concentration or exhaust NO_X concentration.

We believe these provisions can be an effective tool in ensuring urea use for locomotives and large commercial marine vessels because of the relatively small number of railroads and operators of large commercial vessels in the U.S., especially considering that the number of SCR-equipped locomotives and vessels will ramp up quite gradually over time. In-use compliance provisions of the sort we are adopting for locomotives and large commercial marine engines would be much less effective in other mobile source sectors such as highway vehicles because successful enforcement involving millions of vehicle owners would be extremely difficult. In addition, the highway and nonroad diesel sectors are characterized by a wide variety of applications and duty cycles, which further differentiate in-use compliance approaches that may make sense in the relatively uniform rail and marine sectors from those that would be effective in the highway and nonroad sectors.

(8) Temporary In-Use Compliance Margins

Consistent with the approach we took in the highway heavy-duty rule (66 FR 5113) and nonroad diesel rule (69 FR 38957), we are adopting a provision for in-use compliance flexibility in the initial years of the Tier 4 program. We proposed to allow adjusted in-use compliance standards for the first three model years of the Tier 4 locomotive standards to help assure the manufacturers that they will not face recall if they exceed standards by a small amount during this transition to advanced clean diesel technologies.

Commenters suggested that the reasons we gave for applying this provision to locomotives were valid for marine engines too. We agree and are extending this provision to Tier 4 marine diesel engines. Commenters also argued that we over-emphasized the flexibility needed for NO_X technology compared to PM technology. In response, we have concluded that it is appropriate to provide an alternative set of margins available to manufacturers willing to accept more stringent in-use compliance levels for NO_X in exchange for somewhat less stringent levels for PM.

Table IV–1 shows the in-use adjustments that we will apply. These adjustments would be added to the appropriate standards or FELs in determining the in-use compliance level for a given in-use hours accumulation. Our intent is that these add-on levels be available only for highly-effective advanced technologies such as particulate traps and SCR, and so we will apply them only to engines certified at or below the Tier 4 standards without the use of credits, through the first three model years of the new standards. As part of the certification process, manufacturers will still be required to demonstrate compliance with the unadjusted Tier 4 certification standards using deteriorated emission rates. Therefore manufacturers will not be able to use these in-use adjustments in setting design targets for the engine. They need to project that engines will meet the standards in use without adjustment. The in-use adjustments merely provide some assurance that they will not be forced to recall engines because of some small miscalculation of the expected deterioration rates.

Also, to avoid what would essentially be a doubling up of the benefits of the two alternatives, contrary to their purpose, we are requiring that a manufacturer may only use the alternative set of add-ons for an engine family if this choice is indicated in the certification application and may not reverse this choice in carry-over certifications or certifications by design.

TABLE IV–1.—IN-USE ADD-ONS (g/bhp-hr)

For useful life fractions	Primary set		Alternative set	
	NO_X	PM	NO_X	PM
<50% UL	0.7	....	0.2	0.03
50%–75% UL	1.0	0.01	0.3	
>75% UL	1.3	....	0.4	

As discussed in section III.B(1)(a)(ii), in response to industry comments, we are providing another Tier 4 NO_X compliance option for line-haul locomotives with a reduced in-use NO_X add-on of 0.6 g/bhp-hr. Under this option, for the first 8 model years of Tier 4 (2015–2022), a line-haul locomotive manufacturer may certify a locomotive to the 1.3 g/bhp-hr NO_X standard without needing to calculate or apply a deterioration factor. These locomotives, when tested in-use, must comply with an in-use standard of 1.9 g/bhp-hr but do not get the additional NO_X compliance margins discussed above.

Because this option is meant to address manufacturer concerns about manufacturing variability as well as catalyst durability, we are allowing manufacturers using this option to substitute an in-use locomotive test for each required production line test. These tests must be conducted on locomotives with more than 50 hours of accumulated operation, but at less than one-half of their useful life, and are in addition to normally-required manufacturer in-use testing. Furthermore, locomotives certified under this option may not generate credits under the ABT program because of their potentially higher in-use emissions. Also, of course, they may not be purposely designed to emit regulated pollutants at higher levels in use than at certification. This option will be available through the 2022 model year. It will not be available for the 2015–2022 model year locomotives when they are remanufactured in 2023 or later.

(9) Fuel Labels and Misfueling

The advanced emission controls that will be used to comply with many of the new standards will require the use of ULSD. Therefore, we are requiring that manufacturers notify each purchaser of a Tier 4 locomotive or marine engine that it must be fueled only with the ultra low-sulfur diesel fuel meeting our regulations. We are also applying this requirement for locomotives and engines having sulfur-sensitive technology and certified using ULSD. All of these locomotives and vessels must be labeled near the refueling inlet to say: ''Ultra-Low Sulfur Diesel Fuel Only''. These labels are required to be affixed or updated any time any engine on a vessel is replaced after the new program goes into effect.

We are requiring the use of ULSD in locomotives and vessels labeled as requiring such use, including all Tier 4 locomotives and marine engines. More specifically, use of the wrong fuel for locomotives or marine engines would be a violation of 40 CFR 1068.101(b)(1) because use of the wrong fuel would have the effect of disabling the emission controls.

We addressed the supply of ultra-low sulfur fuel in our previous regulation of in-use locomotive and marine diesel fuel. Specifically, we established a 15 ppm sulfur standard at the refinery gate for locomotive and marine (LM) diesel fuel beginning June 1, 2012. However, since we allow the sale, distribution, and use of 500 ppm LM diesel fuel to continue indefinitely, we did not set a ''hard and fast'' downstream requirement that only 15 ppm LM diesel may be sold and distributed in all areas of the country.[159] This was to allow the LM diesel fuel pool to remain an outlet for off-specification distillate product and interface/transmix material. Because refiners cannot intentionally produce off-specification fuel for locomotives—refiners will no longer be able to produce nonroad, locomotive, or marine diesel fuel above 15 ppm beginning June 1, 2012—most in-use locomotive and marine diesel fuel will be ULSD (with a sulfur content of 15 ppm or less). Nevertheless, we expect that some fuel will be available with sulfur levels between 15 and 500 ppm, and our regulations require such fuel to be designated as 500 ppm sulfur diesel fuel.

We received comments regarding the fact that we did not set a strict downstream requirement on the use of 15 ppm LM for the entire country. The commenters feared that while a port might receive deliveries of 15 ppm LM fuel, the port might keep its pump labeled as ''500 ppm LM'' to allow it to receive and dispense either 15 ppm or 500 ppm LM. (As part of the diesel fuel regulations, all pumps dispensing diesel fuel must be labeled with the type and maximum sulfur level of the diesel fuel being dispensed.) The commenters were concerned that if such practice were widespread, marine vessels that require ULSD could potentially have problems finding it.

We understand the commenters' concerns and have discussed a few potential solutions to this problem. One possible option is to require large ports (i.e., ports over some certain size) to make 15 ppm LM diesel fuel available. This size requirement could be by volume of single sale or above some other specified volume. Under this requirement, those ports with multiple tanks could continue to offer 500 ppm LM diesel fuel in addition to the 15 ppm LM diesel fuel. Or, if a port (regardless of size) continues to sell 500 ppm LM diesel fuel, it must also sell 15 ppm LM diesel fuel. Another potential option would be to limit the sale of 500 ppm LM diesel fuel to small ports and locomotives only. However, these potential solutions would need to be discussed thoroughly with all stakeholders (including those in the fuel distribution and marketing industry) and put out for notice and comment. Therefore, we are merely noting potential solutions in this final rule but we are committing to investigate this issue further and, if the facts warrant doing so, addressing it in a separate action.

(10) Deterioration Factor Plan Requirements

In this rulemaking, we are amending our deterioration factor (DF) provisions to include an explicit requirement that DF plans be submitted by manufacturers for our approval in advance of conducting engine durability testing, or in the case where no new durability testing is being conducted, in advance of submitting the engine certification application. We are not fundamentally changing either the locomotive or marine engine DF requirements with this provision, other than to require advance approval.

An advance submittal and approval format will allow us sufficient time to ensure consistency in DF procedures, without the need for manufacturers to repeat any durability testing or for us to deny an application for certification should we find the procedures to be inconsistent with the regulatory provisions. We expect that the DF plan would outline the amount of service accumulation to be conducted for each engine family, the design of the representative in-use duty cycle on which service will be accumulated, and the quantity of emission tests to be conducted over the service accumulation period.

(11) Production Line Testing

We proposed to continue the existing production line testing provisions that apply to manufacturers. Some manufacturers suggested that we should eliminate this requirement on the basis that very low noncompliance rates are being detected at a high expense. While we agree that compliance rates have been very good, we do not agree that they mean that the program has little or no value. As we move toward more stringent emission standards with this rulemaking, we anticipate that the margin of compliance with the standards for these engines is likely to decrease. Consequently, this places an even greater significance on the need to ensure little variation in production engines from the certification engine, which is often a prototype engine. For this reason, it is important to maintain our production line testing program.

However, the existing regulations allow manufacturers to develop alternate programs that provide equivalent assurance of compliance on the production line and to use such programs instead of the specified

[159] However, in the Northeast/Mid-Atlantic (NE/MA) area, as defined at 40 CFR 80.510(g), 500 ppm LM diesel fuel may no longer be sold and/or distributed beginning October 1, 2012. Such fuel may no longer be used in the NE/MA area beginning December 1, 2012.