
ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 80, 85, 86, 94, 1027, 1033, 1039, 1042, 1043, 1045, 1048, 1051, 1054, 1060, 1065, and 1068

[EPA–HQ–OAR–2007–0121; FRL_XXXX-X]

RIN 2060-AO38

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

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final Rule.

SUMMARY: EPA is finalizing emission standards for new marine diesel engines with per-cylinder displacement at or above 30 liters (called Category 3 marine diesel engines) installed on U.S. vessels. These emission standards are equivalent to those adopted in the amendments to Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL Annex VI). The emission standards apply in two stages—near-term standards for newly built engines will apply beginning in 2011; long-term standards requiring an 80 percent reduction in NO_X emissions will begin in 2016. We are also finalizing a change to our diesel fuel program that will allow for the production and sale of 1,000 ppm sulfur fuel for use in Category 3 marine vessels. In addition, the new fuel requirements will generally forbid the production and sale of other fuels above 1,000 ppm sulfur for use in most U.S. waters, unless alternative devices, procedures, or compliance methods are used to achieve equivalent emissions reductions. We are adopting further provisions under the Act to Prevent Pollution from Ships, especially to apply the emission standards to engines covered by MARPOL Annex VI that are not covered by the Clean Air Act, and to require that these additional engines use the specified fuels (or equivalents).

The final regulations also include technical amendments to our motor vehicle and nonroad engine regulations; many of these changes involve minor adjustments or corrections to our recently finalized rule for new nonroad spark-ignition engines, or adjustment to other regulatory provisions to align with this recent final rule.

DATES: This final rule is effective on [*Insert date 60 days after publication in the* **Federal Register]**. The incorporation by reference of certain publications listed in this regulation is approved by the Director of the **Federal Register** as of [*Insert date 60 days after publication in the* **Federal Register].**

ADDRESSES: EPA has established a docket for this action under Docket ID No. **EPA-HQ-OAR-2007-0121**. 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 in www.regulations.gov or in hard copy at the **EPA-HQ-OAR-2007-0121** 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 **EPA-HQ-OAR-2007-0121** is (202) 566-1742.

FOR FURTHER INFORMATION CONTACT: Amy Kopin, 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) 214-4417; fax number: (734) 214-4050; email address: Kopin.Amy@epa.gov, or Assessment and Standards Division Hotline; telephone number: (734) 214-4636.

SUPPLEMENTARY INFORMATION:

General Information

Does this Action Apply to Me?

This action affects companies that manufacture, sell, or import into the United States new marine compression-ignition engines with per cylinder displacement at or above 30 liters for use on vessels flagged or registered in the United States; companies and persons that make vessels that will be flagged or registered in the United States and that use such engines; and the owners or operators of such U.S. vessels. Additionally, this action may affect companies and persons that rebuild or maintain these engines. Finally, this action may also affect those that manufacture, import, distribute, sell, and dispense fuel for use by Category 3 marine vessels. Affected categories and entities include the following:

Category	NAICS Code[a]	Examples of potentially affected entities
Industry	333618	Manufacturers of new marine diesel engines.
Industry	336611	Manufacturers of marine vessels.
Industry	811310	Engine repair and maintenance.
Industry	483	Water transportation, freight and passenger.
Industry	324110	Petroleum Refineries.
Industry	424710, 424720	Petroleum Bulk Stations and Terminals; Petroleum and Petroleum Products Wholesalers.
Industry	483113	Coastal and Great Lakes Freight Transportation
Industry	483114	Coastal and Great Lakes Passenger Transportation

Note:
[a] North American Industry Classification System (NAICS)

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by this action. This table lists the types of entities that EPA is now aware will be regulated by this action. Other types of entities not listed in the table may also be regulated. To determine whether your company is regulated by this action, you should carefully examine the applicability criteria in 40 CFR 80.501, 94.1, 1042.1, and 1065.1, and the final regulations. If you have questions, consult the person listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

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I. Overview

This final rule is part of a coordinated strategy to address emissions from ocean-going vessels and is an important step in EPA's ongoing National Clean Diesel Campaign. In recent years, we have adopted major new programs designed to reduce emissions from new diesel engines, including those used in highway (66 FR 5001, January 18, 2001), nonroad (69 FR 38957, June 29, 2004), locomotive, and marine applications (73 FR 25098, May 6, 2008). When fully phased in, these programs will significantly reduce emissions of harmful pollutants from these categories of engines and vehicles. This final rule sets out the next step in this ambitious effort by addressing emissions from the largest marine diesel engines, called Category 3 marine diesel engines. These are engines with per-cylinder displacement at or above 30 liters per cylinder, which are used primarily for propulsion power on ocean-going vessels (OGV).[1]

Emissions from Category 3 engines remain at high levels. These engines use emission control technology that is comparable to that used by nonroad engines in the early 1990s, and use fuel that can have a sulfur content of 30,000 ppm or more. As a result, these engines emit high levels of pollutants that contribute to unhealthy air in many areas of the U.S. Nationally, in 2009,

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[1] This final rule generally applies to vessels with the largest marine diesel engines, which are called Category 3 engines in our regulations. In this preamble, we often refer to vessels using these engines as Category 3 vessels. We also refer to them as ocean-going vessels although this intended to be only a descriptive term. While the large majority of these vessels operate in the oceans, some operate solely in our internal waters such as in the Great Lakes. Therefore, we do not use the term ocean-going vessels to exclude the few vessels with Category 3 engines that operate only in fresh-water lakes or rivers or to exclude ocean-going vessels with Category 2 or Category 1 engines, but rather to reflect the way the vessels being regulated are more commonly known to the general public. Note also that, pursuant to 40 CFR 1043 which implements APPS, the fuel requirements described in this rule, unless otherwise specified, generally apply also to fuel used in gas turbines and steam boilers on marine vessels.

emissions from Category 3 engines account for about 10 percent of mobile source emissions of nitrogen oxides (NO_X), about 24 percent of mobile source diesel $PM_{2.5}$ emissions (with $PM_{2.5}$ referring to particles with a nominal mean aerodynamic diameter less than or equal to 2.5 µm), and about 80 percent of mobile source emissions of sulfur oxides (SO_X). As we look into the future, however, emissions from Category 3 engines are expected to become an even more dominant inventory source. This will be due to both emission reductions from other mobile sources as new emission controls go into effect and to the anticipated activity growth for ocean transportation. Without new controls, we anticipate the contribution of Category 3 engines to national emission inventories to increase to about 24 percent, 34 percent, and 93 percent of mobile source NO_X, $PM_{2.5}$, and SO_X emissions, respectively in 2020, growing to 40 percent, 48 percent, and 95 percent respectively in 2030. The coordinated emission control strategy will lead to significant reductions in these emissions and important benefits to public health.

The evolution of EPA's strategy to control mobile source diesel emissions has followed a technology progression, beginning with the application of high-efficiency advanced aftertreatment approaches and lower sulfur fuel requirements first to highway vehicles, then to nonroad engines and equipment, followed by locomotives and smaller marine diesel engines. The benefits of this approach include maximizing air quality benefits by focusing on the largest populations of sources with the shortest service lives, allowing engine manufacturers to spread initial research and development costs over a larger population of engines, and allowing manufacturers to address the challenges of applying advanced emission controls on smaller engines first.

This approach also allowed us and the shipping community sufficient lead time to resolve technical issues with the use of advanced emission control technology and lower-sulfur fuel on the largest of these engines on vessels engaged in international trade. To that end, EPA has been working with engine manufacturers and other industry stakeholders for many years to identify and resolve challenges associated with applying advanced diesel engine technology to Category 3 engines to achieve significant NO_X emission reductions and using lower-sulfur fuels to achieve significant PM and SO_X emission reductions. This work was fundamental in developing the emission limits for Category 3 engines that we are finalizing in this action and informed the position advocated by the United States in the international negotiations for more stringent tiers of international engine emission limits.

Our coordinated strategy to control emissions from ocean-going vessels consists of actions at both the national and international levels. It includes: (1) the engine and fuel controls we are finalizing in this action under our Clean Air Act authority; (2) the proposal[2] submitted by the U.S. Government to the International Maritime Organization (IMO) to amend Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL Annex VI) to designate U.S. coasts as an Emission Control Area (ECA)[3] in which all vessels, regardless of flag, would be required to meet the most stringent engine and marine fuel sulfur requirements in Annex

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[2] *Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulphur Oxides and Particulate Matter*, Submitted by the United States and Canada. IMO Document MEPC59/6/5, 27 March, 2009. A copy of this document can be found at http://www.epa.gov/otaq/regs/nonroad/marine/ci/mepc-59-eca-proposal.pdf

[3] For the purpose of this final rule, the term "ECA" refers to both the ECA and internal U.S. waters. Refer to Section VI.B. for a discussion of the application of the fuel sulfur and engine emission limits to U.S. internal waters through APPS.

VI; and (3) the new engine emission and fuel sulfur limits contained in the amendments to Annex VI that are applicable to all vessels regardless of flag through the Act to Prevent Pollution from Ships (APPS), as well as clarification on implementation of those standards, application to domestic and foreign-flagged vessels in internal waters, and application to nonparty foreign-flagged vessels.

The amendments to APPS to incorporate Annex VI require compliance with MARPOL Annex VI by U.S. and foreign vessels that enter U.S. ports or operate in U.S. waters. In light of this, we are deciding not to revisit our existing approach with respect to foreign vessels in this rule. However, the MARPOL Annex VI Tier III NO_X and stringent fuel sulfur limits are geographically based and would not become effective absent designation of U.S. coasts as an ECA. As noted above, the United States forwarded a proposal to IMO to amend Annex VI to designate U.S. coasts as an ECA. This proposal to amend Annex VI was approved in principle and circulated for adoption. We expect the proposed ECA amendment will be adopted at MEPC 60, in March 2010. If this amendment is not adopted in a timely manner by IMO, we intend to take supplemental action to control emissions from vessels that affect U.S. air quality.

Our coordinated strategy for ocean-going vessels will significantly reduce emissions from foreign and domestic vessels that affect U.S. air quality, and the impacts on human health and welfare will be substantial. We project that by 2030 this program will reduce annual emissions of NO_X, SO_X, and particulate matter (PM) by 1.2 million, 1.3 million, and 143,000 tons, respectively, and the magnitude of these reductions would continue to grow well beyond 2030.[4] These reductions are estimated to annually prevent between 12,000 and 30,000 PM-related premature deaths, between 210 and 920 ozone-related premature deaths, 1,400,000 work days lost, and 9,600,000 minor restricted-activity days. The estimated annual monetized health benefits of this coordinated strategy in 2030 would be between $110 and $270 billion, assuming a 3 percent discount rate (or between $99 and $240 billion assuming a 7 percent discount rate). The annual cost of the overall program in 2030 would be significantly less, at approximately $3.1 billion.

A. What are the Elements of EPA's Coordinated Strategy for Ships?

Our coordinated strategy for ocean-going vessels, including the emission standards finalized in this action under the Clean Air Act, continues EPA's program to progressively apply advanced aftertreatment emission control standards to diesel engines and reflects the evolution of this technology from the largest inventory source (highway engines), to land-based nonroad engines, to locomotives and marine diesel engines up to 30 liters per cylinder. The results of these forerunner programs are dramatic reductions in NO_X and $PM_{2.5}$ emissions on the order of 80 to 90 percent, which will lead to significant improvements in national air quality.

The combination of controls in the coordinated strategy for ocean-going vessels will provide significant reductions in $PM_{2.5}$, NO_X, SO_X, and toxic compounds, both in the near term (as early as 2011) and in the long term. These reductions will be achieved in a manner that: (1) is very cost

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[4] These emission inventory reductions include reductions from ships operating within the 24 nautical mile regulatory zone off the California Coastline, beginning with the effective date of the Coordinated Strategy program elements. The California regulation contains a provision that would sunset the requirements of the rule if the federal program achieves equivalent emission reductions. See http://www.arb.ca.gov/regact/2008/fuelogv08/fro13.pdf at 13 CCR 2299.2(j)(1).

effective compared to additional controls on portside vehicles and equipment and other land-based mobile sources that are already subject to stringent technology-forcing emission standards; (2) leverages the international program adopted by IMO to ensure that all ships that operate in areas that affect U.S. air quality are required to use stringent emission control technology; and (3) provides the lead time needed to deal with the engineering design workload that is involved in applying advanced high-efficiency aftertreatment technology to these very large engines. Overall, the coordinated strategy constitutes a comprehensive program that addresses the problems caused by ocean-going vessel 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 vessel owners and manufacturers, and in a way that is consistent with the international requirements for these vessels.

The human health and welfare impacts of emissions from Category 3 vessels, along with estimates of their contribution to national emission inventories, are described in Section II. The new tiers of engine emission standards under the Clean Air Act for addressing these emissions, and our justifications for them, are discussed in Section III. Section IV contains changes to our existing marine diesel fuel program. In Section V, we describe a key component of the coordinated strategy: the recently-submitted proposal to amend MARPOL Annex VI to designate U.S. coasts as an ECA, as well as the IMO amendment process.

In addition to the new emission limits, we are finalizing several revisions to our Clean Air Act testing, certification, and compliance provisions to better ensure emission control in use. We are also finalizing regulations for the purpose of implementing MARPOL Annex VI pursuant to the Act to Prevent Pollution from Ships (33 USC 1901 et seq.). These revisions are described in Section VI. Sections VII and VIII present the estimated costs and benefits of our coordinated program to address OGV emissions.

(1) What CAA Standards is EPA Finalizing?

We are finalizing new tiers of Category 3 marine diesel engine standards under our Clean Air Act authority, as well as certain revisions to our marine fuel program.

Category 3 Engine Standards. Previous standards for Category 3 engines were adopted in 2003. These Tier 1 standards are equivalent to the first tier of MARPOL Annex VI NO_X limits and require the use of control technology comparable to that used by nonroad engines in the early 1990s. We did not adopt PM standards at that time because the vast majority of PM emissions from Category 3 engines are the result of the sulfur content of the residual fuel they use and because of measurement issues.[5] The combination of the engine and fuel standards we are finalizing and the U.S. Government proposal for ECA designation will require all vessels that operate in coastal areas that affect U.S. air quality to control emissions of NO_X, SO_X, and PM.

We are revising our engine requirements under the Clean Air Act to include two additional tiers of NO_X standards for new Category 3 marine diesel engines installed on vessels flagged or

[5] As explained in the proposed rule leading to the 2003 final rule, there were concerns about measuring PM from Category 3 marine engines (67 FR 37569, May 29, 2002). Specifically, established PM test methods showed unacceptable variability when sulfur levels exceed 0.8 weight percent. However, as described in Section VI, we now believe these measurement issues have been resolved.

registered in the United States. The near-term Tier 2 standards will apply beginning in 2011 and will require more efficient use of engine technologies being used today, including engine timing, engine cooling, and advanced computer controls. The long-term Tier 3 standards will apply beginning in 2016 and will require the use of more advanced technology such as selective catalytic reduction.

Because much of the operation of U.S. vessels occurs in areas that will have little, if any, impact on U.S. air quality, our Clean Air Act program will allow the use of alternative emission control devices (AECDs) that will permit a ship to meet less stringent requirements on the open sea. The use of these devices will be subject to certain restrictions, including a requirement that the AECD not disable emission controls while operating in areas where emissions can reasonably be expected to adversely affect U.S. air quality, and that the engine is equipped with a NO_X emission monitoring device. In addition, the engine will be required to meet the Tier 2 NO_X limits when the AECD is implemented, and an AECD will not be allowed on any Tier 2 or earlier engine.

In addition to the NO_X emission limits, we are finalizing standards for emissions of hydrocarbons (HC) and carbon monoxide (CO) from new Category 3 engines. As explained in Section III.B.1, below, we are not setting a standard for PM emissions for Category 3 engines. However, significant PM emissions control will be achieved through the ECA fuel sulfur requirements that will apply through APPS to ships that operate in areas that affect U.S. air quality. We are also requiring engine manufacturers to measure and report PM emissions pursuant to our authority in section 208 of the Clean Air Act.

<u>Fuel Sulfur Limits</u>. We are finalizing fuel sulfur limits under section 211(c) of the Clean Air Act that match the limits that apply under Annex VI in ECAs. First, we are revising our existing diesel fuel program to allow for the production and sale of 1,000 ppm sulfur fuel for use in Category 3 marine vessels. This will allow production and distribution of fuel consistent with the new sulfur limits that will become applicable, under Annex VI, in ECAs beginning in 2015. Our current diesel fuel program sets a sulfur limit of 15 ppm that will be fully phased-in by December 1, 2014 for land-based nonroad, locomotive, and marine (NRLM) diesel fuel produced for distribution, sale and use in the United States. Without this change to our existing diesel fuel regulations, fuel with a sulfur content of up to 1,000 ppm could be used in Category 3 marine vessels, but it could not be legally produced in the U.S. after June 1, 2014. Second, we are generally forbidding the production and sale of fuel oil with a sulfur content above 1,000 ppm for use in the waters within the proposed ECA (*see* Note 3, *supra*). The exception to this is if the vessel uses alternative devices, procedures, or compliance methods that achieve equivalent emission control as operating on 1,000 ppm sulfur fuel.

(2) What is the U.S. Government Proposal for Designation of an Emission Control Area?

MARPOL Annex VI contains international standards for air emissions from ships, including NO_X, SO_X, and PM emissions. The Annex VI NO_X and SO_X/PM limits are set out in Table I-1. Annex VI was adopted by the Parties in 1997 but did not go into force until 2005, after it was ratified by fifteen countries representing at least 50 percent of the world's merchant shipping tonnage. These Annex VI NO_X standards currently apply to all engines above 130 kW installed on a ship constructed on or after January 1, 2000 and reduce NO_X emissions by about 30 percent from uncontrolled levels. As originally adopted, Annex VI included two fuel sulfur limits: a global limit of 45,000 ppm and a more stringent 15,000 ppm limit for SO_X Emission Control Areas (SECAs). This approach ensures that the cleanest fuel is used in areas that demonstrate a need for additional SO_X reductions, while retaining the ability of ships to use higher-sulfur residual fuel on the open ocean.

Annex VI was amended in October 2008, adding two tiers of NO_X limits (Tier II and Tier III) and two sets of fuel sulfur standards.[6] These amendments will enter into force on July 1, 2010. The most stringent NO_X and fuel sulfur limits are regionally based and will apply only in designated ECAs.

Table I-1 Annex VI NO_X Emission Standards and Fuel Sulfur Limits

			Less than 130 RPM	130-2000 RPM[a]	Over 2000 RPM
NO_X	Tier I	2004[b]	17.0	$45.0 \cdot n^{(-0.20)}$	9.8
	Tier II	2011	14.4	$44.0 \cdot n^{(-0.23)}$	7.7
g/kW-hr	Tier III	2016	3.4	$9.0 \cdot n^{(-0.20)}$	2.0

	Global		ECA	
Fuel Sulfur	2004	45,000 ppm[c]	2005	15,000 ppm[c]
	2012	35,000 ppm[c]	2010	10,000 ppm[c]
	2020	5,000 ppm[c,d]	2015	1,000 ppm[c]

Notes:
[a] Applicable standards are calculated from n (maximum in-use engine speed in revolutions per minute (rpm)), rounded to one decimal place.
[b] Tier 1 NO_X standards apply for engines originally manufactured after 2004, and proposed to also to certain earlier engines.
[c] Annex VI standards are in terms of percent sulfur. Global sulfur limits are 4.5%; 3.5%; 0.5%. ECA sulfur limits are 1.5%; 1.0%; 0.1%.
[d] Subject to a feasibility review in 2018; may be delayed to 2025.

To realize the benefits from the MARPOL Annex VI Tier III NO_X and most stringent fuel sulfur controls, areas must be designated as Emission Control Areas. On July 17, 2009, the IMO approved in principle a U.S.-Canada proposal to amend MARPOL Annex VI to designate North American coastal waters as an ECA (referred to as the "U.S./Canada ECA" or the "North American ECA").[7] In addition, France has joined the ECA proposal on behalf of the Saint Pierre and Miquelon archipelago. A description of this proposal and the IMO ECA designation process is set out in Section V. ECA designation would ensure that ships that affect U.S. air quality meet stringent NO_X and fuel sulfur requirements while operating within 200 nautical miles of U.S. coasts.

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[6] Note that the MARPOL Annex VI standards are referred to as Tiers I, II, and III; EPA's Category 3 emission standards are referred to as Tiers 1, 2, and 3.
[7] *Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulphur Oxides and Particulate Matter, Submitted by the United States and Canada.* IMO Document MEPC59/6/5, 27 March, 2009. A copy of this document can be found at http://www.epa.gov/otaq/regs/nonroad/marine/ci/mepc-59-eca-proposal.pdf

We expect the North American proposal will be adopted by the Parties to MARPOL Annex VI in March 2010, entering into force as early as 2012. If, however, the proposed amendment is not adopted in a timely manner, we intend to take supplemental action to control harmful emissions from vessels that affect U.S. air quality.

(3) Regulations to Implement Annex VI

The United States became a party to MARPOL Annex VI by depositing its instrument of ratification with IMO on October 8, 2008. This was preceded by the President signing into law the Maritime Pollution Prevention Act of 2008 (Public Law 110-280) on July 21, 2008, that contains amendments to the Act to Prevent Pollution from Ships (33 USC 1901 et seq.). These APPS amendments require compliance with Annex VI by all persons subject to the engine and vessel requirements of Annex VI. The amendments also authorize the U.S. Coast Guard and EPA to enforce the provisions of Annex VI against domestic and foreign vessels and to develop implementing regulations, as necessary. In addition, APPS gives EPA sole authority to certify engines installed on U.S. vessels to the Annex VI requirements. This final rule contains regulations codifying the Annex VI requirements and regulations to implement several aspects of the Annex VI engine and fuel regulations, which we are finalizing under that APPS authority. Our cost and benefit analyses for the coordinated strategy include the costs for U.S. vessels to implement the requirements of this MARPOL Annex VI program, including requirements that will apply upon entry into force of the North American ECA.

(4) Technical Amendments

The finalized regulations also include technical amendments to our motor vehicle and nonroad engine regulations. Many of these changes involve minor adjustments or corrections to our recently finalized rule for new nonroad spark-ignition engines, or adjustment to other regulatory provisions to align with this recent final rule.

(5) Summary

The emission control requirements in our coordinated strategy are the MARPOL Annex VI global Tier II NO_X standards included in the amendments to Annex VI and the ECA Tier III NO_X limits and fuel sulfur limits that will apply when the U.S. coasts are designated as an ECA through an additional amendment to Annex VI. The Annex VI requirements, including the future ECA requirements, will be enforceable for U.S. and foreign vessels operating in U.S. waters through the Act to Prevent Pollution from Ships.

We are also adopting the NO_X emission standards for Category 3 engines on U.S. vessels under section 213 of the Clean Air Act.

Finally, we are adopting additional requirements that are not part of the Annex VI program or the ECA. These are (1) limits on hydrocarbon and carbon monoxide emissions for Category 3 engines; (2) a PM measurement requirement to obtain data on PM emissions from engines operating on distillate fuel; and (3) changes to our diesel fuel program under the Clean Air Act to allow production and sale of ECA-compliant fuel. We are also changing our emission control program for smaller marine diesel engines to harmonize with the Annex VI NO_X requirements for U.S. vessels that operate internationally.

B. Why is EPA Making this Rule?

(1) Category 3 Engines Contribute to Serious Air Quality Problems

Category 3 engines generate significant emissions of $PM_{2.5}$, SO_X, and NO_X that contribute to nonattainment of the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and ground-level ozone (smog). NO_X and SO_X are both precursors to secondary $PM_{2.5}$ formation. Both $PM_{2.5}$ and NO_X adversely affect human health. NO_X is a key precursor to ozone as well. NO_X, SO_X and $PM_{2.5}$ emissions from ocean-going vessels also cause harm to public welfare, including contributing to deposition of nitrogen and sulfur, 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 costs borne to society imposed as a result of the activity taking place) is not taken into account in the total cost of producing goods and services. In this case, as described in this section below and in Section II, emissions from ocean-going vessels impose public health and environmental costs on society, and these added costs to society are not reflected in the costs of providing the transportation services. The market system itself cannot correct this externality because firms in the market are rewarded for minimizing their production costs, including the costs of pollution control. In addition, firms that may take steps to use equipment that reduces air pollution may find themselves at a competitive disadvantage compared to firms that do not. To correct this market failure and reduce the negative externality from these emissions, we are setting a cap on the rate of emission production from these sources. EPA's coordinated strategy for ocean-going vessels will accomplish this since both domestic and foreign ocean-going vessels will be required to reduce their emissions to a technologically feasible limit.

Emissions from ocean-going vessels account for substantial portions of the country's ambient $PM_{2.5}$, SO_X and NO_X levels. We estimate that in 2009 these engines account for about 80 percent of mobile source sulfur dioxide (SO_2) emissions, 10 percent of mobile source NO_X emissions and about 24 percent of mobile source diesel $PM_{2.5}$ emissions. Emissions from ocean-going vessels are expected to dominate the mobile source inventory in the future, due to both the expected emission reductions from other mobile sources as a result of more stringent emission controls and due to growth in the demand for ocean transportation services. By 2030, the coordinated strategy will reduce annual SO_2 emissions from these diesel engines by 1.3 million tons, annual NO_X emissions by 1.2 million tons, and $PM_{2.5}$ emissions by 143,000 tons, and those reductions will continue to grow beyond 2030 as fleet turnover to the clean engines continues. While a share of these emissions occur at sea, our air quality modeling results described in Section II show they have a significant impact on ambient air quality far inland.

Both ozone and $PM_{2.5}$ are associated with serious public health problems, including premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, lost work days, and restricted activity days), changes in lung function and increased respiratory symptoms, altered respiratory defense mechanisms, and chronic bronchitis. Diesel exhaust is of special public health concern, and since 2002 EPA has classified it as likely to be carcinogenic to humans by inhalation at environmental exposures. 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.[8,9,10]

EPA recently updated its initial screening-level analysis[11] of selected marine port areas to better understand the populations that are exposed to diesel particulate matter emissions from these facilities.[12,13,14,15] This screening-level analysis focused on a representative selection of national marine ports.[16] Of the 45 marine ports selected, the results indicate that at least 18 million people, including a disproportionate number of low-income households, African-Americans, and Hispanics, live in the vicinity of these facilities and are being exposed to ambient diesel PM levels that are 2.0 $\mu g/m^3$ and 0.2 $\mu g/m^3$ above levels found in areas further from these facilities. Considering only ocean-going marine engine diesel PM emissions, the results indicate that 6.5 million people are exposed to ambient diesel particulate matter (DPM) levels that are 2.0 $\mu g/m^3$ and 0.2 $\mu g/m^3$ above levels found in areas further from these facilities. Because those populations exposed to diesel PM emissions from marine ports are more likely to be low-income and minority residents, these

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[8] U. S. EPA. (2004). *Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines, Chapter 3.* Report No. EPA420-R-04-007. http://www.epa.gov/nonroad-diesel/2004fr.htm#ria

[9] State of California Air Resources Board. (2004). *Roseville Rail Yard Study.* Sacramento, CA: California EPA, California Air Resources Board (CARB).Stationary Source Division. This document is available electronically at: http://www.arb.ca.gov/diesel/documents/rrstudy.htm

[10] Di, P., Servin, A., Rosenkranz, K., Schwehr, B., Tran, H., (2006). *Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach.* Sacramento, CA: California EPA, California Air Resources Board (CARB). Retrieved March 19, 2009 from http://www.arb.ca.gov/regact/marine2005/portstudy0406.pdf.

[11] 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.

[12] 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-2007-0121.

[13] 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-2007-0121.

[14] ICF International, December 10, 2008. Estimation of diesel particulate matter population exposure near selected harbor areas with revised harbor emissions. Memorandum to EPA under Work Assignment Number 2-9. Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR- 2007-0121.

[15] ICF International. December 1, 2008. Estimation of diesel particulate matter concentration isopleths near selected harbor areas with revised emissions. Memorandum to EPA under Work Assignment Number 1-9. Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR-2007-0121.

[16] The Agency selected a representative sample from the top 150 U.S. ports including coastal and Great Lake ports.

populations would benefit from the controls being proposed in this action. The detailed findings of this study are available in the public docket for this rulemaking.

Even outside port areas, millions of Americans continue to live in areas that do not meet existing air quality standards today. With regard to $PM_{2.5}$ nonattainment, in 2005 EPA designated 39 nonattainment areas for the 1997 $PM_{2.5}$ NAAQS (70 FR 943, January 5, 2005). These areas are composed 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. As of December 22, 2008, there are 58 2006 $PM_{2.5}$ nonattainment areas composed of 211 full or partial counties. These numbers do not include individuals living in areas that may fail to maintain or achieve the $PM_{2.5}$ NAAQS in the future. 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 December 2008, there are approximately 132 million people living in 57 areas (293 full or partial counties) designated as not in attainment with the 8-hour ozone NAAQS. These numbers do not include people living in areas where there is a potential that the area may fail to maintain or achieve the 8-hour ozone NAAQS.

In addition to public health impacts, there are serious public welfare and environmental impacts associated with $PM_{2.5}$ and ozone emissions. Specifically, NO_X and SO_X emissions from diesel engines contribute to the acidification, nitrification, and eutrophication of water bodies. NO_X, SO_X and direct emissions of $PM_{2.5}$ can contribute to the substantial impairment of visibility in many parts of the U.S. where people live, work, and recreate, including national parks, wilderness areas, and mandatory class I federal areas.[17] The deposition of airborne particles can also reduce the aesthetic appeal of buildings and culturally important articles through soiling, and can contribute directly (or in conjunction with other pollutants) to structural damage by means of corrosion or erosion. Finally, 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.

EPA has already adopted many emission control programs that are expected to reduce ambient $PM_{2.5}$ and ozone levels, including the Nonroad Spark Ignition Engine rule (73 FR 59034, Oct 8, 2008), the Locomotive and Marine Diesel Engine Rule (73 FR 25098, May 6, 2008), the Clean Air Interstate Rule (CAIR) (70 FR 25162, May 12, 2005), the Clean Air Nonroad Diesel Rule (69 FR 38957, June 29, 2004), the Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements (66 FR 5002, Jan. 18, 2001), and the Tier 2 Vehicle and Gasoline Sulfur Program (65 FR 6698, Feb. 10, 2000). The additional $PM_{2.5}$, SO_X, and NO_X emission reductions resulting from the coordinated approach described in this action will assist states in attaining and maintaining the $PM_{2.5}$ and ozone NAAQS near term and in the decades to come.

Our air quality modeling projects that in 2020 at least 13 counties with about 30 million people may violate the 1997 standards for $PM_{2.5}$ and 50 counties with about 50 million people may violate the 2008 standards for ozone. These numbers likely underestimate the impacted population

[17] 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. 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.

since they do not include the people who live in areas which do not meet the 2006 $PM_{2.5}$ NAAQS. In addition, these numbers do not include the additional 13 million people in 12 counties who live in areas that have air quality measurements within 10 percent of the 1997 $PM_{2.5}$ NAAQS and the additional 80 million people in 135 counties who live in areas that have air quality measurements within 10% of the 2008 ozone NAAQS. The emission reductions resulting from this coordinated strategy will assist these and other states to both attain and maintain the $PM_{2.5}$ and ozone NAAQS.

State and local governments are working to protect the health of their citizens and comply with requirements of the Clean Air Act. As part of this effort, they recognize the need to secure additional major reductions in diesel $PM_{2.5}$, SO_X and NO_X emissions by undertaking numerous state level actions, while also seeking Agency action, including the Category 3 engine standards being finalized in this final rule and the U.S. proposal to IMO to amend Annex VI to designate U.S. coastal areas as an ECA, and related certification and fuel provisions under the Clean Air Act to complement that ECA proposal. EPA's coordinated strategy to reduce OGV emissions through engine emission controls and fuel sulfur limits will play a critical part in state efforts to attain and maintain the NAAQS through the next two decades.

In addition to regulatory programs, the Agency has a number of innovative programs that partner government, industry, and local communities together to help address challenging air quality problems. Under the National Clean Diesel Campaign, EPA promotes a variety of emission reduction strategies such as retrofitting, repairing, replacing and repowering engines, reducing idling and switching to cleaner fuels.

In 2008, Congress appropriated funding for the Diesel Emission Reduction Program under the Energy Policy Act of 2005 (EPAct 2005) to reduce emissions from heavy-duty diesel engines in the existing fleet. The EPAct 2005 directs EPA to break the funding into two different components: a National competition and a State allocation program. The National Program, with 70 percent of the funding, consists of three separate competitions: (1) the National Clean Diesel Funding Assistance Program; (2) the National Clean Diesel Emerging Technologies Program; and (3) the SmartWay Clean Diesel Finance Program. The State Clean Diesel Grant and Loan Program utilizes the remaining 30 percent of the funding. In the first year of the program, EPA awarded 119 grants totaling $49.2 million for diesel emission reduction projects and programs across the country for cleaner fuels, verified technologies, and certified engine configurations.

Through $300 million in funding provided to the Diesel Emission Reduction Program under the American Reinvestment and Recovery Act of 2009, EPA will promote and preserve jobs while improving public health and achieving significant reductions in diesel emissions.

Furthermore, EPA's National Clean Diesel Campaign, through its Clean Ports USA program, is working with port authorities, terminal operators, shipping, truck, and rail companies to promote cleaner diesel technologies and strategies through education, incentives, and financial assistance for diesel emission reductions at ports. Part of these efforts involves clean diesel programs that can further reduce emissions from the existing fleet of diesel engines. Finally, many of the companies operating in states and communities suffering from poor air quality have voluntarily entered into Memoranda of Understanding (MOUs) designed to ensure that the cleanest technologies are used first in regions with the most challenging air quality issues.

Taken together, these voluntary approaches can augment the coordinated strategy and help states and communities achieve larger reductions sooner in the areas of our country that need them the most. The Agency remains committed to furthering these programs and others so that all of our citizens can breathe clean healthy air.

(2) Advanced Emission Technology Solutions are Available

Air pollution from marine diesel exhaust is a challenging problem. However, we believe manufacturers can apply a combination of existing and new technologies to meet the emission standards we are adopting in this final rule. Optimizing air intake fuel injection systems can substantially reduce engine-out emissions. Further NO_X control can be achieved with advanced technology such as aftertreatment devices with high-efficiency catalysts. 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 very large emission reductions in NO_X emissions can be achieved. Manufacturers might also deploy other advanced technologies such as water-based in-cylinder controls to reduce NO_X emissions.

While aftertreatment technologies can be sensitive to sulfur, their use will be required only in ECAs designated under MARPOL Annex VI, and they are expected to be able to operate on ECA fuel meeting a 1,000 ppm fuel sulfur. With the lead time available and the assurance of 1,000 ppm fuel for ocean-going vessels in 2015, as would be required through ECA designation for U.S. coasts, we are confident the application of advanced NO_X technology to Category 3 marine engines will proceed at a reasonable rate of progress and will result in systems capable of achieving the finalized standards on schedule. Use of this lower sulfur fuel will also result in substantial PM emission reductions, since PM emissions from Category 3 engines come mostly from the use of high sulfur residual fuel. Note that vessels may be equipped with alternative devices, procedures, or compliance methods provided they achieve equivalent emissions reductions.

C. Statutory Basis for Action

Authority for the actions proposed in this documents is granted to the Environmental Protections Agency by sections 114, 203, 205, 206, 207, 208, 211, 213, 216, and 301(a) of the Clean Air Act as amended in 1990 (42 U.S.C. 7414, 7522, 7524, 7525, 7541, 7542, 7545, 7547, 7550 and 7601(a)), and by sections 1901-1915 of the Act to Prevent Pollution from Ships (33 USC 1909 et seq.).

(1) Clean Air Act Basis for Action

EPA is proposing the fuel requirements pursuant to its authority in section 211(c) of the Clean Air Act, which allows EPA to regulate fuels that contribute to air pollution that endangers public health or welfare (42 U.S.C. 7545(c)). As discussed previously in EPA's Clean Air Nonroad Diesel rule (69 FR 38958) and in Section II, the combustion of high sulfur diesel fuel by nonroad, locomotive, and marine diesel engines contributes to air quality problems that endanger public health and welfare. Section II also discusses the significant contribution to these air quality problems by Category 3 marine vessels. Additional support for the procedural and enforcement-related aspects of the fuel controls in the final rule, including the recordkeeping requirements, comes from Clean Air Act sections 114(a) and 301(a) (42 U.S.C. sections 7414(a) and 7601(a)).

EPA is finalizing emission standards for new Category 3 marine diesel engines pursuant to its authority under section 213(a)(3) of the Clean Air Act, which directs the Administrator to set standards regulating emissions of NO_X, volatile organic compounds (VOCs), or CO 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."

EPA is finalizing a PM measurement requirement for new Category 3 marine diesel engines pursuant to its authority under section 208, which requires manufacturers and other persons subject to Title II requirements to "provide information the Administrator may reasonably require … to otherwise carry out the provisions of this part…"

EPA is also acting under its authority to implement and enforce the Category 3 marine diesel emission standards. Section 213(d) provides that the standards EPA adopts for 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 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.

As required under section 213(a)(3), we believe the evidence provided in Section III.C and in Chapter 4 of Final Regulatory Impact Analysis (RIA) indicates that the stringent NO_X emission standards finalized in this final rule for newly built Category 3 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 finalizing these standards. Our review of the costs and cost-effectiveness of these standards indicate that they are reasonable and comparable to the cost-effectiveness of other mobile source emission reduction strategies that have been required. 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.

The information in Section II and Chapter 2 of the Final Regulatory Impact Analysis regarding air quality and public health impacts provides strong evidence that emissions from Category 3 marine diesel engines 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 CO concentrations in more than one area which has failed to attain the ozone and carbon monoxide NAAQS (64 FR 73300, December 29, 1999).

The NO_X and PM emission reductions achieved through the coordinated strategy will be important to states' efforts to attain and maintain the Ozone and the $PM_{2.5}$ NAAQS in the near term and in the decades to come, and will significantly reduce the risk of adverse effects to human health and welfare.

(2) APPS Basis for Action

EPA is finalizing regulations to implement MARPOL Annex VI pursuant to its authority in section 1903 of the Act to Prevent Pollution from Ships (APPS). Section 1903 gives the Administrator the authority to prescribe any necessary or desired regulations to carry out the provisions of Regulations 12 through 19 of Annex VI.

The Act to Prevent Pollution from Ships implements Annex VI and makes those requirements enforceable domestically. However, certain clarifications are necessary for implementing Regulation 13 and the requirements of the NO_X Technical Code with respect to issuance of Engine International Air Pollution Prevention (EIAPP) certificates and approval of alternative compliance methods. Clarification is also needed with respect to the application of the Annex VI requirements to certain U.S. and foreign vessels that operate in U.S. waters.

II. Air Quality, Health and Welfare Impacts

The coordinated strategy will significantly reduce emissions of NO_X, PM, and SO_X from ocean-going vessels. Emissions of these compounds contribute to PM and ozone nonattainment and environmental effects including deposition, visibility impairment and harm to ecosystems from ozone. In addition diesel particulate matter is associated with a host of adverse health effects, including cancer.

This section summarizes the general health and welfare effects of these emissions and the modeled projections of changes in air quality due to the coordinated strategy. Interested readers are encouraged to refer to the RIA for more in-depth discussions.

A. Public Health Impacts

(1) Particulate Matter

Particulate matter is a generic term for 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. Since 1987, EPA has delineated that subset of inhalable particles small enough to penetrate to the thoracic region (including the tracheobronchial and alveolar regions) of the respiratory tract (referred to as thoracic particles). Current NAAQS use $PM_{2.5}$ as the indicator for fine particles (with $PM_{2.5}$ referring to particles with a nominal mean aerodynamic diameter less than or equal to 2.5 µm), and use PM_{10} as the indicator for purposes of regulating the coarse fraction of PM_{10} (referred to as thoracic coarse particles or coarse-fraction particles; generally including particles with a nominal mean aerodynamic diameter greater than 2.5 µm and less than or equal to 10 µm, or $PM_{10-2.5}$). Ultrafine particles are a subset of fine particles, generally less than 100 nanometers (0.1 µm) in aerodynamic diameter.

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.

(a) Health Effects of PM

Scientific studies show ambient PM is associated with a series of adverse health effects. These health effects are discussed in detail in EPA's 2004 Particulate Matter Air Quality Criteria Document (PM AQCD) and the 2005 PM Staff Paper.[18,19,20] 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, aggravation of cardiovascular and lung disease (as indicated by increased hospital admissions and emergency department visits), increased respiratory symptoms including cough and difficulty breathing, decrements in lung function, altered heart rate rhythm, and other more subtle changes in blood markers related to cardiovascular health.[21] Long-term exposure to $PM_{2.5}$ and sulfates has also been associated with mortality from cardiopulmonary disease and lung cancer, and effects on the respiratory system such as reduced lung function growth or development of respiratory disease. A new analysis shows an association between long-term $PM_{2.5}$ exposure and a subclinical measure of atherosclerosis.[22,23]

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[18] U.S. EPA (2004). *Air Quality Criteria for Particulate Matter*. Volume I EPA600/P-99/002aF and Volume II EPA600/P-99/002bF. Retrieved on March 19, 2009 from Docket EPA-HQ-OAR-2003-0190 at http://www.regulations.gov/.

[19] 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-05-005a. Retrieved March 19, 2009 from http://www.epa.gov/ttn/naaqs/standards/pm/data/pmstaffpaper_20051221.pdf.

[20] The PM NAAQS is currently under review and the EPA is considering all available science on PM health effects, including information which has been published since 2004, in the development of the upcoming PM Integrated Science Assessment Document (ISA). A second draft of the PM ISA was completed in July 2009 and was submitted for review by the Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board. Comments from the general public have also been requested. For more information, see http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=210586.

[21] U.S. EPA. (2006). *National Ambient Air Quality Standards for Particulate Matter*. 71 FR 61144, October 17, 2006.

[22] Künzli, N., Jerrett, M., Mack, W.J., et al. (2004). Ambient air pollution and atherosclerosis in Los Angeles. *Environ Health Perspect.,113*, 201-206

[23] This study is included in the 2006 Provisional Assessment of Recent Studies on Health Effects of Particulate Matter Exposure. The provisional assessment did not and could not (given a very short timeframe) undergo the extensive critical review by CASAC and the public, as did the PM AQCD. The provisional assessment found that the "new" studies expand the scientific information and provide important insights on the relationship between PM exposure and health effects of PM. The provisional assessment also found that "new" studies generally strengthen the evidence that acute and chronic exposure to fine particles and acute exposure to thoracic coarse particles are associated with health effects. Further, the provisional science assessment found that the results reported in the studies did not dramatically diverge from previous findings, and taken in context with the findings of the AQCD, the new information and findings did not materially change any of the broad scientific conclusions regarding the health effects of PM exposure made in

Studies examining populations exposed over the long term (one or more years) to different levels of air pollution, 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 all cause and cardiopulmonary premature mortality.[24,25,26] In addition, an extension of the American Cancer Society Study shows an association between $PM_{2.5}$ and sulfate concentrations and lung cancer mortality.[27]

(b) Health Effects of Diesel Particulate Matter

Marine diesel engines emit diesel exhaust (DE), a complex mixture composed 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 DE 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. Many of the organic compounds present in the gases and on the particles, such as polycyclic organic matter (POM), 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 marine diesel engines.[28]

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the AQCD. However, it is important to note that this assessment was limited to screening, surveying, and preparing a provisional assessment of these studies. For reasons outlined in Section I.C of the preamble for the final PM NAAQS rulemaking in 2006 (see 71 FR 61148-49, October 17, 2006), EPA based its NAAQS decision on the science presented in the 2004 AQCD.

[24] Dockery, D.W., Pope, C.A. 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. Retrieved on March 19, 2009 from http://content.nejm.org/cgi/content/full/329/24/1753.

[25] Pope, C.A., III, Thun, M.J., Namboodiri, M.M., Dockery, D.W., Evans, J.S., Speizer, F.E., and Heath, C.W., Jr. (1995). Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. *Am. J. Respir. Crit. Care Med, 151*, 669-674.

[26] Krewski, D., Burnett, R.T., Goldberg, M.S., et al. (2000). *Reanalysis of the Harvard Six Cities study and the American Cancer Society study of particulate air pollution and mortality.* A special report of the Institute's Particle Epidemiology Reanalysis Project. Cambridge, MA: Health Effects Institute. Retrieved on March 19, 2009 from http://es.epa.gov/ncer/science/pm/hei/Rean-ExecSumm.pdf.

[27] 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.

[28] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust.* EPA/600/8-90/057F Office of Research and Development, Washington DC. Retrieved on March 17, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060. pp. 1-1 1-2.

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.[29]

(i) Diesel Exhaust: Potential Cancer Effects

In EPA's 2002 Diesel Health Assessment Document (Diesel HAD),[30] 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. 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 across a variety of diesel exhaust-exposed occupations.[31,32]

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}

[29] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust*. EPA/600/8-90/057F Office of Research and Development, Washington DC. Retrieved on March 17, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.

[30] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust*. EPA/600/8-90/057F Office of Research and Development, Washington DC. Retrieved on March 17, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060. pp. 1-1 1-2.

[31] Bhatia, R., Lopipero, P., Smith, A. (1998). Diesel exposure and lung cancer. *Epidemiology, 9(1)*, 84-91.

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

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.

(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.[33,34,35,36] The RfC is 5 $\mu g/m^3$ for diesel exhaust as measured by DPM. 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."[37]

(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 $\mu g/m^3$. 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

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[33] 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.
[34] 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.
[35] Mauderly, J.L., Jones, R.K., Griffith, W.C., et al. (1987). Diesel exhaust is a pulmonary carcinogen in rats exposed chronically by inhalation. *Fundam. Appl. Toxicol., 9,* 208-221.
[36] Nikula, K.J., Snipes, M.B., Barr, E.B., 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.
[37] U.S. EPA (2002). *Health Assessment Document for Diesel Engine Exhaust.* EPA/600/8-90/057F Office of Research and Development, Washington DC. Retrieved on March 17, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060. p. 9-9.

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 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 $\mu g/m^3$ to 1,280 $\mu g/m^3$, for a variety of occupations. As discussed in the Diesel HAD, the National Institute of Occupational Safety and Health (NIOSH) has estimated a total of 1,400,000 workers are occupationally exposed to diesel exhaust from on-road and nonroad vehicles including marine diesel engines.

Elevated Concentrations and Ambient Exposures in Mobile Source-Impacted Areas

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

A 2006 study from the California Air Resources Board (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.[38] The port study employed the ISCST3 dispersion model. With local meteorological data used in the modeling, annual average concentrations were substantially elevated over an area exceeding 200,000 acres. Because the ports are located near heavily-populated areas, the modeling indicated that over 700,000 people lived in areas with at least 0.3 $\mu g/m^3$ of port-related diesel PM in ambient air, about 360,000 people lived in areas with at least 0.6 $\mu g/m^3$ of diesel PM, and about 50,000 people lived in areas with at least 1.5 $\mu g/m^3$ of ambient diesel PM directly from the port. This study highlights the substantial contribution ports can make to elevated ambient concentrations in populated areas.

EPA recently updated its initial screening-level analysis of a representative selection of national marine port areas to better understand the populations that are exposed to DPM emissions from these facilities.[39,40,41,42] As part of this study, a computer geographic information system

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[38] Di, P., Servin, A., Rosenkranz, K., Schwehr, B., Tran, H., (2006). *Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach.* Sacramento, CA: California EPA, California Air Resources Board (CARB). Retrieved March 19, 2009 from http://www.arb.ca.gov/regact/marine2005/portstudy0406.pdf.

[39] 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-2007-0121.

[40] 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-2007-0121.

(GIS) was used to identify the locations and property boundaries of 45 marine ports.[43] Census information was used to estimate the size and demographic characteristics of the population living in the vicinity of the ports. The results indicate that at least 18 million people, including a disproportionate number of low-income households, African-Americans, and Hispanics, live in the vicinity of these facilities and are being exposed to annual average 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. These populations will benefit from the coordinated strategy. 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.

(2) Ozone

Ground-level ozone pollution is typically formed by the reaction of VOC and 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.[44] 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 be transported hundreds of miles downwind from precursor emissions, resulting in elevated ozone levels even in areas with low local VOC or NO_X emissions.

(a) Health Effects of Ozone

The health and welfare effects of ozone are well documented and are assessed in EPA's 2006 Air Quality Criteria Document (ozone AQCD) and 2007 Staff Paper.[45, 46] Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or uncomfortable sensation in the chest. Ozone can reduce lung function and make it more difficult to breathe deeply; breathing may

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[41] ICF International, December 10, 2008. Estimation of diesel particulate matter population exposure near selected harbor areas with revised harbor emissions. Memorandum to EPA under Work Assignment Number 2-9. Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR-2007-0121.

[42] ICF International. December 1, 2008. Estimation of diesel particulate matter concentration isopleths near selected harbor areas with revised emissions. Memorandum to EPA under Work Assignment Number 1-9. Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR-2007-0121.

[43] The Agency selected a representative sample from the top 150 U.S. ports including coastal, inland, and Great Lake ports.

[44] U.S. EPA. (2006). Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). EPA/600/R-05/004aF-cF. Washington, DC: U.S. EPA. Retrieved on March 19, 2009 from Docket EPA-HQ-OAR-2003-0190 at http://www.regulations.gov/.

[45] U.S. EPA. (2006). Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). EPA/600/R-05/004aF-cF. Washington, DC: U.S. EPA. Retrieved on March 19, 2009 from Docket EPA-HQ-OAR-2003-0190 at http://www.regulations.gov/.

[46] 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. Washington, DC, U.S. EPA. Retrieved on March 19, 2009 from Docket EPA-HQ-OAR-2003-0190 at http://www.regulations.gov/.

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. In addition, there is suggestive evidence of a contribution of ozone to cardiovascular-related morbidity and highly suggestive evidence that short-term ozone exposure directly or indirectly contributes to non-accidental and cardiopulmonary-related mortality, but additional research is needed to clarify the underlying mechanisms causing these effects. In a recent report on the estimation of ozone-related premature mortality published by the National Research Council (NRC), a panel of experts and reviewers concluded that short-term exposure to ambient ozone is likely to contribute to premature deaths and that ozone-related mortality should be included in estimates of the health benefits of reducing ozone exposure.[47] 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 of particular concern.

The 2006 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.

(3) NO_X and SO_X

Nitrogen dioxide (NO_2) is a member of the NO_X family of gases. Most NO_2 is formed in the air through the oxidation of nitric oxide (NO) emitted when fuel is burned at a high temperature. SO_2, a member of the sulfur oxide (SO_X) family of gases, is formed from burning fuels containing sulfur (e.g., coal or oil derived), extracting gasoline from oil, or extracting metals from ore.

SO_2 and NO_2 can dissolve in water vapor and further oxidize to form sulfuric and nitric acid which react with ammonia to form sulfates and nitrates, both of which are important components of ambient PM. The health effects of ambient PM are discussed in Section II.A.1 of this preamble. NO_X along with non-methane hydrocarbon (NMHC) are the two major precursors of ozone. The health effects of ozone are covered in Section II.A.2.

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[47] National Research Council (NRC), 2008. *Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution*. The National Academies Press: Washington, D.C.

(a) Health Effects of NO_X

Information on the health effects of NO_2 can be found in the U.S. Environmental Protection Agency Integrated Science Assessment (ISA) for Nitrogen Oxides.[48] The U.S. EPA has concluded that the findings of epidemiologic, controlled human exposure, and animal toxicological studies provide evidence that is sufficient to infer a likely causal relationship between respiratory effects and short-term NO_2 exposure. The ISA concludes that the strongest evidence for such a relationship comes from epidemiologic studies of respiratory effects including symptoms, emergency department visits, and hospital admissions. The ISA also draws two broad conclusions regarding airway responsiveness following NO_2 exposure. First, the ISA concludes that NO_2 exposure may enhance the sensitivity to allergen-induced decrements in lung function and increase the allergen-induced airway inflammatory response at exposures as low as 0.26 ppm NO_2 for 30 minutes. Second, exposure to NO_2 has been found to enhance the inherent responsiveness of the airway to subsequent nonspecific challenges in controlled human exposure studies of asthmatic subjects. Enhanced airway responsiveness could have important clinical implications for asthmatics since transient increases in airway responsiveness following NO_2 exposure have the potential to increase symptoms and worsen asthma control. Together, the epidemiologic and experimental data sets form a plausible, consistent, and coherent description of a relationship between NO_2 exposures and an array of adverse health effects that range from the onset of respiratory symptoms to hospital admission.

Although the weight of evidence supporting a causal relationship is somewhat less certain than that associated with respiratory morbidity, NO_2 has also been linked to other health endpoints. These include all-cause (nonaccidental) mortality, hospital admissions or emergency department visits for cardiovascular disease, and decrements in lung function growth associated with chronic exposure.

(b) Health Effects of SO_X

Information on the health effects of SO_2 can be found in the U.S. Environmental Protection Agency Integrated Science Assessment for Sulfur Oxides.[49] SO_2 has long been known to cause adverse respiratory health effects, particularly among individuals with asthma. Other potentially sensitive groups include children and the elderly. During periods of elevated ventilation, asthmatics may experience symptomatic bronchoconstriction within minutes of exposure. Following an extensive evaluation of health evidence from epidemiologic and laboratory studies, the EPA has concluded that there is a causal relationship between respiratory health effects and short-term exposure to SO_2. Separately, based on an evaluation of the epidemiologic evidence of associations between short-term exposure to SO_2 and mortality, the EPA has concluded that the overall evidence is suggestive of a causal relationship between short-term exposure to SO_2 and mortality.

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[48] U.S. EPA (2008). *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report).* EPA/600/R-08/071. Washington, DC,: U.S.EPA. Retrieved on March 19, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=194645.

[49] U.S. EPA. (2008). *Integrated Science Assessment (ISA) for Sulfur Oxides – Health Criteria (Final Report).* EPA/600/R-08/047F. Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=198843

B. Environmental Impacts

(1) Deposition of Nitrogen and Sulfur

Emissions of NO_X and SO_X from ships contribute to atmospheric deposition of nitrogen and sulfur in the U.S. Atmospheric deposition of nitrogen and sulfur contributes to acidification, altering biogeochemistry and affecting animal and plant life in terrestrial and aquatic ecosystems across the U.S. The sensitivity of terrestrial and aquatic ecosystems to acidification from nitrogen and sulfur deposition is predominantly governed by geology. Prolonged exposure to excess nitrogen and sulfur deposition in sensitive areas acidifies lakes, rivers and soils. Increased acidity in surface waters creates inhospitable conditions for biota and affects the abundance and nutritional value of preferred prey species, threatening biodiversity and ecosystem function. Over time, acidifying deposition also removes essential nutrients from forest soils, depleting the capacity of soils to neutralize future acid loadings and negatively affecting forest sustainability. Major effects include a decline in sensitive forest tree species, such as red spruce (*Picea rubens*) and sugar maple (*Acer saccharum*), and a loss of biodiversity of fishes, zooplankton, and macro invertebrates.

In addition to the role nitrogen deposition plays in acidification, nitrogen deposition also causes ecosystem nutrient enrichment leading to eutrophication that alters biogeochemical cycles. Excess nitrogen also leads to the loss of nitrogen sensitive lichen species as they are outcompeted by invasive grasses as well as altering the biodiversity of terrestrial ecosystems, such as grasslands and meadows. Nitrogen deposition contributes to eutrophication of estuaries and the associated effects including toxic algal blooms and fish kills. For a broader explanation of the topics treated here, refer to the description in Section 2.3.1 of the RIA.

There are a number of important quantified relationships between nitrogen deposition levels and ecological effects. Certain lichen species are the most sensitive terrestrial taxa to nitrogen with species losses occurring at just 3 kg N/ha/yr in the Pacific Northwest, southern California and Alaska. A United States Forest Service study conducted in areas within the Tongass Forest in Southeast Alaska found evidence of sulfur emissions impacting lichen communities.[50] The authors concluded that the main source of nitrogen and sulfur found in lichens from Mt. Roberts (directly north of the City of Juneau in southeastern Alaska) is likely the burning of fossil fuels by cruise ships and other vehicles and equipment in Juneau. According to the Alaska DEC, damage to lichen populations has widespread effects in Alaskan ecosystems.[51]

Across the U.S., there are many terrestrial and aquatic ecosystems that have been identified as particularly sensitive to nitrogen deposition. The most extreme effects resulting from nitrogen deposition on aquatic ecosystems are due to nitrogen enrichment which contributes to “hypoxic” zones devoid of life. Three hypoxia zones of special concern in the U.S. are the zones located in the

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[50] Dillman, K., Geiser, L., & Brenner, G. (2007). *Air Quality Bio-Monitoring with Lichens.* The Togass National Forest. USDA Forest Service. Retrieved March 18, 2009 from http://gis.nacse.org/lichenair/?page=reports.

[51] Alaska Department of Conservation, “Statement in Support of EPA Considering Alaska as Part of a Marine Emission Control Area,” October 1, 2008.

Gulf of Mexico, the Chesapeake Bay in the mid-Atlantic region, and Long Island Sound in the northeast U.S.[52]

(2) Deposition of Particulate Matter and Air Toxics

The coordinated strategy will reduce NO_X, SO_X, and $PM_{2.5}$ emissions from ships. Ship emissions of $PM_{2.5}$ contain small amounts of metals: nickel, vanadium, cadmium, iron, lead, copper, zinc, and aluminum.[53,54,55] Investigations of trace metals near roadways and industrial facilities indicate that a substantial burden of heavy metals can accumulate on vegetative surfaces. Copper, zinc, and nickel are directly toxic to vegetation under field conditions.[56] While metals typically exhibit low solubility, limiting their bioavailability and direct toxicity, chemical transformations of metal compounds occur in the environment, particularly in the presence of acidic or other oxidizing species. These chemical changes influence the mobility and toxicity of metals in the environment. Once taken up into plant tissue, a metal compound can undergo chemical changes, accumulate and be passed along to herbivores, or can re-enter the soil and further cycle in the environment.

Although there has been no direct evidence of a physiological association between tree injury and heavy metal exposures, heavy metals have been implicated because of similarities between metal deposition patterns and forest decline.[57,58] This correlation was further explored in high elevation forests in the northeast U.S. and the data strongly imply that metal stress causes tree injury and contributes to forest decline in the Northeast.[59] Contamination of plant leaves by heavy metals can lead to elevated soil levels. Trace metals absorbed into the plant frequently bind to the leaf tissue, and then are lost when the leaf drops. As the fallen leaves decompose, the heavy metals are transferred into the soil.[60,61]

Ships also emit air toxics, including polycyclic aromatic hydrocarbons (PAHs), a class of polycyclic organic matter (POM) that contains compounds which are known or suspected carcinogens. Since the majority of PAHs are adsorbed onto particles less than 1.0 µm in diameter,

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[52] U.S. EPA. (2008). *Nitrogen Dioxide/Sulfur Dioxide Secondary NAAQS Review: Integrated Science Assessment (ISA).* Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=180903

[53] Agrawal H., Malloy Q.G.J., Welch W.A., Wayne Miller J., Cocker III D.R. (2008) In-use gaseous and particulate matter emissions from a modern ocean going container vessel. *Atmospheric Environment, 42(21),* 5504-5510.

[54] Miller, W., et al. (2008 June 10). *Measuring Emissions from Ocean Going Vessels*. Presentation presented at the Fuel, Engines, and Control Devices Workshop, San Pedro, California.

[55] Isakson J., Persson T.A., E. Selin Lindgren E. (2001) Identification and assessment of ship emissions and their effects in the harbour of Gteborg, Sweeden. *Atmospheric Environment, 35(21),* 3659-3666.

[56] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[57] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[58] Gawel, J. E.; Ahner, B. A.; Friedland, A. J.; Morel, F. M. M. (1996) Role for heavy metals in forest decline indicated by phytochelatin measurements. *Nature (London), 381*, 64-65.

[59] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[60] Cotrufo M.F., De Santo A.V., Alfani A., Bartoli G., De Cristofaro A. (1995) Effects of urban heavy metal pollution on organic matter decomposition in Quercus ilex L. Woods. *Environmental Pollution, 89(1),* 81-87.

[61] Niklinska M., Laskowski R., Maryanski M. (1998). Effect of heavy metals and storage time on two types of forest litter: basal respiration rate and exchangeable metals. *Ecotoxicological Environmental Safety, 41,* 8-18.

long range transport is possible. Particles of this size can remain airborne for days or even months and travel distances up to 10,000 km before being deposited on terrestrial or aquatic surfaces.[62] Atmospheric deposition of particles is believed to be the major source of PAHs to the sediments of Lake Michigan, Chesapeake Bay, Tampa Bay and other coastal areas of the U.S.[63,64,65,66,67] PAHs tend to accumulate in sediments and reach high enough concentrations in some coastal environments to pose an environmental health threat that includes cancer in fish populations, toxicity to organisms living in the sediment, and risks to those (e.g., migratory birds) that consume these organisms.[68,69] PAHs tend to accumulate in sediments and bioaccumulate in fresh water, flora and fauna.

Atmospheric deposition of pollutants 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.[70] Atmospheric deposition may 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.

(3) Impacts on Visibility

Emissions from ships contribute to poor visibility in the U.S. through their primary $PM_{2.5}$ emissions, as well as their NO_X and SO_X emissions which contribute to the formation of secondary

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[62] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903
[63] Dickhut R.M., Canuel E.A., Gustafson K.E., Liu K., Arzayus K.M., Walker S.E., Edgecombe G., Gaylor M.O., MacDonald E.H. (2000). Automotive Sources of Carcinogenic Polycyclic Aromatic Hydrocarbons Associated with Particulate Matter in the Chesapeake Bay Region. *Environmental Science & Technology, 34(21)*, 4635-4640.
[64] Simcik M.F., Eisenreich, S.J., Golden K.A., et al. (1996) Atmospheric Loading of Polycyclic Aromatic Hydrocarbons to Lake Michigan as Recorded in the Sediments. *Environmental Science and Technology, 30*, 3039-3046.
[65] Simcik M.F., Eisenreich S.J., Lioy P.J. (1999) Source apportionment and source/sink relationship of PAHs in the coastal atmosphere of Chicago and Lake Michigan. *Atmospheric Environment, 33*, 5071-5079.
[66] Poor N., Tremblay R., Kay H., et al. (2002) Atmospheric concentrations and dry deposition rates of polycyclic aromatic hydrocarbons (PAHs) for Tampa Bay, Florida, USA. *Atmospheric Environment, 38*, 6005-6015.
[67] Arzavus K.M., Dickhut R.M., Canuel E.A. (2001) Fate of Atmospherically Deposited Polycyclic Aromatic Hydrocarbons (PAHs) in Chesapeake Bay. *Environmental Science & Technology, 35,* 2178-2183.
[68] Simcik M.F., Eisenreich, S.J., Golden K.A., et al. (1996) Atmospheric Loading of Polycyclic Aromatic Hydrocarbons to Lake Michigan as Recorded in the Sediments. *Environmental Science and Technology, 30,* 3039-3046.
[69] Simcik M.F., Eisenreich S.J., Lioy P.J. (1999) Source apportionment and source/sink relationship of PAHs in the coastal atmosphere of Chicago and Lake Michigan. *Atmospheric Environment, 33*, 5071-5079.
[70] 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. Retrieved on April 9, 2009 from http://www.epa.gov/ttn/naaqs/standards/pm/data/pmstaffpaper_20051221.pdf

$PM_{2.5}$.[71] Visibility can be defined as the degree to which the atmosphere is transparent to visible light. Airborne particles degrade visibility by scattering and 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.[72,73]

EPA is pursuing a two-part strategy to address visibility. First, EPA has set secondary $PM_{2.5}$ standards which act in conjunction with the establishment of a regional haze program. In setting the secondary $PM_{2.5}$ 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).[74] 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.

(4) 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 impaired photosynthesis, both of which can lead to reduced plant growth and reproduction, resulting in reduced crop yields, forestry production, and use of sensitive ornamentals in landscaping. In addition, the impairment of photosynthesis, the process by which the plant makes carbohydrates (its source of energy and food), can lead to a subsequent reduction in root growth and carbohydrate storage below ground, resulting in other, more subtle plant and ecosystems impacts.

These latter impacts include increased susceptibility of plants to insect attack, disease, harsh weather, interspecies competition and overall decreased plant vigor. The adverse effects of ozone

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[71] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Volume I Document No. EPA600/P-99/002aF and Volume II Document No. EPA600/P-99/002bF. Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[72] U.S. EPA. (2004). *Air Quality Criteria for Particulate Matter (AQCD).* Volume I Document No. EPA600/P-99/002aF and Volume II Document No. EPA600/P-99/002bF. Washington, DC: U.S. Environmental Protection Agency. Retrieved on March 18, 2009 from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

[73] 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. Washington, DC: U.S. Environmental Protection Agency.

[74] 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.

on forest and other natural vegetation can potentially lead to species shifts and loss from the affected ecosystems, resulting in a loss or reduction in associated ecosystem goods and services. Lastly, visible ozone injury to leaves can result in a loss of aesthetic value in areas of special scenic significance like national parks and wilderness areas. The final 2006 ozone AQCD presents more detailed information on ozone effects on vegetation and ecosystems.

C. Air Quality Modeling Results

Air quality modeling was performed to assess the impact of the coordinated strategy. We looked at impacts on future ambient $PM_{2.5}$ and ozone levels, as well as nitrogen and sulfur deposition levels and visibility impairment. In this section, we present information on current levels of pollution as well as model projected levels of pollution for 2020 and 2030.[75]

The air quality modeling uses EPA's Community Multiscale Air Quality (CMAQ) model. The CMAQ modeling domain is rectangular in shape and encompasses all of the lower 48 states, portions of Canada and Mexico, and areas extending into the ocean up to 1,000 nautical miles (nm), depending on the coast. The smallest area of ocean coverage is over the northeast U.S. In places like Maine and Cape Cod, the easternmost points of the contiguous U.S., the distance to the edge of the CMAQ modeling domain is approximately 150 nm. The rest of the U.S. shoreline has at least 200 nm between the shoreline and boundary of the air quality modeling. The CMAQ modeling domain is described in more detail in Section 2.4.5.2 of the RIA. The performance of the CMAQ modeling was evaluated using a 2002 base case simulation. More detail about the performance evaluation is contained within the Section 2.4.5.4 of the RIA. The model was able to reproduce historical concentrations of ozone and $PM_{2.5}$ at land-based monitors with low amounts of bias and error. While we are not able to evaluate the model's performance over the ocean due to the absence of surface monitors, there is no evidence to suggest that model performance is unsatisfactory over the ocean.

The emission control scenarios used in the air quality modeling are slightly different than the final coordinated strategy emission control scenarios. For example, the 2020 air quality impacts are based on inventory estimates that were modeled using incorrect ECA boundary information off of the western coast of the U.S. A calculation error placed the western 200 nautical mile (nm) ECA boundary approximately 50 nm closer to shore. Additionally, the 2020 air quality control case does not reflect emission reductions related to global controls for areas that are beyond 200 nm but within the CMAQ air quality modeling domain. Finally, the emission control scenarios do not consider the exemption of Great Lakes steamships from the final fuel sulfur standards. The impact of these differences is expected to be minimal.

[75] As discussed in Section 3.7 of the RIA, the inventories used for the air quality modeling in 2020 and 2030 differ slightly from each other. The difference between 2020 and 2030 is small and was due to an error in calculating the 200 nautical miles distance. In addition, as discussed in Section 3.7 of the RIA, the 2020 air quality control case does not include global controls for areas that are beyond 200 nautical miles but within the air quality modeling domain. The impact of this latter difference is expected to be minimal.

(1) Particulate Matter

The coordinated strategy described in this final rule will significantly reduce ambient PM concentrations through reductions in emissions of direct PM, as well as NO_X and SO_X which contribute to secondary PM.

(a) Current Levels

$PM_{2.5}$ concentrations exceeding the level of the $PM_{2.5}$ NAAQS occur in many parts of the country. In 2005, EPA designated 39 nonattainment areas for the 1997 $PM_{2.5}$ NAAQS (70 FR 943, January 5, 2005). These areas are composed 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 24-hour $PM_{2.5}$ NAAQS became effective on December 18, 2006. On October 8, 2009, the EPA issued final nonattainment area designations for the 24-hour $PM_{2.5}$ NAAQS (74 FR 58688, November 13, 2009). These designations include 31 areas composed of 120 full or partial counties.

(b) Projected Levels

A number of state governments have told EPA that they need the reductions the coordinated strategy will provide in order to meet and maintain the $PM_{2.5}$ NAAQS.[76] Most 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 2006 24-hour $PM_{2.5}$ nonattainment areas will be required to attain in the 2014 to 2019 time frame and then maintain thereafter. The fuel sulfur emission standards will become effective in 2010 and 2015, and the NO_X engine emission standards will become effective in 2016. Therefore, the coordinated strategy emission reductions will be 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 rule projects that in 2020, with all current controls but excluding the reductions expected to occur as a result of the coordinated strategy, at least 13 counties with a population of almost 30 million may not attain the 1997 annual $PM_{2.5}$ standard of 15 $\mu g/m^3$ and 47 counties with a population of over 53 million may not attain the 2006 24-hour $PM_{2.5}$ standard of 35 $\mu g/m^3$. These numbers do not account for those areas that are close to (e.g., within 10 percent of) the $PM_{2.5}$ standards. 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 of the expected impacts of the coordinated strategy shows that in 2020 and 2030 all of the modeled counties will experience decreases in their annual and 24-hour $PM_{2.5}$ design values. For areas with current annual $PM_{2.5}$ design values greater than 15$\mu g/m^3$, the modeled future-year, population-weighted annual $PM_{2.5}$ design values are expected to decrease on average by 0.8 $\mu g/m^3$ in 2020 and by 1.7 $\mu g/m^3$ in 2030. For areas with current 24-hour $PM_{2.5}$ design values greater than 35$\mu g/m^3$, the modeled future-year, population-weighted annual $PM_{2.5}$ design values are expected to decrease on average by 1.3 $\mu g/m^3$ in 2020 and by 3.4 $\mu g/m^3$ in 2030.

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[76] See the Advanced Notice of Proposed Rule Making at Docket Number: EPA-HQ-OAR-2007-0121

In 2030, the maximum projected decrease for an annual $PM_{2.5}$ design value is 6.0 $\mu g/m^3$ in Miami, FL, and the maximum projected decrease for a 24-hour $PM_{2.5}$ design value is 11.7 $\mu g/m^3$ in Los Angeles, CA. The air quality modeling methodology and the projected reductions are discussed in more detail in Chapter 2 of the RIA.

(2) Ozone

(a) Current Levels

In 2008, the U.S. EPA amended the ozone NAAQS (73 FR 16436, March 27, 2008). The final 2008 ozone NAAQS rule set forth revisions to the previous 1997 NAAQS for ozone to provide increased protection of public health and welfare. As of July 31, 2009 there are 54 areas designated as nonattainment for the 1997 8-hour ozone NAAQS, comprising 282 full or partial counties with a total population of almost 127 million people. These numbers do not include the people living in areas where there is a future risk of failing to maintain or attain the 1997 8-hour ozone NAAQS. The numbers above likely underestimate the number of counties that are not meeting the ozone NAAQS because the nonattainment areas associated with the more stringent 2008 8-hour ozone NAAQS have not yet been designated.[77] Table II-1 provides an estimate, based on 2005-07 air quality data, of the counties with design values greater than the 2008 8-hour ozone NAAQS of 0.075 ppm.

Table II-1 Counties with Design Values Greater Than the 2008 Ozone NAAQS Based on 2005-2007 Air Quality Data

	NUMBER OF COUNTIES	POPULATION[a]
1997 Ozone Standard: counties within the 54 areas currently designated as nonattainment (as of 7/31/09)	282	126,831,848
2008 Ozone Standard: additional counties that would not meet the 2008 NAAQS[b]	227	41,285,262
Total	509	168,117,110

Notes:
[a] Population numbers are from 2000 census data.
[b] Attainment designations for the 2008 ozone NAAQS have not yet been made. Nonattainment for the 2008 Ozone NAAQS will be based on three years of air quality data from later years. Also, the county numbers in this row include only the counties with monitors violating the 2008 Ozone NAAQS. The numbers in this table may be an

[77] On September 16, 2009, the Administrator announced that the EPA is reconsidering the 2008 ozone standards to determine whether they adequately protect public health and the environment. She also announced that the Agency will propose to temporarily stay the 2008 standards for the purpose of attainment and nonattainment area designations. Under the stay, all activities to designate areas for the 2008 ozone standards would be suspended for the duration of the reconsideration period. EPA intends to complete the reconsideration by August 31, 2010. If, as a result of the reconsideration, EPA determines that the 2008 ozone standards are not supported by the scientific record and promulgates different ozone standards, the new 2010 ozone standards would replace the 2008 ozone standards and the requirement to designate areas for the 2008 standards would no longer apply. If EPA promulgates new ozone standards in 2010, EPA intends to accelerate the designations process to that the designations would be effective in August 2011.

underestimate of the number of counties and populations that will eventually be included in areas with multiple counties designated nonattainment.

(b) Projected Levels

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 for the 1997 standard (69 FR 23951, April 30, 2004), most 8-hour ozone nonattainment areas will be required to attain the 1997 ozone NAAQS in the 2007 to 2013 time frame and then maintain the NAAQS thereafter. In addition, there will be attainment dates associated with the designation of nonattainment areas as a result of the reconsideration of the 2008 ozone NAAQS. Many of these nonattainment areas will need to adopt additional emission reduction programs, and the NO_X reductions that will result from the coordinated strategy will be particularly important for these states.

EPA has already adopted many emission control programs that are expected to reduce ambient ozone levels and assist in reducing the number of areas that fail to achieve the ozone NAAQS. Even so, our air quality modeling projects that in 2020, with all current controls but excluding the reductions achieved through the coordinated strategy, up to 50 counties with a population of almost 50 million may not attain the 2008 ozone standard of 0.075 ppm. These numbers do not account for those areas that are close to (e.g., within 10 percent of) the 2008 ozone standard. These areas, although not violating the standards, will also benefit from the additional reductions from this rule ensuring long-term maintenance of the ozone NAAQS.

These air quality modeling results suggest that emission reductions achieved through the coordinated strategy will improve both the average and population-weighted average ozone design value concentrations for the U.S. in 2020 and 2030. In addition, the air quality modeling shows that on average the coordinated program described in this action will help bring counties closer to ozone attainment as well as assist counties whose ozone concentrations are within 10 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 0.5 ppb in 2020 and 1.6 ppb in 2030. The air quality modeling methodology and the projected reductions are discussed in more detail in Chapter 2 of the RIA.

It should be noted that even though our air quality modeling predicts important reductions in nationwide ozone levels, three counties (of 661 that were part of the analysis) are expected to experience an increase in their ozone design values in 2030. There are two counties in Washington, Clallam County and Clark County, and Orange County CA, 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 2.4.5), the projected reductions (Section 2.4), and the limited NO_X disbenefits (Section 2.4.2.2.2), are discussed in more detail in Chapter 2 of the RIA.

(c) Case Study of Shipping Emissions and Ozone Impacts on Forests

The section below attempts to estimate the impacts of the coordinated strategy on forests through a case study.

Assessing the impact of ground-level ozone on forests in the United States involves understanding the risk/effect of tree species to ozone ambient concentrations and accounting for the prevalence of those species within the forest. As a way to quantify the risk/effect of particular plants to ground-level ozone, scientists have developed ozone-exposure/tree-response functions by exposing tree seedlings to different ozone levels and measuring reductions in growth as "biomass loss".[78]

With knowledge of the distribution of sensitive species and the level of ozone at particular locations, it is possible to estimate a "biomass loss" for each species across their range. EPA performed an analysis for 2020 in which we examined biomass loss with and without ship emissions to determine the benefit of reducing these emissions on sensitive tree species in the U.S.[79] The biomass loss attributable to shipping appears to range from 0 to 6.5 % depending on the particular species. The species most sensitive to ozone related biomass loss in the U.S. is black cherry (*Prunus serotina*); the area of its range with more than 10% total biomass loss in 2020 decreased by 8.5% in the case in which emissions from ships were removed. Likewise, yellow-poplar (*Liriodendron tulipifera*), eastern white pine (*Pinus strobus*), aspen (*Populus spp.*), and ponderosa pine (*Pinus ponderosa*) saw areas with more then 2% biomass loss reduced by 2.1% to 3.8% in 2020. This 2% level of biomass loss is important, because a consensus workshop on ozone effects reported that a 2% annual biomass loss causes harm due to the potential for compounding effects over multiple years as short-term negative effects on seedlings affect long-term forest health.[80,81]

(3) Nitrogen and Sulfur Deposition

(a) Current Levels

Over the past two decades, the EPA has undertaken numerous efforts to reduce nitrogen and sulfur deposition across the U.S. Analyses of long-term monitoring data for the U.S. show that deposition of both nitrogen and sulfur compounds has decreased over the last 17 years although many areas continue to be negatively impacted by deposition. Deposition of inorganic nitrogen and sulfur species routinely measured in the U.S. between 2004 and 2006 were as high as 9.6 kg N/ha/yr and 21.3 kg S/ha/yr. The data shows that reductions were more substantial for sulfur compounds than for nitrogen compounds. These numbers are generated by the U.S. national monitoring network and they likely underestimate nitrogen deposition because NH_3 is not measured. In the eastern U.S., where data are most abundant, total sulfur deposition decreased by about 36 %

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[78] Chappelka, AH, Samuelson, LJ. (1998). Ambient ozone effects on forest trees of the Eastern United States: a review. *New Phytologist*, *139*, 91-108.
[79] Note that while the coordinated strategy does not eliminate ship emissions, it will be directionally helpful in reducing ship emissions.
[80] Prasad, A.M, Iverson L.R. (2003). Little's range and FIA importance value database for 135 eastern U.S. tree species. Northeastern Research Station, USDA Forest Service, Delaware, Ohio. [online] Retrieved on March 19,2009 from http://www.fs.fed.us/ne/delaware/4153/global/littlefia/index.html
[81] Heck W.W., Cowling E.B. (1997) The need for a Long Term Cumulative Secondary Ozone Standard – an Ecological Perspective. *Air and Waste Management Association, EM,* 23-33.

between 1990 and 2005 while total nitrogen deposition decreased by 19% over the same time frame.[82]

(b) Projected Levels

The emissions reductions that result from the coordinated strategy will significantly reduce the annual total sulfur and nitrogen deposition occurring in sensitive U.S. ecosystems including forests, wetlands, lakes, streams, and estuaries. For sulfur deposition, adopting the coordinated strategy will result in reductions ranging from 5% to 20% in 2020 along the entire Atlantic and Gulf coasts with higher levels of reduction, exceeding 25%, occurring in the near-land coastal waters of the U.S. In a few land areas on the Atlantic and Gulf coasts, such as the southern parts of the States of Louisiana, Texas, and Florida, 2020 sulfur deposition reductions will be much higher, i.e., over 30%. Along the Pacific Coast, sulfur deposition reductions will exceed 25% in the entire Southern California area, and the Pacific Northwest. For a map of 2020 sulfur reductions and additional information on these impacts see Section 2.4.3 of the RIA.

Overall, nitrogen deposition reductions in 2020 resulting from the coordinated strategy described in this action are less than sulfur deposition reductions. Nitrogen deposition reductions will range from 3% to 7% along the entire Atlantic, Pacific and Gulf Coasts. As with sulfur deposition reductions, a few areas such as the southern parts of the States of Louisiana, Texas, and Florida will experience larger reductions of nitrogen up to 9%. The Pacific coastal waters will see higher nitrogen reductions, exceeding 20% in some instances. See Section 2.4.3 of the RIA for a map and additional information on nitrogen deposition impacts.

(4) Visibility

(a) Current Levels

As mentioned in Section II.C.1, millions of people live in nonattainment areas for the $PM_{2.5}$ 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. In summary, visibility impairment is experienced throughout the U.S., in multi-state regions, urban areas, and remote mandatory class I federal areas.

(b) Projected Levels

The air quality modeling conducted for the coordinated strategy was also used to project visibility conditions in 133 mandatory class I federal areas across the U.S. in 2020 and 2030. The results indicate that improvements in visibility due to OGV emissions reductions will occur in all 133 mandatory class I federal areas in the future, although all areas will continue to have annual average deciview levels above background in 2020 and 2030.[83] The average visibility on the 20

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[82] U.S. EPA. U.S. EPA's 2008 Report on the Environment (Final Report). U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-07/045F (NTIS PB2008-112484).

[83] The level of visibility impairment in an area is based on the light-extinction coefficient and a unit less visibility index, called a "deciview", which is used in the valuation of visibility. The deciview metric provides a scale for perceived visual changes over the entire range of conditions, from clear to hazy. Under many scenic conditions, the average

percent worst days at these scenic locales is projected to improve by 0.22 deciviews, or 1.4 percent in 2020 and by 0.43 deciviews or 2.7% in 2030.

The greatest improvements in visibilities will occur in coastal areas. For instance, the Agua Tibia Wilderness area (near Los Angeles) will see a 9% improvement (2.17 DV) in 2020 and a 17% improvement (4.6 DV) in 2030 as a result of the emission reductions from the coordinated strategy. National parks and national wilderness areas in other parts of the country will also see improvements. For example, in 2030 the Swanquarter National Wildlife Refuge (North Carolina) will have a 5% improvement in visibility (1.11 DV) and Acadia National Park (Maine) will have a 6% improvement (1.27 DV) with the coordinated strategy. Even inland mandatory class I federal areas are projected to see improvements as a result of the controls from the coordinated strategy. For example in 2030, the Grand Canyon National Park, located in the state of Arizona, will see a 54% improvement in visibility (0.42 DV) with the coordinated strategy. For the table which contains the full visibility results over the 133 analyzed areas see Section 2.2.4.2 of the RIA.

D. Emissions from Ships with Category 3 Engines

(1) Overview

This section describes the contribution of Category 3 vessels to national emission inventories of NO_X, $PM_{2.5}$, and SO_2. A Category 3 vessel has a Category 3 propulsion engine. Emissions from a Category 3 vessel include the emissions from both the propulsion and auxiliary engines on that vessel. Propulsion and auxiliary engine emissions were estimated separately to account for differences in emission factors, engine size and load, and activity.

We estimate that in 2009, Category 3 vessels will contribute almost 913,000 tons (10 percent) to the national mobile source NO_X inventory, about 71,000 tons (24 percent) to the mobile source diesel $PM_{2.5}$ inventory, and nearly 597,000 tons (80 percent) to the mobile source SO_2 inventory. Expressed as a percentage of all anthropogenic emissions, Category 3 vessels contribute 6 percent to the national NO_X inventory, 3 percent to the national $PM_{2.5}$ inventory, and 11 percent to the total SO_2 inventory in 2009. In 2030, absent the strategy discussed in this rule, these vessels will contribute about 2.1 million tons (40 percent) to the mobile source NO_X inventory, 168,000 tons (75 percent) to the mobile source diesel $PM_{2.5}$ inventory, and about 1.4 million tons (95 percent) to the mobile source SO_2 inventory. Expressed as a percentage of all anthropogenic emissions, Category 3 vessels will contribute 19 percent to the national NO_X inventory, 5 percent to the national $PM_{2.5}$ inventory, and 15 percent to the total SO_2 inventory in 2030. Under this strategy, by 2030, annual NO_X emissions from these vessels will be reduced by 1.2 million tons, $PM_{2.5}$ emissions by 143,000 tons, and SO_2 emissions by 1.3 million tons.[84]

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person can generally perceive a change of one deciview. The higher the deciview value, the worse the visibility. Thus, an improvement in visibility is a decrease in deciview value.

[84] These emission inventory reductions include reductions from ships operating within the 24 nautical mile regulatory zone off the California Coastline, beginning with the effective date of the Coordinated Strategy program elements. The California regulation contains a provision that would sunset the requirements of the rule if the federal program achieves equivalent emission reductions. See http://www.arb.ca.gov/regact/2008/fuelogv08/fro13.pdf at 13 CCR 2299.2(j)(1).

Each sub-section below discusses one of the three affected pollutants, including expected emission reductions that will result from the combination of the proposed CAA NO_X standards along with the ECA designation through amendment to MARPOL Annex VI and related fuel standards. Table II-2 summarizes the impacts of these reductions for 2020 and 2030 on a national basis. Chapter 3 of the RIA also presents regional emissions inventories, such as those for the Great Lakes. Table II-3 provides the estimated 2030 NO_X emission reductions (and PM reductions) for the coordinated strategy compared to the Locomotive and Marine rule, Clean Air Nonroad Diesel (CAND) program, and the Heavy-Duty Highway rule. Further details on our inventory estimates are available in Chapter 3 of the RIA. Note that the inventories presented here do not consider the exemption of Great Lakes steamships from the final fuel sulfur standards. This change to the program is not expected to have a significant impact on national inventory estimates. We intend to follow up with a more detailed study of the impacts of the emission control program on Great Lakes carriers which may provide information that will help us refine our Great Lakes emission inventories.

As described in Chapter 3 of the RIA, the Category 3 vessel emission inventories presented in this section are estimated by combining two sets of emissions inventories, one for U.S. port areas and one for operation on the open ocean. With regard to operation on the open ocean, it was necessary to specify an outer boundary of the modeling domain; otherwise, emissions from ships operating as far away as Asia or Europe would be included in the U.S. emission inventory. For simplicity, we set the outer boundary for inventory modeling roughly equivalent to the U.S. Exclusive Economic Zone (EEZ). It consists of the area that extends 200 nautical miles (nm) from the official U.S. baseline, which is recognized as the low-water line along the coast as marked on the official U.S. nautical charts in accordance with the articles of the Law of the Sea. The U.S. region was then clipped to the boundaries of the U.S. EEZ. While this area will exclude emissions that occur outside the 200 nm boundary but that are transported to the U.S. landmass, it has the advantage of corresponding to an area in which the United States has a clear environmental interest. This area also corresponds well to the CMAQ modeling domain for most coasts.

Table II-2 Estimated National (50 State) Reductions in Emissions from Category 3 Commercial Marine Vessels[a]

Pollutant [short tons]	**2020**	**2030**
NO_X		
NO_X Emissions without Coordinated Strategy	1,361,000	2,059,000
NO_X Emissions with Coordinated Strategy	952,000	878,000
NO_X Reductions Resulting from Coordinated Strategy	409,000	1,181,000
Direct $PM_{2.5}$		
$PM_{2.5}$ Emissions without Coordinated Strategy	110,000	168,000
$PM_{2.5}$ Emissions with Coordinated Strategy	16,000	25,000

$PM_{2.5}$ Reductions Resulting from Coordinated Strategy	94,000	143,000
SO_2		
SO_2 Emissions without Coordinated Strategy	928,000	1,410,000
SO_2 Emissions with Coordinated Strategy	51,000	78,000
SO_2 Reductions Resulting from Coordinated Strategy	877,000	1,332,000

Notes:
[a] Emissions are included within 200 nautical miles of the U.S. coastline.

Table II-3 Projected 2030 Emissions Reductions from Recent Mobile Source Rules (short tons)[a]

Rule	NO_X	$PM_{2.5}$
Category 3 Marine	1,181,000	143,000
Locomotive and Marine	795,000	27,000
Clean Air Nonroad Diesel	738,000	129,000
Heavy-Duty Highway	2,600,000	109,000

Notes:
[a] Locomotive and Marine Rule (73 FR 25098, May 6, 2008)
Clean Air Nonroad Diesel Rule (69 FR 38957, June 29, 2004)
Heavy-Duty Highway Rule (66 FR 5001, January 18, 2001)

(2) NO_X Emission Reductions

In 2009, annual emissions from Category 3 marine vessels will total about 913,000 tons. Earlier Tier 1 NO_X engine standards became effective in 2000, but the reductions due to the Tier 1 standards are offset by the growth in this sector, resulting in increased NO_X emissions of 1.4 million tons and 2.1 million tons in 2020 and 2030, respectively.

As shown in Table II-2, the coordinated strategy will reduce annual NO_X emissions from the current national inventory baseline by 409,000 tons in 2020 and 1,181,000 tons in 2030.

As shown in

Table II-3, the 2030 NO_X reductions for the coordinated strategy will exceed those for the other two nonroad rules.

(3) $PM_{2.5}$ Emissions Reductions

In 2009, annual emissions from Category 3 marine vessels will total about 71,000 tons. By 2030, these engines, absent the coordinated strategy, would contribute about 168,000 tons.

As shown in Table II-2, the coordinated strategy will reduce annual $PM_{2.5}$ emissions by 94,000 tons in 2020 and 143,000 tons in 2030. As seen in Table II-3, the 2030 $PM_{2.5}$ emission reduction will be larger than any of the reductions achieved with other recent rules.

(4) SO_2 Emissions Reductions

In 2009, annual emissions from Category 3 marine vessels will total about 597,000 tons. By 2030, these engines, absent the coordinated strategy, will contribute about 1.4 million tons.

As shown in Table II-2 the coordinated strategy will reduce annual SO_2 emissions by 877,000 tons in 2020 and 1.3 million tons in 2030.

III. Engine Standards

This section details the emission standards, implementation dates, and other major requirements being finalized under the Clean Air Act. A discussion of the technological feasibility of the finalized NO_X standards follows the description of the proposed program.

Other elements of our coordinated strategy to control emissions from ships are discussed in subsequent sections. Provisions related to our Clean Air Act fuel controls are described in Section IV. Section V summarizes the U.S. and Canada's recent proposal to amend MARPOL Annex VI to designate much of the U.S. and Canadian coasts as an Emission Control Area.[85] Finally, provisions revising our Clean Air Act test procedures and related certification requirements, provisions to implement MARPOL Annex VI through APPS, and various changes we are making to our Category 1 and 2 (marine diesel engines with per cylinder displacement less than 30 liters per cylinder) marine diesel engine program are described in Section VI.

A. What Category 3 Marine Engines are Covered?

Consistent with our existing marine diesel emission control program, the engine emission standards being finalized will apply to any new marine diesel engine with per-cylinder displacement at or above 30 liters installed on a vessel flagged or registered in the United States.

With regard to marine diesel engines on foreign vessels that enter U.S. ports, we are retaining our current approach and not applying this Clean Air Act program to those engines. This

[85] The ECA proposal and associated Technical Support Document can be found at www.epa.gov/otaq/oceanvessels.htm. France has since joined the ECA proposal on behalf of the Saint Pierre and Miquelon archipelago

is appropriate because engines on foreign vessels are subject to the same NO_X limits through MARPOL Annex VI, and the United States can enforce compliance pursuant to Annex VI and the recent amendments to the Act to Prevent Pollution from Ships (33 USC 1901 et seq.). At the same time, however, the effectiveness of this approach is contingent on the designation of U.S. coasts as an ECA pursuant to MARPOL Annex VI, since the Annex VI Tier III NO_X limits are geographic in scope and apply only if an ECA has been adopted. We anticipate that MARPOL Annex VI will be amended to include the North American ECA proposal. However, if the proposed amendment is not adopted in a timely manner by IMO, we will reconsider whether additional action in necessary to control harmful emissions from all vessels affecting U.S. air quality. Section V contains a description of the ECA designation process.

The combination of this Clean Air Act program, MARPOL Annex VI, and APPS will apply comparable emission standards to the vast majority of vessels entering U.S. ports or operating in U.S. waters.[86] Most significantly, these vessels will be required to meet the NO_X limits described below. As described later in this Section III and in Section VI, there will be some minor differences between the finalized Clean Air Act program and the requirements that apply under MARPOL Annex VI. Nevertheless, with respect to U.S. air quality, these differences will have a negligible effect on emissions from foreign vessels.

B. What Standards are we Finalizing for Newly Manufactured Engines?

This subsection details the emission standards (and implementation dates) we are finalizing for freshly manufactured (i.e., new) Category 3 engines on U.S. vessels. As described in Section III.C, we believe the standards will be challenging to manufacturers, yet ultimately feasible and cost-effective within the finalized lead time. These standards, along with other parts of our program, are the outcome of our work with stakeholders to resolve the challenges associated with applying advanced diesel engine technology to Category 3 engines to achieve significant NO_X reductions.

(1) NO_X Standards

We are finalizing new Tier 2 and Tier 3 NO_X emission standards for Category 3 marine diesel engines. Our existing Tier 1 NO_X standards for Category 3 engines were dependent on the rated speed of the engine for speeds between 130 revolutions per minute (rpm) and 2000 rpm. Fixed standards applied for lower and higher speeds. Thus, the standards were expressed as an equation that applies for speeds between 130 rpm and 2000 rpm, along with fixed values that were calculated from the equation for 130 rpm and 2000 rpm that apply for lower and higher speeds. This was done to account for the fact that brake-specific NO_X emissions are inherently higher for lower speed engines (and lower for higher speed engines). Note that this same approach is used by the IMO for the same technical reasons. We are continuing this approach for Tier 2 and Tier 3, as shown in Table III-1.

[86] Certain public vessels such as military vessels and foreign vessels in innocent passage may be exempt.

Table III-1 NO_X Emission Standards for Category 3 Engines (g/kW-hr)

		Less than 130 RPM	130-2000 RPM[a]	Over 2000 RPM
Tier 1	2004[b]	17.0	$45.0 \cdot n^{(-0\ .20)}$	9.8
Tier 2	2011	14.4	$44.0 \cdot n^{(-0.23)}$	7.7
Tier 3	2016	3.4	$9.0 \cdot n^{(-0.20)}$	2.0

Notes:
[a] Applicable standards are calculated from n (maximum in-use engine speed in RPM), rounded to one decimal place.
[b] Tier 1 NO_X standards applied for engines originally manufactured after 2004, and also to certain earlier engines.

Our analysis, which is described in the RIA, shows that these standards will give the greatest degree of emission control achievable considering compliance costs, lead time, and other relevant factors. The technological bases are also discussed briefly below.

Note that other important provisions related to compliance with these standards are described in Section VI. This includes provisions to ensure effective control of NO_X emissions over a broad range of operating conditions.

(a) Tier 2 NO_X Limits

We are finalizing the proposed Tier 2 NO_X emission standards for Category 3 marine diesel engines. In-cylinder emission control technology for Category 3 marine engines has progressed substantially in recent years. Significant reductions can be achieved in the near term with little or no impact on overall vessel performance. These technologies include traditional engine-out controls such as electronically-controlled high-pressure common-rail fuel systems, turbocharger optimization, compression-ratio changes, and electronically-controlled exhaust valves. We are setting a near-term NO_X emission standard requiring a reduction of approximately 20 percent below the current Tier 1 standard beginning 2011.

(b) Tier 3 NO_X Limits

While the Tier 2 standards will achieve modest reductions quickly, the finalized Tier 3 standards are intended to achieve much greater emission reductions through the use of more advanced emission control technology. These standards will achieve reductions of about 80 percent from the current Tier 1 standards. As explained in the RIA, we evaluated the possibility of requiring the Tier 3 limits on an earlier schedule than 2016. However, we found that a schedule requiring Tier 3 limits prior to 2016 had significant feasibility issues, and are therefore finalizing the 2016 implementation date for Tier 3 standards. Under the finalized approach, manufacturers of Category 3 engines will have about the same amount of lead time allowed manufacturers for smaller diesel marine engines and for locomotives.

(2) PM and SO_X Standards

We are not establishing new engine standards for PM or SO_X emissions. We intend to rely instead on the use of cleaner fuels as described in Section IV and V. SO_X emissions and the majority of the direct PM emissions from Category 3 marine engines operated on residual fuels are a direct result of fuel quality, most notably the sulfur in the fuel, and engine-based PM controls are not currently feasible for engines using these higher sulfur fuels. Other components of residual fuel, such as ash and heavy metals, also contribute directly to PM.

Using cleaner distillate fuel is the most effective means to achieve significant PM and SO_X reductions for Category 3 engines. We are finalizing requirements to substantially reduce the sulfur content of fuel purchased in the U.S. for use in an ECA. This complements Annex VI which requires that fuels used in ECAs around the world have sulfur levels no higher than 1,000 ppm. This sulfur limit is expected to necessitate the use of distillate fuel which will result not only in reductions in sulfate PM emissions, but also reductions in organic PM and metallic ash particles in the exhaust.

Even though the sulfur limit is much lower than current levels, it is not clear if this fuel sulfur level would be low enough to allow Category 3 engines to be equipped with the catalytic PM filters similar to those being used by trucks today. If we were to require technology that needs lower sulfur fuel, such as 15 ppm, ship operators would need to have access to this fuel around the world and at this time, it is not clear if 15 ppm sulfur fuel could be made available globally. Operating on higher sulfur fuel, such as for outside of our waters, could otherwise result in damage to the PM control equipment. In any case, the 1,000 ppm sulfur fuel requirement alone will eliminate 85 percent of PM emissions from ships operating in ECAs.

To further our understanding of PM emissions from ships, we are requiring engine manufacturers to measure and report PM emissions even though we are not finalizing a PM standard. The information gathered will help support our efforts as we continue to evaluate the feasibility of achieving further PM reductions. It will also help us to better characterize the PM emission rates associated with operating Category 3 engines on distillate fuel. If we determine that further PM reductions are feasible or that a specific PM limit is necessary to ensure anticipated reductions in PM emissions from ships, we may propose PM standards for Category 3 engines in the future.

(3) HC and CO Standards

We are finalizing HC and CO standards of 2.0 g/kW-hr and 5.0 g/kW-hr, respectively. Emission control technologies for Category 3 marine engines have been concentrated on reducing NO_X and PM emissions, but these emission standards will prevent increases in emissions of HC and CO that might otherwise occur as a result of use of certain technologies for controlling NO_X, such as those that significantly degrade combustion efficiency.

(4) CO_2 Standards

We are not adopting CO_2 standards for marine diesel engines at this time. Marine diesel engines are included in other ongoing Agency actions, including our Advance Notice of Proposed Rulemaking (ANPRM) for mobile sources (73 FR 44353, July 30, 2008) and our Greenhouse Gas Reporting Rule (74 FR 16448, April 10, 2009). In addition, EPA is participating in the U.S.

Government delegation to IMO, which is currently engaged in negotiations for an international program to address greenhouse emissions from ships.

C. Are the Standards Feasible?

We have analyzed a variety of technologies available for NO_X reduction in the Category 3 marine sector. As described in more detail in our RIA, we are projecting that marine diesel engine manufacturers will choose to use in-cylinder, or engine design-based emission control technologies to achieve the NO_X reductions required to meet the final Tier 2 standard.

The in-cylinder, or engine-out, NO_X emissions of a diesel engine can be controlled by utilizing engine design and calibration parameters (e.g., fuel delivery and valve timing) to limit the formation of NO_X. NO_X formation rate has a strong exponential relationship to combustion temperature. Therefore, high temperatures result in high NO_X formation rates.[87,88] Any changes to engine design and calibration which can reduce the peak temperature realized during combustion will also reduce NO_X emissions. Many of the approaches and technologies for reducing in-cylinder NO_X emissions are discussed in our RIA.

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[87] Flynn, P., et al, "Minimum Engine Flame Temperature Impacts on Diesel and Spark-Ignition Engine NO_X Production", SAE 2000-01-1177, 2000.
[88] Heywood, John B., "Internal Combustion Engine Fundamentals", McGraw-Hill, 1988.

To achieve the 80 percent NO_X reductions required to meet the final Tier 3 standard, we believe many manufacturers will choose selective catalytic reduction (SCR) exhaust aftertreatment technology. SCR is a commonly-used technology 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 European heavy-duty truck manufacturers are currently 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 limited to marine ferryboat and stationary electrical power generation demonstration projects in California and several of the Northeast states. SCR systems are currently being designed and developed for use on ocean-going vessels worldwide, and we project that SCR will continue to be a viable technology for control of Category 3 NO_X emissions.

When operating in the ECA, SCR units would be active, meaning that urea would be injected into the exhaust to facilitate catalytic reduction of NO_X emissions. When outside of the ECA, the unit would likely be inactive, meaning that urea would not be injected into the exhaust. When the SCR unit is inactive, the exhaust flow could either continue to pass through the SCR unit or be diverted around the catalyst. Under the MARPOL NO_X Technical Code, a means for monitoring the use of urea must be provided which must include "sufficient information to allow a ready means of demonstrating that the consumption of such additional substances is consistent with achieving compliance with the applicable NO_X limit." In addition, where a NO_X reducing device, such as SCR, is used, one of the options for providing verification of compliance with the NO_X standard is through direct measurement and monitoring of NO_X emissions. A more detailed discussion of SCR technology can be found in our RIA.

SCR is not the only approach under consideration for meeting the Tier 3 standards. Manufacturers may choose a combination of other in-cylinder technologies, such fuel-water emulsification, direct water injection, intake air humidification, or exhaust gas recirculation (EGR) to reduce NO_X emissions and meet the final standards. These "in-cylinder" approaches could be calibrated and applied in one manner to achieve Tier 3 NO_X levels when operating with an ECA, and then adjusted, or re-calibrated, in another manner to achieve Tier 2 NO_X levels when operating outside an ECA. This is discussed in more detail in the RIA.

Another technology, which is currently under investigation, is the use of an exhaust gas cleaning unit (EGCS) to reduce NO_X emissions. One significant technological issue that must be addressed is the prevention of nitrates from being introduced into the water. In a typical diesel exhaust gas mixture, NO_X is composed of roughly 5-10% NO_2, with the majority of the remainder in the form of NO. NO_2 is soluble in water, and therefore may be removed by the water in the scrubber. It is possible to treat the exhaust upstream of the scrubber to convert more of the NO_X to NO_2, thereby facilitating the use of a scrubber to remove NO_2. However, we are concerned that this would add to nitrogen loading of the water in which the ship is operating. As discussed in Section II.B.1, nitrogen loading can lead to serious water quality impacts. This issue addressed in the IMO EGCS guidelines by limiting the amount of nitrates that may be removed by the scrubber, and washed overboard. However, a scrubber design may be acceptable if it removes nitrates from the wash water, which in turn are disposed of properly, or prevents nitrates from forming in the wash water. One manufacturer has stated that their unique EGCS design converts NO_X to nitrogen (N_2), rather than nitrates. This is discussed in more detail in the RIA.

IV. Fuel Standards

A. Background

EPA is finalizing standards for fuel manufactured or distributed in the U.S. that are consistent with those recently adopted as amendments to MARPOL Annex VI. As amended, Annex VI includes revised fuel sulfur standards for use in engines onboard ships, and it also set more stringent fuel sulfur limits for "any fuel oil used onboard ships…operating within an Emission Control Area" (Annex VI, Regulation 14).

Under the Annex, the process by which an Emission Control Area (ECA) is to be designated is through amendment of the Annex. The U.S. and Canadian governments have submitted a proposal to amend MARPOL Annex VI to designate an ECA to include waters off much of the U.S. and Canada. Specifically, the proposed ECA includes the waters off of the contiguous 48 states, Southeastern Alaska, and the Main Hawaiian Islands, extending to a distance of 200 nautical miles from the coastline. This amendment was considered at the July 2009 Marine Environment Protection Committee (MEPC 59), and we expect that the amendment will be adopted in March 2010, at MEPC 60. If this amendment is not adopted in a timely manner by IMO, we intend to take supplemental action to control emissions from vessels that affect U.S. air quality.

EPA is in this notice finalizing fuel sulfur limits under section 211(c) of the Clean Air Act that match the limits that apply under Annex VI in ECAs. The adoption of such standards will: (1) allow for the production and sale of up to 1,000 ppm sulfur fuel for use in Category 3 marine vessels; and (2) forbid the production and sale of fuel oil above 1,000 ppm sulfur for use in the waters within an ECA and ECA associated areas (per 40 CFR 1043.20) except as allowed under 40 CFR Part 1043, as described below.[89,90]

There are a few exceptions that will allow for the use of fuel greater than 1,000 ppm sulfur in an ECA. First, as an alternative to using lower sulfur fuel, Annex VI allows for the use of approaches, such as exhaust gas scrubbers, that can achieve equivalent emission reductions even when the fuel is operating on high sulfur residual fuel. In the event that a vessel is using an alternative device, procedure, or compliance method, provided they achieve equivalent emissions reductions, fuel oil above 1,000 ppm sulfur may be purchased in the U.S. for use in an ECA and ECA associated areas. This is discussed in more detail in Section V of this preamble. As discussed further in Section VI.B.5, existing steamships operating exclusively on the Great Lakes are not subject to the 1,000 ppm sulfur requirement, and vessels that have been granted temporary relief on

[89] Per 40 CFR 1043.20, "ECA associated areas" are U.S. internal waters that are navigable from the ECA. This term does not include internal waters that are shoreward of ocean waters that are not part of an emission control area. Though the outer limits of the sulfur limitation are the same as for the proposed ECA, the sulfur limitation in this final rule is not dependent on adoption of the ECA.

[90] For the purpose of the discussion in this section with regard to the CAA fuel standards in 40 CFR 80, "Category 3 vessel" refers to a commercial vessel with a Category 3 propulsion engine; "Category 2 vessel" refers to a commercial or recreational vessel with a Category 2 propulsion engine; and "Category 1 vessel" refers to a commercial or recreational vessel with only Category 1 or smaller engines. The fuel provisions being finalized today apply to all of the engines on a given vessel.

the basis of serious economic hardship are also not subject to the standard. These three exceptions are all set out in the regulations at 40 CFR Part 1043.

The majority of vessels with a Category 3 propulsion engine operate on high-sulfur, heavy fuel oil (HFO) (also known as residual, or bunker, fuel). Due to their use of heavy fuel, these marine diesel engines have very high PM and SO_2 emissions. Sulfur in the fuel is emitted from engines primarily as SO_2; however a small fraction is emitted as sulfur trioxide (SO_3) which immediately forms sulfate and is emitted as PM by the engine. In addition, much of the SO_2 emitted from the engine reacts in the atmosphere to form secondary PM. Reductions in residual fuel sulfur levels will lead to significant sulfate PM and SO_2 emission reductions which will provide dramatic environmental and public health benefits. However, in most cases, fuels that meet the long-term fuel sulfur standards will likely be distillate fuels, rather than HFO. In addition to reductions in sulfate PM, switching from HFO to distillate fuel may reduce black carbon emissions, fine particle counts, organic carbon, and metallic ash particles. Further information on these impacts as well as a discussion of the technological feasibility of fuel switching, or using alternative approaches, is discussed in Section V.

HFO sold for use by these vessels is currently not subject to any EPA sulfur limits (as it is not regulated by our current sulfur program) and generally has very high levels of sulfur. The finalized modifications to our existing diesel fuel program prohibit the production and sale of this fuel for use in an ECA associated area, and fuel sold for use in such areas will not be allowed to exceed a sulfur content of 1,000 ppm, except as allowed under 40 CFR Part 1043. In a complementary fashion, the amendment to MARPOL Annex VI designating the North American ECA will ensure that fuel used in an ECA, including fuel purchased in another country but used within the North American ECA, also either meets a 1,000 ppm sulfur limit or meets required emissions limits through the use of alternative devices, procedures, or compliance methods, provided they achieve equivalent emissions reductions (equivalents),. Under our finalized regulations, fuel sold for use by Category 3 vessels without equivalents in an ECA and ECA associated areas will be allowed to have a sulfur content as high as this 1,000 ppm sulfur limit (except as otherwise allowed under 40 CFR Part 1043), while fuel sold for use in Category 1 (marine diesel engines up to 7 liters per cylinder displacement) and Category 2 (marine diesel engines from 7 to 30 liters per cylinder) vessels will continue to be subject to the nonroad, locomotive, and marine[91] (NRLM) diesel fuel sulfur requirements. In the event that the North American ECA is not approved in a timely manner, we will revisit the standards being finalized here in that context.

B. Diesel Fuel Standards Prior to this Final Rule

The Nonroad Diesel program (finalized on June 29, 2004 (69 FR 38958)) reduces the sulfur content of NRLM diesel fuel from uncontrolled levels down to a maximum sulfur level of 15 ppm. Refiners and importers are required to produce or import all NRLM diesel fuel at a sulfur level of 15 ppm or less by June 1, 2014. The main compliance mechanism of the diesel sulfur program is

[91] For the purposes of this final rule (and the final 40 CFR Part 80 regulations), the term “marine” as it is used here refers to Category 1 and 2 marine diesel engines unless otherwise stated.

the Designate and Track (D&T) provisions, which allows NRLM diesel fuel to be distinguished from similar products (e.g., heating oil) and yet provides a means for diesel fuel to be fungibly transported through the fuel production and distribution system. Under D&T, refiners and importers are required to designate the type and sulfur level of each batch of fuel produced or imported. As this fuel is transferred through the distribution system, product transfer documents (PTDs) must be exchanged each time the batch changes custody. Along with PTDs, other required elements of D&T include quarterly and annual reporting, fuel pump labeling, and recordkeeping.

The Nonroad Diesel program also contains certain provisions to ease refiners' transition to the lower sulfur standards and to enable the efficient distribution of all diesel fuels. These provisions, as discussed more below in Section IV.B.2, include special provisions for qualified small refiners, transmix processors, and entities in the fuel distribution system.

(1) Scope of the Nonroad Diesel Fuel Program

The sulfur standards finalized by the Nonroad Diesel rule apply to all the diesel fuel that is produced and sold for use in NRLM diesel applications (all fuel used in NRLM diesel engines, except for fuels heavier than a No. 2 distillate used in Category 2 and 3 marine engines[92] and any fuel that is exempted for national security or other reasons). While the Nonroad Diesel rule did not set sulfur standards for other distillate fuels (such as jet fuel, heating oil, kerosene, and No. 4 fuel oil), it did implement provisions to prevent the inappropriate use of heating oil and other higher sulfur distillate fuels in NRLM and locomotive and marine (LM) diesel applications. Sale of distillate fuels for use in nonroad, locomotive, or marine diesel engines will generally be prohibited unless the fuel meets the diesel fuel sulfur standards of 40 CFR Part 80.[93] The regulated fuels under our diesel fuel sulfur program include those fuels listed in the regulations at 40 CFR 80.2(qqq).

The sulfur standards do not apply to: (1) No. 1 distillate fuel used to power aircraft; (2) Number 4, 5, and 6 fuels (e.g., residual fuels or residual fuel blends, intermediate fuel oil (IFO) Heavy Fuel Oil Grades 30 and higher), used for stationary source purposes; (3) any distillate fuel with a T–90 distillation point greater than 700 °F, when used in Category 2 or 3 marine diesel engines (this includes Number 4, 5, and 6 fuels (e.g., IFO Heavy Fuel Oil Grades 30 and higher), including fuels meeting the American Society for Testing and Materials (ASTM) specifications DMB, DMC, and RMA–10 and heavier); and (4) any fuel for which a national security or research and development exemption has been approved or fuel that is exported from the U.S. The criterion that any distillate fuel with a T–90 greater than 700 °F will not be subject to the sulfur standards when used in Category 2 or 3 marine engines was intended to exclude fuels heavier than No. 2 distillate, including blends containing residual fuel. In addition, residual fuel was not subject to the sulfur standards.

[92] Category 3 marine engines frequently are designed to use residual fuels and include special fuel handling equipment to use the residual fuel.

[93] For the purposes of the diesel sulfur program, the term heating oil basically refers to any No. 1 or No. 2 distillate other than jet fuel, kerosene, and diesel fuel used in highway or NRLM applications. For example, heating oil includes fuel which is suitable for use in furnaces and similar applications and is commonly or commercially known or sold as heating oil, fuel oil, or other similar trade names.

While many marine diesel engines use No. 2 distillate, ASTM specifications for marine fuels identify four kinds of marine distillate fuels: DMX, DMA, DMB, and DMC. DMX is a special light distillate intended mainly for use in emergency engines. DMA (also called marine gas oil, or “MGO”) is a general purpose marine distillate that contains no trace of residual fuel. These fuels can be used in all marine diesel engines but are primarily used by Category 1 engines. DMX and DMA fuels intended for use in any marine diesel engine are subject to EPA’s fuel sulfur standards.

DMB, also called marine diesel oil, is not typically used with Category 1 engines, but is used for Category 2 and 3 engines. DMB is allowed to have a trace of residual fuel, which can be high in sulfur. This contamination with residual fuel usually occurs due to the distribution process, when distillate is brought on board a vessel via a barge that has previously contained residual fuel, or using the same supply lines as are used for residual fuel. DMB is produced when fuels such as DMA are brought on board the vessel in this manner. EPA’s fuel sulfur standards do apply to the distillate that is used to produce the DMB, for example the DMA distillate, up to the point that it becomes DMB. However, DMB itself is not subject to the EPA fuel sulfur standards when it is used in Category 2 or 3 engines.

DMC is a grade of marine fuel that may contain some residual fuel and is often a residual fuel blend. This fuel is similar to No. 4 diesel, and can be used in Category 2 and Category 3 marine diesel engines. DMC is produced by blending a distillate fuel with residual fuel, for example at a location downstream in the distribution system. EPA’s fuel sulfur standards apply to the distillate that is used to produce the DMC, up to the point that it is blended with the residual fuel to produce DMC. However, DMC itself is not subject to the EPA fuel sulfur standards when it is used in Category 2 or 3 marine engines.

Residual fuel was not previously covered by the sulfur content standards as it is not a distillate fuel. Residual fuel is typically designated by the prefix RM (e.g., RMA, RMB, etc.). These fuels are also identified by their nominal viscosity (e.g., RMA10, RMG35, etc.). Most residual fuels require treatment by an onboard purifier-clarifier centrifuge system, although RMA and RMB do not require this.

The distillation criterion adopted by EPA, T–90 greater than 700 °F, was designed to identify those fuels that are not subject to the sulfur standards when used in Category 2 or 3 marine diesel engines. It is intended to exclude DMB, DMC, and other heavy distillates or blends, when used in Category 2 or 3 marine diesel engines. We are not amending this provision in this action. However, under this final rule, all of these fuels, and any other diesel fuels or fuel oils, will be subject to a 1,000 ppm sulfur limit if they are produced or sold for use in an ECA, except as otherwise allowed under 40 CFR Part 1043.

(2) Flexibilities

Compliance flexibilities were provided in the nonroad diesel sulfur regulations for qualified small refiners (69 FR 39047; Section IV.B.1) and for transmix processors (69 FR 39045; Section IV.A.3.d). Small refiners were provided, among other flexibility options, additional time for compliance with the 15 ppm NRLM standard, until June 1, 2014. Transmix processors, who distill off-specification interface mixtures of petroleum products from pipeline systems into gasoline and distillate fuel, have a simple refinery configuration that does not make it cost-effective for them to install and operate a hydrotreater to reduce distillate fuel sulfur content. As a result, transmix processors were provided with the flexibility to continue to produce all of their NRLM diesel fuel to meet the 500 ppm sulfur standard until June 1, 2014, and all of their LM diesel fuel to meet a 500 ppm sulfur limit indefinitely. The latter flexibility also allows for an outlet for off-spec fuel that may be produced in the distribution system.

The D&T provisions, first established to distinguish highway from nonroad 500 ppm fuel, were thus continued beyond 2014 to ensure that 500 ppm NRLM could be distinguished from similar fuel (e.g., heating oil that has a sulfur level of 500 ppm). In 2014 and beyond, D&T is essential to ensure that heating oil is not being inappropriately shifted downstream of the refiner into the NRLM and LM diesel fuel markets, circumventing the NRLM standards (as mentioned above in Section IV.B.1). Provisions in the Nonroad Diesel rule to ensure that heating oil is not used in NRLM applications include the use of a fuel marker to distinguish heating oil from NRLM and LM diesel fuel, dye solvent yellow 124, which is added to heating oil at the terminal level. The D&T provisions also provided parties in the diesel fuel industry with inherent flexibility. D&T maximizes the efficiency of the distribution system by allowing for fungible distribution of physically similar products, and minimizing the need for product segregation. Under D&T, diesel fuel with similar sulfur levels can be fungibly shipped up to the point of distribution from a terminal (where off-highway diesel fuels must be dyed red, pursuant to Internal Revenue Service (IRS) requirements, to indicate its tax exempt status).

(3) Northeast/Mid-Atlantic Area

In the Northeast, heating oil is distributed in significant quantities. Discussions with terminal operators in the Northeast (and other representatives of heating oil users and distributors) during the development of the Nonroad Diesel rule revealed concerns that the heating oil marker requirement would represent a significant burden on terminal operators and users of heating oil given the large volume of heating oil used in the Northeast. These parties suggested that if EPA prohibited the sale and use of diesel fuel produced by those utilizing the flexibilities described above, this area could be exempted from the marker requirement.

Thus, the Northeast/Mid-Atlantic (NE/MA) area was developed (69 FR 39063, Section IV.D.1.b.ii; see also 40 CFR 80.510(g) for the specific states and counties that comprise the NE/MA area). As there would be no way to distinguish heating oil from 500 ppm NRLM and 500 ppm LM diesel fuel in 2014 and beyond without the fuel marker, these fuel types are not allowed to be produced/imported, distributed and/or sold in the NE/MA area during this time period (500 ppm NRLM diesel fuel may not be produced/imported, distributed and/or sold in the NE/MA area after 2012).

Similarly, high sulfur NRLM (HSNRLM) produced through the use of credits is not allowed in Alaska. However, EPA-approved small refiners in Alaska may produce HSNRLM diesel fuel. To receive this approval, a small refiner must provide EPA with a compliance plan showing how their HSNRLM diesel fuel will be segregated from all other distillate fuels through its distribution to end-users.

(4) Nonroad Diesel Program Transition Schedule

The transition to lower sulfur diesel fuel for NRLM equipment is depicted in Figure VI-1 below. The transition for urban (areas served by the Federal Aid Highway System) and rural Alaska are shown below in Figure VI-2.

Highway and Nonroad Diesel Fuel Standards										
Who	**Covered Fuel**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
	Highway Diesel Fuel	80% 15 ppm/ 20% 500 ppm				100% 15 ppm (including small refiner fuel)				
Large Refiners/ Importers	***NR***		500	500	500	15	15	15	15	15
Large Refiners/ Importers	***LM***		500	500	500	500	500	15	15	15
	NRLM w/ credits(not in NE/MA or AK)		HS	HS	HS	500	500	500	500	15
Small Refiners	***NRLM (not in NE/MA, w/ approval in AK)***		HS	HS	HS	500	500	500	500	15
Transmix Processor & In-use	***NR (not in NE/MA or AK)***		HS	HS	HS	500	500	500	500	15
Transmix Processor & In-use	***LM (not in NE/MA or AK)***		HS	HS	HS	500	500	500	500	500

***2006 dates for HW diesel fuel**: June 1 for refiners/importers, September 1 for downstream parties, and October 15 for retailers and wholesale purchaser-consumers*

***2010 dates for HW diesel fuel**: As of the following dates, all HW diesel fuel must meet the 15 ppm standard- June 1 for refiners/importers, October 1 for downstream parties, and December 1 for retailers and wholesale purchaser-consumers (WPCs)*

2007 dates for NRLM diesel fuel**: June 1 for refiners, downstream requirements for NE/MA area** only (August 1 for terminals, October 1 for retailers/WPCs, and December 1 for in-use)*

***2010+ dates for NRLM diesel fuel**: June 1 for refiners, August 1 for terminals, October 1 for retailers/WPCs, and December 1 for in-use*

** ***Anti-downgrading provisions begin October 15, 2006*** **

****NOTE**- No small refiner or credit NRLM can be used in the NE/MA area. Thus, the large refiner NRLM standard is also the in-use standard in the NE/MA area.*

Figure IV-1 Highway, Nonroad, Locomotive, and Marine Diesel Fuel Sulfur Standards Prior to This Final Rule

Urban AK (areas served by the FAHS)

HW-

- pre-2006: HS/uncontrolled
- 2006: 6/1/06- refiners to 15; 9/1/06- pipelines & terminals to 15; 10/15/06- retail & WPC to 15

NRLM-

- pre-2007: HS/uncontrolled
- 2007: 6/1/07- refiners to 500; 8/1/07- pipelines & terminals to 500; 10/1/07- retail & WPC to 500; 12/1/07- in-use, farm & construction tanks to 500 (*note- urban AK is on same downstream schedule as NE/MA*)
- 2010: 6/1/10- refiners to 15 NR; 8/1/10- pipelines & terminals to 15 NR; 10/1/10- retail & WPC to 15 NR; 12/1/10- in-use, farm & construction tanks to 15 NR
- 2012: 6/1/12- refiners to 15 LM; 8/1/12- pipelines & terminals to 15 LM; 10/1/12- retail & WPC to 15 LM; 12/1/12- in-use, farm & construction tanks to 15 LM

** *Urban AK is on the same schedule as the main HW & NR diesel programs (except they're on the same downstream schedule as the NE/MA for NRLM in 2007); permanently exempt from dye & marker requirements* **

Rural AK

HW-

- pre-2010: HS/uncontrolled
- 2010: 6/1/10- refiners to 15 HW; 8/1/10- pipelines & terminals to 15 HW; 10/1/10- retail & WPC to 15 HW; 12/1/10- in-use, farm & construction tanks to 15 HW

NRLM-

- pre-2010: HS/uncontrolled
- 2010: 6/1/10- refiners to 15 NRLM; 8/1/10- pipelines & terminals to 15 NRLM; 10/1/10- retail & WPC to 15 NRLM; 12/1/10- in-use, farm & construction tanks to 15 NRLM

** Downstream transition dates are same for HW & NRLM in rural AK; permanent exemption from dye & marker requirements **

General Note- credit & transmix fuel cannot be used in any area of AK; small refiner fuel can be used with approval (and only if properly labeled and segregated)

Figure IV-2 Highway, Nonroad, Locomotive, and Marine Diesel Fuel Sulfur Standards for Alaska Prior to This Final Rule

C. Applicability

Assuming adoption of an amendment to MARPOL Annex VI establishing a U.S. ECA, pursuant to Annex VI, the fuel used in that ECA cannot exceed 1,000 ppm sulfur beginning January 1, 2015.[94] As mentioned above, we are incorporating a similar 1,000 ppm sulfur limit into our CAA regulations at 40 CFR Part 80 through both a prohibition on the production and sale of fuel oil above 1,000 ppm sulfur for use in any marine vessels (Categories 1, 2, and 3) in an ECA and ECA associated areas except as allowed under 40 CFR Part 1043, and an allowance for the production and use of 1,000 ppm sulfur fuel to be used in Category 3 marine vessels. Fuel produced and sold for use in any engine on Category 1 and Category 2 marine vessels will continue to be subject to the existing diesel sulfur requirements which are more stringent than those being finalized in this action for Category 3 marine vessels. We requested comment on whether or not Category 1 and 2 engines installed on Category 3 marine vessels should be allowed to use 1,000 ppm sulfur fuel. To reduce burden that could potentially be caused by requiring that these engines burn 15 ppm diesel fuel (which could result in a vessel needing to carry three different types of fuel onboard), we are finalizing that Category 1 and 2 auxiliary engines installed on Category 3 marine vessels will be allowed to use 1,000 ppm fuel.

Discussions with stakeholders in the diesel fuel production and distribution industry have indicated that they anticipate that most (if not all) fuel oil that could meet a 1,000 ppm sulfur standard would be considered a distillate or diesel fuel, because at a 1,000 ppm sulfur level it is nearly impossible for fuel to have a T–90 distillation point at or above 700 °F (i.e., be considered residual fuel). As discussed in Section IV.B.1, fuel with a T–90 less than 700 °F will be required to meet the standards of our existing diesel sulfur program which, in 2014 and beyond, is 15 ppm. We believe that because of the limits on the sulfur content of fuel used in ECAs, the existing diesel fuel sulfur program should be revised to allow for the production, distribution, purchase, and use of 1,000 ppm sulfur fuel oil for use in Category 3 marine vessels. Therefore, we are finalizing a new 1,000 ppm sulfur category for fuel oil produced and purchased for use in Category 3 marine vessels (called "ECA marine fuel"). This finalized fuel sulfur requirement will largely supplement the existing diesel fuel sulfur requirements and will harmonize EPA's diesel sulfur program with the requirements of Annex VI. Under this final action, owners of Category 3 marine vessels will be able to purchase and use 1,000 ppm sulfur ECA marine fuel, which will allow those vessels to comply with the sulfur limits in any ECA worldwide and in ECA associated areas.

D. Fuel Sulfur Standards

As discussed above in Section IV.C, in addition to the prohibition on the sale of fuel greater than 1,000 ppm sulfur for use in marine vessels (except as allowed under 40 CFR Part 1043) operating within an ECA and ECA associated areas, we are also finalizing the allowance of the production, distribution, and sale of 1,000 ppm sulfur ECA marine fuel, which we discuss more in this section.

Prior to this action and, pending the establishment of the North American ECA, the kind of fuel produced and sold for use by Category 3 marine vessels had uncontrolled sulfur levels as it was

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[94] Annex VI, Regulation 14 (located in the rulemaking docket, EPA–HQ–OAR–2007–0121-0107).

not subject to the NRLM sulfur limits. This was reflected in the regulations by exempting these kinds of fuel from the definition of NRLM diesel fuel and the NRLM sulfur limits (40 CFR 80.2(nnn)). The combined effect of Annex VI and these regulations is to require that any fuel sold for use in a Category 3 marine vessel operating in an ECA be 1,000 ppm sulfur or lower, except as allowed under 40 CFR Part 1043. Fuel oil used or sold for use in Category 3 marine vessels in an ECA and ECA associated areas will therefore go from uncontrolled, high sulfur levels to no higher than 1,000 ppm sulfur (except as otherwise allowed under 40 CFR Part 1043). Under Annex VI, fuel with sulfur levels greater than 1,000 ppm cannot be used in a marine vessel without sulfur abatement technology operating in an ECA, no matter where the fuel is purchased. Consistent with this, the finalized section 211(c) controls will prohibit the production and sale of any fuel for use in an ECA and ECA associated areas that is above 1,000 ppm sulfur, except as allowed under 40 CFR Part 1043.

The requirements for 1,000 ppm sulfur fuel oil will apply to the North Sea, the Baltic Sea, and any other ECAs established around the world, so this fuel will be produced by refiners in other countries. Under EPA's NRLM program prior to this final rule, 1,000 ppm sulfur fuel would have been subject to the 15 ppm NRLM sulfur limit in 2014 and later. If EPA were to require that fuel produced, distributed, and sold for use for Category 3 vessels in the North American ECA and ECA associated areas meet the 15 ppm sulfur standard after 2014, we believe that Category 3 vessel owners would simply purchase 1,000 ppm sulfur fuel elsewhere to be used here in the North American ECA. This could be an extremely inefficient process for ship owners. It would also mean a loss of sales for U.S. refiners of fuel that these Category 3 vessel owners purchase. These impacts would add to the costs and burdens of the program with no corresponding environmental benefit. Therefore, we believe that it is reasonable to allow U.S. refiners and importers to produce 1,000 ppm sulfur fuel for use by Category 3 vessels. Thus, we are finalizing a new fuel sulfur standard of 1,000 ppm for fuel produced, distributed, and sold for use in Category 3 marine vessels. While we expect use of this fuel to be concentrated in the area of the North American ECA and ECA associated areas (and any other ECA), we are allowing its use by Category 3 marine vessels in all locations, to encourage its general use. After 2014, no fuel above 15 ppm can be used in Category 1 or Category 2 vessels.

We note that the combination of the Annex VI ECA provisions and the modifications proposed in this action for the diesel sulfur program will achieve very significant benefits compared to the existing program. The production and use of 1,000 ppm ECA marine fuel, as well as 15 ppm NRLM diesel fuel, will replace much higher sulfur fuel usage, and there is no additional benefit to be gained by requiring the sale of 15 ppm sulfur diesel fuel for use by Category 3 vessels as a practical matter because we believe Category 3 vessels would simply purchase 1,000 ppm sulfur fuel elsewhere. In order to incorporate these modifications into our existing program under the Clean Air Act, we needed to create a new fuel designation for allowable fuel under our program.

(1) Amendments to the Diesel Fuel Sulfur Program

We are prohibiting the production, distribution, and sale or offer for sale of any fuel for use in any marine diesel vessels (Categories 1, 2, and 3) operating in the North American ECA and ECA associated areas that is greater than 1,000 ppm sulfur, except as otherwise allowed under 40 CFR Part 1043. We are also finalizing a sulfur standard of 1,000 ppm for fuel produced, distributed, and sold or offered for sale for use in Category 3 marine vessels operating in an ECA and ECA associated areas. To simplify the existing diesel fuel sulfur program, we are also eliminating the 500 ppm LM diesel fuel standard once the 1,000 ppm ECA marine fuel standard becomes effective. Under the diesel sulfur program prior to this final rule, 500 ppm LM diesel fuel could be produced by transmix processors indefinitely, and could be used by locomotives and marine vessels that do not require 15 ppm. The original intent of allowing for this fuel was to serve as an outlet for interface and downgraded diesel fuel post-2014 that would otherwise not meet the 15 ppm sulfur standard. However, we believe that the 1,000 ppm sulfur ECA marine fuel can now serve as this outlet. We believe that transmix generated near the coasts would have ready access to marine applications, and transmix generated in the mid-continent could be shipped via rail or fuel barge to markets on the coasts.

Elimination of the 500 ppm LM diesel fuel standard will simplify the diesel sulfur program such that sulfur can serve as the distinguishing factor for fuels available for use after 2014 (the designated products under the diesel fuel program will thus be: 15 ppm motor vehicle, nonroad, locomotive, and marine (MVNRLM) diesel fuel, heating oil, and 1,000 ppm ECA marine fuel). With this approach, beginning in 2014, only 15 ppm NRLM diesel fuel can be used in locomotive and Category 1/Category 2 marine diesel applications (and 1,000 ppm ECA marine fuel could be used in Category 3 marine vessels). Further, this will help to streamline the D&T program as there will no longer be a need for a fuel marker to distinguish 500 ppm LM diesel fuel from heating oil. Below, we discuss the aspects of D&T that we are changing, which we believe will greatly simplify the diesel sulfur program.

(a) Compliance and Implementation

(i) Northeast/Mid-Atlantic Area and the Fuel Marker

With the elimination of the 500 ppm LM designation in 2014, parties in the fuel production and distribution industry will still be required to register and designate their products and adhere to PTD, fuel pump labeling, and recordkeeping requirements. But we believe that the tracking portion of D&T can be simplified. Annual reporting was required under §80.601 for D&T through June 30, 2015 (the final annual report is due August 31, 2015). The final reporting period was set to ensure that heating oil was not being inappropriately shifted into the 500 ppm LM diesel fuel pool. However, with the elimination of this fuel designation, the final annual reporting period will instead be July 1, 2013 through May 31, 2014, with the report due to EPA on August 31, 2014.

As stated in the preamble to the proposed rule, we believe that the elimination of the 500 ppm LM diesel fuel designation will also, beginning June 1, 2014, negate the need for the heating oil marker and the NE/MA area. After 2014, the heating oil marker requirement in the diesel sulfur program prior to this final rule was for the sole purpose of distinguishing heating oil from 500 ppm LM diesel fuel, to prevent heating oil from swelling the 500 ppm LM diesel fuel pool. Also, as there is no marker requirement for heating oil in the NE/MA area, the diesel sulfur program did not allow for 500 ppm LM diesel fuel to be produced, distributed, or purchased for use in the NE/MA area after 2012. As also noted in the proposed rule, without 500 ppm LM diesel fuel there is no need for the heating oil marker; fuel designations and sulfur level could serve as the distinguishing factor between the available fuels (15 ppm MVNRLM diesel fuel, 1,000 ppm ECA marine fuel, and heating oil). Further, there is no need for the NE/MA area without the heating oil marker. Thus, we are finalizing to remove the NE/MA area designation and the heating oil marker requirement.

(ii) PTDs and Labeling

We are finalizing new PTD language for the 1,000 ppm ECA marine fuel designation at regulation §80.590. As stated in regulation §80.590(a)(7)(vii), we are adding the following statement to PTDs accompanying 1,000 ppm sulfur ECA marine fuel: "1,000 ppm sulfur (maximum) ECA Marine Fuel. For use in Category 3 marine vessels only. Not for use in engines not installed on Category 3 marine vessels."

Appendix V of Annex VI also includes language that is required on bunker delivery notes. Compliance requirements of this action, such as PTDs, are not intended to supplant or replace requirements of Annex VI (and we encourage regulated entities to consult Annex VI to ensure that they are fully aware of all requirements that must be met in addition to EPA's requirements). However, if a party's bunker delivery note also contains the information required under our regulations for PTDs, we will consider the bunker delivery note to also suffice as a PTD.

We are also finalizing new pump labeling language for the 1,000 ppm sulfur ECA marine fuel designation at regulation §80.574. Diesel fuel pump labels required under the existing diesel sulfur regulations must be prominently displayed in the immediate area of each pump stand from which diesel fuel is offered for sale or dispensing. However, we understand that there may be cases where it is not feasible to affix a label to a fuel pump stand due to space constraints (such as diesel fuel pumps at marinas) or where there is no pump stand, thus the current regulations allow for alternative labeling with EPA approval. Previously approved alternative labeling has included the use of permanent placards in the immediate vicinity of the fuel pump; and we will also allow other reasonable alternatives to labeling for situations where pump labeling may not be feasible. As stated in regulation §80.574, we are replacing the 500 ppm LM diesel fuel pump label language with the following fuel pump label language for 1,000 ppm sulfur ECA marine fuel: "1,000 ppm SULFUR ECA MARINE FUEL (1,000 ppm Sulfur Maximum). For use in Category 3 marine vessels only. WARNING- Federal law prohibits use in any engine that is not installed on a Category 3 marine vessel; use of fuel oil with a sulfur content greater than 1,000 ppm in an ECA is prohibited, except as allowed by 40 CFR Part 1043."

Under this program, we are also eliminating MVNRLM diesel fuel labeling requirements from EPA's regulations. In 2014 and beyond, EPA will not require "visible evidence" of red dye in off-road fuels; however this requirement still exists in IRS's taxation regulations to denote that off-road fuels are untaxed. EPA's required label for 15 ppm NRLM diesel fuel (instead of one 15 ppm MVNRLM diesel fuel label) is mainly to denote that 15 ppm NRLM will be dyed red, while 15 ppm MV diesel fuel will not. Further, after October 1, 2014, all MVNRLM diesel fuel available for purchase and/or distribution will be 15 ppm. We believe that it is not appropriate for EPA to retain a labeling requirement for MVNRLM diesel fuel given the fact that the red dye provision is no longer EPA's requirement. Please note, however, that marketers and wholesale purchaser-consumers are still free to continue to label their pump stands to help with consumer awareness. Labeling will continue to be required for heating oil and, as proposed above, for 1,000 ppm sulfur ECA marine fuel.

Additionally, EPA will consult with IRS regarding handling labels in IRS's regulations at Title 26 of the Code of Federal Regulations.

(b) Timing of the Standard

Currently, all refiners and importers are required to produce all of their NRLM diesel fuel to meet the 15 ppm standard beginning June 1, 2014. To allow transition time for the distribution system, terminals are allowed until August 1, 2014 to begin dispensing 15 ppm NRLM diesel fuel, retailers and wholesale purchaser-consumers are allowed until October 1, 2014, and end-users are allowed until December 1, 2014. To be consistent with the existing diesel program, we are allowing refiners to begin producing 1,000 ppm sulfur ECA marine fuel beginning June 1, 2014, and downstream parties will follow the current NRLM transition schedule (August, October, and December). We believe that following the same transition schedule as the existing diesel sulfur program would best facilitate the availability of 1,000 ppm ECA marine fuel for purchase and use by the Annex VI January 1, 2015 date.

(2) Proposed Alternative Options

We identified two potential alternatives in the proposed rule to the changes to the existing diesel fuel sulfur program discussed above: the creation of an expanded NE/MA area and the retention of the 500 ppm LM diesel fuel designation. We requested comment on these alternative options, as well as any additional alternative options. We received a comment stating that the 500 ppm sulfur designation should be retained because, the commenter stated, Category 3 engines can use both 500 ppm and 1,000 ppm sulfur fuel. Another commenter who supported the elimination of this fuel category noted that if it is determined that the 500 ppm LM designation is necessary for the locomotive industry, it would support the concept of an expanded NE/MA area as a secondary option.

E. Technical Amendments to the Current Diesel Fuel Sulfur Program Regulations

Following publication of the technical amendments to the Highway and Nonroad Diesel Regulations (71 FR 25706, May 1, 2006), we discovered additional errors and clarifications within the diesel regulations at 40 CFR Part 80, Subpart I that we are addressing in this action. These items are merely typographical/printing error and grammar corrections. A list of the changes that we are making to Subpart I is below in Table IV-1.

Table IV-1 Technical Amendments to the Diesel Fuel Sulfur Regulations

Section	Description of Change
80.525(a)-(d)	Removal of the term "motor vehicle" from this section.
80.551(f)	Correction of printing error.
80.561	Correction of typographical error in title.
80.570(a) and (b)	Amended to correct date ("November 30, 2010" instead of "September 30, 2010".
80.593	Correction of typographical error in introductory text.
80.599(e)(4)	Correction of printing error in definition of terms "$\#1MV15_I$" and "$NPMV15_I$".
80.600(a)(12)	Amended to correct date ("May 31, 2014" instead of "June 1, 2014").
80.600(i)	Amended to remove duplicate sentence.
80.601(b)(3)(x)	Amended to correct dates ("August 31" instead of "August 1").
80.612(b)	Amended to fix typographical error in paragraph.

V. Emission Control Areas for U.S. Coasts

The finalized Clean Air Act standards described above are part of a coordinated strategy for ensuring that all ships that affect U.S. air quality will be required to meet stringent NO_X and fuel sulfur requirements. Another component of this strategy consists of pursuing ECA designation for U.S. and Canadian coasts in accordance with Annex VI of MARPOL. ECA designation will ensure that all ships, foreign-flagged and domestic, are required to meet stringent NO_X and fuel sulfur requirements while operating within 200 nautical miles of most U.S. coasts. This section describes what an ECA is, the process for obtaining ECA designation at the International Maritime Organization, and summarizes the U.S. and Canadian proposal for an amendment to MARPOL Annex VI designating most U.S. and Canadian coasts as an ECA (referred to as the "North American ECA"), submitted to IMO on March 27, 2009.[95]

This section also discusses technological approaches to comply with the fuel standards. These approaches include switching to lower sulfur fuel and equivalents, such as exhaust gas cleaning units. We also discuss how emissions from foreign-flagged ships may be covered should approval of the U.S. ECA be delayed.

[95] *Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulphur Oxides and Particulate Matter*, Submitted by the United States and Canada. IMO Document MEPC59/6/5, 27 March, 2009. A copy of this document can be found at http://www.epa.gov/otaq/regs/nonroad/marine/ci/mepc-59-eca-proposal.pdf

A. What is an ECA?

(1) What Emissions Standards Apply in an ECA?

MARPOL Annex VI contains international standards to control air emissions from ships. The NO_X and SO_X/PM programs each contain two sets of standards. The global standards for the sulfur content of fuel and NO_X emissions from engines apply to ships at all times. In recognition that some areas may require further control, Annex VI also contains more stringent NO_X and SO_X/PM geographic-based standards that apply to ships operating in designated Emission Control Areas. Once a North American ECA is designated through amendment to MARPOL Annex VI, the requirements will be enforceable for most vessels through the Act to Prevent Pollution from Ships (see Section VI.B).

The current global fuel sulfur (S) limit is 45,000 ppm[96] S and will tighten to 35,000 ppm S in 2012. Depending on a 2018 fuel availability review, the MARPOL Annex VI global fuel sulfur limit will be further reduced to 5,000 ppm S as early as 2020. In contrast, ships operating in designated ECAs are subject to a fuel sulfur limit of 15,000 ppm S. The ECA limit is reduced to 10,000 ppm S in July 2010 and 1,000 ppm S in 2015. In addition, Tier 3 NO_X standards will apply to new engines operating in ECAs beginning in 2016. These Tier 3 NO_X standards represent an 80 percent reduction in NO_X beyond current Tier 1 standards and are anticipated to require the use of aftertreatment technology such as SCR. We are adopting similar Tier 3 standards as part of our Clean Air Act program (see Section III).

There are currently two ECAs in effect today, exclusively controlling SO_X; thus they are called Sulfur Emission Control Areas, or SECAs. The first SECA was designated to control the emissions of SO_X in the Baltic Sea area and entered into force in May 2005. The second SECA was designated to control the emissions of SO_X in the North Sea area and entered into force in November 2006.

(2) What is the Process for Obtaining ECA Designation?

A proposal to amend Annex VI to designate an ECA can be submitted by a party to Annex VI. A party is a country that ratified Annex VI. The proposal for amendment must be approved by the Parties to MARPOL Annex VI; this would take place at a meeting of the Marine Environment Protection Committee (MEPC). The U.S. deposited its Instrument of Ratification with the IMO on October 8, 2008. Annex VI entered into force for the U.S. on January 8, 2009, making the U.S. eligible to apply for an ECA.

The criteria and procedures for ECA designation are set out in Appendix III to MARPOL Annex VI. A proposal to designate an ECA must demonstrate a need to prevent, reduce, and control emissions of SO_X, PM, and/or NO_X from ships operating in that area. The specific criteria are summarized below:

- A delineation of the proposed area of application;

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[96] Note that MARPOL Annex VI expresses these standards in units of % (m/m) sulfur. 10,000 ppm S equals 1 percent S.

- A description of the areas at risk on land and at sea, from the impacts of ship emissions;
- An assessment of the contribution of ships to ambient concentrations of air pollution or to
- Adverse environmental impacts;
- Relevant information pertaining to the meteorological conditions in the proposed area of
- Application to the human populations and environmental areas at risk;
- Description of ship traffic in the proposed ECA;
- Description of the control measures taken by the proposing Party or Parties;
- Relative costs of reducing emissions from ships compared with land-based controls; and
- An assessment of the economic impacts on shipping engaged in international trade.

An amendment to designate an ECA must be adopted by the Parties to Annex VI, as an amendment to Annex VI. The proposal to amend Annex VI was approved at MEPC 59, and circulated for adoption. The earliest possible adoption date is at MEPC 60, which will take place in March 2010 entering into force as early as August 2012.

B. U.S. Emission Control Area Designation

EPA worked with the U.S. Coast Guard, State Department, the National Oceanic and Atmospheric Administration and other agencies to develop the analysis supporting ECA designation for U.S. coasts contained in the U.S. and Canadian submittal to IMO. In addition, we collaborated with Environment Canada and the California Air Resources Board. In developing the ECA proposal, EPA consulted with stakeholders including representatives from the shipping industry, ports, master mariners, environmental interests and representatives from state and local governments. EPA began conducting outreach in advance of this year's ECA proposal; in fact we have been engaged with this industry for many years with regards to the development of an Emission Control Area for the United States. Stakeholders also had the opportunity to comment on the strategy we announced in the Advance Notice of Proposed Rulemaking (ANPRM) for the Category 3 Marine Diesel Engine Rule, published on December 7, 2007. In the ANPRM, EPA outlined an approach to regulating emissions from both new and existing vessels using a framework that aligns with MARPOL Annex VI, including applying the standards for Emission Control Areas along U.S. coasts.

The proposal for ECA designation that the USG submitted to IMO earlier this year is for a combined U.S./Canada ECA submission. This approach has several advantages. First, the emission reductions within a Canadian ECA will lead to air quality improvements in the U.S. Second, a joint ECA helps minimize any competitive issues between U.S. and Canadian ports, such as in the Puget Sound area, which could arise from ECA standards. Third, IMO encourages a joint submittal where there is a common interest in emission reductions on neighboring waters. In addition, France has since joined the ECA proposal on behalf of the Saint Pierre and Miquelon archipelago.

(1) What Areas would be Covered in a North American ECA?

The area included in the North American ECA submittal to IMO for ECA designation generally extends 200 nautical miles from the coastal baseline, except where this distance would enter the Exclusive Economic Zones (EEZ) of a neighboring country. This area would include the Pacific Coast, the Atlantic/Gulf Coast and the Southeastern Hawaiian Islands. On the Pacific Coast, the ECA would be bounded in the north such that it includes the approaches into Anchorage, Alaska, but not the Aleutian Islands or points north. It would continue contiguously to the south including the Pacific coasts of Canada and the U.S., with its southernmost boundary at the point where California meets the border with Mexico. In the Atlantic/Gulf Coast, the ECA would be bounded in the west by the border of Texas with Mexico and continue contiguously to the east around the peninsula of Florida and north up the Atlantic coasts of the U.S. and Canada and would be bounded in the north by the 60th North parallel. The Southeastern Hawaiian Islands that were included in the ECA submittal are Hawaii, Maui, Oahu, Molokai, Niihau, Kauai, Lanai, and Kahoolawe.

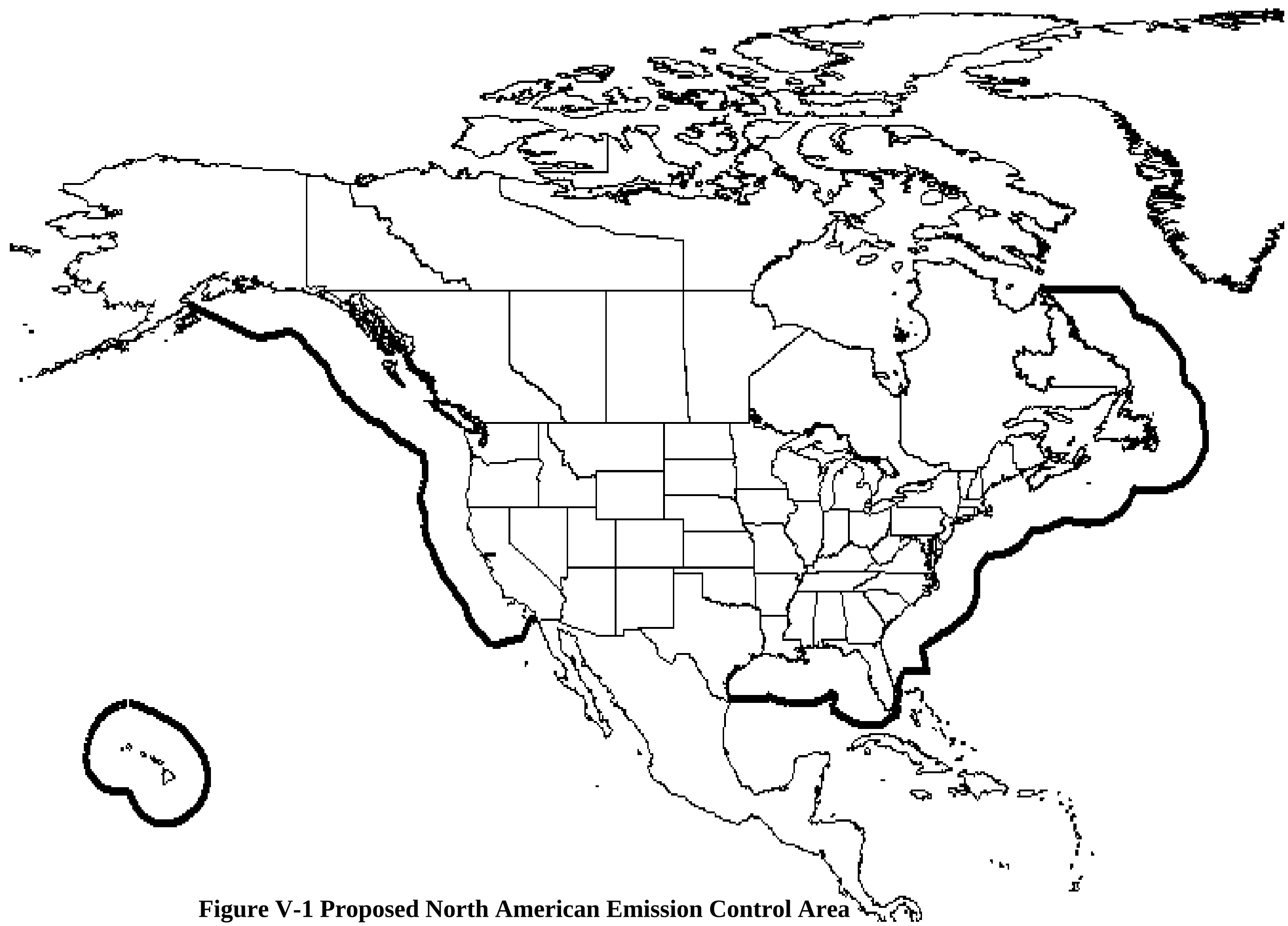

Figure V-1 Proposed North American Emission Control Area

Not included in the ECA submittal were the Pacific U.S. territories, smaller Hawaiian Islands, the U.S. territories of Puerto Rico and the U.S. Virgin Islands, Western Alaska including the Aleutian Islands, and the U.S. and Canadian Arctic. The U.S. and Canada did not make a determination or imply that these areas suffer no adverse impact from shipping. Rather, we concluded that information must be gathered to properly assess these areas. If further information supports the need for an ECA designation in any of these areas, we would submit a future, proposal for ECA designation of these areas.

We are currently performing the analyses necessary to support an ECA designation for Puerto Rico and the U.S. Virgin Islands and will be engaging stakeholders as part of that effort. That outreach will include neighboring countries, shipping companies, environmental organizations, and other stakeholders. Puerto Rico has a population of 4 million people, sees significant shipping traffic and experiences the highest asthma rate in the United States. Addressing the impact of ship emissions on Puerto Rico and U.S. Virgin Islands is a top priority for the Agency. We plan to complete the appropriate analysis and stakeholder outreach regarding an ECA designation for these U.S. territories such that the U.S. with any interested Caribbean neighbors could make a proposal to the IMO in advance of MEPC 61 with the intent to see the ECA adopted at MEPC 62 (July 2011) and enter into force 28 months later (December 2013). In this way, we can be confident that there will be ample time for consideration and adoption of such an ECA well in advance of January 1, 2015 when the 1,000 ppm fuel sulfur standard enters into effect.

Establishing the ECA boundary for Puerto Rico and the U.S. Virgin Islands would require vessels operating in this area to meet Tier 3 NO_X requirements that become effective in 2016. EPA will remove the Tier 3 NO_X exemption from applying to Puerto Rico and the U.S. Virgin Islands through an appropriate rule amendment once the Caribbean ECA boundary is established.

(2) What Analyses were Performed in Support of a North American ECA?

We performed a comprehensive analysis to estimate the degree of human health risk and environmental degradation that is posed by air emissions from ships operating in their ports and along our coasts. To evaluate the risk to human populations, state-of-the-art assessment tools were used to apply widely accepted methods with advanced computer modeling techniques. The analyses incorporated detailed ship traffic data, the most recent emissions estimates, detailed observed meteorological data, current scientific understanding of exhaust plume behavior (both physical dispersion and photochemical reaction) and the latest epidemiologic databases of health effects attributable to pollutant exposure levels to estimate the current impacts of shipping on human health and the environment. In addition, sulfate and nitrate deposition modeling was performed to assess the impacts of nitrogen nutrient loading and acidification on U.S. ecosystems.

Two contrasting future scenarios were evaluated: one in which ships continue to operate with current emissions performance while operating in the specified area, and one in which ships comply with ECA standards. The analysis demonstrated that ECA designation for U.S. coasts could save thousands of lives each year, relieve millions of acute respiratory symptoms, and benefit many of the most sensitive ecosystems. This analysis is consistent with, and incorporated in, the benefits estimates presented in Section VIII.

C. Technological Approaches to Comply with Fuel Standards

When operating within the ECA, all ships would have to comply with the 0.1 percent fuel sulfur limit beginning in 2015 and vessels built after December 31, 2015 would have to comply with the Tier 3 NO_X limits described above. This section describes how ships would comply with the fuel standards. Approaches for compliance with the NO_X standards are discussed in Section 3 above.

(1) Fuel Switching

As discussed above, the MARPOL Annex VI fuel sulfur limit for ships operating in an ECA is 15,000 ppm today and reduces to 10,000 ppm in July 2010 and further to 1,000 ppm in 2015. We anticipate that the 1,000 ppm fuel sulfur limit, beginning in 2015, will likely result in the use of distillate fuel for operation in ECAs. This would require the vessel to switch from a higher sulfur fuel to 1,000 ppm S fuel before entering the ECA. The practical implications of fuel switching are discussed below.

Currently, the majority of ocean-going vessels use residual fuel (also called HFO or IFO) in their main propulsion engines, as this fuel is relatively inexpensive and has a good energy density. This fuel is relatively dense ('heavy') and is created as a refining by-product from typical petroleum distillation. Residual fuels typically are composed of heavy, residuum hydrocarbons and can contain various contaminants such as heavy metals, water and sulfur compounds. It is these sulfur compounds that cause the SO_X emissions when the fuel is combusted. If the vessel does not employ the use of a sulfur scrubber or other technology, it will most likely operate on a marine distillate fuel while in an ECA in order to meet the sulfur emission requirements.

The sulfur in marine fuel is primarily emitted as SO_2; however, a small fraction (about 2 percent) is converted to SO_3. SO_3 almost immediately forms sulfate and is emitted as direct PM by the engine. Consequently, emissions of SO_2 and sulfate PM are very high for engines operating on residual fuel. Switching from high sulfur residual fuel to lower sulfur distillate fuel results in large reductions in SO_2 and sulfate PM emissions. In addition to high sulfur levels, residual fuel contains relatively high concentrations of low volatility, high molecular weight organic compounds and metals. Organic compounds that contribute to PM can be present either as a nucleation aerosol or as a material adsorbed on the surfaces of agglomerated elemental carbon soot particles and metallic ash particles. The sulfuric acid aerosol in the exhaust provides a nucleus for agglomeration of organic compounds. Operation on higher volatility distillate fuel reduces both nucleation and adsorption of organic compounds into particulate matter. Therefore, in addition to direct sulfate PM reductions, switching from residual fuel to distillate fuel reduces organic PM and metallic ash particles in the exhaust.

In the majority of vessels which operate on residual fuel, marine distillate fuel is still used for operation during routine maintenance, prior to and immediately after engine shut-down, or in emergencies. Standard procedures today have been established to ensure that this operational fuel switchover is performed safely and efficiently. Mainly, in order for the vessel to completely switch between residual and distillate fuel, the fuel pumps and wetted lines will need to be completely purged by the new fuel to ensure that the ship is burning the correct fuel for the area. This purging will vary from ship to ship due to engine capacity, design, operation, and efficiency. Provided the ship has separate service tanks for distillate and residual fuel (most, if not all, vessels do), fuel switching time should be limited only by maximum allowable rate of fuel temperature change. Additionally, for a longer operation period such as would occur while in an ECA, we investigated several other fuel switching topics to ensure that vessels would not have long-term issues from operating on the marine distillate fuels.

Marine distillate fuels are similar in composition and structure to other petroleum-based middle distillate fuels such as diesel and No. 2 heating oil, but they have a much lower allowable sulfur content than residual fuels. This lower sulfur content means that by combusting marine distillate fuel in their propulsion engines, vessels operating within the ECA would meet the stricter SO_X requirements. However, sulfur content is not the only difference between the marine residual and distillate fuels; they also have different densities, viscosities, and other specification limits.

The maritime industry has analyzed the differences between residual and distillate fuel compositions to address any potential issues that could arise from switching operation of a Category 3 engine from residual fuel to distillate fuel. The results from this research has evolved into routine operational switching procedures that ensure a safe and efficient way for the Category 3 engines to switch operation between the residual and distillate fuels. Engine manufacturers, fuel suppliers, the American Bureau of Shipping, and the U.S. Coast Guard have provided guidance on fuel switching procedures.[97,98,99,100,101] A brief summary of the fuel differences, as well as any potential issues and their usual solutions, is presented below.

(a) Fuel Density

Due to its chemical composition, residual fuel has a slightly higher density than marine distillates. Using a less dense fuel could affect the ballast of a ship at sea and would have to require compensation. Therefore, when beginning to operate on the distillate fuel, the vessel operator would have to pay attention to the vessel's ballast and may have to compensate for any changes that may occur. We anticipate that these procedures would be similar to operating the vessel with partially-full fuel tanks.

Another consideration when switching to a lower density fuel is the change in volumetric energy content. Distillate fuel has a lower energy density content on a per gallon basis when compared to the residual fuel; however, per ton, distillate fuel's energy density is larger than the residual fuel. This means that when switching from residual fuel to distillate fuel, if the vessel's tanks are volumetrically limited (i.e., the tanks can only hold a set quantity of fuel gallons), the distance a vessel can travel on the distillate fuel may be slightly shorter than the distance the vessel could travel on the residual fuel due to the lower volumetric energy content of distillate fuel, which could require compensation. This distance reduction would be approximately 5 percent and would

[97] MAN B&W Diesel, "Operation on Low-Sulphur Fuels; Two-Stroke Engines," 2004.
[98] Wartsila, "Low Sulphur Guidelines," January 9, 2006.
[99] American Petroleum Institute, "Technical Considerations of Fuel Switching Practices," API Technical Issues Workgroup, June 3, 2009.
[100] American Bureau of Shipping, "ABS Notes: Use of Low-Sulphur Marine Fuel for Main and Auxiliary Diesel Engines," Fuel Oil Piping, EWZ-001-02-P04-W007, Attachment G – Revision 1.
[101] United States Coast Guard, "Avoiding Propulsion Loss from Fuel Switching: American Petroleum Institute, Technical Considerations," Marine Safety Alert 03-09, June 16, 2009.

only be of concern while the vessel was operating on the distillate fuel (i.e., while in the U.S. ECA) as the majority of the time the vessel will be operating on the residual fuel. However, if the vessel is limited by weight (draft), the higher energy content per ton of fuel would provide an operational advantage.

(b) Kinematic Viscosity

Residual fuel's kinematic viscosity is much higher than marine distillate fuel's viscosity. Viscosity is the 'thickness' of the fuel. If this parameter is lowered from the typical value used within a pump, some issues could arise. If a distillate fuel is used in a system that typically operates on residual fuel, the decrease in viscosity could cause problems with high-pressure fuel injection pumps due to the increased potential for internal leakage of the thinner fuel through the clearances in the pumping elements. Internal leakage is part of the design of a fuel pump and is used in part to lubricate the pumping elements. However, if this leakage rate is too high, the fuel pump could produce less than optimal fuel injection pressures. If the distillate fuel's lower viscosity becomes an issue, it is possible to cool the fuel and increase the viscosity above 2 centistokes, which is how most vessels operate today during routine fuel switchovers.

(c) Flash Point

Flash point is the temperature at which the vapors off the fuel ignite with an outside ignition source. This can be a safety concern if the owner/operator uses an onroad diesel fuel rather than a designated 'marine distillate' fuel for operation because marine fuels have a specified minimum flash point of 60°C (140°F) to ensure onboard safety, whereas onroad diesel has a minimum specified flash point of 52°C (125.6°F). However, since most distillate fuels are created in the same fashion, typical flash points of onroad diesel are above 60°C (140°F), and would meet the marine fuel specification for this property. Bunker suppliers ensure that marine fuels meet a minimum flash point of 60°C (140°F) through fuel testing as designated on the bunker delivery note.

(d) Lubricity

Lubricity is the ability of the fuel to lubricate the engine/pump during operation. Fuels with higher viscosity and high sulfur content tend to have very good lubricity without the use of specific lubricity-improving additives. Refining processes that lower fuel sulfur levels and their viscosities can also remove some of the naturally-occurring lubricating compounds. Severe hydrotreating of fuel to obtain ultra-low sulfur levels can result in poor fuel lubricity. Therefore, refineries commonly add lubricity improvers to ultra-low sulfur diesel. This will most likely become a concern when very low levels of sulfur are present in the fuel and/or the fuel has been hydrotreated to reduce sulfur, e.g., if ultra-low sulfur highway diesel (ULSD) is used in the engine. Several groups have conducted studies on this subject, and for some systems where fuel lubricity has become an issue, lubricity additives can be utilized or the owner/operator can install a lubricating system for the fuel pump.

(e) Lube Oil

Lube oils are used to neutralize acids formed in combustion, most commonly sulfuric acids created from sulfur in the fuel. The quantity of acid-neutralizing additives in lube oil should match the total sulfur content of the fuel. If excessive amounts of these additives are used, they may create deposits on engine components. Marine engine manufacturers have recommended that lube oil only needs to be adjusted if the fuel is switched for more than one week, but the oil feed rate may need to be reduced as well as engine operating power. Additional research has been conducted in this area and several oil companies have been working to create a lubricating oil that would be compatible with several different types of fuel.

(f) Asphaltenes

Asphaltenes are heavy, non-volatile, aromatic compounds which are contained naturally in some types of crude oil. Asphaltenes may precipitate out of the fuel solution when a fuel rich in carbon disulfide, such as residual fuel, is mixed with a lighter hydrocarbon fuel, such as *n*-pentane or *n*-heptane found in some distillate fuels. When these heavy aromatic compounds fall out of the fuel solution, they can clog filters, create deposition along the fuel lines/combustion chamber, seize the fuel injection pump, or cause other system troubles. This risk can be minimized through onboard test kits and by purchasing distillate and residual fuel from the same refiner. However, according to the California Air Resources Board, the formation of asphaltenes is not seen as an issue based on data from previous maritime rules.

As can be seen, if vessel operators choose to operate on marine distillate fuel while in the ECA, some prudence is required. However, as described above, issues that could arise with switching between residual and distillate fuel are addressed through changes to operating procedures. To conduct a successful switchover between the residual and marine distillate fuels, vessel operators will need to keep the above issues in mind and follow the engine manufacturer's standard fuel switching procedure.

(g) Boilers

Steamships operate through the use of steam produced by boilers. In addition, boilers are often used on diesel-propelled ships for auxiliary power. Many of these boilers are designed to operate on heavy fuel oil. As such, the fuel must be heated and the system optimized to atomize heavy fuel oil and then mix it with air for combustion. To operate these systems on distillate fuel, certain modifications to the boiler may be necessary to the burner and fuel systems. These modifications are more likely to be necessary for older boilers. First, as with diesel engines, residual fuel needs to be heated to flow through the pumps. Distillate fuel does not. In addition, the fuel pumps and injection nozzles must be matched to the viscosity and lubricity of the fuel. Second, the fuel burners and air mixing system must be matched to the fuel. In modern boilers, burners generally are able to operate on distillate fuel and heavy fuel oil. The air mixing generally needs to be reduced when using distillate fuel which evaporates easier. The control system must be adjusted so that the main burner does not accidently re-ignite after a flame-out. If the boiler loses its ignition source (flame) too high of a mass of fuel may be vaporized for the boiler to be safely re-lighted. In this case, the boiler should be purged before relighting the flame. Third, proper monitoring of the boiler operation will optimize flame supervision and minimize the risk of problems when operating on distillate fuel.

(2) Equivalents

Regulation 4 of Annex VI allows for alternative devices, procedures, or compliance methods if they are "at least as effective in terms of emissions reductions as that required by this Annex." As an alternative to operating on lower sulfur fuel, an exhaust gas cleaning device may be used to remove SO_X and PM emissions from the exhaust. These devices are colloquially known as SO_X scrubbers. This section describes the technological feasibility of SO_X scrubbers and how they may be used to achieve equivalent emission reductions as fuel switching.

SO_X scrubbers are capable of removing up to 95 percent of SO_X from ship exhaust using the ability of seawater to absorb SO_X. SO_X scrubbers have been widely used in stationary source applications, where they are a well-established SO_X reduction technology. In these applications, lime or caustic soda are typically used to neutralize the sulfuric acid in the washwater. While SO_X scrubbers are not widely used on ocean-going vessels, there have been prototype installations to demonstrate their viability in this application such as the Krystallon systems installed on the P&O ferry Pride of Kent and the Holland America Line cruise ship the ms Zaandam. These demonstrations have shown scrubbers can replace and fit into the space occupied by the exhaust silencer units and can work well in marine applications.

There are two main scrubber technologies. The first is an open-loop design which uses seawater as exhaust washwater and discharges the treated washwater back to the sea. Such open-loop designs are also referred to as seawater scrubbers. In a seawater scrubber, the exhaust gases are brought into contact with seawater, either through spraying seawater into the exhaust stream or routing the exhaust gases through a water bath. The SO_2 in the exhaust reacts with oxygen to produce sulfur trioxide which then reacts with water to form sulfuric acid. The sulfuric acid in the water then reacts with carbonate and other salts in the seawater to form sulfates which may be removed from the exhaust. The washwater is then treated to remove solids and raise the pH prior to discharge back to the sea. The solids are collected as sludge and held for proper disposal ashore.

A second type of SO_X scrubber which uses a closed-loop design is also feasible for use on marine vessels. In a closed loop system, fresh water is used as washwater, and caustic soda is injected into the washwater to neutralize the sulfur in the exhaust. A small portion of the washwater is bled off and treated to remove sludge, which is held and disposed of at port, as with the open-loop design. The treated effluent is held onboard or discharged at open sea. Additional fresh water is added to the system as needed. While this design is not completely closed-loop, it can be operated in zero discharge mode for periods of time.

Exhaust gas scrubbers can achieve reductions in particulate matter as well. By removing sulfur from the exhaust, the scrubber removes most of the direct sulfate PM. Sulfates are a large portion of the PM from ships operating on high sulfur fuels. By reducing the SO_X emissions, the scrubber will also control much of the secondary PM formed in the atmosphere from SO_X emissions. However, simply mixing alkaline water in the exhaust does not necessarily remove much of the carbonaceous PM, ash, or metals in the exhaust. While SO_2 associates with the washwater, particles can only be washed out of the exhaust through direct contact with the water. In simple scrubber designs, much of the mass of particles can reside in gas bubbles and escape out the exhaust.

Manufacturers have been improving their scrubber designs to address carbonaceous soot and other fine particles. Finer water sprays, longer mixing times, and turbulent action would be expected to directionally reduce PM emissions through contact impactions. One scrubber design uses an electric charge on the water to attract particles in the exhaust to the water. In another design, demisters are used that help effectively wash out PM from the exhaust stream. In either of these designs, however, the systems would be effective at removing SO_2 from the exhaust even if the additional hardware needed for non-sulfate PM reduction were not used.

Annex VI does not present specific exhaust gas limits that are deemed to be equivalent to the primary standard of operating on lower sulfur fuel. Prior to the recent amendments to Annex VI, Regulation 14 included a limit of 6 g/kW-hr SO_2 as an alternative to the 15,000 ppm sulfur limit for sulfur emission control areas. Under the amended requirements, the specific SO_2 limit was removed and more general language on equivalents was included.

IMO has developed guidelines for the use of exhaust gas cleaning systems (EGCS) such as SO_X scrubbers as an alternative to operating on lower sulfur fuel.[102] These guidelines include a table of SO_2 limits intended to correspond with various fuel sulfur levels. Based on the methodology that was used to determine the SO_2 limit of 6.0 g/kW-hr for existing ECAs, the corresponding limit is 0.4 g/kW-hr SO_2 for a 1,000 ppm fuel sulfur limit. This limit is based on an assumed fuel consumption rate of 200 g/kW-hr and the assumption that all sulfur in the fuel is converted to SO_2 in the exhaust. The IMO guidelines also allow for an alternative approach of basing the limit on a ratio of SO_2 to CO_2. This has the advantage of being easier to measure during in-use monitoring. In addition, this ratio holds more constant at lower loads than a brake-specific limit, which would approach infinity as power approaches zero. For the existing 15,000 ppm fuel sulfur limit in ECAs, a SO_2 (ppm)/CO_2 (%) limit of 65 was developed. The equivalent limit for a 1,000 ppm fuel sulfur level is 4.0 SO_2 (ppm)/CO_2 (%).

It is our intent that the IMO guidelines will be used by the U.S. Government in making the determination whether an EGCS meets the requirements of MARPOL Annex VI, Regulation 4. We are currently working with the U.S. Coast Guard on developing the U.S. Government process for approving equivalents. It is not yet clear if a request for an equivalent determination will be made to EPA or the U.S. Coast Guard. To prevent multiple requests from having to be made, today's regulations require such a request to be made to EPA only. This could change as a result of the discussions between EPA and the U.S. Coast Guard. If so, we will update the regulatory text accordingly.

Scrubbers are effective at reducing SO_2 emissions and sulfate PM emissions from the exhaust. However, as discussed above, the effectiveness of the scrubber at removing PM emissions other than sulfates is dependent on the scrubber design. In addition to sulfate PM reductions, switching from residual fuel to distillate fuel results in reductions in organic PM and metallic ash particles in the exhaust. We expect that ECGS designs will achieve similar PM reductions as fuel switching; however, if this turns out to not be the case, we will address this issue, as appropriate, through further action.

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[102] International Maritime Organization, "2009 Guidelines for Exhaust Gas Cleaning Systems," Resolution MEPC.184(59), Adopted on 17 July 2009, MEPC 59/24/Add.1/Annex 9.

Water-soluble components of the exhaust gas such as SO_2, SO_3, and NO_2 form sulfates and nitrates that are dissolved into the discharge water. Scrubber washwater also includes suspended solids, heavy metals, hydrocarbons and polycyclic aromatic hydrocarbons (PAH). Before the scrubber water is discharged, there are several approaches that may be used to process the scrubber water to remove solid particles. Heavier particles may be trapped in a settling or sludge tank for disposal. The removal process may include cyclone technology similar to that used to separate water from residual fuel prior to delivery to the engine. However, depending on particle size distribution and particle density, settling tanks and hydrodynamic separation may not effectively remove all suspended solids. Other approaches include filtration and flocculation techniques. Flocculation, which is used in many waste water treatment plants, refers to adding a chemical agent to the water that will cause the fine particles to aggregate so that they may be filtered out. Sludge separated from the scrubber water would be stored on board until it is disposed of at proper facilities.

The IMO guidelines for the use of exhaust gas cleaning devices such as SO_X scrubbers include recommended monitoring and water discharge practices. The washwater should be continuously monitored for pH, PAHs and turbidity. Further, the IMO guidance include specifications for these same items, as well as nitrate content when washwater is discharged in ports, harbors or estuaries. Finally, the IMO guidance recommends that washwater residue (sludge) be delivered ashore to adequate reception facilities and not discharged to the sea or burned on board.

Any discharges directly into waters of the United States may be subject to Clean Water Act or other U.S. regulation. To the extent that the air pollution control technology results in a wastewater discharge, such discharge will require a permit under the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) permit program. For example, the NPDES Vessel General Permit in Section 2.2.26 contains conditions for Exhaust Gas Scrubber Washwater Discharge. Also, the Act to Prevent Pollution for Ships may apply to such discharge.

D. ECA Designation and Foreign-Flagged Vessels

In our previous marine diesel engine rulemakings, EPA did not extend our Clean Air Act standards to engines on vessels flagged by other countries. In our 2003 rule, many states and localities expressed concern about the high levels of emissions from ocean-going vessels. We examined our position and concluded that no change was necessary at that time because the Tier 1 standards we adopted for Category 3 engines on U.S. vessels were the same as those contained in MARPOL Annex VI. We indicated we would re-examine this issue in our current rulemaking and would also review the progress made by the international community toward the adoption of new more stringent international standards that reflect the application of advanced emission control technologies.

We received comments from a broad range of interested parties on the Advanced Notice of Proposed Rulemaking (ANPRM) for this rulemaking. Generally, those commenters remained concerned about the contribution of ocean-going vessels to air quality problems. Many took the position that EPA should cover engines on foreign-flagged OGV under Clean Air Act section 213 since they account for the vast majority of OGV emissions in the United States and because of their perception, at the time these comments were submitted, that the international process to set stringent standards was stalled.

In the Notice of Proposed Rulemaking (NPRM) for this rulemaking, we provided background on EPA's past statements with regard to the application of our Clean Air Act section 213 standards to engines on foreign-flagged vessels, and summarized comments we received on this issue in response to our ANPRM. Because the NO_X standards adopted in the amendments to Annex VI are comparable in stringency and timing to our final CAA NO_X standards, we did not believe it necessary to extend our Clean Air Act Tier 2 and 3 standards to engines on foreign-flagged vessels. Therefore, we did not seek to resolve the issue of whether section 213 of the Act allows us to set standards for engines on foreign-flagged vessels. However, we stated that our proposed decision rested on the timely adoption of an amendment to Annex VI designating the U.S. coastal waters as an ECA, since the most stringent of the NO_X standards will be applicable in such areas. We maintain the position we expressed in the NPRM, particularly in light of the recent approval, and circulation for adoption, of the North American ECA. If the amendment designating a U.S. ECA is not timely adopted by the Parties to IMO, we will revisit this issue.

EPA received a number of comments in response to the NPRM on the issue of whether EPA should or could address emissions from engines on foreign-flagged vessels. Most commenters reiterate their positions as stated in comments received on the ANPRM.[103] Environmental group commenters who previously expressed their position that EPA has authority – and even obligation – within the Clean Air Act to regulate foreign-flagged vessels, maintain that position and recognize that application of the new standards to all vessels, including those that are foreign-flagged, is necessary to achieve the new standards' public health and environmental benefits. While some commenters accept EPA's position that it will revisit this issue without delay in the event that a U.S. ECA designation is not timely adopted by the Parties to the IMO,[104] others are concerned about the potential for delay within the IMO and, thus, urge EPA to commence a parallel rulemaking as a backstop to that potential delay.[105] Still others find EPA's reliance on an ECA designation to be insufficient and suggest that EPA should presently assert authority and extend this rule's application to foreign-flagged vessels.[106] That suggestion also includes a concern that too much reliance on the IMO for authority to regulate foreign-flagged vessels could expose a gap wherein ships that are flagged in nations that are not parties to Annex VI would go unregulated in U.S. waters.[107] To close that gap, the commenter recommends direct application of CAA standards to all foreign-

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[103] Ohio Environmental Council, Earth Day Coalition, Marsh Area Regional Council, Ohio League of Conservation Voters, OAR-2007-0121-0314; Northeast States for Coordinated Air Use Management, OAR-2007-0121-0227; American Lung Association with Environmental Defense Fund, OAR-2007-0121-0366 and OAR-2007-0121-0227; Santa Barbara Air Pollution Control District, OAR-2007-0121-0231; Clean Air Task Force, OAR-2007-0121-0264 and OAR-2007-0121-0227; South Coast Air Quality Management District, OAR-2007-0121-0309 and OAR-2007-0121-0232.

[104] Ohio Environmental Council, Earth Day Coalition, Marsh Area Regional Council, Ohio League of Conservation Voters, OAR-2007-0121-0314; Northeast States for Coordinated Air Use Management, OAR-2007-0121-0227; American Lung Association with Environmental Defense Fund, OAR-2007-0121-0366 and OAR-2007-0121-0227.

[105] Santa Barbara Air Pollution Control District, OAR-2007-0121-0231.

[106] Clean Air Task Force, OAR-2007-0121-0264 and OAR-2007-0121-0227; South Coast Air Quality Management District, OAR-2007-0121-0309 and OAR-2007-0121-0232; Earthjustice, Friends of the Earth, and Center for Biological Diversity, OAR-2007-0121-0320.

[107] Earthjustice, Friends of the Earth, and Center for Biological Diversity, OAR-2007-0121-0320.

flagged vessels. That concern echoes industry commenters' calls for equal application of the standards to all vessels in U.S. waters to ensure a "level playing field" and "uniform treatment of the entire merchant fleet."[108]

We appreciate the comments we received and are committed to revisiting the issue if the U.S. ECA proposal is not timely adopted. However, we continue to believe we need not revisit this issue at this time given that foreign-flagged vessels will be subject to standards under APPS that are comparable to those for U.S.-flagged vessels under section 213 of the CAA. The issue of whether EPA is compelled to cover foreign-flagged vessels under section 213 of the CAA was raised in *Bluewater v. EPA*, 372 F.3d 404 (D.C.Cir. 2004), a challenge to EPA's decision in 2003 not to revisit the issue of whether foreign-flagged vessels may and should be covered by nonroad emissions standards issued under section 213 of the CAA. In finding Bluewater's claim to be premature, the *Bluewater* court referred back to its determination in *Engine Mfrs. Ass'n v. EPA*, 88 F.3d at 1086-87, that "new nonroad engine" as used in 213(a)(3) is ambiguous and reiterated EPA's undisputed finding that there would be no significant loss of emission reductions by not revisiting the issue. We do not believe circumstances have changed to call into question the *Bluewater* court's finding as applied to today's setting. In fact, the only changed circumstances further support EPA's decision not to revisit the issue. Since issuance of the 2003 final rule and the court's decision in *Bluewater*, Annex VI has entered into force, and the United States has becomes a Party to Annex VI and has successfully negotiated significant new emission and fuel standards. In addition, Congress has adopted amendments to the Act to Prevent Pollution from Ships to implement both the original and amended Annex VI requirements. Therefore, given that foreign-flagged vessels are subject to the original and new Annex VI NO_X and fuel requirements under the operation of APPS, we do not believe it is currently necessary to address whether EPA may or should cover foreign-flagged vessels under section 213 of the CAA. *See South Coast v. EPA*, 554 F.3d 1076, 1081 (D.C.Cir. 2009)("Deferring resolution of the issue until it will have an effect remains reasonable and the petitioners' objection therefore remains premature.").

However, as noted above, we are committed to revisiting this issue if the proposed ECA, within which the most stringent NO_X and fuel requirements are applicable, is not timely adopted. Meetings to discuss adoption of the U.S.-proposed ECA are scheduled shortly after this rule is finalized, and thus, taking into consideration the lead times adopted, little time is lost in not revisiting this issue in this rulemaking. We also note that ships that are flagged in nations that are not a Party to Annex VI are subject to Annex VI requirements in U.S. waters under the Act to Prevent Pollution from Ships. Our regulations to implement the requirements of Annex VI with respect to such vessels make clear the applicability of those provisions to such vessels.

[108] World Shipping Council, OAR-2007-0121-0227 and OAR-2007-0121-0325; Marine Engineers Beneficial Association, OAR-2007-0121-0259.

VI. Certification and Compliance Program

This section describes the regulatory changes being finalized for the CAA Category 3 engine compliance program. In general, these changes are being finalized to ensure that the benefits of the standards are realized in-use and throughout the useful life of these engines, and to incorporate lessons learned over the last few years from the existing test and compliance program.

The most obvious change is that we are applying the plain language regulations of 40 CFR 1042 to Category 3 engines. These part 1042 regulations were adopted in 2008 for Category 1 and Category 2 engines (73 FR 25098, May 6, 2008). They were structured to contain the provisions that are specific to marine engines and vessels in part 1042, and apply the parts 1065 and 1068 for other provisions not specific to marine engines. This approach is not intended to significantly change the compliance program from the program currently applicable to Category 3 engines under 40 CFR part 94, except as specifically noted in this notice. These plain language regulations supersede the regulations in part 94 for Category 3 engines beginning with the 2011 model year. See Section VI.E for additional discussion of the transition from part 94 to part 1042.

The changes from the existing programs are described below along with other notable aspects of the compliance program. These changes are necessary to implement the new standards as well as to implement the Annex VI program as required under the amendments to the Act to Prevent Pollution from Ships.

Finally, we are also including several changes and clarifications to the compliance program that are not specific to Category 3 engines. Some of these apply only for marine diesel engines below 30 liters per cylinder displacement.

A. Compliance Provisions for Category 3 Engines

In general, we are retaining the certification and compliance provisions adopted with the Tier 1 standards for Category 3 engines. These include testing, durability, labeling, maintenance, prohibited acts, etc. However, we believe additional testing and compliance provisions will be necessary for new standards requiring more advanced technology and more sophisticated emission control systems. These changes, as well as other modifications to our certification and compliance provisions for Category 3 engines, are discussed below.

Our certification process is similar to the process specified in the Annex VI NO_X Technical Code (NTC) for pre-certification. However, the Clean Air Act specifies certain requirements for our certification program that are different from the NTC requirements. The EPA approach differs most significantly from the NTC in three areas. First, the NTC allows but does not require certification of engines before installation (known as pre-certification under the NTC), while EPA does require it. Second, we include various provisions to hold the engine manufacturer responsible for the durability of emission controls, while the NTC holds the engine manufacturer liable only before the engine is placed into service. Finally, we specify broader temperature ranges and allow manufacturers less discretion in setting engine parameters for testing, with the goal of adopting test procedures that represent a wide range of normal in-use operation. We believe the regulations in this final rule are sufficiently consistent with NTC that manufacturers can continue to use a single harmonized compliance strategy to certify under both systems.

(1) Testing

We are largely continuing the testing requirements that currently apply for Category 3 engines with a few exceptions.

(a) General Test Procedures

We are applying the general engine testing procedures of 40 CFR part 1065 to Category 3 engines. This is part of our ongoing initiative to update the content, organization and writing style of our regulations. For each engine sector for which we have recently promulgated standards (such as smaller marine diesel engines), we refer to one common set of test procedures in part 1065. This is because we recognized that a single set of test procedures would allow for improvements to occur simultaneously across engine 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.

These procedures replace those currently published in parts 92 and 94 and are fundamentally similar to those procedures. The primary differences are related to tighter tolerances to reduce test-to-test variability. In most cases, a manufacturer should be able to comply with 1065 using its current test equipment. Nevertheless, full compliance with part 1065 would take some effort on the part of manufacturers. As such, we are including some flexibility to make a gradual transition from the part 92 and 94 procedures. For several years, manufacturers will be able to optionally use the part 1065 procedures. Part 1065 procedures will generally be required for any new testing by 2016 (except as noted below). This is very similar to the allowance already provided with respect to Category 1 and Category 2 engines.

Several manufacturers raised in their comments general objections to applying the 1065 test procedures. However, since we proposed to allow Category 3 manufacturers to submit data collected using the test equipment, test fuels, and procedures specified in the NO_X Technical Code, we believe that the requirement should be finalized as proposed. The procedures in 1065 will still be the official test procedures, however, and manufacturers will be liable with respect to any test results from1065 testing. We do not believe this allowance will have any effect on the stringency of the standards, or how manufacturers design and produce their engines.

(b) Test Fuel

Appropriate test procedures need to represent in-use operating conditions as much as possible, including specification of test fuels consistent with the fuels that compliant engines will use over their lifetimes. Our Part 94 regulations allow Category 3 engine testing using distillate fuel, even though many vessels with these engines currently use less expensive residual fuel. This provision is consistent with the specifications of the NO_X Technical Code. We are continuing this approach for Tier 2 and Tier 3. Our primary reason for continuing this approach is that we expect these Category 3 engines will generally be required to use distillate fuels in areas that will affect U.S. air quality for most of their operational lives. (We expect this because we expect IMO to approve our proposal to amend Annex VI to designate the U.S. coastal waters as an ECA.) However, since these engines will not be required to use low-sulfur or ultra low-sulfur fuel, we are also adding an explicit requirement that a high-sulfur distillate test fuel be used for both Tier 2 and

Tier 3 testing. Our testing regulations (40 CFR 1065.703) are being revised to specify that high-sulfur diesel test fuels contain 800 to 2,500 ppm sulfur. This will be lower than the prior specification of 2,000 to 4,000 ppm. This will allow manufacturers to test with fuels near the ultimate in-use limit of 1,000 ppm.

(c) Testing Catalyst-Equipped Engines

In our existing programs that require compliance with catalyst-based engines (such as the Category 1 & 2 engine program), we have required manufacturers to test prototype engines equipped with prototype catalyst systems. However, it is not clear that this approach would be practical for Category 3 engines. These are problematic because of their size and because they tend to be a least partially custom built on a vessel by vessel basis. Requiring a manufacturer to construct a full-scale catalyst system for each certification test would be extremely expensive.

We are finalizing an optional special certification procedure to address this concern. The provisions are in §1042.655 of the finalized regulations. The emission-data engine must be tested in the specified manner to verify that the engine-out emissions comply with the Tier 2 standards. The catalyst material must be tested under conditions that accurately represent actual engine conditions for the test points. This catalyst testing may be performed on a benchscale. Manufacturers must include a detailed engineering analysis describing how the test data collected for the engine and catalyst material demonstrate that all engines in the family will meet all applicable emission standards. Manufacturers must verify their design by testing a complete production engine and catalysts in its final assembled configuration. It is important to note that this allowance does not limit in any way the manufacturers' or operators' obligations with respect to safety for catalyst systems, such as those specified by Coast Guard.

(d) Testing Production Engines

Under the current regulations, manufacturers must test a sample of their Category 1 and Category 2 engines during production. We are now finalizing similar provisions for Category 3 engines. While in the past we did not believe that such testing was necessary, circumstances have changed in two important ways. First, relatively inexpensive portable test systems have recently become available. This greatly reduces the cost of testing an engine in a ship. Second, the need to verify that production engines actually comply with the emission standards increases as standards become more stringent and emission control technologies become more complicated.

Specifically, every new Tier 2 or later Category 3 engine must be tested during the vessel's sea trial to show compliance with the applicable NO_X standard. Any engine that fails to comply with the standard will need to be repaired and retested. Since we are not finalizing PM standards for Category 3 engines, and because PM measurement is more difficult than measuring only gaseous emission, we will not require PM measurement during testing after installation, provided PM emissions were measured during certification.

One concern that manufacturers have raised in the past is that it can be difficult to achieve the exact test points in use. Therefore, we are allowing manufacturers flexibility with respect to test points when testing production engines, consistent with the equivalent allowance under the NO_X Technical Code. Where manufacturers are unable to duplicate the certification test points during production testing, we are allowing them to comply with an alternate "at-sea standard" that is 10 percent higher than the otherwise applicable standard. This is specified in §1042.104(g).

Since we are requiring testing of every production engine, we are also excluding Category 3 engines from selective enforcement audits under 40 CFR part 1068.

(e) PM Measurement

We are requiring manufacturers to measure PM emissions along with NO_X, HC, and CO during certification testing to report these results along with the other test data. This is similar to our recently proposed requirement for manufacturers to measure and report certain greenhouse gas emissions for a variety of nonroad engine sectors.[109] Manufacturers should be able to collect these data using stand-alone partial flow PM measurement systems. In recent years, several vendors have developed such systems to be compliant with the requirements of 1065.

It is worth noting that in the past, there has been some concern regarding the use of older PM measurement procedures with high sulfur fuels. The primary issue of concern was variability of the PM measurement, which was strongly influenced by the amount of water bound to sulfur. However, we believe improvements in PM measurement procedures, such as those specified in 40 CFR 1065, have addressed these issues of measurement variability. The U.S. Government recently submitted proposed procedures for PM measurement to IMO.[110]

(2) Low Power Operation and Mode Caps

Emission control performance can vary with the power at which the engine operates. This is potentially important because Category 3 engines can operate at relatively low power levels when they are operating in port areas. Ship pilots generally operate engines at reduced power for several miles to approach a port, with even lower power levels very close to shore. The International Organization for Standardization (ISO) E3 and E2 test cycles, which are used for emission testing of propulsion marine engines, are heavily weighted towards high power. In the absence of other requirements, it would be possible for manufacturers to meet the cycle-weighted average emission standards without significantly reducing emissions at low-power modes. This could be especially problematic for Tier 3 engines relying on urea-SCR for NO_X control, since the effectiveness of the control is directly affected by the amount of urea that is injected and there would be an obvious economic incentive for manufacturers and operators to minimize the amount of urea injected.

We are addressing these concerns in two ways. First, we are applying mode caps for NO_X emissions that will ensure that manufacturers design their emission controls to be fully effective at 25 percent power. This will require that manufacturers meet the applicable NO_X standard at each individual test point, and not merely as a weighted average of the test points. The caps will only apply for NO_X emissions, and manufacturers will not be required to meet the HC and CO standards

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[109] 74 FR 16448, April 10, 2009.

[110] "Measurement Method For Particulate Matter Emitted From Marine Engines," Submitted by the United States to the International Maritime Organization Intersessional [sic] Meeting Of the BLG Working Group On Air Pollution, 5 October 2007.

at each test point. For HC and CO, manufacturers will only be required to meet the applicable standards as a weighted average of the test points

The other concern is related to power levels other than the test points. To address this, we will continue to rely on our prohibition of defeat devices to ensure effective control for lower powers. Most significantly, this will prohibit manufacturers from turning off the urea supply to SCR systems at these points, unless the exhaust gas temperature was too cool for the SCR catalyst to function properly. (Urea at these low temperatures does not react with NO_X molecules and can lead to high emissions of ammonia.)

(3) On-off Technologies

Many of technologies that are projected to be used to meet the Tier 3 NO_X standards (such as SCR, water injection, and EGR) are not integral to operation of the engine allowing the engine to be operated without them. They will also require the operator to supply the proper reductant. Thus, these technologies are potentially "on-off" technologies. Switching to distillate fuel instead of residual fuel to reduce SO_X and PM emissions can be thought of in the same way.

The increased operating costs of such controls associated with urea (or other reductants) or with distillate usage suggest that it may be reasonable to allow these systems to be turned off while a ship is operated on the open ocean, far away from sensitive areas that are affected by ship emissions. This is the basis of the MARPOL Annex VI ECA approach, with one set of limits that would apply when ships are operated in sensitive areas and another that would apply when ships are operated outside those designated areas.

We are finalizing the proposed regulatory provision in §1042.115(g) to address the use of on-off technologies on Category 3 engines subject to the Tier 3 standards. This provision will require the manufacturer to obtain EPA approval to design the engines to have on-off features. It will also require the engine's onboard computer to record the on-off operation (including geographic position and time) and require that the engine comply fully with the Tier 2 standards when the Tier 3 controls are turned off.

In response to comments, we are expanding this option slightly to address other possible technological solutions. In particular, we will allow a manufacturer to design the system to have a Tier 3 mode and a Tier 2 mode that correspond to "on" and "off", without regard to whether any given controls are turned on or off. For example, under this allowance, a manufacturer could design the system have a Tier 2 (off) mode in which the SCR system continues to function, while engine-out emissions are increased. Such a design would be allowed as long as the emission downstream of the aftertreatment met the Tier 2 standards.

Our goal is to require manufacturers to comply with the Tier 3 standards in all areas where the emissions significantly affect U.S. air quality. We expect that all such areas will also ultimately be included in one or more Emission Control Areas. We describe a North American ECA in Section V.A, which is intended to include most areas where the emissions significantly affect U.S. air quality. However, we have not yet determined the extent to which Category 3 engines affect air quality in other areas - specifically, the U.S. territories, areas of Alaska west of Kodiak, the smallest Hawaiian islands, or Puerto Rico and the U.S. Virgin Islands. Therefore, we are including an interim provision to exclude those areas with respect to the Tier 3 standards at this time. We will revisit this should our review of available modeling results or other information indicate that compliance with the Tier 3 standards should be required for some or all of these areas.

(4) NO_X Monitoring

Category 3 engines equipped with on-off controls must be equipped to continuously monitor NO_X concentrations in the exhaust. Engine manufacturers will be required to include systems to automatically alert operators of any operation with the emission controls on where NO_X concentrations indicate malfunctioning emission controls. We are also requiring the engine to record in nonvolatile computer memory any such operation. However, we are not requiring monitoring NO_X concentrations during operation for which the emission controls are allowed to be turned off, provided the record indicated that the controls were turned off. Where the NO_X monitor system indicates a malfunction, operators will be required to investigate the cause and make any necessary adjustments or repairs.

We are defining as a malfunction of the emission controls any condition that would cause an engine to fail to comply with the applicable NO_X standard (See Section VI.A.1.d for a discussion of standards that will apply for installed engines at sea). Such malfunctions could include maladjustment of the engine or controls, inadequate reductant, or emission controls turned off completely. We recognize that it is not possible to perfectly correlate a measured NO_X concentration with an equivalent cycle-weighted emission result. Therefore, the requirement will allow engine manufacturers to exercise good engineering judgment in using measured NO_X concentrations to monitor the emission performance of the engine. Should manufacturers decide that it would be helpful to have a less subjective (and less flexible) requirement, we will be willing to work with them to make such improvements to this provision through a future rulemaking.

(5) Parameter Adjustment

Given the broad range of ignition properties for in-use residual fuels, we expect that our in-use adjustment allowance for Category 3 engines will result in a broad range of adjustment. We requested comment on a requirement for operators of ships equipped with NO_X monitors to perform a simple NO_X check test to confirm emissions after parameter adjustments or maintenance operations, using onboard emission measurement systems with electronic-logging equipment. While we are not adopting such a requirement at this time, we may do so in the future should we determine that these engines are being improperly adjusted in use.

(6) In-Use Liability

Under the Tier 1 program for Category 3 engines, owners and operators are required to maintain, adjust, and operate the engines in such a way as to ensure proper function of the emission controls. These requirements, which are described in 40 CFR 94.1004, are being continued in the regulations in part 1042 (See §1042.660 of the finalized regulations for these requirements). Owners will also continue to be required to keep certain records onboard the vessel and report annually to EPA whether or not the vessel has complied with these and other requirements.

Specifically, these provisions require that all maintenance, repair, adjustment, and alteration of the engine be performed using good engineering judgment so that the engine continues to meet the emission standards. Each two-hour period of operation of an engine in a condition not complying with this requirement will be considered a separate violation. Some commenters expressed concern that treating each two-hour period of operation as a separate violation would be inappropriate for events that occur while the vessel is out at sea. These commenters correctly noted that where a repair cannot be made at sea, the operator has no choice but to continue operating the vessel in its noncompliant condition. Therefore, we are revising the regulations to clarify that we would not consider operating a vessel in need of repair to be a violation, if such a repair was not possible.

(7) Replacement Engines

The existing provisions of §1042.615 provide an exemption that allows manufacturers to produce new uncertified engines when they are needed to replace equivalent existing engines that fail prematurely. For many engine sectors, this practice is common, but represents a very small faction of a manufacturer's total engine production. We do not believe this practice is either common or necessary for Category 3 engines, and therefore we proposed to not allow this exemption for Category 3 engines. However, engine manufacturers commented that there have been infrequent but real occurrences where they have needed to provide a Category 3 replacement engine in response to premature engine failure. To address this concern, we are finalizing a provision that would allow us to make an exception in very unusual circumstances and allow a manufacturer to make a new Category 3 engine that is exempt from current emission standards. Even for the rare case where manufacturers would need to supply a replacement Category 3 engine, we would expect them generally to be able to provide a certified engine. It is clear that removing a failed engine and installing a replacement will involve a very significant effort; we would expect this effort to include reasonable modifications to accommodate a certified engine even if it was somewhat different than the engine being replaced. However, if manufacturers can demonstrate under §1042.615 that no certified engine has the physical and performance characteristics to properly power the vessel, they may produce a new engine that is exempt from emission standards. This may be most likely for vessels that have paired Category 3 engines where one of the engines fails prematurely and cannot be repaired without being removed from the vessel.

It is also important to note that the provisions of Annex VI related to replacement engines also apply. This generally limits replacement engines to those that are identical to the engines being replaced.

B. Compliance Provisions to Implement Annex VI NO_X Regulation and the NO_X Technical Code

In addition to the Clean Air Act provisions being finalized in this action, we are also establishing new regulations to implement certain provisions of the Act to Prevent Pollution from Ships. These regulations are a new part 1043 of title 40.

The Act to Prevent Pollution from Ships establishes a general requirement for vessels operating in the exclusive economic zone and navigable waters of the United States to comply with MARPOL Annex VI. It also gives EPA and the Administrator the authority to further implement MARPOL Annex VI. Many of the requirements relating to NO_X emissions and fuel sulfur limits can be implemented without the need for further elaboration because the Annex, along with the NO_X Technical Code, provides instructions on how to demonstrate compliance with those requirements. However, APPS authorizes the Administrator to prescribe any necessary or desired additional regulations to assist in carrying out the provisions of Regulations 12 through 19 of Annex VI (see 33 USC 1903(c)(2)). Specifically, the regulations being finalized in this FRM in part 1043 of title 40 are intended to assist in the implementation of the engine and fuel requirements contained in Regulation 13, 14, and 18 of MARPOL Annex VI. They address such issues as how to obtain an Engine International Air Pollution Prevention (EIAPP) certificate (which is equivalent in many ways to a Clean Air Act certificate of conformity), exemptions for vessels used exclusively in domestic service, and requirements for vessels not registered by a country that is a Party to Annex VI.

The requirements being finalized in part 1043 will generally begin July 1, 2010. However, the ECA NO_X requirements will not begin until the Tier 3 NOx standards begin (or when the ECA enters into force for the U.S., whichever is later), and the ECA fuel requirements will not begin until 12 months after the ECA enters into force for the U.S., as provided by Annex VI. It is also important to clarify that Annex VI itself was effective for the United States as of January 8, 2009. The requirement of the Annex for ships to have a valid International Air Pollution Prevention (IAPP) certificate applies for U.S. vessels based on when the keel is laid and when it is dry-docking. Vessels for which keels were laid (or which were at a similar stage of construction) before January 8, 2009 must have on board a valid IAPP certificate no later than the first scheduled dry-docking, but in no case later than January 8, 2012. Vessels for which keels are laid (or which are at a similar stage of construction) after January 8, 2009 must have on board a valid IAPP certificate upon completion of its initial survey before the ship is placed into service.

The MARPOL Annex VI NO_X requirements apply to all marine diesel engines above 130 kW. Similarly, the MARPOL Annex VI fuel requirements apply to all fuel oil used onboard a vessel, defined as any fuel delivered to and intended for combustion purpose for propulsion or operation on board any ship, including distillate and residual fuels. Thus the part 1043 compliance program described here applies somewhat more broadly than the Clean Air Act compliance program described earlier for Category 3 engines.

It is worth noting that while APPS generally requires compliance with Annex VI and future amendments to Annex VI, we have incorporated by reference the existing 2008 version of the Annex for certain purposes. Specifically, we require compliance with the 2008 Annex VI NO_X and fuel requirements by non-Party vessels and require compliance with the ECA requirements by all vessels in our internal waters; both of these issues are discussed later. We fully expect to update this incorporation by reference whenever aspects of the Annex relating to these provisions are amended. However, we recognize that it is possible that there will be a brief period during which the incorporated version differs slightly from any amended provisions. To the extent that occurs, vessels in our internal waters and non-Party vessels would be subject to the requirements in the 2008 version (or the latest version that has been incorporated by reference).

In §1043.1(d), we clarify that these regulations do not limit requirements that would otherwise apply pursuant to APPS, except for excluding domestic vessels from the Annex VI NO_X standard (consistent with the allowance in Regulation 13.1.2.2 of the Annex).

(1) EIAPP Certificates

In general, an engine can be dual-certified under EPA's Clean Air Act marine diesel engine program and the MARPOL Annex VI/APPS program. However, we require that engine manufacturers submit separate applications for the 1042 and EIAPP certificates. The regulations in part 1043 specify the process that would apply. The process for obtaining the EIAPP is very similar to the process for obtaining a certificate of conformity under part 1042, and although there are differences between the programs, manufacturers should be able to comply with both programs with very little additional work. The primary differences are that, to certify to the MARPOL Annex VI standards, the manufacturer must include a copy of the Technical File and onboard NO_X verification procedures (as specified in Section 2.4 of the NO_X Technical Code) and is not required to provide information about useful life, emission labels, deterioration factors, or PM emissions.[111] Engine manufacturers will be able to apply for both certifications using the same certification templates and test data.

Consistent with our 1042 program, our 1043 program will require that each engine installed or intended to be installed on a U.S.-flagged vessel have an EIAPP before it is introduced into U.S. commerce. The finalized regulations will create a presumption that all marine engines manufactured, sold, or distributed in U.S. commerce will be considered to be intended to be installed on a U.S.-flagged vessel, although this presumption could be rebutted by clear and convincing evidence to the contrary (evidence that the engine is intended for export, for example). We will also require that all engines that are intended only for domestic use be labeled as such. Thus, all engines not labeled for domestic use will be presumed to be intended for use on vessels subject to part 1043.

(2) Approved Methods

The 2008 amendments to MARPOL Annex VI added a new provision to the engine standards in Regulation 13 that extends the Tier I NO_X limits to certain engines installed on ships constructed on or after January 1, 1990 through December 31, 1999. Specifically, engines with power output greater than 5,000 kW and with per cylinder displacement at or above 90 liters installed on such ships would be required to meet the Tier I NO_X limits if a certified Approved Method is available. An Approved Method may be certified by the Administration of any flag state, but once one is registered with the IMO the owner of such an engine must either install the Approved Method or demonstrate compliance with the Annex VI Tier I limits through some other method. We are including a regulatory section codifying this requirement. These regulations are contained in §1043.50.

(3) Other Annex VI Compliance Requirements

Engine manufacturers, vessel manufacturers, vessel owners, and fuel providers, fuel distributors, and other directly regulated stakeholders are required to comply with all aspects of Regulations 13, 14, and 18 of Annex VI as well as the NO_X Technical Code. These include requirements for engine operation, fuel use, fuel oil quality, and various recordkeeping requirements

[111] See 68 FR 9746, February 28, 2003, at 9774-5 for a discussion of these differences as they relate to Category 3 marine diesel engines.

(e.g., record book of engine parameters, engine technical file, fuel switching procedures, bunker delivery notes and associated fuel samples, and fuel sampling procedures).

Regulation 18 of both the original and the revised Annex VI sets out the requirements for bunker delivery notes and associated fuel samples. All vessels 400 gross tons and above, and each fixed and floating drilling rig and other platforms (i.e., those vessels subject to Regulations 5 and 6 of both the original and the revised Annex VI) are required to keep onboard the vessel bunker delivery notes that specify the details of fuel oil brought onboard for combustion purposes. These bunker delivery notes may be inspected by the competent authority of a Party while the ship is in its port or offshore terminals. The competent authority may also verify the contents of bunker delivery notes. A fuel sample is required to accompany each bunker delivery note, sealed and signed by the supplier's representative and the master or officer in charge of fuel operations. The sample should be taken pursuant to IMO guidelines and is to be retained for at least 12 months from the date of delivery. While the IMO guidelines were not in place at the time the original Annex was adopted, they were subsequently developed and Regulation 18 of amended Annex VI refers specifically to these guidelines: MEPC.96(47).

Although these are Annex VI requirements, we are not creating a regulatory requirement for the certification of bunker delivery notes or fuel samples. Such a requirement would be infeasible with respect to the time and resources that would be necessary to certify every batch of fuel sold to a vessel above 400 GT in the United States. In addition, the requirements in Annex VI clearly call for the sulfur content of gas fuels delivered to a ship for combustion purposes be documented by the fuel supplier, and that the required fuel sample be sealed and signed by the fuel provider and the representative of the ship owner.

It has been brought to the attention of EPA and the Coast Guard that some fuel providers in the United States and elsewhere have not been issuing bunker delivery notes and/or fuel samples at the time of fuel delivery. Ship owners and operators, and fuel providers, are reminded that the bunker delivery notes and fuel samples are requirements under Annex VI; a vessel can be found in noncompliance with the Annex VI fuel requirements if the vessel is inspected at a domestic or foreign port. Therefore, ship owners and operators should exercise care and diligence in obtaining the necessary bunker delivery notes and fuel samples at the time fuel is brought onboard, through the fuel contractual arrangement or through other agreement at the time of sale, and fuel providers should be certain that they have procedures and processes in place to provide the bunker delivery note and fuel sample for each batch of fuel delivered.

(4) Non-Party Vessels

The finalized regulations specify that vessels flagged by a country that is not a party to MARPOL (known as non-Party vessels) must comply with Regulations 13, 14, and 18 of Annex VI when operating in U.S. waters. This requirement fulfills the requirement of 33 U.S.C. 1902 (e), which requires the adoption of regulations for non-Party vessels such that they are not treated more favorably than vessels of countries that are party to the MARPOL Protocol. However, since such vessels cannot get EIAPP certificates, this provision requires non-party vessels to obtain equivalent documentation of compliance with the NO_X standards of Annex VI.

(5) Internal Waters

APPS applies Annex VI requirements, including amendments to Annex VI that have entered into force for the United States, to ships that are in the internal waters of the U.S. Among the requirements added in the 2008 amendments to Annex VI are more stringent standards for fuel quality and NO_X emissions. Many of these standards apply in "Emission Control Areas" (ECAs) to be designated by the Parties to Annex VI. As described earlier, the U.S. and Canada submitted an application for a North American ECA, adoption of which is anticipated in March 2010.

As some commenters have noted, the ECA proposal does not include U.S. or Canadian internal waters. While the two governments did not specifically seek designation for internal waters in their ECA proposal, it is evident that emissions in internal waters are of greater concern than emissions occurring from the baseline seaward to 200 nautical miles. Vessel emissions in internal waters are often even closer to U.S. population centers than emissions in coastal waters. Emissions in internal waters affect U.S. air quality to an equal, if not greater, degree to emissions in coastal waters. Given these considerations, EPA believes that Congress' direction to apply Annex VI requirements to ships in the internal waters of the United States, as well as its grant of authority to EPA to administer the relevant regulations of Annex VI, confers the authority to apply the fuel quality and emissions requirements that apply to ECAs to ships in internal waters.

We also note the application of these standards to internal waters should not disturb reasonable expectations or impose a significant burden on industry. It has always been presumed in our analyses supporting the ECA proposal and this rule, and is the customary practice in the North Sea and Baltic Sea SECAs, that vessels will continue to comply with the emissions standards anytime they operate on the landward side of the ECA boundary, including in a country's internal waters. We are not aware of anyone ever suggesting that a vessel complying with ECA standards would increase its emissions while it remains in port or other body of water that is part of or connected to an ECA. We do not believe that vessels would generally choose to switch to higher sulfur fuels or choose to turn off Tier III control strategies in internal waters. In most cases, ocean-going vessels only operate in internal waters for short periods of time while entering and leaving ports. Switching to high sulfur fuel or turning off and on NO_X control strategies could be time consuming and may not be justified by the limited operational cost savings.

We are finalizing regulatory text to codify Annex VI global requirements and clarify application of Annex VI ECA requirements to ships in U.S. internal waters. Specifically, the regulatory text includes the APPS requirements for vessels to comply with Annex VI global requirements in our internal waters. The regulatory text also clarifies that vessels operating in U.S. internal waters, shoreward of an ECA, that can be accessed by ocean-going vessels must meet Annex VI ECA requirements. This includes ports and internal waters such as the Great Lakes. In the regulatory text we refer to the internal waters in which we are applying the ECA requirements as the "ECA associated area." The regulatory text will apply the ECA requirements for these internal waters beginning the same time the ECA takes effect under Annex VI.

Application of the ECA requirements under APPS to our internal waters does not replace but rather augments our Clean Air Act standards. The Clean Air Act exhaust emission and fuel standards apply regardless of the APPS provisions, except to the extent that any of the new CAA provisions refer to the ECA boundaries.

We received extensive comments on the economic and safety impacts of applying the ECA engine and fuel requirements to vessels that operate on the Great Lakes. The Summary and Analysis of Comments for this rule includes a discussion of the economic impacts of applying the ECA engine and fuel requirements to vessels that operate on the Great Lakes. In addition, EPA will perform a study and issue a report evaluating the economic impact of the final rule on Great Lakes carriers. We will work with Great Lakes stakeholders in conducting the study and expect to complete the report in Summer 2010.

In addition to recommending the above-mentioned study, Conference Report 111-316 accompanying HR2996, the Department of Interior, Environment, and Related Agencies Appropriations Act, 2010, suggests that EPA should include two waiver provisions for Great Lakes carriers in this final rule. Based on this statement and concerns that have been raised by the Great Lakes shipping industry, we are finalizing a new provision to address certain vessels operating exclusively on the Great Lakes (hereinafter, "Great Lakes vessels"). Specifically, we are finalizing a provision that provides for relief in the event of serious economic hardship. This economic hardship provision allows Great Lakes shippers to petition EPA for a temporary exemption from the 2015 fuel sulfur standards. The shipper must show that despite taking all reasonable business, technical, and economic steps to comply with the fuel sulfur requirements, the burden of compliance costs would create a serious economic hardship for the company. The Agency will evaluate each application on a case-by-case basis. Our experience to date shows that detailed technical and financial information from the companies seeking relief has been necessary to fully evaluate whether a hardship situation exists. As such, we may request additional information as needed. Typically, because of EPA's comprehensive evaluation of both financial and technical information, action on hardship applications can take approximately six months. Because of this, applications for an economic hardship waiver must be submitted to EPA by January 1, 2014. As is our historic practice with fuel waivers, if we approve a delay in meeting the fuel sulfur requirements, we expect to impose appropriate conditions to: (1) ensure the shipper is making its best effort; and (2) minimize any loss of emissions benefits from the program.

In the Conference Report, Congress also indicated that EPA should provide a waiver for the requirement for the use of 1.0 percent fuel sulfur (10,000 ppm) standard if residual fuel meeting that standard is not available on the Great Lakes. In response to this statement and comments from the Lake Carriers Association, we are creating a provision that will ensure that operators on the Great Lakes will be able to buy marine residual fuels if compliant 10,000 ppm S fuel is not available. Under this provision, if marine residual fuel meeting the 10,000 ppm S standard is not available, it will not be a violation of our standards for vessel operators to bunker and use marine residual fuel with sulfur content above 10,000 ppm S provided the fuel they do purchase is the lowest sulfur marine residual fuel available at the port. We believe this market based approach will provide a significant incentive to fuel suppliers to provide 10,000 ppm S fuel, while giving Great Lakes shippers confidence that marine residual fuel will be available for their use during the 10,000 ppm S fuel program.

Finally, some commenters raised technical and safety issues associated with operating Great Lakes steamships on distillate fuel. Great Lakes steamships operate in fresh water and therefore have very long lives. Many of the boilers used on these vessels were manufactured and constructed in the 1940s and 1950s and were designed specifically to operate on heavy fuel oils. Due to these technical issues, we considered a number of options for how to address these vessels. However, Congress placed a prohibition on EPA's use of funds in this fiscal year to issue a final rule that includes fuel sulfur standards applicable to existing steamships that operate exclusively within the Great Lakes. Therefore, we are excluding Great Lakes steamships from the fuel sulfur requirements. For the purpose of this exclusion, Great Lakes steamships means vessels, operating exclusively on the Great Lakes and Saint Lawrence Seaway, whose primary propulsion is a steam turbine or steam reciprocating engine. In addition, these steamships must have been in service on the Great Lakes prior to October 30, 2009. This does not include diesel propulsion Category 3 vessels with auxiliary boilers.

Totem Ocean Trailer Express (TOTE) raised similar concerns for the small number of steamships operating along the U.S. coasts. As these vessels do not operate exclusively within U.S. internal waters, they fall under the U.S. Government's (primarily EPA and Coast Guard's) implementation of the ECA provisions of Annex VI. The requirements of the Annex VI ECA fuel sulfur limits apply to all vessels and have no exemptions for steamships. It is not within the scope of this rulemaking to amend the requirements of the MARPOL Annex VI treaty. However, through TOTE's comments and follow-up conversations with ship owners, we agree that special challenges exist for the use of lower sulfur fuel in steamships. Therefore, we will continue to work on this issue with the United States Coast Guard and other members of the U.S. Delegation to IMO as well as other interested stakeholders including the affected steamship operators. We are committed to resolving this issue before the end of 2011, well in advance of January 2015 when the 0.1 percent fuel sulfur standard will enter into force.

(6) Exemptions and Exclusions

Under MARPOL Annex VI and APPS, certain vessels are excluded from some or all of the requirements. Consistent with Annex VI and APPS, the regulations in 1043 will exclude public vessels and engines intended to be used solely for emergencies. For the purpose of this provision, the term "public vessels" includes all warships and naval auxiliary vessels, as well as any other vessels owned or operated by a sovereign country engaged in noncommercial service. Consistent with the provisions in APPS, we are not applying the Annex VI requirements to U.S.-flagged public vessels (or foreign public vessels excluded by their flag states). It should be noted, however, that not all public vessels are exempt from our Clean Air Act engine and fuel requirements. Only public vessels covered by a national security exemption under §94.908 or §1042.635 are exempt from the Clean Air Act program.

The category of emergency engines includes engines that power equipment such as pumps that are intended to be used solely for emergencies and engines installed in lifeboats intended to be used solely in emergencies. It should be noted that the emergency engine provisions in the Annex and part 1043 are similar but not identical to the emergency engine provisions in our Clean Air Act program or the process of obtaining our CAA exemptions. In particular, the emergency engine exemption from the CAA requirements applies only with respect to the catalyst-based Tier 4 standards.

We are exempting from the MARPOL Annex VI NO_X standards engines installed on vessels registered or flagged in the United States provided the vessel remains within the EEZ of the United States. These engines will still be required to meet stringent emission standards since they are covered by our Clean Air Act program. In addition, the fuels used by these vessels are also covered by our Clean Air Act program, which has more stringent fuel requirements than Annex VI.

Therefore, as long as the operators of these domestic vessels comply with these more stringent Clean Air Act fuel requirements, they will be deemed to be in compliance with the Annex VI requirements. The combination of these proposed provisions will mean that a fishing vessel that operates out of a U.S. port and that never leaves U.S. waters will not be required to have an EIAPP for all engines above 130 kW, a record book of engine parameters and a technical file for each engines, and vessels over 400 gross tons will not be required to maintain bunker delivery notes (vessels under 400 gross tons are not required by Regulation 18 of MARPOL Annex VI to have bunker delivery notes). Instead, the engines on that vessel will be required to be in compliance with our marine diesel engine standards and be required to comply with the manufacturer's requirements with regard to the proper fueling of those engines. We are also explicitly precluding these engines from being certified to use residual fuel if they are exempt from the part 1043 requirements. Thus, these engines will be required to always use cleaner fuels than are required by Annex VI. U.S. vessels that operate or may operate in waters that are under the jurisdiction of another country are not exempt from these provisions, and the owner of any such vessel may be required by that country to show compliance with Annex VI. Therefore, the owner should be sure to maintain the appropriate paperwork for that engine and have the appropriate engine certification. It should be noted that engines that must show compliance with the Annex VI standards are not exempt from EPA's standards for Category 1 or Category 2 engines.

Finally, spark-ignition, non-reciprocating engines, and engines that do not use liquid fuel are not included in Regulation 13 of the Annex VI program and therefore they will not be covered by the proposed APPS regulations with respect to NO_X emissions. However, the MARPOL Annex VI fuel requirements do apply for these vessels. These engines are generally subject to separate Clean Air Act fuel requirements and/or emission standards that effectively require the use of low sulfur fuels, either directly or indirectly.

C. Changes to the Requirements Specific to Engines Below 30 Liters per Cylinder

The amendments to MARPOL Annex VI were adopted in October of 2008, after we finalized our Clean Air Act Tier 3 and Tier 4 standards for Category 1 and Category 2 engines (May 6, 2008, 73 FR 25097). While these two programs are very similar, there are a few differences between them with regard to their engine requirements. We are adopting some changes to our CAA program to facilitate compliance with both programs. In addition, some of the provisions described in Section VI.D may also apply to Category 1 and Category 2 marine diesel engines, regarding non-diesel engines and technical amendments to our current program.

(1) MARPOL Annex VI and EPA's Standards for Category 1 and Category 2 Engines

Our existing regulations include an exemption for Category 1 and Category 2 engines on certain migratory vessels. This allowance is limited to vessels that are operated primarily outside of the United States, and that obtain and maintain SOLAS certification and appropriate EIAPP certification demonstrating compliance with Annex VI. We are making some minor modifications to this allowance to reflect the new Annex VI standards.

We are also revising §1042.650 to add exemption provisions for Category 1 and Category 2 auxiliary engines on vessels with Category 3 propulsion engines. These auxiliary engines would be exempt from the part 1042 standards, but would still be required to comply with the Annex VI standards. In addition, engines that would have been subject to the Tier 4 standards of part 1042 would be required to conform to the Tier III NO_X requirements, irrespective of whether they would be required to comply under Annex VI. For example, this would affect 2015 Category 2 engines with a maximum engine power of 3000 kW installed on a 2015 vessel since such an engine would be subject to the Tier 4 standards under §1042.101, but would have only been subject to the Tier II standards under Annex VI.

Given the MARPOL Annex VI and CAA NO_X requirements are comparable, with slightly different phase-in dates and cut-offs, we believe this approach will be a less burdensome implementation approach over transitioning years, and will not have a meaningful impact on emission reductions. In the absence of this exemption, manufacturers would have been required to certify special auxiliary engines that met both Annex VI and 1042 requirements for a U.S. market that could be as small as one engine per year. By allowing manufacturers to meet only the Annex VI requirements, they would be able to produce a single international engine and spread the administrative costs over many more engines. It is important to note that we are not extending this exemption to vessels powered by smaller engines because these factors cannot be presumed for such vessels.

(2) On/Off Technology for Category 1 and 2 Engines

As described in Section VI.A.3 above, we proposed to allow the use of auxiliary emission control devices (AECDs) that would allow modulation of emission control equipment on Category 3 engines outside of specific geographic areas. These AECDs would be subject to certain restrictions: (1) the AECD would be available for the Tier 3 standards only; (2) the AECD would modulate emission controls only while operating in areas where emissions could reasonably be expected to not adversely affect U.S. air quality; and (3) and an engine equipped with an AECD must also be equipped with a NO_X emission monitoring device.

We are expanding our proposed allowance for ocean-going vessels with Category 3 propulsion engines to also include Category 1 and Category 2 engines to provide auxiliary power. We are not allowing this option for U.S. vessels with Category 1 or Category 2 propulsion engines.

D. Other Regulatory Issues

In addition to the changes described in Sections VI.A and VI.C, we are also finalizing changes that apply to marine engines in general, and/or to other types of engines.

(1) Non-Diesel Engines

Most of the preceding discussions have focused on conventional diesel engines using either diesel fuel or residual fuels. It is important to highlight two other types of engines being affected by this proposal: engines using other fuels and gas turbine engines.

(a) Engines not using Diesel Fuel

For all categories of marine engines, our existing standards apply to all engines meeting the definition of compression-ignition, regardless of the fuel type. For example, compression-ignition Category 3 engines that burn natural gas are subject to our Tier 1 standards and will be subject to our finalized Tier 2 and Tier 3 standards. We are continuing to apply this approach for all marine engines subject to our standards.

The testing regulations in part 1065 include test fuel specifications for diesel fuel, residual fuel, and natural gas (as well as for gasoline and liquefied petroleum gas, which would not typically be used in a compression-ignition engine). To certify an engine for a different fuel type, a manufacturer will need to obtain EPA approval to use an alternate fuel which it recommends for testing. All other aspects of certification will be the same.

(b) Gas Turbine Engines

Gas turbine engines are internal combustion engines that can operate using a variety of fuels (such as diesel fuel or natural gas) but do not operate on a compression-ignition or other reciprocating engine cycle. Power is extracted from the combustion gas using a rotating turbine rather than reciprocating pistons. The primary type of U.S.-flagged vessels that use gas turbine engines are naval combat ships. While a small number have been used in commercial ships, we are not aware of any current sales for commercial applications. They can range in size from those equivalent in power to mid-size Category 1 engines to those that produce the same power as Category 3 engines. None of these engines have been subject to our current standards because they do not meet the definition of compression-ignition engines in our existing regulations.

To date, this omission has not been a concern because only a small number of turbine-powered vessels have been produced and nearly all of them would have been eligible for a national security exemption. However, we were concerned that this exclusion may become a loophole in the future for operators hoping to avoid using engines with advanced catalytic emission controls. To a lesser degree, we also had concerns about the possibility of other non-reciprocating engines being excluded. We are closing this potential loophole by revising the regulations to treat new gas turbine engines (as well as other non-reciprocating engines) the same as compression-ignition engines and to apply our standards for new Category 1 and Category 2 engines (including NO_X, HC, CO, and PM standards) to gas turbine engines.

Several commenters objected to finalizing this requirement. They argued primarily that this would not align with MARPOL. They also asserted that the proposed requirements would not pass a cost/benefit analysis and that turbines cannot be tested under the procedures of 40 CFR part 1065. However, they did not provide any information about costs, benefits, or test procedures. As described in the RIA and the Summary and Analysis of Comments Document, we continue to believe the requirements are feasible and appropriate. As described below, we are finalizing these requirements largely as proposed. The primary revision being made is to delay them until the Tier 4 timeframe to provide turbine manufacturers additional lead time.

To incorporate this approach in our marine emission control program, we are changing our definitions of Category 1 and Category 2 to include gas turbine engines. Since turbine engines have no cylinders, we are adopting a conversion convention to apply the regulatory provisions that depend on a specified value for per-cylinder displacement. This convention is intended to apply the standards based on equivalent power ratings, to the extent possible. Specifically, we are redefining "Category 1" to include gas turbines with rated power up to 2250 kW and redefining "Category 2" to include all gas turbines with higher power ratings. This means we will not consider any gas turbines as “Category 3” engines. The largest gas turbine engines will be considered to be Category 2 engines, even those that had rated power more typical of Category 3 diesel engines. We are adopting this approach primarily because our Category 3 standards vary with engine speed, and are specified based on a speed range typical of diesel engines. These formulas do not make sense for gas turbine engines since they have much higher engine speeds.

We are aware that some companies are manufacturing new high-performance recreational vessels using gas turbine engines. In at least some cases, the engines are modified from surplus military aircraft engines. We have not yet determined whether such recreational engines should be held to the same standards as conventional diesel engines. It is also important to note that under our current regulations, diesel engines meeting the definition of “recreational marine engine” in §1042.901 are not subject to catalyst forcing standards. This approach was applied because of factors such as the usage patterns for recreational diesel engines. We believe these same factors to apply for recreational gas turbine engines. Thus, we are not as concerned about a potential gas turbine loophole for recreational engines as for commercial engines. We also do not have enough information at this time to know how feasible it would be for small gas turbine engine manufacturers to comply with the standards for recreational diesel engines, or to accurately assess the environmental impact of these vessels. Nevertheless, it is clear that the environmental impact of such small numbers of these engines cannot be large. Thus, at this time, we are not applying this regulatory change to recreational gas turbine engines (i.e., that is gas turbine engines installed on recreational vessels). We will continue to investigate these engines and may subject them to standards in the future.

Our diesel engine program contains a national security exemption that automatically exempts vessels “used or owned by an agency of the federal government responsible for national defense, where the vessel has armor, permanently attached weaponry, specialized electronic warfare systems, unique stealth performance requirements, and/or unique combat maneuverability requirements.” Since it is not our intent to prohibit naval vessels from using turbine engines, we are revising this provision to automatically exempt military vessels owned by an agency of the federal government responsible for national defense powered by gas turbine engines.

We are confident that gas turbine engines could use the same type of aftertreatment as is projected for diesel engines. The basic reactions through which SCR reduces NO_X emissions can occur under a wide range of conditions, and exhaust from gas turbine engines is fundamentally similar to exhaust from diesel engines. Viewed another way, however, this requirement can be considered to be feasible based on the fact that the only circumstance in which a vessel would actually need a gas turbine engine would be for military purposes where our national security exemption provisions will apply. For all other vessels, it is entirely feasible for the vessel to be powered by a diesel engine. In fact, that is what is being done today.

This program for gas turbine engines will apply to freshly manufactured engines only. We are not applying our marine remanufacture program to gas turbine engines. Because there are so few engines in the fleet, it is not possible to know what common rebuilding process are or whether and how those practices would return an existing engine to as-new condition. We may review this approach in the future if there is an increase in the number of gas turbines in the fleet.

Finally, it is important to address some confusion expressed by the commenters about our definitions. We agree that it would be incorrect to actually define turbine engines as reciprocating or compression ignition, which is what the commenters thought we had proposed. However, we did not propose to define turbines to be reciprocating or compression-ignition engines. The commenters misread §1042.1(f), which states that certain marine engines "are subject to all the requirements of this part even if they do not meet the definition of 'compression-ignition' in §1042.901." This provision subjects marine gas turbine engines to the requirements of part 1042, but it explicitly recognizes that they do not meet the definition of compression-ignition in §1042.901. The confusion seems to arise from the statement that these engines "are deemed to be compression-ignition engines for the purposes of this subchapter." This statement is merely a regulatory convention that means the part applies to turbines as if they did meet the definition.

(2) Technical Amendments

The finalized regulations include technical amendments to our motor vehicle and nonroad engine regulations. These changes are generally corrections and clarifications. A large number of these changes are the removal of obsolete highway engine text that applied only for past model years. Many others are changes to the text of part 1042 to make it more consistent with the language of our other recently corrected nonroad parts. The last large category of changes includes those related to the test procedures in part 1065. See the memorandum in the docket entitled "Technical Amendments to EPA Regulations" for a full description of these changes.[112]

E. U.S. Vessels Enrolled in the Maritime Security Program

The U.S. Department of Transportation Maritime Administration (MARAD) oversees the Maritime Security Program (MSP) established by the Maritime Security Act of 1996 and reauthorized by the Maritime Security Act of 2003 (MSA). The MSA requires that the Secretary of Transportation, in consultation with the Secretary of Defense, establish a fleet of active, commercially viable and militarily useful vessels to meet national defense and other security requirements and maintain a U.S. presence in international commercial shipping. The fleet consists of privately-owned, U.S.-flagged vessels known as the Maritime Security Fleet (MSF). 46 U.S.C. 53102 outlines that vessels complying with applicable international agreements and associated guidelines are eligible for a certificate of inspection from Coast Guard, and thus inclusion in the MSF.

The requirements of the MSP may have created confusion for owners of non-U.S.-flagged vessels regarding their obligation to also comply with EPA's domestic marine diesel engine emission standards at the time they re-flag for inclusion in the MSF. We want to remind vessel owners that the MSA does not preempt the Clean Air Act or alleviate their obligation to comply with EPA's marine diesel engine program, or any other EPA requirements that apply to marine vessels. As is clear from our past rulemakings, it has always been our intent that each U.S.-flagged vessel must comply with all of EPA's domestic standards, regardless of whether the vessel was flagged in the U.S. upon original delivery into service.

[112] See "Technical Amendments to EPA Regulations," EPA memorandum from Alan Stout, in the docket for this rule, Docket No.: EPA-HQ-OAR-2007-0121.

We are revising the regulations to clarify these requirements and, as noted earlier, to provide exemptions for auxiliary engines on Category 3. First, we are revising §1042.1 to clarify that our regulations apply for all U.S.-flagged vessels. In conjunction with this, we are revising the definitions of "model year" and "new marine engine" to clarify that our marine engine program applies to all U.S.-flagged vessels regardless of where that vessels is built or operated, and how the regulations apply for vessels that are re-flagged to be U.S. vessels.

We are clarifying that engines on foreign vessels that vessels become "new marine engines" under part 1042 at the point at which they are reflagged. As new marine engines, we would expect them to be covered by valid certificates and/or exemptions prior to being placed into service. If engines on U.S.-flagged vessels are not covered by valid certificates and/or exemptions when they first enter U.S. waters, they would be subject to all of the prohibitions of part 1068.101. The operator would be in violation of the prohibition against introduction of an uncertified new engine into U.S. commerce.

Some of the revisions being finalized are intended to simplify the transition from part 94 to part 1042. Under the revised regulations, part 1042 becomes the default regulatory part for compression-ignition marine engines. Section 1043.1 specifies that such marine engines are subject to part 1042 unless they are certified under part 94. In addition, §1042.1(c) specifies that the definition of "new marine engine" in §1042.901 applies for engines certified under part 94. This is important because our standards and prohibitions apply for engines meeting the definition of "new marine engine". Thus, to determine whether an uncertified marine engine is subject to our standards and prohibitions, you must determine whether it meets any of the criteria of the definition of "new marine engine" in §1042.901.

Each "new marine engine", is subject to standards based on its model year. The revised definition of "model year" specifies that engines on re-flagged vessels would generally be subject to the standards that would have applied in the year they were originally manufactured. If the engine has a model year before the years the part 94 standards first applied, it would not be subject to any standards. If the engine has a later model year but one that is before the years the part 1042 standards apply, it would be subject to the standards of part 94. According to §1042.1(c), if the engine is certified to these part 94 standards, it is not required to comply with the requirements of part 1042.

To further smooth this transition, we are finalizing a new interim provision in §1042.145(i). This provision is intended to apply for vessel operators that were not aware that their vessels were required to comply with our regulations. Once this amendment takes effect, it will allow them to operate in U.S. waters until July 1, 2010 without certificates or exemptions for their engines. After that, it will be a violation of 40 CFR 1068.101 to operate in U.S. waters with uncertified engines if those engines are subject to our standards. Operation of such vessels in U.S. waters on or after July 1, 2010 is deemed to be introduction into U.S. commerce of a new marine engine.

VII. Costs and Economic Impacts

In this section, we present the projected cost impacts and cost effectiveness of the coordinated emission control strategy for large marine vessels with a per cylinder displacement greater than 30 Liters per cylinder. We also present our analysis of the economic impacts of the coordinated strategy, which consists of the estimated social costs of the program and how those costs will likely be shared across stakeholders. The projected benefits and benefit-cost analysis of the coordinated strategy are presented in Section VIII.

We estimate the costs of the coordinated strategy to be about $1.85 billion in 2020, increasing to $3.11 billion in 2030.[113] Of the 2020 costs, nearly 89 percent or $1.64 billion are attributable to the fuel sulfur provisions. The total operational costs are estimated to be $1.82 billion in 2020. The costs to apply engine controls to U.S.-flagged vessels are expected to be $31.9 million in 2020, increasing to $47.4 million in 2030 as more ships are built to comply with Clean Air Act (CAA) Tier 3 NO_X limits. All costs are presented in 2006 U.S. dollars.

When attributed by pollutant, at a net present value of 3 percent from 2010 through 2040, the NO_X controls are expected to cost about $510 per ton of NO_X reduced, SO_X controls are expected to cost about $930 per ton of SO_X reduced, and the PM controls are expected to cost about $7,950 per ton of PM reduced ($500, $920, and $7,850 per ton of NO_X, SO_X, and PM respectively, at a net present value of 7 percent over the same period.) These costs are comparable to our other recently-adopted mobile source programs, and are one of the most cost-effective programs in terms of NO_X and PM when compared to recent mobile and stationary programs. The coordinated strategy also provides very cost-effective SO_X reductions comparable to the Heavy-Duty Nonroad diesel rulemaking.

The social costs of the program are estimated to be approximately $3.1 billion in 2030. The impact of these costs on society is estimated to be minimal. For example, we estimate the cost of shipping a 20-foot container on the Pacific route, with 1,700 nm of operation in the ECA, would increase by about $18, or less than 3 percent. Similarly, the price of a seven-day Alaska cruise that operates mainly in the ECA is expected to increase by about $7 per day.

The estimated costs presented in this section are for the entire coordinated strategy, including those requirements that are the subject of this action and those that are associated with the proposed ECA designation. Table VII-1 sets out the different components of the coordinated strategy for 2020. The costs of the coordinated strategy consist of the costs associated with the MARPOL Annex VI global standards that are operational through APPS, some of which we are also adding to our CAA emission control program for U.S. vessels (Tier 2 and Tier 3 NO_X emission control hardware for U.S. vessels; operating costs for the Tier 2 NO_X requirements; controls for existing vessels; certain compliance requirements). Also included are the costs associated with complying with the engine standards and low sulfur fuel limits in U.S. internal waters (Tier 3 operating costs; fuel sulfur hardware and operating costs.)

Note that, with regard to hardware costs, the coordinated strategy includes the entire cost for new U.S. vessels to comply with the Tier 3 NO_X standards and fuel limits, even though some of the

[113] These total estimated costs are slightly different than those reported in the ECA proposal, because the ECA proposal did not include costs associated with the Annex VI existing engine program, Tier II, or the costs associated with existing vessel modifications that may be required to accommodate the use of lower sulfur fuel. Further, the cost totals presented in the ECA package included Canadian cost estimates.

benefits from using these emission control systems will occur outside the United States. Conversely, we do not include any new vessel Tier 3 or fuel hardware costs for foreign vessels that operate in U.S. waters even though a significant share of the benefits of the coordinated strategy will arise from foreign vessels that comply with the engine and fuel sulfur limits while operating within the U.S. ECA and internal waters.

The regulatory changes finalized for Category 1 and 2 engines are not included in this cost analysis as they are intended to be compliance flexibilities and not result in increased compliance costs. Similarly, the technical amendments finalized for other engines will not have significant economic impacts and are therefore not addressed here. Finally, to provide for a representative comparison between costs and benefits of the program, the cost analysis presented here assumes that all vessels currently using residual fuel will operate on distillate fuel in an ECA, including Great Lakes steamships. As noted in earlier chapters, Great Lakes steamships have been excluded from the final fuel sulfur standards. This change is not expected to have a significant impact on the estimated costs or benefits of the rule as those vessels are not a large part of the national inventory.

Table VII-1 Costs Associated with the U.S. Coordinated Strategy and Canadian ECA (Estimated Costs for 2020, $2006)

Program Element		U.S. Coordinated Strategy	Canadian ECA
Hardware – T2 (variable costs; fixed costs applied in 2010)	U.S. vessels	$3,310,000	NA – not part of ECA
	Foreign Vessels	N/A – global std	NA – not part of ECA
Hardware – T3 (variable costs; fixed costs recovered in the year in which they occur: 2011-15)	U.S. vessels (variable costs; fixed costs recovered in the year in which they occur: 2011-15)	$28,700,000	$100,000,000
	Foreign vessels: 30% of vessels making 75% of entrances to U.S. ports[a]	$296,700,000	
	Foreign vessels: 70% of vessels making 25% of entrances to U.S. ports[a]	$692,200,000	
Hardware – Fuel	U.S. vessels (new vessel costs)	$804,000	$10,000,000
	Foreign vessels (new vessel costs)	$23,600,000	
Operating – T2 (inside full inventory modeling domain)	U.S. vessels	$5,630,000	NA – not part of ECA
	Foreign vessels	$32,900,000	NA – not part of ECA
Operating – T3 (inside relevant part of affected waterways)	U.S. vessels	$15,800,000	$30,000,000
	Foreign vessels	$127,000,000	
Operating – Fuel (inside relevant part of affected waterways)	U.S. vessels	$210,000,000	$260,000,000
	Foreign vessels	$1,430,000,000	

Existing vessels – engine costs (all U.S. vessels 1990-99 retrofit during first 5 years of program, 2011-15)	U.S. vessels	$0	NA – not part of ECA
	Foreign vessels	N/A – global std	NA – not part of ECA
Existing vessels – vessel fuel switching costs (all U.S. vessels 1999-90 retrofit during first 5 years of program, 2011-15)	U.S. vessels	$0	Canada did not provide
	Foreign vessels	$0	Canada did not provide

The estimated costs presented in this section are for the federal program as a whole. We do not estimate costs on a regional or owner-specific basis. We received several comments from owners of vessels operating on the Great Lakes contending that the impact of the proposed control program on their operations is unique, and that the economic impacts of the program on these operators should be estimated separately. As explained in Section VI of this preamble and in more detail in the Summary and Analysis of Comments prepared for this final rule, we are providing various regulatory flexibilities for operators that may have difficulty complying with the requirements of this rule. In addition, as part of EPA's appropriation bill (Public Law 111-88), Congress recommended that EPA perform a study to evaluate the economic impact of the final rule on Great Lakes carriers, with a final report due in the summer of 2010. We will be soliciting input from affected entities as we prepare that report.

A. Estimated Fuel Costs

The coordinated strategy includes fuel sulfur limits which are included in this cost analysis. Prior to this final rule, all distillate fuels produced at refineries in the U.S. had a sulfur limitation of 15 ppm. The coordinated strategy does not impose additional costs for refiners in the U.S. and actually allows additional flexibility. Specifically, we are allowing distillate fuel to have up to 1,000 ppm sulfur for use in Category 3 vessels. The fuel requirements will impose a cost to the ship owners. This section presents estimates of the cost of compliance with the 1,000 ppm sulfur limit in the U.S. waterways.

Distillate fuel will likely be used to meet the 1,000 ppm fuel sulfur limit, beginning in 2015. As such, the primary cost of the fuel sulfur limit for ship owners will be that associated with switching from heavy fuel oil to higher-cost distillate fuel. Some engines already operate on distillate fuel and will not be affected by fuel switching costs. However, distillate fuel costs may be affected by the need to further refine the distillate fuel to meet the 1,000 ppm sulfur limit.

To investigate these effects, studies were performed on the impact of a North American ECA on global fuel production and costs, to inform the application for such ECA.[114] These studies were performed prior to the ECA being defined; thus, we picked a maximum distance boundary to

[114] Research Triangle Institute, 2009. "Global Trade and Fuels Assessment— Future Trends and Effects of Designating Requiring Clean Fuels in the Marine Sector". Prepared for U.S. Environmental Protection Agency. Research Triangle Park, NC.

ensure the fuel volumes used for the cost analysis would be larger than required by the program. Specifically, we used the total fuel consumption in the U.S. and Canada exclusive economic zones.[115] The studies are relevant to this regulation as well, since they estimate the cost of 1,000 ppm sulfur fuel for Category 3 vessels operating in U.S. waterways.

To assess the effect on the refining industry of the imposition of a 1,000 ppm sulfur limit on fuels, we needed to first understand and characterize the fuels market. Research Triangle Institute (RTI) was contracted to conduct a fuels study using an activity-based economic approach. The study established baseline bunker fuel demand, projected a growth rate for bunker fuel demand, and established future bunker fuel demand volumes.[116] These volumes then became the input to the World Oil Refining Logistics and Demand (WORLD) model to evaluate the effect of the coordinated strategy on fuel cost.

The WORLD model was run by Ensys Energy & Systems, the owner and developer of the refinery model. The WORLD model is the only such model currently developed for this purpose and was developed by a team of international petroleum consultants. It has been widely used by industries, government agencies, and Organization of the Petroleum Exporting Countries (OPEC) over the past 13 years, including the Cross Government/Industry Scientific Group of Experts, established to evaluate the effects of the different fuel options proposed under the revision of MARPOL Annex VI. The model incorporates crude sources, global regions, refinery operations, and world economics. The results of the WORLD model have been comparable to other independent predictions of global fuel, air pollutant emissions and economic predictions.

The WORLD model was run for 2020, in which the control case included a fuel sulfur level of 1,000 ppm in the U.S. The baseline case was modeled as “business as usual” in which ships continue to use the same fuel as today. Because of the recent increases and fluctuations in oil prices, we had additional WORLD model runs conducted. For these runs, we used new reference case and high oil price estimates that were recently released by the U.S. Energy Information Administration (EIA). In addition to increased oil price estimates, the updated model accounts for increases in natural gas costs, capital costs for refinery upgrades, and product distribution costs.

Because only a small portion of global marine fuel is consumed in the ECA, the overall impact on global fuel production is small. Global fuel use in 2020 by ships is projected to be 500 million metric tonnes/yr. Of this amount, 90 million metric tonnes of fuel is used for U.S./Canadian trade, or about 18 percent of total global fuel use. In the proposed ECA, less than 20 million metric tonnes of fuel will be consumed in 2020, which is less than 4 percent of total global marine fuel use. Of the amount of fuel to be consumed in the proposed ECA in 2020, about 4 million metric tonnes of distillate will be consumed in the Business as Usual (BAU) case, which is about 20 percent of the amount of total fuel to be consumed in the proposed ECA.

There are two main components to projected increased marine fuel cost associated with the ECA. The first component results from shifting from operation on residual fuel to operation on

[115] In this analysis, the U.S. included the lower 48 contiguous states and southeastern Alaska.
[116] Research Triangle Institute, 2009. “Global Trade and Fuels Assessment— Future Trends and Effects of Designating Requiring Clean Fuels in the Marine Sector”. Prepared for U.S. Environmental Protection Agency. Research Triangle Park, NC.

higher cost distillate fuel. This is the dominant cost component. However, there is also a small cost associated with desulfurizing the distillate to meet the 1,000 ppm sulfur standard. Based on the WORLD modeling, the average increase in costs associated with switching from marine residual to distillate will be $145 per metric tonne of fuel consumed. Due to the differences in energy density between the two fuels, this translates to a cost increase of $123 for each metric tonne of residual fuel replaced by distillate fuel.[117] This is the cost increase that will be borne by the shipping companies purchasing the fuel. Of this amount, $6 per metric tonne is the increase in costs associated with distillate desulfurization.

Table VII-2 summarizes the fuel cost estimates with and without an ECA. In the baseline case, fuel volumes for operation are 18% marine gas oil (MGO), 7% marine diesel oil (MDO), and 75% IFO. Weighted average baseline distillate fuel cost is $462/tonne. In the ECA, all fuel volumes are modeled as MGO, at $468/tonne.

Table VII-2 Estimate Marine Fuel Costs

Fuel	units	Baseline	ECA
MGO	$/bbl	$ 61.75	$ 62.23
	$/tonne	$ 464	$ 468
MDO	$/bbl	$ 61.89	$ 62.95
	$/tonne	$ 458	$ 466
IFO	$/bbl	$ 49.87	$ 49.63
	$/tonne	$ 322	$ 321

The increased cost of distillate desulfurization is due both to additional coking and hydrotreating capacities at refineries. Cokers crack residual blends in IFO bunker fuel into distillates, using heat and residence time to make the conversion. The process also produces useful byproducts such as petroleum coke and off gas. The WORLD model did not use hydrocracking technology to convert residual fuels into distillates for either the reference or high price crude cases. Because of the higher capital and operating costs of hydrocrackers, the WORLD model favored the use of coking units. As such, the WORLD model assumed that cokers would convert the residual blendstocks in Intermediate Fuel Oil grades to distillates. The model added coking processes to refineries located in the U.S. and, to a lesser extent, to refiner regions outside of the U.S. Specifically, the model added one additional coking unit with a capacity of 30 thousand barrels per stream day (KBPSD), and one to two hydrocracking units representing 50 and 80 KBPSD additional capacity.

The WORLD model also added new conventional distillate hydrotreating capacity to lower the sulfur levels for the marine distillate fuel, in addition to the existing slack distillate hydrotreating capacity that existed in refiner regions for these fuels. In addition, the model used lighter crudes

[117] Note that distillate fuel has a higher energy content, on a per ton basis, than residual fuel. As such, there is an offsetting cost savings, on a per metric ton basis, for switching to distillate fuel. Based on a 5 percent higher energy content for distillate, the net equivalent cost increase is estimated as $123 for each metric ton of residual fuel that is being replaced by distillate fuel.

and adjusted operating parameters in refineries. This had the effect of increasing the projected production of lower sulfur distillate fuels in lieu of adding distillate hydrotreating capacity. The model elected to use lower sulfur crudes and used operational adjustments. Higher capital and operating costs of new units under the high-priced crude scenario favored use of existing refinery capacity made available from lower global refiner utilizations.

B. Estimated Engine Costs

To quantify the cost impacts associated with the coordinated strategy, we estimated the hardware and operational costs to U.S.-flagged ships, as well as affected foreign-flagged ships. The hardware costs included in the total cost of the coordinated strategy are only applied to U.S.-flagged vessels, and include those associated with the CAA Tier 2 and Tier 3 NO_X standards, the Annex VI existing engine program, and the use of lower sulfur fuel. Tier 2 hardware costs consist of changes to the engine block and the migration from mechanical fuel injection to common rail fuel injection systems. Tier 3 hardware costs include engine modifications, the migration from mechanical fuel injection to common rail fuel injection systems, and the installation of Selective Catalytic Reduction (SCR). Hardware costs associated with the use of lower sulfur fuel are from applying additional tanks and equipment to enable a vessel to switch from residual fuel to lower sulfur fuel. These equipment costs were applied to those new vessels that may need additional hardware, and also include the estimated cost of retrofitting the portion of the fleet that may require additional hardware to accommodate the use of lower sulfur fuel in 2015. The hardware costs also include a per engine cost of $10,000 associated with the requirement to test each production engine (§1042.302). These are the sole engine hardware costs specifically attributable to our CAA rule.

The operational costs were applied to both U.S.- and foreign-flagged vessels and include additional operational costs associated with the applicable NO_X limits and the use of lower sulfur fuel. The operational costs for NO_X controls consist of the additional fuel required due to an estimated two percent fuel penalty associated with the use of technologies to meet CAA Tier 2 and global Tier II NO_X standards, and the use of urea for ships equipped with an SCR unit to meet CAA Tier 3 and global Tier III NO_X standards. The operational costs associated with the use of lower sulfur fuel include both the differential cost of using lower sulfur fuel that meets ECA standards instead of using marine distillate fuel, and the differential cost of using lower sulfur fuel that meets ECA standards instead of using residual fuel.

To assess the potential cost impacts, we must understand (1) the makeup of the fleet of ships expected to visit the U.S. when these requirements go into effect, (2) the emission reduction technologies expected to be used, and (3) the cost of these technologies. Chapter 5 of the RIA presents this analysis in greater detail. The total engine and vessel costs associated with the coordinated strategy are based on a cost per unit value applied to the number of affected vessels. Operational costs are based on fuel consumption values determined in the inventory analysis (Section 5.2). This section discusses a brief overview of the methodology used to develop the hardware and operational costs, and the methodology used to develop a fleet of future vessels to which these hardware and engineering costs were applied.

(1) Methodology

To estimate the hardware costs to ships that may be affected by the coordinated strategy, we used an approach similar to that used to estimate the emissions inventory. Specifically, the same inputs were used to develop a fleet of ships by ship type and engine type that may be expected to visit U.S. ports through the year 2040. In order to determine the cost of applying emission reduction technology on a per vessel basis, ICF International was contracted by the U.S. EPA to conduct a cost study of the various compliance strategies expected to be used to meet the new NO_X standards and fuel sulfur requirements.[118] ICF was instructed to develop cost estimates covering a range of vessel types and sizes, which could be scaled according to engine speed and power to arrive at an estimated cost per vessel. The costs developed for these engine configurations were used to develop a $/kW value that could be applied to any slow or medium speed engine. Using the average propulsion power by ship type presented in the inventory analysis, the per-vessel hardware costs were then applied to the estimated number of applicable vessels built after the standards take effect.

(a) Hardware Costs

The hardware cost estimates include variable costs (components, assembly, and the associated markup) and fixed costs (tooling, research and development, redesign efforts, and certification). Hardware costs associated with the Annex VI existing engine standards were applied to the portion of existing U.S.-flagged vessels built between 1990 and 1999 expected to be subject to these standards) in 2011 when the standards go into effect (engines with a per-cylinder displacement of at least 90 liters and a power output of over 5,000 kW. These costs were applied over a five year period beginning in 2011 where 20 percent of the total subject fleet was estimated to undergo service each year. The existing engine program fixed costs were phased in over a five year period beginning in 2010 and applied on a per-vessel basis.

Hardware costs associated with the CAA Tier 2 program were applied to all new U.S.-flagged vessels beginning in the year 2011 when the standards take effect. The fixed costs associated with Tier 2 standards are expected to be incurred over a five year period, however, as the Tier 2 standards take effect in 2011, it was assumed that manufacturers are nearing the end of their research and development. In order to capture all of these costs, all fixed costs that would have been incurred during that five year phase-in period were applied in the year 2010. Hardware costs associated with Tier 3 were estimated for U.S. vessels and were applied as of 2016. The fixed costs associated with Tier 3 were phased in over a five year period beginning in 2011.

Hardware costs associated with the use of lower sulfur fuel are estimated separately for both new and existing vessels that may require additional hardware to accommodate the use of lower sulfur fuel. The fuel sulfur control related hardware costs for new vessels begin to apply in 2015, while all retrofit costs are expected to be incurred by 2015 and as such are applied in this year. The fixed costs for both new and existing vessels that may require additional hardware to accommodate the use of lower sulfur fuel are applied on a per-vessel basis and are phased in over a five year period beginning as of 2010.

[118] ICF International, "Costs of Emission Reduction Technologies for Category 3 Marine Engines," prepared for the U.S. Environmental Protection Agency, December 2008. EPA Report Number : EPA-420-R-09-008.

(b) Operational Costs

The operational costs estimated here are composed of three parts: (1) the estimated increase in fuel consumption expected to occur with the use of Tier II technologies on U.S.- and foreign-flagged vessels, (2) the differential cost of using lower sulfur fuel applicable for both U.S.- and foreign-flagged vessels, and (3) the use of urea with SCR as a Tier III NO_X emission reduction technology on both U.S.- and foreign-flagged vessels. The fuel consumption values associated with Tier II and Tier III standards were determined in the inventory analysis (see Chapter 3 of the RIA), with an estimated Tier II fuel consumption penalty of 2 percent (see Chapter 4 of the RIA). The two percent fuel penalty estimate is based on the use of modifications to the fuel delivery system to achieve Tier II NO_X reductions, and does not reflect the possibility that there may be other technologies available to manufacturers that could offset this fuel penalty. Additionally, Tier III will provide the opportunity to re-optimize engines for fuel economy when using aftertreatment, such as SCR, to provide NO_X reductions similar to the compliance strategy for some heavy-duty truck manufacturers using urea SCR to meet our 2010 truck standard. The differential cost of using lower sulfur fuel is discussed above in Section VII.A of this preamble. The estimated urea cost associated with the use of Tier III SCR is derived from a urea dosage rate that is 7.5 percent of the fuel consumption rate.

Operating costs per vessel vary depending on what year the vessel was built, e.g., vessels built as of 2016 will incur operating costs associated with the use of urea necessary when using SCR as a Tier III NO_X emission control technology, while vessels built prior to 2016 do not use urea but will incur operating costs associated with the differential cost of using lower sulfur fuel. Further, we have assumed vessels built as of 2011 that meet Tier II standards will incur a 2 percent fuel consumption penalty; see Table 5-31 of the RIA for further details on fuel costs and fuel volumes. In addition, vessels built as of 2016 that meet Tier III NO_X standards while traveling in the regulated U.S. waterways are still required to at least meet Tier II NO_X standards outside of an ECA and will continue to incur the associated fuel penalty. Therefore, an estimated fleet had to be developed over a range of years, and provide a breakout of ships by age in each year.

(2) Fleet Development

There are currently no available estimates of the number of ships that may visit U.S. ports in the future or comprehensive engine sales predictions. Therefore, to develop the costs associated with the coordinated strategy, an approximation of the number of ships by age and engine type that may visit U.S. ports in the future was constructed. To characterize the fleet of ships visiting U.S. ports, we used U.S. port call data collected in 2002 for the inventory port analysis (see Chapter 3 of the RIA) which included only vessels with C3 engines where the engine size and type was identified.[119] We used this data with the growth rates developed in the inventory analysis to estimate how many ships, by ship type and engine type, would visit U.S. ports in future years. Due to the long life of these vessels, and the fact that there has been no significant event that would have changed the composition of the world fleet since this baseline data was taken, it is reasonable to use 2002 data as the basis for modeling the future fleet upon which to base hardware cost estimates. An

[119] In order to separate slow speed engines from medium speed engines where that information was not explicitly available, 2-stroke engines were assumed to be slow speed, where 4-stroke engines were assumed to be medium speed.

analysis is presented in Section 5.1.2.2 of Chapter 5 of the RIA which confirms the reasonableness of this assumption using 2007 MARAD data.

The ship type information gathered from this baseline data, for the purposes of both this analysis and the inventory, was categorized into one of the following ship types: Auto Carrier, Bulk Carrier, Container, General Cargo, Miscellaneous, Passenger, Refrigerated Cargo (Reefer), Roll-On Roll-Off (RoRo), and Tankers. Average engine and vessel characteristics were developed from the baseline data, and these values were used to represent the characteristics of new vessels used in this cost analysis (see Chapter 3 of the RIA). Estimated future fleets were developed by ship type and engine type through the year 2040 for both new and existing vessels and both U.S.- and foreign-flagged vessels. Hardware costs were applied on a per-vessel basis.

Although most ships primarily operate on residual fuel, they typically carry some amount of distillate fuel as well. Switching to the use of lower sulfur distillate fuel is the compliance strategy assumed here to be used by both new and existing ships in 2015 when the new lower sulfur fuel standards go into effect. To estimate the potential cost of this compliance strategy, we evaluated the distillate storage capacity of the current existing fleet to estimate how many ships may require additional hardware to accommodate the use of lower sulfur fuel. We performed this analysis on the entire global fleet listed in Lloyd's database as of 2008.[120] Of the nearly 43,000 vessels listed, approximately 20,000 vessels had provided Lloyds with fuel tankage information, cruise speed, and propulsion engine power data. Using this information, we were able to estimate how far each vessel could travel on its existing distillate carrying capacity.

In order to determine if the current distillate capacity of a particular ship was sufficient to call on a U.S. coordinated strategy without requiring additional hardware, we evaluated whether or not each ship could travel 1,140 nm, or the distance between the Port of Los Angeles and the Port of Tacoma. This distance was selected because it represents one of the longer trips a ship could travel without stopping at another port, and should overestimate the number of vessels that would require such a modification. The resulting percentages of ships estimated to require a retrofit were then applied to the number of existing ships in the 2015 fleet to estimate the total cost of this compliance strategy for existing ships built prior to 2015. The same percentages were also applied to all new ships built as of 2015 to determine the number of ships that may require additional hardware and estimate the cost of this compliance strategy for new vessels.

(3) NO_X Reduction Technologies

(a) Tier 2

Most engine manufacturers are expected to be able to meet Tier 2 NO_X standards using engine modifications. This cost estimate includes the hardware costs associated with the use of retarded fuel injection timing, higher compression ratios, and better fuel distribution. There are no variable costs associated with the engine modifications as the changes are not expected to require any additional hardware. Some engines may also be equipped with common-rail fuel systems

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[120] www.sea-web.com

instead of mechanical fuel injection to meet Tier 2 NO_X standards. It is expected that approximately 75 percent of SSD and 30 percent of MSD engines will get this modification for Tier 2. The Tier 2 hardware costs developed here include the costs of the migration of some engines to common-rail fuel systems. It was also estimated that these technologies may increase fuel consumption by up to 2 percent; this fuel penalty is included in the Tier 2 operational costs. Tier 2 hardware costs included in the total estimated cost of the coordinated strategy are only associated with U.S.-flagged vessels; operational costs are applied to both U.S.-and foreign-flagged vessels.

(b) Tier 3

Tier 3 NO_X standards are approximately 80 percent below Tier 1 NO_X standards, and are likely to require exhaust aftertreatment such as SCR. ICF performed a detailed cost analysis for the U.S. EPA that included surveying engine and emission control technology manufacturers regarding these advanced technology strategies and their potential costs. Tier 3 NO_X standards are projected to be met through the use of SCR systems. While other technologies such as EGR or those that include introduction of water into the combustion chamber either through fumigation, fuel emulsions, or direct water injection may also enable Tier 3 compliance, we assume they will only be selected if they are less costly than SCR. Therefore, we have based this analysis on the exclusive use of SCR.

(c) Engine Modifications

In addition to SCR, it is expected that manufacturers will also use compound or two-stage turbocharging as well as electronic valving to enhance performance and emission reductions to meet Tier 3 NO_X standards. Engine modifications to meet Tier 3 emission levels will include a higher percentage of common-rail fuel injection coupled with two-stage turbocharging and electronic valving. Engine manufacturers estimate that nearly all SSD and 80 percent of MSD engines will use common-rail fuel injection. Two stage turbocharging will most likely be used on least 70 percent of all engines required to meet Tier 3 emission levels. Electronically- (hydraulically) actuated intake and exhaust valves for MSD and electronically-actuated exhaust valves for SSD are necessary to accommodate two-stage turbocharging. Additionally, the remaining SSD engines still using mechanical injection (approximately 25 percent mechanically-controlled, and 75 percent electronically-controlled) are expected to migrate to common rail for Tier 3, while an additional 40 percent of MSD engines are expected to receive common rail totaling approximately 80 percent of all MSD engines. The engine modification variable costs were applied to all new U.S.-flagged vessels equipped with either SSD or MSD engines. Costs to foreign-flagged vessel expected to visit U.S. ports are presented as a separate analysis in Chapter 5 of the RIA, and are not included in the total estimated cost of the coordinated strategy.

(4) SO_X/PM Emission Reduction Technology

In addition to Tier 3 NO_X standards, the IMO ECA requirements also include lower fuel sulfur limits that will result in reductions in SO_X and PM. Category 3 marine engines typically operate on heavy fuel oil with a sulfur content of 2.7 percent, therefore significant SO_X and PM reductions will be achieved using distillate fuels with a sulfur content of 0.1 percent. This cost analysis is based on the assumption that vessel operators will operate their engines using lower sulfur fuel in the U.S. coordinated strategy waterways. We believe fuel switching will be the primary compliance approach; fuel scrubbers would be used in the event that the operator expected to realize a cost savings and are not considered in this analysis. In some cases, additional capacity and equipment to accommodate the use of lower sulfur fuel may need to be installed on a vessel. The potential costs due to these additional modifications applied to new ships as well as retrofits to any existing ships are discussed here, and these hardware costs are included as part of the total cost of this coordinated program.

Although most ships operate on heavy fuel oil, they typically carry small amounts of distillate fuel. Some vessel modifications and new operating practices may be necessary to use lower sulfur distillate fuels on vessels designed to operate primarily on residual fuel. Installation and use of a fuel cooler, associated piping, and viscosity meters to the fuel treatment system may be required to ensure viscosity matches between the fuel and injection system design. While there are many existing ships that already have the capacity to operate on both heavy fuel oil and distillate fuel and have separate fuel tank systems to support each type of fuel, some ships may not have sufficient onboard storage capacity. If a new or segregated tank is desired, additional equipment for fuel delivery and control of these systems may be required.

(5) NO_X and SO_X Emission Reduction Technology Costs

(a) NO_X Emission Reduction Technology

The costs associated with SCR include variable and fixed costs. SCR hardware costs include the reactor, dosage pump, urea injectors, piping, bypass valve, an acoustic horn or a cleaning probe, the control unit and wiring, and the urea tank (the size of the tank is based on 250 hours of normal operation when the ship is operating in the regulated U.S. waterways and the SCR system is activated.) The size of the tank is dependent on the frequency with which the individual ship owner prefers to fill the urea tank. The methodology used here to estimate the capacity of the SCR systems is based on the power rating of the propulsion engines only. Auxiliary engine power represents about 20 percent of total installed power on a vessel; however, it would be unusual to operate both propulsion and auxiliary engines at 100 percent load. Typically, ships operate under full propulsion power only while at sea when the SCR is not operating; when nearing ports, the auxiliary engine is operating at high loads while the propulsion engine is operating at very low loads.

In this analysis, we determined the average number of hours a ship would spend calling on a U.S. port: if the call was straight in and straight out at 200 nm, the average time spent was slightly over 35 hours. If the distance travelled was substantial, such as from the Port of Los Angeles to the Port of Tacoma, or 1140 nm, the average time spent travelling was approximately 75 hours. Therefore, the size of the tanks and corresponding $/kW values estimated here to carry enough urea for 250 hours of continuous operation may be an overestimate. Based on 250 hours of operation, a range of urea tank sizes from 20 m^3 to approximately 256 m^3 was determined for the six different engine configurations used in this analysis.

To understand what impacts this may have on the cargo hauling capacity of the ship, we looked at the ISO standard containers used today. Currently, over two-thirds of the containers in use today are 40 feet long, total slightly over 77 m^3 and are the equivalent of two TEU.[121] The urea tank sizes estimated here reflect a cargo equivalence of 0.5-2 TEUs, based on a capacity sufficient for 250 hours of operation. The TEU capacity of container ships, for example, continues to increase and can be as high as 13,000 TEUs.[122] Based on a rate of approximately $1,300 per TEU to ship a container from Asia to the U.S., a net profit margin of 10%, and an average of 16 trips per year, the estimated cost due to displaced cargo to call on a U.S./Canada ECA may be $2,100.[123,124,125] The cost analysis presented here does not include displaced cargo due to the variability of tank sizes owners choose to install.

To estimate the SCR hardware costs associated with newly built ships, we needed to generate an equation in terms of $/kW that could be applied to other engine sizes. Therefore, the $/kW values representing the hardware costs estimated for the six different engine types and sizes used in this analysis was developed using a curve fit for both SSD and MSD engines. The resulting $/kW values range from $40-$80 per kW for MSD, and $40-70 for SSD. These costs were then applied based on the characteristics of the average ship types described in the inventory section of the RIA (see Chapter 3) to the representative portion of the future fleet in order to estimate the total costs associated with this program. Table VII-3 presents the estimated costs of this technology as applied to different ship and engine types representing the average ship characteristics discussed in Section VII.A.2.

(b) Lower Sulfur Fuel Hardware Costs

This cost analysis is based on the use of switching to lower sulfur fuel to meet the fuel sulfur standards. The costs presented here may be incurred by some existing and some newly-built ships if additional fuel tank equipment is required to facilitate the use of lower sulfur fuel. Based on existing vessel fleet data, we estimate that approximately one-third of existing vessels may need additional equipment installed to accommodate additional lower sulfur fuel storage capacity beyond that installed on comparable new ships. In order to include any costs that may be incurred on new vessels that choose to add additional lower sulfur fuel capacity, we also estimated that one-third of new vessels may require additional hardware. Separate $/kW values were developed for new and existing vessels as the existing vessel retrofit would likely require more labor to complete installation.

The size of the tank is dependent on the frequency with which the individual ship owner prefers to fill the lower sulfur fuel tank. The size of the tanks and corresponding $/kW value estimated here will carry capacity sufficient for 250 hours of propulsion and auxiliary engine operation. This is most likely an overestimate of the amount of lower sulfur fuel a ship owner would need to carry, resulting in an overestimate of the total cost to existing and new vessels. The

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[121] www.iicl.org, Institute of International Container Lessors
[122] Kristensen, Hans Otto Holmegaard, "Preliminary Ship Design of Container Ships, Bulk Carriers, Tankers, and Ro-Ro Ships. Assessment of Environmental Impact from Sea-Borne Transport Compared with Landbased Transport," March, 2008.
[123] http://people.hofstra.edu/geotrans/eng/ch2en/conc2en/maritimefreightrates.html
[124] http://moneycentral.msn.com/investor/invsub/results/hilite.asp?Symbol=SSW
[125] Based on a container ship carrying nearly 9,000 TEUs traveling from Hong Kong to the Port of Los Angeles (approximately 6,400 nm) with a cruise speed of 25 nm/hr, the round trip time is nearly 21 days and this trip could be made roughly 16 times per year.

tank sizes based on 250 hours of operation and based on the six different engine configuration used in this analysis range from 240 m^3 to nearly 2,000 m^3. This would be the equivalent of 6-50 TEUs. This cost analysis does not reflect other design options such as partitioning of a residual fuel tank to allow for lower sulfur fuel capacity which would reduce the amount of additional space required, nor does this analysis reflect the possibility that some ships may have already been designed to carry smaller amounts of distillate fuel in separate tanks for purposes other than continuous propulsion. The $/kW value hardware cost values for the six data points corresponding to the six different engine types and sizes used in this analysis are $2-7 for SSD and $3-8 for MSD. A curve fit was determined for the slow-speed engine as well as for the medium speed engines to determine a $/kW value for each engine type. Table VII-3 presents the estimated costs of the technologies used to meet the different standards as applied to different ship and engine types representing the average ship characteristics discussed in Section VII.A.2. The estimated hardware costs of retrofitting existing U.S.-flagged vessels that may require additional hardware to accommodate the use of lower sulfur fuel is estimated to be $10.4 million in 2015.

Table VII-3 Estimated Variable Costs of Emission Control Technology on a per-Ship Basis – by Ship Type and Engine Type[126]

Ship Type	Engine Speed	Average Propulsion Power (kW)	MFI to Common Rail	EFI to Common Rail	Tier 3 (SCR and Engine Modifications)	Lower Sulfur Fuel Hardware - New Vessels	Lower Sulfur Fuel Hardware - Existing Vessels
Auto Carrier	MSD	9640	$80,500	$30,400	$566,000	$42,300	$56,400
Bulk Carrier	MSD	6360	$67,200	$24,600	$479,000	$36,900	$48,500
Container	MSD	13878	$92,300	$35,400	$678,000	$49,200	$66,600
General Cargo	MSD	5159	$60,400	$21,700	$448,000	$34,900	$45,600
Passenger	MSD	23762	$109,600	$42,800	$939,000	$65,400	$90,400
Reefer	MSD	7360	$71,900	$26,600	$506,000	$38,500	$50,900
RoRo	MSD	8561	$76,700	$28,700	$538,000	$40,500	$53,800
Tanker	MSD	6697	$68,800	$25,300	$488,000	$37,400	$49,300
Misc.	MSD	9405	$79,800	$30,000	$560,000	$41,900	$55,800
Auto Carrier	SSD	11298	$152,400	$55,500	$819,000	$48,000	$64,800
Bulk Carrier	SSD	8434	$132,900	$48,400	$669,000	$42,700	$57,700
Container	SSD	27454	$211,600	$77,200	$1,521,000	$63,900	$86,700
General Cargo	SSD	7718	$127,000	$46,200	$630,000	$41,100	$55,500
Passenger	SSD	23595	$201,500	$73,500	$1,374,000	$61,200	$83,000
Reefer	SSD	10449	$147,200	$53,600	$776,000	$46,500	$62,900
RoRo	SSD	15702	$174,300	$63,500	$1,034,000	$53,900	$72,900
Tanker	SSD	9755	$142,600	$51,900	$739,000	$45,300	$61,200
Misc.	SSD	4659	$93,300	$33,900	$50,000	$32,000	$43,100

[126] The values presented in Table VII-3 are provided only to show what the estimated costs would be for a range of vessel types given average characteristics (such as DWT, total main, and total auxiliary power) for both SSD and MSD engine types. Not all vessels will require all of these technologies; for example, it is estimated that only 30 percent of MSD will get common-rail fuel injection systems for Tier II.

(6) Total Costs Associated with the Coordinated Strategy

The total hardware costs associated with the coordinated strategy were estimated using the number of new ships by ship type and engine type entering the fleet each year. Table VII-4 presents the total hardware costs to U.S.-flagged vessels associated with the coordinated strategy. These costs consist of the variable and fixed hardware costs associated with the Annex VI existing engine program, Tier 2 and Tier 3 standards, and additional components that may be required to accommodate the use of lower sulfur fuel on both new and existing vessels. This table also presents the total estimated operational costs associated with the coordinated strategy. These costs consist of the 2 percent fuel consumption penalty associated with Tier 2 (Annex VI Tier II), the use of urea on vessels equipped with SCR systems, and the differential cost of using lower sulfur fuel; these costs are incurred by both U.S.- and foreign-flagged vessels. The total estimated cost of the coordinated strategy is $3.41 billion in 2030. The total costs from 2010 through 2040 are estimated to be $42.9 billion at a 3 percent discount rate or $22.1 at a 7 percent discount rate.

Table VII-4 Total Hardware and Operational Costs Associated with the Coordinated Strategy (Thousands of $)

Year	Total Hardware Costs for Existing Engines	Total New Engine Hardware Costs	Total Vessel Hardware Costs	TOTAL OPERATING COSTS		Total Costs Associated with the Coordinated Strategy
				U.S. Flag	Foreign Flag	
2010	$9,400	$319	$166	$0	$0	$485
2011	$161,000	$3,580	$173	$173	$1,130	$5,060
2012	$153,000	$3,700	$179	$841	$5,590	$10,300
2013	$145,000	$3,830	$186	$32,400	$213,000	$249,000
2014	$137,000	$3,960	$192	$34,400	$226,000	$265,000
2015	$131,000	$4,100	$11,100	$180,000	$1,190,000	$1,390,000
2016	$0	$27,300	$691	$189,000	$1,250,000	$1,470,000
2017	$0	$28,500	$717	$199,000	$1,330,000	$1,560,000
2018	$0	$29,600	$745	$210,000	$1,410,000	$1,650,000
2019	$0	$30,700	$773	$221,000	$1,500,000	$1,750,000
2020	$0	$31,900	$803	$233,000	$1,590,000	$1,860,000
2021	$0	$33,200	$834	$246,000	$1,680,000	$1,960,000
2022	$0	$34,600	$866	$258,000	$1,770,000	$2,060,000
2023	$0	$35,900	$899	$272,000	$1,880,000	$2,190,000
2024	$0	$37,400	$934	$286,000	$1,980,000	$2,300,000
2025	$0	$38,800	$970	$300,000	$2,090,000	$2,430,000
2026	$0	$40,400	$1,010	$315,000	$2,200,000	$2,560,000
2027	$0	$42,100	$1,050	$330,000	$2,310,000	$2,680,000
2028	$0	$43,700	$1,090	$345,000	$2,430,000	$2,820,000
2029	$0	$45,500	$1,130	$362,000	$2,550,000	$2,960,000
2030	$0	$47,400	$1,180	$378,000	$2,680,000	$3,110,000
2031	$0	$49,300	$1,220	$395,000	$2,810,000	$3,260,000
2032	$0	$51,300	$1,270	$413,000	$2,950,000	$3,420,000
2033	$0	$53,400	$1,320	$431,000	$3,080,000	$3,570,000
2034	$0	$55,500	$1,370	$451,000	$3,240,000	$3,750,000
2035	$0	$57,900	$1,430	$471,000	$3,390,000	$3,920,000
2036	$0	$60,200	$1,490	$494,000	$3,560,000	$4,120,000
2037	$0	$62,800	$1,540	$517,000	$3,740,000	$4,320,000

2038	$0	$65,300	$1,610	$541,000	$3,930,000	$4,540,000
2039	$0	$68,000	$1,670	$566,000	$4,110,000	$4,750,000
2040	$0	$70,800	$1,740	$591,000	$4,310,000	$4,970,000
NPV @ 3%	$677,000	$663,000	$26,500	$5,260,000	$36,900,000	$42,900,000
NPV @ 7%	$610,000	$346,000	$16,900	$2,730,000	$19,000,000	$22,100,000

C. Cost Effectiveness

One tool that can be used to assess the value of the coordinated strategy is the engineering costs incurred per ton of emissions reduced. This analysis involves a comparison of our program to other measures that have been or could be implemented. As summarized in this section, the coordinated strategy represents a highly cost effective mobile source control program for reducing NO_X, PM and SO_X emissions.

We have estimated the cost per ton based on the net present value of 3 percent and 7 percent of all hardware costs incurred by U.S.-flagged vessels, all operational costs incurred by both U.S. and foreign-flagged vessels, and all emission reductions generated from the year 2010 through the year 2040. The baseline case for these estimated reductions is the existing set of engine standards for C3 marine diesel engines and fuel sulfur limits. Table VII-5 shows the annual emissions reductions associated with the coordinated strategy; these annual tons are undiscounted. A description of the methodology used to estimate these annual reductions can be found in Section II of this preamble and Chapter 3 of the RIA.

Table VII-5 Estimated Emissions Reductions Associated with the Coordinated Strategy (Short tons)

Calendar Year	Reductions (tons)		
	NO_X	SO_X PM	
2010	47,000	0	0
2011	54,000	0	0
2012	70,000	0	0
2013	88,000	390,000	48,400
2014	105,000	406,000	50,400
2015	123,000	641,000	68,000
2016	150,000	668,000	70,800
2017	209,000	695,000	73,700
2018	279,000	724,000	76,800
2019	349,000	755,000	80,000
2020	409,000	877,000	94,100
2021	488,000	916,000	98,200
2022	547,000	954,000	102,000
2023	634,000	995,000	107,000
2024	714,000	1,040,000	111,000
2025	790,000	1,080,000	116,000
2026	866,000	1,130,000	121,000
2027	938,000	1,170,000	126,000
2028	1,020,000	1,220,000	131,000

2029	1,100,000	1,280,000	137,000
2030	1,180,000	1,330,000	143,000
2031	1,260,000	1,390,000	149,000
2032	1,330,000	1,450,000	155,000
2033	1,410,000	1,510,000	162,000
2034	1,500,000	1,580,000	169,000
2035	1,590,000	1,650,000	177,000
2036	1,690,000	1,720,000	184,000
2037	1,810,000	1,800,000	193,000
2038	1,920,000	1,880,000	201,000
2039	2,020,000	1,970,000	210,000
2040	2,130,000	2,050,000	220,000
NPV at 3%	14,400,000	19,100,000	2,100,000
NPV at 7%	6,920,000	10,100,000	1,090,000

The net estimated reductions by pollutant, using a net present value of 3 percent from 2010 through 2040 are 14.4 million tons of NO_X, 19.1 million tons of SO_X, and 2.1 million tons of PM (6.9 million, 10.1 million, and 1.1 million tons of NO_X, SO_X, and PM, respectively, at a net present value of 7 percent over the same period.)

Using the above cost and emission reduction estimates, we estimated the lifetime (2010 through 2040) cost per ton of pollutant reduced. For this analysis, all of the hardware costs associated with the Annex VI existing engine program and Tier 2 and Tier 3 NO_X standards as well as the operational costs associated with the global Tier II and Tier III standards were attributed to NO_X reductions. The costs associated with lower sulfur fuel operational costs as applied to all vessels visiting U.S. ports and the hardware costs associated with accommodating the use of lower sulfur fuel on U.S.-flagged vessels were associated with SO_X and PM reductions. In this analysis, half of the costs associated with the use of lower sulfur fuel were allocated to PM reductions and half to $SO_{X,}$ reductions, because the costs incurred to reduce SO_X emissions directly reduce emissions of PM as well. Using this allocation of costs and the emission reductions shown in Table VII-5 we can estimate the lifetime cost per ton reduced associated with each pollutant. These results are shown in Table VII-6. Using a net present value of 3 percent, the discounted lifetime cost per ton of pollutant reduced is $510 for NO_X, $930 for SO_X, and $7,950 for PM ($500, $920, and $7,850 per ton of NO_X, SO_X, and PM, respectively, at a net present value of 7 percent.) As shown in Table VII-6, these estimated discounted lifetime costs are similar to the annual long-term (2030) cost per ton of pollutant reduced.

Table VII-6 Coordinated Strategy Estimated Aggregate Discounted Lifetime Cost per Ton (2010-2040) and Long-Term Annual Cost per Ton (2030)[127]

Pollutant	2010 Thru 2040 Discounted Lifetime Cost Per Ton At 3%	2010 Thru 2040 Discounted Lifetime Cost Per Ton At 7%	Long-Term Cost Per Ton (for 2030)
NO_X	$510	$500	$520
SO_X	$930	$920	$940
PM	$7,950	$7,850	$8,760

Note: These costs are in 2006 U.S. dollars.

These results for the coordinated strategy compare favorably to other air emissions control programs. Table VII-7 compares the coordinated strategy to other air programs. This comparison shows that the coordinated strategy will provide a cost-effective strategy for generating substantial NO_X, SO_X, and PM reductions from Category 3 vessels. The results presented in Table VII-7 are lifetime costs per ton discounted at a net present value of 3 percent, with the exception of the stationary source program and locomotive/marine retrofits, for which annualized costs are presented. While results at a net present value of 7 percent are not presented, the results would be similar. Specifically, the coordinated strategy falls within the range of values for other recent programs.

Table VII-7 Estimated $/ton for the Coordinated Strategy Compared to Previous Mobile Source Programs for NO_X, SO_X, and PM_{10}

SOURCE CATEGORY[a,]	IMPLEMENTATION DATE	NO_X COST/TON	SO_X COST/TON	PM_{10} COST/TON
Category 3 Marine Compression Ignition Engine Coordinated Strategy FRM, 2009	2011	510	930	7,950
Nonroad Small Spark-Ignition Engines 73 FR 59034, October 8, 2008	2010	330-1,200[b,c]	-	-
Stationary Diesel (CI) Engines 71 FR 39154, July 11, 2006	2006	580 – 20,000	-	3,500 – 42,000
Locomotives and C1/C2 Marine (Both New and Retrofits) 73 FR 25097, May 6, 2008	2015	730 [b]	-	8,400 (New) 45,000 (Retrofit)
Heavy Duty Nonroad Diesel Engines 69 FR 38957, June 29, 2004	2015	1,100 [b]	780	13,000
Heavy Duty Onroad Diesel Engines 66 FR 5001, January 18, 2001	2010	2,200 [b]	5,800	14,000

Notes:
[a] Table presents aggregate program-wide cost/ton over 30 years, discounted at a 3 percent NPV, except for Stationary CI Engines and Locomotive/Marine retrofits, for which annualized costs of control for individual sources are presented. All figures are in 2006 U.S. dollars per short ton.

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[127] The $/ton numbers presented here vary from those presented in the ECA proposal due to the net present value of the annualized reductions being applied from 2015-2020, and the use of metric tonnes rather than of short tons.

[b] Includes NO_X plus non-methane hydrocarbons (NMHC). NMHC are also ozone precursors, thus some rules set combined NO_X+NMHC emissions standards. NMHC are a small fraction of NO_X so aggregate cost/ton comparisons are still reasonable.
[c] Low end of range represents costs for marine engines with credit for fuel savings, high end of range represents costs for other nonroad SI engines without credit for fuel savings.

D. Economic Impact Analysis

This section contains our analysis of the expected economic impacts of our coordinated strategy on the markets for Category 3 marine diesel engines, vessels using these engines, and the U.S. marine transportation service sector. We briefly describe our methodology and present our estimated expected economic impacts.

The total estimated social costs of the coordinated strategy in 2030 are equivalent to the estimated engineering compliance costs of the program, at approximately $3.1 billion.[128] As explained below, these costs are expected to accrue initially to the owners and operators of affected vessels when they purchase engines, vessels, and fuel. These owners and operators are expected to pass their increased costs on to the entities that purchase international marine transportation services, in the form of higher freight rates. Ultimately, these social costs are expected to be borne by the final consumers of goods transported by affected vessels in the form of slightly higher prices for those goods.

We estimate that compliance with the coordinated strategy would increase the price of a new vessel by 0.5 to 2 percent, depending on the vessel type. The price impact of the coordinated strategy on the marine transportation services sector would vary, depending on the route and the amount of time spent in waterways covered by the engine and fuel controls (the U.S. ECA and U.S. internal waters covered by the coordinated strategy). For example, we estimate that the cost of operating a ship in liner service between Singapore, Seattle, and Los Angeles/Long Beach, which includes about 1,700 nm of operation in waterways covered by the coordinated strategy, would increase by about 3 percent. For a container ship, this represents a price increase of about $18 per container (3 percent price increase), assuming the total increase in operating costs is passed on to the purchaser of the marine transportation services. The per passenger price of a seven-day Alaska cruise on a vessel operating entirely within waterways covered by the coordinated strategy is expected to increase by about $7 per day, again assuming that the total increase in operating costs is passed on to the passengers of the vessel. Ships that spend less time in covered areas would experience relatively smaller increases in their operating costs, and the impacts on their freight prices is expected to be smaller.

It should be noted that this economic analysis holds all other aspects of the market constant except for the elements of the coordinated strategy. It does not attempt to predict future market equilibrium conditions, particularly with respect to how excess capacity in today's market due to the

[128] The costs totals reported in this FRM are slightly different than those reported in the ECA proposal. This is because the ECA proposal did not include costs associated with the Annex VI existing engine program, Tier II, or the costs associated with existing vessel modifications that may be required to accommodate the use of lower sulfur fuel. Further, the cost totals presented in the ECA package included Canadian cost estimates.

current economic downturn will be absorbed. This approach is appropriate because the goal of an economic impact analysis is to explore the impacts of a specific program; allowing changes in other market conditions would confuse the impacts due to the regulatory program.

The remainder of this section provides information on the methodology we used to estimate these economic impacts and the results of our analysis. A more detailed discussion can be found in Chapter 7 of the RIA prepared for this rule.

(1) What is the Purpose of an Economic Impact Analysis?

In general, the purpose of an Economic Impact Analysis (EIA) is to provide information about the potential economic consequences of a regulatory action, such as the coordinated strategy to reduce emissions from Category 3 vessels. Such an analysis consists of estimating the social costs of a regulatory program and the distribution of these costs across stakeholders. The estimated social costs can then be compared with the estimated social benefits as presented elsewhere in this preamble.

In an economic impact analysis, social costs are the value of the goods and services lost by society resulting from (a) the use of resources to comply with and implement a regulation and (b) reductions in output. There are two parts to the analysis. In the market analysis, we estimate how prices and quantities of goods directly affected by the emission control program can be expected to change once the program goes into effect. In the economic welfare analysis, we look at the total social costs associated with the program and their distribution across key stakeholders.

(2) How Did We Estimate the Economic Impacts of the Coordinated Strategy?

Our analysis of the economic impacts of the coordinated strategy is based on the application of basic microeconomic theory. In this analysis, we use a competitive market model approach in which the interaction between supply and demand determines equilibrium market prices and quantities. The competitive model approach is appropriate for the vessel building and transportation service markets because in each of those markets there are many producers and consumers are not constrained to use one producer over the others.[129]

We also use a competitive market structure for the Category 3 engine market. This market is characterized by a small number of manufacturers (2 companies comprising about 60 percent of the market, with two others having a notable share), which suggests that this limited number of manufacturers may have certain market power. However, an important characteristic of the market suggests this market may nevertheless be competitive. Specifically while the primary engine companies design and patent Category 3 marine diesel engines, they manufacture only key components and not the actual engine itself. Engines are manufactured through licensing agreements with shipyards or other companies. Licensees pay a fixed cost to the primary engine manufacturers for using their designs and brands. Engine prices are then set by the licensees,

[129] Stopford describes these markets as competitive. See Stopford, Martin. Maritime Economics, 3rd Edition (Routledge, 2009), Chapter 4.

sometimes as part of the price of a completed vessel, and there is competition among these firms to manufacturer engines and vessels.

Nevertheless, to estimate the maximum economic impact of the program, we can examine how the results of this economic impact analysis would change if we assumed an imperfectly competitive market structure. In markets with a small number of producers, it is not uncommon for manufacturers to exercise market power to obtain prices above their costs, thereby securing greater profits. In this case, market prices would be expected to increase by more than the compliance costs of the regulatory program, although the magnitude of the increase would be limited by the existing dynamics of the market (i.e., the current difference between the actual market price and the competitive market price). This impact is discussed in more detail in Section VII.D.5, below. The higher price impact from imperfect competition would be transmitted to the vessel and marine transportation markets. However, even in this case, the price impacts of this rule on the Category 3 engine market are not expected to be large given the price increases estimated for the competitive case, described below. This is because the compliance costs for engine program are relatively small compared to the price of a vessel.

Finally, the existence of only a small number of firms in a market does not mean that the market necessarily behaves noncompetitively. In the Bertrand competition model, firms compete with each other by choosing a lower price.[130] When they compete repeatedly, the market price is expected to approximate the price that would occur in a perfectly competitive market. In this case, the two primarily engine producers compete against each other and against the smaller producers in the market. They also compete to sell the same or similar engines in the land-based electrical power generating market, where they face many more competitors.

In a competitive structure model, we use the relationships between supply and demand to simulate how markets can be expected to respond to increases in production costs that occur as a result of the new emission control program. We use the laws of supply and demand to construct a model to estimate the social costs of the program and identify how those costs will be shared across the markets and, thus, across stakeholders. The relevant concepts are summarized below and are presented in greater detail in Chapter 7 of the RIA.

Before the implementation of a control program, a competitive market is assumed to be in equilibrium, with producers producing the amount of a good that consumers desire to purchase at the market price. The implementation of a control program results in an increase in production costs by the amount of the compliance costs. This generates a "shock" to the initial equilibrium market conditions (a change in supply). Producers of affected products will try to pass some or all of the increased production costs on to the consumers of these goods through price increases, without changing the quantity produced. In response to the price increases, consumers will decrease the quantity they buy of the affected good (a change in the quantity demanded). This creates surplus production at the new price. Producers will react to the decrease in quantity demanded by reducing the quantity they produce, and they will be willing to sell the remaining production at a lower price that does not cover the full amount of the compliance costs. Consumers

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130 Tirole, Jean. The Theory of Industrial Organization (1989). MIT Press. See pages 223-224.

will then react to this new price. These interactions continue until the surplus production is removed and a new market equilibrium price and quantity combination is achieved.

The amount of the compliance costs that will be borne by stakeholders is ultimately limited by the price sensitivity of consumers and producers in the relevant markets, represented by the price elasticities of demand and supply for each market. An "inelastic" price elasticity (less than one) means that supply or demand is not very responsive to price changes (a one percent change in price leads to less than one percent change in quantity). An "elastic" price elasticity (more than one) means that supply or demand is sensitive to price changes (a one percent change in price leads to more than one percent change in quantity). A price elasticity of one is unit elastic, meaning there is a one-to-one correspondence between a percent change in price and percent change in quantity.

On the production side, price elasticity of supply depends on the time available to adjust production in response to a change in price, how easy it is to store goods, and the cost of increasing (or decreasing) output. In this analysis, we assume the supply for engines, vessels, and marine transportation services is elastic: an increase in the market price of an engine, vessel or freight rates will lead producers to want to produce more, while a decrease will lead them to produce less (this is the classic upward-sloping supply curve). It would be difficult to estimate the slope of the supply curve for each of these markets given the global nature of the sector and, as explained in Chapter 7 of the RIA it is not necessary to have estimated supply elasticities for this analysis due to the assumption of nearly perfectly inelastic demand for the marine transportation sector. However, we can make some observations about the supply elasticities based on the nature of each sector. For the marine transportation sector, it is reasonable to assume a supply elasticity equal to or greater than one because the amount of transportation services provided can easily be adjusted due to a change in price in most cases (e.g., move more or fewer containers or passengers) especially if the market can carry a certain amount of excess capacity. For the new Category 3 engine market the supply elasticity is also likely to be greater than one. These engines are often used in other land-based industries, notably in power plants, which provide a market to accommodate production fluctuations as manufacturers adjust their output for the marine market. The supply elasticity for the vessel construction market, on the other hand, is upward sloping but the slope (supply elasticity) may be less than or equal to one depending on the vessel type. This would be expected since it may be harder to adjust production and/or store output if the price drops, or rapidly increase production if the price increases. Because of the nature of this industry, it may not be possible to easily switch production to other goods, or to stop or start production of new vessels.

On the consumption side, we assume that the demand for engines is a function of the demand for vessels, which is a function of the demand for international shipping (demand for engines and vessels is derived from the demand for marine transportation services). This makes intuitive sense: Category 3 engine and vessel manufacturers would not be expected to build an engine or vessel unless there is a purchaser, and purchasers will want a new vessel/engine only if there is a need for one to supply marine transportation services. Deriving the price elasticity of demand for the vessel and engine markets from the international shipping market is an important feature of this analysis because it provides a link between the product markets.

In this analysis, the price elasticity of demand for marine transportation services, and therefore for vessels and Category 3 engines, is assumed to be nearly perfectly inelastic (the demand for marine transportation services will remain the same for all price changes). This stems from the fact that for most goods, there are no reasonable alternative shipping modes. In most cases, transportation by rail or truck is not feasible, and transportation by aircraft is too expensive. Approximately 90 percent of world trade by tonnage is moved by ship, and ships provide the most efficient method to transport these goods on a tonne-mile basis.[131] Stopford notes that "shippers need the cargo and, until they have time to make alternative arrangements, must ship it regardless of cost … The fact that freight generally accounts for only a small portion of material costs reinforces this argument."[132] A nearly perfectly inelastic price elasticity of demand for marine transportation services means that virtually all of the compliance costs can be expected to be passed on to the consumers of marine transportation services, with no change in output for engine producers, ship builders, or owners and operators of ships engaged in international trade. Section VII.D.5, below, provides a discussion of the impact of relaxing the of nearly perfectly demand elasticity for marine transportation services in general, and for the cruise industry specifically. Relaxing this assumption is not expected to change the estimated total social costs of the program, which are limited by the engineering compliance costs. However, it would change the way those costs are shared among stakeholders.

Finally, with regard to the fuel markets, the impacts of the coordinated strategy on fuel costs were assessed using the World Oil Refining Logistics and Demand (WORLD) model, as run by Ensys Energy & Systems, the owner and developer of the refinery model. As described in Chapter 5 of the RIA, the WORLD model is the only such model currently developed for this purpose, and was developed by a team of international petroleum consultants. It has been widely used by industries, government agencies, and OPEC over the past 13 years, including the Cross Government/Industry Scientific Group of Experts, established to evaluate the effects of the different fuel options proposed under the revision of MARPOL Annex VI. The model incorporates crude sources, global regions, refinery operations, and world economics, as well as assumptions about how these markets respond to regulatory programs. The results of the WORLD model have been shown to be comparable to other independent predictions of global fuel, air pollutant emissions and economic predictions.

WORLD is a comprehensive, bottom-up model of the global oil downstream that includes crude and noncrude supplies; refining operations and investments; crude, products, and intermediates trading and transport; and product blending/quality and demand. Its detailed simulations are capable of estimating how the global system can be expected to operate under a wide range of different circumstances, generating model outputs such as price effects and projections of refinery operations and investments.

This analysis of the economic impacts of the coordinated strategy relies on the estimated engineering compliance costs for engines and fuels described in Sections VII.A (fuels) and VII.B (engines) above. These costs include hardware costs for new U.S. vessels to comply with the Tier 2 and Tier 3 engine standards, and for existing U.S. vessels to comply with the MARPOL Annex VI requirements for existing engines. There are also hardware costs for fuel switching equipment on new and existing U.S. vessels to comply with the 1,000 ppm fuel sulfur limit; the cost analysis

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[131] Harrould-Koleib, Ellycia. Shipping Impacts on Climate: A Source with Solutions. Oceana, July 2008. A copy of this report can be found at http://www.oceana.org/fileadmin/oceana/uploads/Climate_Change/Oceana_Shipping_Report.pdf

[132] Stopford, Martin. *Maritime Economics, 3rd Edition*. Routledge, 2009. p. 163.

assumes that 32 percent of all vessels require fuel switching equipment to be added (new vessels) or retrofit (existing vessels). Also included are expected increases in operating costs for U.S. and foreign vessels operating in the inventory modeling domain (the waterways covered by the engine and fuel controls, i.e., the U.S. ECA and U.S. internal waters covered by the coordinated strategy.[133] These increased operating costs include changes in fuel consumption rates, increases in fuel costs, and the use of urea for engines equipped with SCR, as well as a small increase in operating costs for operation outside the waterways affected by the coordinated strategy due to the fuel price impacts of the program.

(3) What are the Estimated Market Impacts of the Coordinated Strategy?

(a) What are the Estimated Engine and Vessel Market Impacts of the Coordinated Strategy?

The estimated market impacts for engines and vessels are based on the variable costs associated with the engine and vessel compliance programs; fixed costs are not included in the market analysis. This is appropriate because in a competitive market the industry supply curve is generally based on the market's marginal cost curve; fixed costs do not influence production decisions at the margin. Therefore, the market analysis for a competitive market is based on variable costs only.

The assumption of nearly perfectly inelastic demand for marine transportation services means that the quantity of these services purchased is not expected to change as a result of costs of complying with the requirements of the coordinated strategy. As a result, the demand for vessels and engines would also not change compared to the no-control scenario, and the quantities produced would remain the same.

The assumption of nearly perfectly inelastic demand for marine transportation services also means the price impacts of the coordinated strategy on new engines and vessels would be equivalent to the variable engineering compliance costs. Estimated price impacts for a sample of engine-vessel combinations are set out in Table VII-8 for medium speed engines, and Table VII-9 for slow speed engines. These are the estimated price impacts associated with the Tier 3 engine standards on a vessel that will switch fuels to comply with the fuel sulfur requirements while operating in the waterways covered by the engine and fuel controls. Because there is no phase-in for the standards, the estimated price impacts are the same for all years, beginning in 2016.

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[133] The MARPOL amendments include Tier II and Tier III NO_X standards that apply to all vessels, including foreign vessels. While the analysis does not include hardware costs for the MARPOL Tier II and Tier III standards for foreign vessels because foreign vessels operate anywhere in the world, it is appropriate to include the operating costs for these foreign vessels while they are operating in our inventory modeling domain. This is because foreign vessels complying with the Tier II and Tier III standards will have a direct beneficial impact on U.S. air quality, and if we consider the benefits of these standards we should also consider their costs.

Table VII-8 Summary of Estimated Market Impacts – Medium Speed Tier 3 Engines and Vessels ($2006)[a]

SHIP TYPE	AVERAGE PROPULSION POWER	NEW VESSEL ENGINE PRICE IMPACT (NEW TIER 3 ENGINE PRICE IMPACT)[b]	NEW VESSEL FUEL SWITCHING EQUIPMENT PRICE IMPACT[c]	NEW VESSEL TOTAL PRICE IMPACT
Auto Carrier	9,600	$573,200	$42,300	$615,500
Bulk Carrier	6,400	$483,500	$36,900	$520,400
Container	13,900	$687,800	$49,200	$736,000
General Cargo	5,200	$450,300	$34,900	$475,200
Passenger	23,800	$952,500	$65,400	$1,107,900
Reefer	7,400	$511,000	$38,500	$549,500
RoRo	8,600	$543,800	$40,500	$584,300
Tanker	6,700	$492,800	$37,400	$530,200
Misc.	9,400	$566,800	$41,900	$608,700

Notes:
[a] The new vessel engine price impacts listed here do not include a per engine cost of $10,000 for engines installed on U.S. vessels to comply with the proposed production testing requirement (§1042.302)
[b] Medium speed engine price impacts are estimated from the cost information presented in Chapter 5 of the RIA using the following formula: (10%*($/SHIP_MECH→CR))+(30%*($/SHIP_ELEC→CR))+(T3 ENGINE MODS)+(T3SCR))
[c] Assumes 32 percent of new vessels would require the fuel switching equipment.

Table VII-9 Summary of Estimated Market Impacts – Slow Speed Tier 3 Engines and Vessels ($2006)[a]

SHIP TYPE	AVERAGE PROPULSION POWER	NEW VESSEL ENGINE PRICE IMPACT (NEW TIER 3 ENGINE PRICE IMPACT)[b]	NEW VESSEL FUEL SWITCHING EQUIPMENT PRICE IMPACT[c]	NEW VESSEL TOTAL PRICE IMPACT
Auto Carrier	11,300	$825,000	$48,000	$873,000
Bulk Carrier	8,400	$672,600	$42,700	$715,300
Container	27,500	$1,533,100	$63,900	$1,597,000
General Cargo	7,700	$632,900	$41,000	$673,900
Passenger	23,600	$1,385,300	$61,200	$1,446,500
Reefer	10,400	$781,000	$46,500	$827,500
RoRo	15,700	$1,042,100	$53,900	$1,096,000
Tanker	9,800	$744,200	$45,300	$789,500
Misc.	4,700	$453,600	$32,000	$485,600

Notes:
[a] The new vessel engine price impacts listed here do not include a per engine cost of $10,000 for engines installed on U.S. vessels to comply with the proposed production testing requirement (§1042.302)
[b] Slow speed engine price impacts are estimated from the cost information presented in Chapter 5 using the following formula: (5%*($/SHIP_MECH→CR))+(15%*($/SHIP_ELEC→CR))+(T3 ENGINE MODS)+(T3 SCR))
[c] Assumes 32 percent of new vessels would require the fuel switching equipment

The estimated price impacts for Tier 2 vessels would be substantially lower, given the technology that will be used to meet the Tier 2 standards is much less expensive. The cost of complying with the Tier 2 standards ranges from about $56,000 to $100,000 for a medium speed engine, and from about $130,000 to $250,000 for a slow speed engine (see discussion in Chapter 7 of the RIA). Again, because the standards do not phase in, the estimated price impacts are the same for all years the Tier 2 standards are required, 2011 through 2015.

These estimated price impacts for Tier 2 and Tier 3 vessels are small when compared to the price of a new vessel. A selection of new vessel prices is provided in Table VII-10; these range from about $40 million to $480 million. The program price increases range from about $600,000 to $1.5 million. A price increase of $600,000 to comply with the Tier 3 standards and fuel switching requirements would be an increase of approximately 2 percent for a $40 million vessel. The largest vessel price increase noted above for a Tier 3 passenger vessel is about $1.5 million; this is a price increase of less than 1 percent for a $478 million passenger vessel. Independent of the nearly-perfect inelasticity of demand, price increases of this magnitude would be expected to have little, if any, effect on the sales of new vessels, all other economic conditions held constant.

Table VII-10 Newbuild Vessel Price by Ship Type and Size, Selected Vessels (Millions, $2008)

Vessel Type	Vessel Size Category	Size Range (Mean) (DWT)	Newbuild
Bulk Carrier	Handy	10,095 – 39,990 (27,593)	$56.00
	Handymax	40,009 – 54,881 (47,616)	$79.00
	Panamax	55,000 – 78,932 (69,691)	$97.00
	Capesize	80,000 – 364,767 (157,804)	$175.00
Container	Feeder	1,000-13,966 (9,053)	$38.00
	Intermediate	14,003-36,937 (24,775)	$70.00
	Panamax	37,042-54,700 (45,104)	$130.00
	Post Panamax	55,238-84,900 (67,216)	$165.00
Gas carrier	Midsize	1,001-34,800 (7,048)	$79.70
	LGC	35,760-59,421 (50,796)	$37.50
	VLGC	62,510-122,079 (77,898)	$207.70
General cargo	Coastal Small	1,000-9,999 (3,789)	$33.00
	Coastal Large	10,000-24,912 (15,673)	$43.00
	Handy	25,082-37,865 (29,869)	$52.00
	Panamax	41,600-49,370 (44,511)	$58.00
Passenger	All	1,000–19,189 (6,010)	$478.40
Reefer	All	1,000–19,126 (6,561)	$17.30
Ro-Ro	All	1,000–19,126 (7,819)	$41.20
Tanker	Coastal	1,000-23,853 (7,118)	$20.80
	Handymax	25,000-39,999 (34,422)	$59.00
	Panamax	40,000-75,992 (52,300)	$63.00
	AFRAmax	76,000-117,153 (103,112)	$77.00
	Suezmax	121,109-167,294 (153,445)	$95.00
	VLCC	180,377-319,994 (294,475)	$154.00

Sources: Lloyd's Shipping Economist (2008), Informa (2008), Lloyd's Sea-Web (2008) *(b) What are the Estimated Fuel Market Impacts of the Coordinated Strategy?*

The market impacts for the fuel markets were estimated through the modeling performed to estimate the fuel compliance costs for the coordinated strategy. In the WORLD model, the total quantity of fuel used is held constant, which is consistent with the assumption that the demand for international shipping transportation would not be expected to change due to the lack of transportation alternatives.

The expected price impacts of the coordinated strategy are set out in Table VII-11. Note that on a mass basis, less distillate than residual fuel is needed to go the same distance (5 percent less). The prices in Table VII-11 are adjusted for this impact.

Table VII-11 shows that the coordinated strategy is expected to result in a small increase in the price of marine distillate fuel, about 1.3 percent. The price of residual fuel is expected to decrease slightly, by less than one percent, due to a reduction in demand for that fuel.

Table VII-11 Summary of Estimated Market Impacts - Fuel Markets

FUEL	UNITS	BASELINE PRICE	CONTROL PRICE	ADJUSTED FOR ENERGY DENSITY	% CHANGE
Distillate	$/tonne	$462	$468	N/A	+1.3%
Residual	$/tonne	$322	$321	N/A	-0.3%
Fuel Switching	$/tonne	$322	$468	$444	+38.9% [a]

Notes:
[a] Energy adjusted value

Because of the need to shift from residual fuel to distillate fuel for ships while operating in the waterways covered by the engine and fuel controls (the U.S. ECA and U.S. internal waters covered by the coordinated strategy), ship owners are expected to see an increase in their total cost of fuel. This increase is because distillate fuel is more expensive than residual fuel. Factoring in the higher energy content of distillate fuel relative to residual fuel, the fuel cost increase would be about 39 percent.

(c) What Are the Estimated Marine Transportation Market Impacts of the Coordinated Strategy?

We used the above information to estimate the impacts on the prices of marine transportation services. This analysis, which is presented in Chapter 7 of the RIA, is limited to the impacts of increases in operating costs due to the fuel and emission requirements of the coordinated strategy. Operating costs would increase due to the increase in the price of fuel, the need to switch to fuel with a sulfur content not to exceed 1,000 ppm while operating in the waterways covered by the engine and fuel controls, and due to the need to dose the aftertreatment system with urea to meet the Tier 3 standards. Table VII-12 summarizes these price impacts for selected transportation markets. Table VII-12 also lists the vessel and engine parameters that were used in the calculations.

Table VII-12 Summary of Impacts of Operational Fuel / Urea Cost Increases

VESSEL TYPE	VESSEL AND ENGINE PARAMETERS	OPERATIONAL PRICE INCREASES
Container North Pacific Circle Route	36,540 kW 50,814 DWT	$17.53/TEU
Bulk Carrier North Pacific Circle Route	3,825 kW 16,600 DWT	$0.56/tonne
Cruise Liner (Alaska)	31,500 kW 226,000 DWT 1,886 passengers	$6.60/per passenger per day

This information suggests that the increase in marine transportation service prices would be small, both absolutely and when compared to the price charged by the ship owner per unit transported and are estimated to be about $18 per TEU on the North Pacific Circle Route and $0.56 per tonne for bulk cargo on the North Pacific Circle Route. Stopford notes that the price of transporting a 20 foot container between the UK and Canada is estimated to be about $1,500; of that, $700 is the cost of the ocean freight; the rest is for port, terminal, and other charges.[134] Thus, a price increase of about $18 represents an increase of less than 3 percent of ocean freight cost, and about one percent of transportation cost. Similarly, the price of a 7-day Alaska cruise varies from $100 to $400 per night or more. In that case, a price increase of about $7 per night would be a 1.5 percent to about 6 percent increase.

(4) What Are the Estimated Social Costs of the Coordinated Strategy and How Are They Expected to Be Distributed Across Stakeholders?

The total social costs of the coordinated strategy are based on both fixed and variable costs. Fixed costs are a cost to society: they displace other product development activities that may improve the quality or performance of engines and vessels. In this economic impact analysis, fixed costs are accounted for in the year in which they occur, with the fixed costs associated with the Tier 2 engine standards accounted for in 2010 and the fixed costs associated with the Tier 3 engine standards and the fuel sulfur controls for vessels operating on the waterways covered by the coordinated strategy are accounted for in the five-year period beginning prior to their effective dates.

The estimated social costs of the coordinated strategy for all years are presented in Table VII-4. For 2030, the social costs are estimated to be about $3.1 billion.[135] For the reasons described above and explained more fully in the RIA, these costs are expected to be borne fully by consumers of marine transportation services.

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[134] Stopford, Martin, *Maritime Economics*, 3rd Edition. Routledge, 2009. Page 519.

[135] The costs totals reported in this FRM are slightly different than those reported in the ECA proposal. This is because the ECA proposal did not include costs associated with the Annex VI existing engine program, Tier II, or the costs associated with existing vessel modifications that may be required to accommodate the use of lower sulfur fuel. Further, the cost totals presented in the ECA package included Canadian cost estimates.

These social costs are small when compared to the total value of U.S. waterborne foreign trade. In 2007, waterborne trade for government and non-government shipments by vessel into and out of U.S. foreign trade zones, the 50 states, the District of Columbia, and Puerto Rico was about $1.4 trillion. Of that, about $1 trillion was for imports.[136]

If only U.S. vessels are considered, the social costs of the coordinated strategy in 2030 would be about $427.5 million. Again, these social costs are small when compared to the annual revenue for this sector. In 2002, the annual revenue for this sector was about $19.8 billion.[137]

(5) Sensitivity Analyses

In this section we briefly discuss the impact of relaxing several of the assumption used in our economic impact analysis for the coordinated strategy, including the assumption of nearly perfectly inelastic demand for marine transportation services, nearly perfectly inelastic demand for cruise services, and a competitive market structure for the Category 3 marine diesel engine market. Each of these cases in examined more fully in Chapter 7 of the RIA for this rule.

To examine the impact of the assumption of nearly perfectly inelastic demand elasticity for marine transportation services, we would determine a discrete value for that elasticity and then create a computer model to model the effects of the coordinated strategy. It would be difficult to develop such an elasticity using available industry information. Therefore, this alternative analysis relies on the price elasticities we developed for our 2008 rulemaking that set technology-forcing standards for Category 1 and Category 2 engines (73 FR 25098, May 6, 2008). Although these price elasticities of demand and supply were developed using data for United States markets only, they reflect behavioral reactions to price changes if alternative modes of transportation were available. While they are not specific to the global marine transportation market, they are useful to provide an idea of the change in results that could be expected if the demand elasticity for marine transportation is not nearly perfectly inelastic.

The values used for the behavioral parameters for the Category 1 and 2 markets are provided in Table VII-13. In this case, the demand for marine transportation services is estimated to be somewhat inelastic: a one percent increase in price will result in a 0.5 percent decrease in demand.

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[136] Census Bureau's Foreign Trade Division, *U.S. Waterborne Foreign Trade by U.S. Custom Districts*, as reported by the Maritime Administration at http://www.marad.dot.gov/library_landing_page/data_and_statistics/Data_and_Statistics.htm, accessed April 9, 2009.
[137] U.S. Census Bureau, Industry Statistics Sampler, NAICS 48311, Deep sea, coastal, and Great Lakes transportation, at http://www.census.gov/econ/census02/data/industry/E48311.HTM, assessed on April 9, 2009.

Table VII-13 Behavioral Parameters Used in Locomotive/Marine Economic Impact Model

Sector	Market	Demand Elasticity	Source	Supply Elasticity	Source
Marine	Marine Transportation Services	-0.5 (inelastic)	Literature Estimate	0.6 (inelastic)	Literature Estimate
	Commercial Vessels[a]	Derived	N/A	2.3 (elastic)	Econometric Estimate
	Engines	Derived	N/A	3.8 (elastic)	Econometric Estimate

Notes:
[a] Commercial vessels include tug/tow/pushboats, ferries, cargo vessels, crew/supply boats, and other commercial vessels.

In general, relaxing the condition of nearly perfectly inelastic demand elasticity would result in the compliance costs of the coordinated strategy being shared by consumers and suppliers. The distribution of compliance costs from our earlier rule are presented in Table VII-14 While the emission control requirements and the compliance cost structure of the coordinated strategy are somewhat different, these results give an idea of how costs would be shared if the assumption of nearly perfectly inelastic price elasticity of demand for the transportation services market in the ocean-going marine sector were relaxed.

Table VII-14 Distribution of Social Costs among Stakeholder Groups – Category 1 and Category 2 Engine Program

Stakeholder Group	2020	2030
Marine engine producers	0.8%	0.5%
Marine vessel producers	10.7%	3.8%
Recreational and fishing vessel consumers	8.4%	4.1%
Marine transportation service providers	36.4%	41.5%
Marine transportation service consumers	43.8%	50.0%
Total	100.0%	100.0%

With regard to cruise transportation, commenters remarked that demand is not nearly perfectly inelastic. Cruises are a recreational good, and if the price of a cruise increases, consumers will choose to spend their recreational budgets on other activities.

The same analysis described above would also apply in this particular sector of the marine transportation market. In this case, the share of the compliance costs that will be borne by the cruise industry suppliers will depend on the magnitude of the demand elasticity. If the price elasticity of demand is larger (in absolute value) than the price elasticity of supply, ship owners will bear a larger share of the costs of the program; if the price elasticity of demand is smaller (in absolute value) than the price elasticity of supply, consumers will bear a larger share of the program.

In our 2002 recreational vehicle rule, we estimated the demand elasticity for inboard cruisers to be about -1.4 and the supply elasticity to be about 1.6.[138] Using these values as a proxy for cruise ship demand and supply, this suggests that the compliance costs will be share among passengers and operators roughly evenly.

As described in Section 7.3 of the RIA, the compliance costs associated with the coordinated strategy are expected to be small compared to the daily costs of a cruise, at about $7 per night. Overall, total engine and vessel costs are expected to increase about one percent and operating costs increasing between 1.5 and 6 percent. These increases are within the range of historic variations in bunker fuel prices. So, although relaxing the assumption of nearly perfectly elastic demand elasticity for cruises means the burden of the coordinated strategy would be shared between cruise ship operators and cruise ship passengers, those costs, and therefore the expected price increases, are expected to be small compared to the price of a cruise.

Finally, this Economic Impact Analysis assumes that the market structure for the Category 3 marine diesel engine market is competitive. As explained above, this assumption is reasonable even though there are few producers in this market. If, in fact, this market is noncompetitive and behaves more like an oligopoly, then the results of the analysis would be somewhat different. Specifically, oligopolistic producers can set the market price at a level higher than the competitive market price, capturing larger profits than would otherwise be the case. However, this price premium would already be reflected in the prices of Category 3 marine diesel engines. What would change in the analysis is the magnitude of the compliance costs passed on to consumers of these engines (vessel builders and the transportation services market), which would be higher than the compliance costs. This effect is discussed in Chapter 7 of the RIA.

VIII. Benefits

This section presents our analysis of the health and environmental benefits that will occur as a result of EPA's coordinated strategy to address emissions from Category 3 engines and ocean-going vessels throughout the period from initial implementation through 2030. We provide estimated benefits for the entire coordinated strategy, including the Annex VI Tier 2 NO_X requirements and the ECA controls that will be mandatory for U.S. and foreign vessels through the Act to Prevent Pollution from Ships. However, unlike the cost analysis, this benefits analysis does not allocate benefits between the components of the program (the requirements in this rule and the requirements that would apply through MARPOL Annex VI and ECA implementation). This is because the benefits of the coordinated strategy will be fully realized only when the U.S. ECA is in place and both U.S. and foreign vessel are required to use lower sulfur fuel and operate their Tier 3 NO_X controls while in the designated area, and therefore it makes more sense to consider the benefits of the coordinated strategy as a whole.

[138] EPA420-02-022, Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines, Chapter 9. A copy of this document is available at http://www.epa.gov/otaq/regs/nonroad/2002/r02022j.pdf

The components of the coordinated strategy will apply stringent NO_X and SO_X standards to virtually all vessels that affect U.S. air quality, and impacts on human health and welfare will be substantial. As presented in Section II, the coordinated strategy is expected to provide very large reductions in direct PM, NO_X, SO_X, and toxic compounds, both in the near term and in the long term. Emissions of NO_X (a precursor to ozone formation and secondarily-formed $PM_{2.5}$), SO_X (a precursor to secondarily-formed $PM_{2.5}$) and directly-emitted $PM_{2.5}$ contribute to ambient concentrations of $PM_{2.5}$ and ozone. Exposure to ozone and $PM_{2.5}$ is linked to adverse human health impacts such as premature deaths as well as other important public health and environmental effects.

Using the most conservative premature mortality estimates (Pope et al., 2002 for $PM_{2.5}$ and Bell et al., 2004 for ozone),[139,140] we estimate that implementation of the coordinated strategy will reduce approximately 12,000 premature mortalities in 2030 and yield approximately \$110 billion in total benefits. The upper end of the premature mortality estimates (Laden et al., 2006 for $PM_{2.5}$ and Levy et al., 2005 for ozone)[141,142] increases avoided premature mortalities to approximately 31,000 in 2030 and yields approximately \$270 billion in total benefits. Thus, even taking the most conservative premature mortality assumptions, the health impacts of the coordinated strategy presented in this rule are clearly substantial.

A. Overview

We base our analysis on peer-reviewed studies of air quality and human health effects (see U.S. EPA, 2006 and U.S. EPA, 2008).[143,144] These methods are described in more detail in the RIA that accompanies this action. To model the ozone and PM air quality impacts of the CAA standards and requirements and the ECA designation, we used the Community Multiscale Air Quality (CMAQ) model (see Section II). The modeled ambient air quality data serves as an input to the Environmental Benefits Mapping and Analysis Program (BenMAP).[145] BenMAP is a computer program developed by the U.S. EPA that integrates a number of the modeling elements used in previous analyses (e.g., interpolation functions, population projections, health impact functions,

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[139] Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. (2002). Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. *Journal of the American Medical Association,* 287, 1132-1141.
[140] Bell, M.L., et al. (2004). Ozone and short-term mortality in 95 U.S. urban communities, 1987-2000.*Journal of the American Medical Association*, *292(19)*, 2372-2378.
[141] Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. (2006). Reduction in Fine Particulate Air Pollution and Mortality. *American Journal of Respiratory and Critical Care Medicine*. *173*, 667-672.
[142] Levy, J.I., S.M. Chemerynski, and J.A. Sarnat. (2005). Ozone exposure and mortality: an empiric bayes metaregression analysis. *Epidemiology. 16(4)*, 458-68.
[143] U.S. Environmental Protection Agency. (2006). *Final Regulatory Impact Analysis (RIA) for the Proposed National Ambient Air Quality Standards for Particulate Matter*. Prepared by: Office of Air and Radiation. Retrieved March, 26, 2009 at http://www.epa.gov/ttn/ecas/ria.html
[144] U.S. Environmental Protection Agency. (2008). *Final Ozone NAAQS Regulatory Impact Analysis*. Prepared by: Office of Air and Radiation, Office of Air Quality Planning and Standards. Retrieved March, 26, 2009 at http://www.epa.gov/ttn/ecas/ria.html
[145] Information on BenMAP, including downloads of the software, can be found at http://www.epa.gov/ttn/ecas/ benmodels.html.

valuation functions, analysis and pooling methods) to translate modeled air concentration estimates into health effects incidence estimates and monetized benefits estimates.

The range of total ozone- and PM-related benefits associated with the coordinated strategy to control ship emissions is presented in Table VIII-1. We present total benefits based on the PM- and ozone-related premature mortality function used. The benefits ranges therefore reflect the addition of each estimate of ozone-related premature mortality (each with its own row in Table VIII-1) to estimates of PM-related premature mortality. These estimates represent EPA's preferred approach to characterizing the best estimate of benefits associated with the coordinated strategy. As is the nature of Regulatory Impact Analyses (RIAs), the assumptions and methods used to estimate air quality benefits evolve to reflect the Agency's most current interpretation of the scientific and economic literature. This analysis, therefore, incorporates a number important changes from recent RIAs released by the Office of Transportation and Air Quality (OTAQ):

- The 2030 air quality modeling of the final coordinated strategy reflects air quality impacts associated with an ECA boundary distance of 200 nm with global controls (set through IMO) beyond the ECA boundary. For the proposal, however, the air quality modeling reflected impacts associated with an ECA boundary distance of 100 nm with global controls beyond. To estimate the 2030 benefits associated with a 200 nm ECA boundary in the proposal, we transferred the relationship between modeled impacts between 100 nm and 200 nm ECA boundaries observed in 2020. For each health endpoint and associated valuation, we calculated a ratio based on the national-level estimate for the 200 nm and 100 nm scenario and applied that to the related 2030 100 nm estimate. For the final RIA, we estimated benefits based on the actual 2030 200 nm air quality modeling results. The net effect of this change results in a small decrease in 2030 benefits compared to the proposal.

- For a period of time (2004-2008), the Office of Air and Radiation (OAR) valued mortality risk reductions using a value of statistical life (VSL) estimate derived from a limited analysis of some of the available studies. OAR arrived at a VSL using a range of $1 million to $10 million (2000$) consistent with two meta-analyses of the wage-risk literature. The $1 million value represented the lower end of the interquartile range from the Mrozek and Taylor (2002)[146] meta-analysis of 33 studies and $10 million represented the upper end of the interquartile range from the Viscusi and Aldy (2003)[147] meta-analysis of 46 studies. The mean estimate of $5.5 million (2000$)[148] was also consistent with the mean VSL of $5.4 million estimated in the Kochi et al. (2006)[149] meta-analysis. However, the Agency neither changed its official guidance on the use of VSL in rule-makings nor subjected the interim estimate to a scientific peer-review process through the Science Advisory Board (SAB) or other peer-review group.

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[146] Mrozek, J.R., and L.O. Taylor. (2002). What Determines the Value of Life? A Meta-Analysis. *Journal of Policy Analysis and Management* 21(2):253-270.
[147] Viscusi, V.K., and J.E. Aldy. (2003). The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty* 27(1):5-76.
[148] In this analysis, we adjust the VSL to account for a different currency year (2006$) and to account for income growth to 2020 and 2030. After applying these adjustments to the $5.5 million value, the VSL is $7.7m in 2020 and $7.9 in 2030.
[149] Kochi, I., B. Hubbell, and R. Kramer. 2006. An Empirical Bayes Approach to Combining Estimates of the Value of Statistical Life for Environmental Policy Analysis. Environmental and Resource Economics. 34: 385-406.

During this time, the Agency continued work to update its guidance on valuing mortality risk reductions, including commissioning a report from meta-analytic experts to evaluate methodological questions raised by EPA and the SAB on combining estimates from the various data sources. In addition, the Agency consulted several times with the Science Advisory Board Environmental Economics Advisory Committee (SAB-EEAC) on the issue. With input from the meta-analytic experts, the SAB-EEAC advised the Agency to update its guidance using specific, appropriate meta-analytic techniques to combine estimates from unique data sources and different studies, including those using different methodologies (i.e., wage-risk and stated preference) (U.S. EPA-SAB, 2007).[150]

Until updated guidance is available, the Agency determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received. Therefore, the Agency has decided to apply the VSL that was vetted and endorsed by the SAB in the Guidelines for Preparing Economic Analyses (U.S. EPA, 2000) while the Agency continues its efforts to update its guidance on this issue.[151] This approach calculates a mean value across VSL estimates derived from 26 labor market and contingent valuation studies published between 1974 and 1991. The mean VSL across these studies is $6.3 million (2000$).[152]

The Agency is committed to using scientifically sound, appropriately reviewed evidence in valuing mortality risk reductions and has made significant progress in responding to the SAB-EEAC's specific recommendations. The Agency anticipates presenting results from this effort to the SAB-EEAC in Winter 2009/2010 and that draft guidance will be available shortly thereafter.

- In recent analyses, OTAQ has estimated $PM_{2.5}$-related benefits assuming that a threshold exists in the PM-related concentration-response functions (at 10 $\mu g/m^3$) below which there are no associations between exposure to $PM_{2.5}$ and health impacts. EPA strives to use the best available science to support our benefits analyses, and we recognize that interpretation of the science regarding air pollution and health is dynamic and evolving. Based on our review of the body of scientific literature, EPA applied the no-threshold model in this analysis. EPA's draft Integrated Science Assessment,[153,154] which was recently reviewed by EPA's Clean Air

[150] U.S. Environmental Protection Agency (U.S. EPA). 2007. SAB Advisory on EPA's Issues in Valuing Mortality Risk Reduction. http://yosemite.epa.gov/sab/sabproduct.nsf/4128007E7876B8F0852573760058A978/$File/sab-08-001.pdf

[151] In the (draft) update of the Economic Guidelines, EPA retained the VSL endorsed by the SAB with the understanding that further updates to the mortality risk valuation guidance would be forthcoming in the near future. Therefore, this report does not represent final agency policy. The 2000 guidelines can be downloaded here: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html, and the draft updated version (2008) of the guidelines can be downloaded here: http://yosemite.epa.gov/ee/epa/eerm.nsf/vwRepNumLookup/EE-0516?OpenDocument

[152] In this analysis, we adjust the VSL to account for a different currency year (2006$) and to account for income growth to 2020 and 2030. After applying these adjustments to the $6.3 million value, the VSL is $8.9m in 2020 and $9.1m in 2030.

[153] U.S. Environmental Protection Agency (U.S. EPA). Integrated Science Assessment for Particulate Matter (External Review Draft). National Center for Environmental Assessment, Research Triangle Park, NC. EPA/600/R-08/139. December. Available on the Internet at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=201805>.

Scientific Advisory Committee,[155,156] concluded that the scientific literature consistently finds that a no-threshold log-linear model most adequately portrays the PM-mortality concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function.[157] Although this document does not represent final agency policy that has undergone the full agency scientific review process, it provides a basis for reconsidering the application of thresholds in $PM_{2.5}$ concentration-response functions used in EPA's RIAs.[158] It is important to note that while CASAC provides advice regarding the science associated with setting the National Ambient Air Quality Standards, typically other scientific advisory bodies provide specific advice regarding benefits analysis.[159] Please see Section 6.4.1.3 of the RIA that accompanies this preamble for more discussion of the treatment of thresholds in this analysis.

- For the coordinated strategy, we rely on two empirical (epidemiological) studies of the relationship between ambient $PM_{2.5}$ and premature mortality (the extended analyses of the Harvard Six Cities study by Laden et al (2006) and the American Cancer Society (ACS) cohort by Pope et al (2002)) to anchor our benefits analysis, though we also present the $PM_{2.5}$-related premature mortality benefits associated with the estimates supplied by the expert elicitation as a sensitivity analysis. This approach was recently adopted in the proposed Portland Cement MACT RIA. Since 2006, EPA has calculated benefits based on these two empirical studies and derived the range of benefits, including the minimum and maximum results, from an expert elicitation of the relationship between exposure to $PM_{2.5}$ and premature mortality (Roman et al.,

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154 U.S. Environmental Protection Agency (U.S. EPA). Integrated Science Assessment for Particulate Matter (Second External Review Draft). National Center for Environmental Assessment, Research Triangle Park, NC. EPA/600/R-08/139B. July. Available on the Internet at <http://cfint.rtpnc.epa.gov/ncea/prod/recordisplay.cfm?deid=210586>.

155 U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). Review of EPA's Integrated Science Assessment for Particulate Matter (First External Review Draft, December 2008). EPA-COUNCIL-09-008. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/73ACCA834AB44A10852575BD0064346B/$File/EPA-CASAC-09-008-unsigned.pdf>.

156 U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). Consultation on EPA's Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment. EPA-COUNCIL-09-009. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/723FE644C5D758DF852575BD00763A32/$File/EPA-CASAC-09-009-unsigned.pdf>.

157 It is important to note that uncertainty regarding the shape of the concentration-response function is conceptually distinct from an assumed threshold. An assumed threshold (below which there are no health effects) is a discontinuity, which is a specific example of non-linearity.

158 The final PM ISA, which will have undergone the full agency scientific review process, is scheduled to be completed in late December 2009.

159 In the proposed Portland Cement RIA, EPA solicited comment on the use of the no-threshold model for benefits analysis within the preamble of that proposed rule. The comment period for the Portland Cement proposed NESHAP closed on September 4, 2009 (Docket ID No. EPA–HQ–OAR–2002–0051 available at http://www.regulations.gov). EPA is currently reviewing those comments. U.S. Environmental Protection Agency. (2009). Regulatory Impact Analysis: National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry. Office of Air and Radiation. Retrieved on May 4, 2009, from http://www.epa.gov/ttn/ecas/regdata/RIAs/portlandcementria_4-20-09.pdf

2008).[160] Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates have fallen between the two epidemiology-based estimates (Roman et al., 2008). Assuming no threshold in the empirically-derived premature mortality concentration response functions used in the analysis of the coordinated strategy, only one expert falls below the empirically-derived range while two of the experts are above this range (see Tables 6-5 and 6-6 in the RIA that accompanies this preamble). Please refer to the proposed Portland Cement MACT RIA for more information about the preferred approach and the evolution of the treatment of threshold assumptions within EPA's regulatory analyses.

- The range of ozone benefits associated with the coordinated strategy is estimated based on risk reductions derived from several sources of ozone-related mortality effect estimates. This analysis presents six alternative estimates for the association based upon different functions reported in the scientific literature. We use three multi-city studies,[161,162,163] including the Bell, 2004 National Morbidity, Mortality, and Air Pollution Study (NMMAPS) that was used as the primary basis for the risk analysis in the ozone Staff Paper[164] and reviewed by the Clean Air Science Advisory Committee (CASAC).[165] We also use three studies that synthesize ozone mortality data across a large number of individual studies.[166,167,168] This approach is consistent with recommendations provided by the NRC in their ozone mortality report (NRC, 2008),[169] "The committee recommends that the greatest emphasis be placed on estimates from new systematic multicity analyses that use national databases of air pollution and mortality, such as in the NMMAPS, without excluding consideration of meta-analyses of previously published studies." The NRC goes on to note that there are uncertainties within each study that are not fully captured by this range of estimates.

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[160] Roman, Henry A., Walker, Katherine D., Walsh, Tyra L., Conner, Lisa, Richmond, Harvey M., Hubbell, Bryan J., and Kinney, Patrick L.. (2008). Expert Judgment Assessment of the Mortality Impact of Changes in Ambient Fine Particulate Matter in the U.S. Environ. Sci. Technol., 42, 7, 2268 – 2274.

[161] Bell, M.L., et al. (2004). Ozone and short-term mortality in 95 U.S. urban communities, 1987-2000. Jama, 2004. 292(19): p. 2372-8.

[162] Huang, Y.; Dominici, F.; Bell, M. L. (2005) Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics 16: 547-562.

[163] Schwartz, J. (2005) How sensitive is the association between ozone and daily deaths to control for temperature? Am. J. Respir. Crit. Care Med. 171: 627-631.

[164] 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. Retrieved on April 10, 2009, from http:www.epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_sp.html

[165] CASAC (2007). Clean Air Scientific Advisory Committee's (CASAC) Review of the Agency's Final Ozone Staff Paper. EPA-CASAC-07-002. March 26.

[166] Bell, M.L., F. Dominici, and J.M. Samet. (2005). A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. *Epidemiology*, 16(4): p. 436-45.

[167] Ito, K., S.F. De Leon, and M. Lippmann. (2005). Associations between ozone and daily mortality: analysis and meta-analysis. *Epidemiology*. 16(4): p. 446-57.

[168] Levy, J.I., S.M. Chemerynski, and J.A. Sarnat. (2005). Ozone exposure and mortality: an empiric bayes metaregression analysis. *Epidemiology*. 16(4): p. 458-68.

[169] National Research Council (NRC), 2008. Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution. The National Academies Press: Washington, D.C.

Table VIII-1 Estimated 2030 Monetized PM-and Ozone-Related Health Benefits of a Coordinated U.S. Strategy to Control Ship Emissions[a]

2030 Total Ozone and PM Benefits – PM Mortality Derived from American Cancer Society Analysis and Six-Cities Analysis[a]			
Premature Ozone Mortality Function	Reference	Total Benefits (Billions, 2006$, 3% Discount Rate)[c,d]	Total Benefits (Billions, 2006$, 7% Discount Rate)[c,d]
Multi-city analyses	Bell et al., 2004	\$110 - \$260	\$99 - \$240
	Huang et al., 2005	\$110 - \$260	\$100 - \$240
	Schwartz, 2005	\$110 - \$260	\$100 - \$240
Meta-analyses	Bell et al., 2005	\$110 - \$260	\$100 - \$240
	Ito et al., 2005	\$110 - \$270	\$110 - \$240
	Levy et al., 2005	\$110 - \$270	\$110 - \$240

Notes:
[a] Total includes premature mortality-related and morbidity-related ozone and $PM_{2.5}$ benefits. Range was developed by adding the estimate from the ozone premature mortality function to the estimate of $PM_{2.5}$-related premature mortality derived from either the ACS study (Pope et al., 2002) or the Six-Cities study (Laden et al., 2006).
[b] Note that total benefits presented here do not include a number of unquantified benefits categories. A detailed listing of unquantified health and welfare effects is provided in Table VIII-2.
[c] Results reflect the use of both a 3 and 7 percent discount rate, as recommended by EPA's Guidelines for Preparing Economic Analyses and OMB Circular A-4. Results are rounded to two significant digits for ease of presentation and computation.

The benefits in Table VIII-1 include all of the human health impacts we are able to quantify and monetize at this time. However, the full complement of human health and welfare effects associated with PM and ozone remain unquantified because of current limitations in methods or available data. We have not quantified a number of known or suspected health effects linked with ozone and PM for which appropriate health impact functions are not available or which do not provide easily interpretable outcomes (i.e., changes in heart rate variability). Additionally, we are unable to quantify a number of known welfare effects, including reduced acid and particulate deposition damage to cultural monuments and other materials, and environmental benefits due to reductions of impacts of eutrophication in coastal areas. These are listed in Table VIII-2. As a result, the health benefits quantified in this section are likely underestimates of the total benefits attributable to the implementation of the coordinated strategy to control ship emissions.

Table VIII-2 Unquantified and Non-Monetized Potential Effects of a Coordinated U.S. Strategy to Control Ship Emissions

Pollutant/Effects	Effects Not Included in Analysis - Changes in:
Ozone Health[a]	Chronic respiratory damage[b] Premature aging of the lungs[b] Non-asthma respiratory emergency room visits Exposure to UVb (+/-)[e]

Ozone Welfare	Yields for -commercial forests -some fruits and vegetables -non-commercial crops Damage to urban ornamental plants Impacts on recreational demand from damaged forest aesthetics Ecosystem functions Exposure to UVb (+/-)[e]
PM Health[c]	Premature mortality - short term exposures[d] Low birth weight Pulmonary function Chronic respiratory diseases other than chronic bronchitis Non-asthma respiratory emergency room visits Exposure to UVb (+/-)[e]
PM Welfare	Residential and recreational visibility in non-Class I areas Soiling and materials damage Damage to ecosystem functions Exposure to UVb (+/-)[e]
Nitrogen and Sulfate Deposition Welfare	Commercial forests due to acidic sulfate and nitrate deposition Commercial freshwater fishing due to acidic deposition Recreation in terrestrial ecosystems due to acidic deposition Existence values for currently healthy ecosystems Commercial fishing, agriculture, and forests due to nitrogen deposition Recreation in estuarine ecosystems due to nitrogen deposition Ecosystem functions Passive fertilization
CO Health	Behavioral effects
HC/Toxics Health[f]	Cancer (benzene, 1,3-butadiene, formaldehyde, acetaldehyde) Anemia (benzene) Disruption of production of blood components (benzene) Reduction in the number of blood platelets (benzene) Excessive bone marrow formation (benzene) Depression of lymphocyte counts (benzene) Reproductive and developmental effects (1,3-butadiene) Irritation of eyes and mucus membranes (formaldehyde) Respiratory irritation (formaldehyde) Asthma attacks in asthmatics (formaldehyde) Asthma-like symptoms in non-asthmatics (formaldehyde) Irritation of the eyes, skin, and respiratory tract (acetaldehyde) Upper respiratory tract irritation and congestion (acrolein)
HC/Toxics Welfare	Direct toxic effects to animals Bioaccumulation in the food chain Damage to ecosystem function Odor

Notes:

[a] The public health impact of biological responses such as increased airway responsiveness to stimuli, inflammation in the lung, acute inflammation and respiratory cell damage, and increased susceptibility to respiratory infection are likely partially represented by our quantified endpoints.
[b] The public health impact of effects such as chronic respiratory damage and premature aging of the lungs may be partially represented by quantified endpoints such as hospital admissions or premature mortality, but a number of other related health impacts, such as doctor visits and decreased athletic performance, remain unquantified.
[c] In addition to primary economic endpoints, there are a number of biological responses that have been associated with PM health effects including morphological changes and altered host defense mechanisms. The public health impact of these biological responses may be partly represented by our quantified endpoints.
[d] While some of the effects of short-term exposures are likely to be captured in the estimates, there may be premature mortality due to short-term exposure to PM not captured in the cohort studies used in this analysis. However, the PM mortality results derived from the expert elicitation do take into account premature mortality effects of short term exposures.
[e] May result in benefits or disbenefits.
[f] Many of the key hydrocarbons related to this rule are also hazardous air pollutants listed in the CAA.

B. Quantified Human Health Impacts

Tables VIII-3 and VIII-4 present the annual $PM_{2.5}$ and ozone health impacts in the 48 contiguous U.S. states associated with the coordinated strategy for both 2020 and 2030. For each endpoint presented in Tables VIII-3 and VIII-4, we provide both the mean estimate and the 90% confidence interval.

Using EPA's preferred estimates, based on the ACS and Six-Cities studies and no threshold assumption in the model of mortality, we estimate that the coordinated strategy will result in between 5,300 and 14,000 cases of avoided $PM_{2.5}$-related premature deaths annually in 2020 and between 12,000 and 30,000 avoided premature deaths annually in 2030. As a sensitivity analysis, when the range of expert opinion is used, we estimate between 1,900 and 18,000 fewer premature mortalities in 2020 and between 4,300 and 40,000 fewer premature mortalities in 2030 (see Tables 6-5 and 6-6 in the RIA that accompanies this rule).

For ozone-related premature mortality, we estimate a range of between 61 to 280 fewer premature mortalities as a result of the coordinated strategy in 2020 and between 210 to 920 in 2030. The increase in annual benefits from 2020 to 2030 reflects additional emission reductions from coordinated strategy, as well as increases in total population and the average age (and thus baseline mortality risk) of the population.

Table VIII-3 Estimated $PM_{2.5}$-Related Health Impacts Associated with a Coordinated U.S. Strategy to Control Ship Emissions[a]

Health Effect	2020 Annual Reduction in Ship-Related Incidence (5^{th}% - 95^{th}%ile)	2030 Annual Reduction in Ship-Related Incidence (5^{th}% - 95^{th}%ile)

Premature Mortality – Derived from epidemiology literature[b]		
Adult, age 30+, ACS Cohort Study (Pope et al., 2002)	5,300 (2,100 – 8,500)	12,000 (4,700 – 19,000)
Adult, age 25+, Six-Cities Study (Laden et al., 2006)	14,000 (7,400 – 20,000)	30,000 (17,000 – 44,000)
Infant, age <1 year (Woodruff et al., 1997)	20 (0 – 55)	34 (0 – 93)
Chronic bronchitis (adult, age 26 and over)	3,800 (700 – 6,900)	8,100 (1,500 – 14,000)
Non-fatal myocardial infarction (adult, age 18 and over)	8,800 (3,200 – 14,000)	20,000 (7,600 – 33,000)
Hospital admissions - respiratory (all ages)[c]	1,200 (590 – 1,800)	2,700 1,300 – 4,000)
Hospital admissions - cardiovascular (adults, age >18)[d]	2,700 (2,000 – 3,200)	6,600 (4,700 – 7,700)
Emergency room visits for asthma (age 18 years and younger)	3,500 (2,000 – 4,900)	7,300 (4,300 – 10,000)
Acute bronchitis, (children, age 8-12)	8,500 (0 – 17,000)	17,000 (0 – 35,000)
Lower respiratory symptoms (children, age 7-14)	100,000 (49,000 – 150,000)	210,000 (100,000 – 310,000)
Upper respiratory symptoms (asthmatic children, age 9-18)	77,000 (24,000 – 130,000)	160,000 (50,000 – 270,000)
Asthma exacerbation (asthmatic children, age 6-18)	95,000 (10,000 – 260,000)	200,000 (22,000 – 550,000)
Work loss days	720,000 (630,000 – 810,000)	1,400,000 (1,300,000 – 1,600,000)
Minor restricted activity days (adults age 18-65)	4,300,000 (3,600,000 – 4,900,000)	8,500,000 (7,200,000 – 9,800,000)

Notes:
[a] Incidence is rounded to two significant digits. Estimates represent incidence within the 48 contiguous United States.
[b] PM-related adult mortality based upon the American Cancer Society (ACS) Cohort Study (Pope et al., 2002) and the Six-Cities Study (Laden et al., 2006). Note that these are two alternative estimates of adult mortality and should not be summed. PM-related infant mortality based upon a study by Woodruff, Grillo, and Schoendorf, (1997).[170]
[c] Respiratory hospital admissions for PM include admissions for chronic obstructive pulmonary disease (COPD), pneumonia and asthma.
[d] Cardiovascular hospital admissions for PM include total cardiovascular and subcategories for ischemic heart disease, dysrhythmias, and heart failure.

[170] Woodruff, T.J., J. Grillo, and K.C. Schoendorf. 1997. "The Relationship Between Selected Causes of Postneonatal Infant Mortality and Particulate Air Pollution in the United States." *Environmental Health Perspectives* 105(6):608-612.

Table VIII-4 Estimated Ozone-Related Health Impacts Associated with a Coordinated U.S. Strategy to Control Ship Emissions[a]

Health Effect	2020 Annual Reduction in Ship-Related Incidence (5th% - 95th%ile)	2030 Annual Reduction in Ship-Related Incidence (5th% - 95th%ile)
Premature Mortality, All ages[b]		
Multi-City Analyses		
Bell et al. (2004) – Non-accidental	61 (23 – 98)	210 (70 – 340)
Huang et al. (2005) – Cardiopulmonary	100 (43 – 160)	350 (130 – 570)
Schwartz (2005) – Non-accidental	93 (34 – 150)	320 (100 – 530)
Meta-analyses:		
Bell et al. (2005) – All cause	200 (100 – 290)	660 (320 – 1,000)
Ito et al. (2005) – Non-accidental	270 (170 – 370)	920 (560 – 1,300)
Levy et al. (2005) – All cause	280 (200 – 360)	920 (640 – 1,200)
Hospital admissions- respiratory causes (adult, 65 and older)c	470 (46 – 830)	1,900 (120 – 3,300)
Hospital admissions -respiratory causes (children, under 2)	380 (180 – 590)	1,200 (490 – 1,900)
Emergency room visit for asthma (all ages)	210 (0 – 550)	690 (0 – 1,800)
Minor restricted activity days (adults, age 18-65)	360,000 (160,000 – 570,000)	1,100,000 (430,000 – 1,700,000)
School absence days	130,000 (51,000 – 190,000)	420,000 (150,000 – 630,000)

Notes:
[a] Incidence is rounded to two significant digits. Estimates represent incidence within the 48 contiguous U.S.
[b] Estimates of ozone-related premature mortality are based upon incidence estimates derived from several alternative studies: Bell et al. (2004); Huang et al. (2005); Schwartz (2005) ; Bell et al. (2005); Ito et al. (2005); Levy et al. (2005). The estimates of ozone-related premature mortality should therefore not be summed.
[c] Respiratory hospital admissions for ozone include admissions for all respiratory causes and subcategories for COPD and pneumonia.

C. Monetized Benefits

Table VIII-5 presents the estimated monetary value of reductions in the incidence of ozone and $PM_{2.5}$-related health effects. All monetized estimates are stated in 2006$. These estimates account for growth in real gross domestic product (GDP) per capita between the present and the years 2020 and 2030. As the tables indicate, total benefits are driven primarily by the reduction in premature fatalities each year.

Our estimate of total monetized benefits in 2020 for the coordinated strategy, using the ACS and Six-Cities PM mortality studies and the range of ozone mortality assumptions, is between $47 billion and $110 billion, assuming a 3 percent discount rate, or between $42 billion and $100 billion, assuming a 7 percent discount rate. In 2030, we estimate the monetized benefits to be between $110 billion and $270 billion, assuming a 3 percent discount rate, or between $99 billion and $240 billion, assuming a 7 percent discount rate. The monetized benefit associated with reductions in the risk of both ozone- and $PM_{2.5}$-related premature mortality ranges between 90 to 98 percent of total monetized health benefits, in part because we are unable to quantify a number of benefits categories (see Table VIII-2). These unquantified benefits may be substantial, although their magnitude is highly uncertain.

Table VIII-5 Estimated Monetary Value in Reductions in Incidence of Health and Welfare Effects (in millions of 2006$) [a,b]

		2020	2030
$PM_{2.5}$-Related Health Effect		Estimated Mean Value of Reductions (5th and 95th %ile)	
Premature Mortality – Derived from Epidemiology Studies[c,d,]	Adult, age 30+ - ACS study (Pope et al., 2002)		
	3% discount rate	$43,000 ($5,000 - $110,000)	$99,000 ($12,000 - $260,000)
	7% discount rate	$38,000 ($4,500 - $100,000)	$89,000 ($11,000 - $230,000)
	Adult, age 25+ - Six-cities study (Laden et al., 2006)		
	3% discount rate	$110,000 ($14,000 - $270,000)	$250,000 ($33,000 - $630,000)
	7% discount rate	$98,000 ($13,000 - $250,000)	$230,000 ($30,000 - $570,000)
	Infant Mortality, <1 year – (Woodruff et al. 1997)	$180 ($0 - $670)	$310 ($0 - $1,200)
Chronic bronchitis (adults, 26 and over)		$1,900 ($140 - $6,500)	$4,100 ($320 - $14,000)
Non-fatal acute myocardial infarctions			
3% discount rate		$960 ($170 - $2,300)	$2,700 ($460 - $6,700)
7% discount rate		$930 ($160 - $2,300)	$2,600 ($430 - $6,600)
Hospital admissions for respiratory causes		$17 ($8.4 - $25)	$39 ($19 - $57)
Hospital admissions for cardiovascular causes		$76 ($48 - $110)	$180 ($120 - $250)
Emergency room visits for asthma		$1.3 ($0.70 - $1.9)	$2.7 ($1.5 - $4.1)
Acute bronchitis (children, age 8–12)		$0.63 ($0 - $1.6)	$1.3 ($0 - $3.2)
Lower respiratory symptoms (children, 7–14)		$2.0 ($0.75 - $3.7)	$4.1 ($1.6 - $7.6)
Upper respiratory symptoms (asthma, 9–11)		$2.4 ($0.65 - $5.3)	$5.0 ($1.4 - $11)
Asthma exacerbations		$5.1 ($0.51 - $15)	$11 ($1.1 - $32)
Work loss days		$110 ($94 - $120)	$220 ($190 - $250)
Minor restricted-activity days (MRADs)		$270 ($150 – $390)	$540 ($310 - $780)
Ozone-related Health Effect			

Premature Mortality, All ages – Derived from Multi-city analyses	Bell et al., 2004	$540 ($63 - $1,400)	$1,800 ($210 - $4,900)
	Huang et al., 2005	$910 ($110 - $2,300)	$3,100 ($360 - $8,200)
	Schwartz, 2005	$830 ($94 - $2,200)	$2,800 ($310 - $7,600)
Premature Mortality, All ages – Derived from Meta-analyses	Bell et al., 2005	$1,700 ($220 - $4,400)	$5,800 ($740 - $15,000)
	Ito et al., 2005	$2,400 ($330 - $5,900)	$8,200 ($1,100 - $20,000)
	Levy et al., 2005	$2,400 ($340 - $5,900)	$8,200 ($1,100 - $20,000)
Hospital admissions- respiratory causes (adult, 65 and older)		$11 ($1.1 - $20)	$45 ($2.8 - $79)
Hospital admissions- respiratory causes (children, under 2)		$3.8 ($1.8 – $5.9)	$12 ($4.9 - $19)
Emergency room visit for asthma (all ages)		$0.08 ($0.03 - $0.20)	$0.25 ($0 - $0.63)
Minor restricted activity days (adults, age 18-65)		$23 ($9.8 - $41)	$69 ($25 - $120)
School absence days		$12 ($4.6 - $17)	$37 ($13 - $57)

Notes:
[a] Monetary benefits are rounded to two significant digits for ease of presentation and computation. PM and ozone benefits are nationwide.
[b] Monetary benefits adjusted to account for growth in real GDP per capita between 1990 and the analysis year (2020 or 2030).
[c] Valuation assumes discounting over the SAB recommended 20 year segmented lag structure. Results reflect the use of 3 percent and 7 percent discount rates consistent with EPA and OMB guidelines for preparing economic analyses.

D. What Are the Limitations of the Benefits Analysis?

Every benefit-cost analysis examining the potential effects of a change in environmental protection requirements is limited to some extent by data gaps, limitations in model capabilities (such as geographic coverage), and uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Limitations of the scientific literature often result in the inability to estimate quantitative changes in health and environmental effects, such as potential increases in premature mortality associated with increased exposure to carbon monoxide. Deficiencies in the economics literature often result in the inability to assign economic values even to those health and environmental outcomes which can be quantified. These general uncertainties in the underlying scientific and economics literature, which can lead to valuations that are higher or lower, are discussed in detail in the RIA and its supporting references. Key uncertainties that have a bearing on the results of the benefit-cost analysis of the coordinated strategy include the following:

- The exclusion of potentially significant and unquantified benefit categories (such as health, odor, and ecological benefits of reduction in air toxics, ozone, and PM);
- Errors in measurement and projection for variables such as population growth;
- Uncertainties in the estimation of future year emissions inventories and air quality;
- Uncertainty in the estimated relationships of health and welfare effects to changes in pollutant concentrations including the shape of the C-R function, the size of the effect estimates, and the relative toxicity of the many components of the PM mixture;

- Uncertainties in exposure estimation; and
- Uncertainties associated with the effect of potential future actions to limit emissions.

As Table VIII-5 indicates, total benefits are driven primarily by the reduction in premature mortalities each year. Some key assumptions underlying the premature mortality estimates include the following, which may also contribute to uncertainty:

- Inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis. Although biological mechanisms for this effect have not yet been completely established, the weight of the available epidemiological, toxicological, and experimental evidence supports an assumption of causality. The impacts of including a probabilistic representation of causality were explored in the expert elicitation-based results of the PM NAAQS RIA.
- All fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because PM produced via transported precursors emitted from marine engines may differ significantly from PM precursors released from electric generating units and other industrial sources. However, no clear scientific grounds exist for supporting differential effects estimates by particle type.
- The C-R function for fine particles is approximately linear within the range of ambient concentrations under consideration. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of PM, including both regions that may be in attainment with $PM_{2.5}$ standards and those that are at risk of not meeting the standards.
- There is uncertainty in the magnitude of the association between ozone and premature mortality. The range of ozone benefits associated with the coordinated strategy is estimated based on the risk of several sources of ozone-related mortality effect estimates. In a recent report on the estimation of ozone-related premature mortality published by the National Research Council, a panel of experts and reviewers concluded that short-term exposure to ambient ozone is likely to contribute to premature deaths and that ozone-related mortality should be included in estimates of the health benefits of reducing ozone exposure.[171] EPA has requested advice from the National Academy of Sciences on how best to quantify uncertainty in the relationship between ozone exposure and premature mortality in the context of quantifying benefits.

Emissions and air quality modeling decisions are made early in the analytical process. For this reason, the emission control scenarios used in the air quality and benefits modeling are slightly different than the coordinated strategy. The discrepancies impact the benefits analysis in two ways:

- The air quality modeling used for the 2020 scenario is based on inventory estimates that were modeled using incorrect boundary information. We believe the impact of this difference, while modest, likely leads to a small underestimate of the benefits that are presented in this section. The correct boundary information was used for the 2030 scenario. Please refer to the Chapter 3 of the RIA for more information on the emissions excluded from the health impacts analysis.
- The 2020 air quality modeling scenarios do not include emission reductions associated with the implementation of global controls (set through IMO) beyond the assumed ECA boundary of 200

[171] National Research Council (NRC), 2008. Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution. The National Academies Press: Washington, D.C.

nautical miles (nm). Again, while we expect the impact of this difference is modest, the omission of these additional emission reductions likely leads to a small underestimate of the 2020 benefits presented in this section. The 2030 air quality modeling scenario did include emission reductions associated with global controls beyond the assumed ECA boundary of 200 nm.

Despite the uncertainties described above, we believe this analysis provides a conservative estimate of the estimated economic benefits of the standards in future years because of the exclusion of potentially significant benefit categories that are not quantifiable at this time. Acknowledging benefits omissions and uncertainties, we present a best estimate of the total benefits based on our interpretation of the best available scientific literature and methods supported by EPA's technical peer review panel, the Science Advisory Board's Health Effects Subcommittee (SAB-HES). The National Academies of Science (NRC, 2002) has also reviewed EPA's methodology for analyzing the health benefits of measures taken to reduce air pollution. EPA addressed many of these comments in the analysis of the final PM NAAQS.[172,173] This analysis incorporates this most recent work to the extent possible.

E. Comparison of Costs and Benefits

This section presents the cost-benefit comparison related to the expected impacts of our coordinated strategy for ocean-going vessels. In estimating the net benefits of the coordinated strategy, the appropriate cost measure is 'social costs.' Social costs represent the welfare costs of a rule to society and do not consider transfer payments (such as taxes) that are simply redistributions of wealth. For this analysis, we estimate that the social costs of the coordinated program are equivalent to the estimated compliance costs of the program. While vessel owners and operators will see their costs increase by the amount of those compliance costs, they are expected to pass them on in their entirety to consumers of marine transportation services in the form of increased freight rates. Ultimately, these costs will be borne by the final consumers of goods transported by ocean-going vessels in the form of higher prices for those goods. The social benefits of the coordinated strategy are represented by the monetized value of health and welfare improvements experienced by the U.S. population. Table VIII-6 contains the estimated social costs and the estimated monetized benefits of the coordinated strategy.

The results in Table VIII-6 suggest that the 2020 monetized benefits of the coordinated strategy are greater than the expected costs. Specifically, the annual benefits of the total program will range between $47 to $110 billion annually in 2020 using a three percent discount rate, or between $42 to $100 billion assuming a 7 percent discount rate, compared to estimated social costs of approximately $1.9 billion in that same year. These benefits are expected to increase to between $110 and $270 billion annually in 2030 using a three percent discount rate, or between $99 and $240 billion assuming a 7 percent discount rate, while the social costs are estimated to be approximately $3.1 billion. Though there are a number of health and environmental effects

[172] National Research Council (NRC). 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations. The National Academies Press: Washington, D.C.

[173] U.S. Environmental Protection Agency. October 2006. *Final Regulatory Impact Analysis (RIA) for the Proposed National Ambient Air Quality Standards for Particulate Matter*. Prepared by: Office of Air and Radiation. Available at http://www.epa.gov/ttn/ecas/ria.html.

associated with the coordinated strategy that we are unable to quantify or monetize (see Table VIII-2), the benefits of the coordinated strategy far outweigh the projected costs.

Using a conservative benefits estimate, the 2020 benefits outweigh the costs by a factor of 22. Using the upper end of the benefits range, the benefits could outweigh the costs by a factor of 58. Likewise, in 2030 benefits outweigh the costs by at least a factor of 32 and could be as much as a factor of 87. Thus, even taking the most conservative benefits assumptions, benefits of the coordinated strategy clearly outweigh the costs.

Table VIII-6 Summary of Annual Benefits and Costs Associated with a Coordinated U.S. Strategy to Control Ship Emissions[a]
(Millions of 2006 dollars)

Description	2020	2030
Total Estimated Costs[b]	$1,900	$3,100
Total Estimated Health Benefits[c,d,e,f]		
3 percent discount rate	$47,000 to $110,000	$110,000 to $270,000
7 percent discount rate	$42,000 to $100,000	$99,000 to $240,000
Annual Net Benefits (Total Benefits – Total Costs)		
3 percent discount rate	$45,000 to $110,000	$110,000 to $270,000
7 percent discount rate	$40,000 to $98,000	$96,000 to $240,000

Notes:
[a] All estimates represent annual benefits and costs anticipated for the years 2020 and 2030. Totals are rounded to two significant digits and may not sum due to rounding.
[b] The calculation of annual costs does not require amortization of costs over time. Therefore, the estimates of annual cost do not include a discount rate or rate of return assumption (see Chapter 7 of the RIA). In Chapter 7, however, we use both a 3 percent and 7 percent social discount rate to calculate the net present value of total social costs consistent with EPA and OMB guidelines for preparing economic analyses.
[c] Total includes ozone and $PM_{2.5}$ benefits. Range was developed by adding the estimate from the Bell et al., 2005 ozone premature mortality function to $PM_{2.5}$-related premature mortality derived from the ACS (Pope et al., 2002) and Six-Cities (Laden et al., 2006) studies.
[d] Annual benefits analysis results reflect the use of a 3 percent and 7 percent discount rate in the valuation of premature mortality and nonfatal myocardial infarctions, consistent with EPA and OMB guidelines for preparing economic analyses.
[e] Valuation of premature mortality based on long-term PM exposure assumes discounting over the SAB recommended 20-year segmented lag structure described in the Regulatory Impact Analysis for the Final Clean Air Interstate Rule (March, 2005).
[f] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table VIII-2.

IX. Public Participation

Two public hearings were held to provide interested parties the opportunity to present data, views, or arguments concerning the proposed rule; the first hearing was held in New York, NY on August 4, 2009, and the second in Long Beach, CA on August 6, 2009. The public was invited to submit written comments on the proposed rule during the formal comment period, which ended on September 28, 2009. EPA received 126 comments, and a detailed summary and response to these comments can be found in the Summary and Analysis of Comments document in the docket (Docket ID **EPA–HQ–OAR–2007–0121).**

EPA received a number of comments on the value that a voluntary verification program would provide as well as comments on how best to implement such a program. The proposed program is discussed in Chapter 9 of the RIA. EPA is still reviewing these comments and is not taking any action today with regard to such a program. We will continue to evaluate the potential for such a program and will work in an open process with stakeholders should we conclude that such a program is appropriate.

EPA also received a number of comments on the technical challenges of operating steamships on lower sulfur fuel. In response, we are not taking final action today to apply the ECA fuel sulfur requirements to Great Lakes steamships in service prior to January 1, 2009. We will continue to study these technical issues and address these vessels in a future action, if appropriate.

This rule includes several technical amendments unrelated to Category 3 marine diesel engines. Two of these have generated a significant degree of interest from commenters. First, we raised for discussion a variety of temporary changes to the bonding requirements for nonroad spark-ignition engines below 19 kW (Small SI engines) based on feedback received by manufacturers and surety agents. We learned over the last several months that manufacturers have been struggling to obtain a bond for 2010, as required under §1054.690. It seemed that the bond values specified in the regulation were in some cases preventing surety agents and manufacturers from reaching agreeable terms. While we were considering these changes, we learned that one manufacturer in the United States and nine manufacturers from China were able to establish a bond policy. We expect to continue to monitor implementation experiences with respect to the bonding provision, but we believe it is no longer necessary to adopt the interim regulatory provisions we were considering. We are proceeding with one adjustment to the bonding provisions. We believe it is appropriate to set a maximum value of $10 million for any bond that is required under §1054.690. Setting this value the same as the maximum level of fixed assets that we require to be exempted from getting a bond would allow for a logical correlation regarding the liability for manufacturers that are exempt from the bonding requirement and those that are not. Nevertheless, we believe it is appropriate to adopt this change for a three-year transition period. At that point, we would either change the regulation to adopt some permanent cap on bond values or let the regulation revert to the original provisions with no maximum value.

We communicated our intent to make these bonding-related changes to those that commented on the bonding provisions when we first adopted them, including the Outdoor Power Equipment Institute, the Engine Manufacturers Association, and the California Air Resources Board. The Outdoor Power Equipment Institute and the Engine Manufacturers Association objected to the change, arguing that the reduced bond requirement would be insufficient to recover penalties for noncompliance in most cases. Based on these comments and on the fact that several companies have established bond policies, we have decided not to make these changes in this rulemaking. We may choose to pursue these or other long-term adjustments to the bonding regulations based on our experiences over the next several months, but we would do that in the context of a new rulemaking, which would include ample opportunity for comment and collaboration. In the meantime, we anticipate that small businesses may continue to have difficulty establishing a bond. If this is the case, we would be ready to consider an application for hardship under the provisions of §1054.635. Small businesses applying for relief under this provision would need to provide us with enough information to be able to act on their request. In any hardship approval, we would likely first consider the same kinds of relief reflected in the interim regulation changes we were considering. In particular, we could reduce the specified bond amount to preserve a measure of protection that is more carefully calibrated for very small sales volumes. We could also consider a manufacturer to be exempted from getting a bond based on a good compliance history of less than ten years.

The proposed rule also included new regulatory provisions to clarify what we would consider acceptable inventory and stockpiling practices for engine and vehicle manufacturers relative to the new emission standards for heavy-duty highway engines that take effect in 2010 and later model years. We have received extensive input in the comments, including concerns about how to define and potentially apply certain terms such as "normal inventory" and "production" practices given the dynamics of today's market and placed in the context of the timing of this final rule, and how such terms might be used by the Agency to determine whether inappropriate stockpiling has occurred. Based on this, we have decided to defer codification of the stockpiling prohibition until a later rulemaking. In the meantime, we plan to implement the 2010 standards based on the Agency's existing stockpiling guidance and to monitor engine and vehicle manufacturers in order to ensure that no circumventions of the Clean Air Act have occurred.

X. Statutory and Executive Order Reviews

As explained in Section I.A, the program we are finalizing is part of a coordinated strategy to address emissions from ocean-going vessels. That coordinated strategy includes, among other actions, the combination the global Tier 2 NO_X standards included in the amendments to Annex VI and the ECA Tier 3 NO_X limits and fuel sulfur limits that will apply when the U.S. coasts are designated as an ECA through an additional amendment to Annex VI. These engine and fuel standards will be enforceable for all vessels, U.S. and foreign, operating in the United States through the Act to Prevent Pollution from Ships. Because the coordinated strategy in its entirety is economically significant (see cost analysis in Section V), the components we are adopting in this rule (engine controls for Category 3 engines on U.S. vessels under our Clean Air Act program, as required by section 213 of the Act that are identical to the MARPOL Annex VI NO_X limits; limits on hydrocarbon and carbon monoxide emissions for Category 3 engines; PM measurement requirement; changes to our Clean Air Act diesel fuel program to allow production and sale of ECA-compliant fuel; changes to our emission control program for smaller marine diesel engines to harmonize with the Annex VI NO_X requirements, for U.S. vessels that operate internationally) may also be considered to be economically significant.

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order (EO) 12866 (58 FR 51735, October 4, 1993), this action is a "significant regulatory action" because it raises novel legal or policy issues due to the international nature of the use of Category 3 marine diesel engines. Accordingly, EPA submitted this action to the Office of Management and Budget (OMB) for review under EO 12866 and any changes made in response to OMB recommendations have been documented in the docket for this action.

In addition, EPA prepared an analysis of the potential costs and benefits associated with our coordinated strategy for controlling emissions from ocean-going vessels. While the costs of the coordinated strategy are "significant," the largest part of these costs are related to compliance with MARPOL Annex VI, which applies independently of this final rule. The costs of the requirements we are adopting in this rule are minimal. This analysis is contained in the Regulatory Impact Analysis that was prepared, and is available in the docket for this rulemaking and at the docket internet address listed under **ADDRESSES** above.

B. Paperwork Reduction Act

The information collection requirements in this rule will be submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 et seq. The information collection requirements are not enforceable until OMB approves them.

Section 208(a) of the Clean Air Act requires that manufacturers provide information the Administrator may reasonably require to determine compliance with the regulations; submission of the information is therefore mandatory. We will consider confidential all information meeting the requirements of section 208(c) of the Clean Air Act. Recordkeeping and reporting requirements for manufacturers would be pursuant to the authority of section 208 of the Clean Air Act.

The data we require in this action is necessary to comply with Title II of the Clean Air Act, as amended in 1990. The Act directs us to adopt regulations for nonroad engines if we determine those engines contribute significantly to air pollution in the U.S. Now that we have made this determination, the Act directs us to set emission standards for any category of nonroad engines that contribute to air quality nonattainment in two or more areas in the U.S. We can only meet the requirements of the Act by collecting data from the regulated industry. Also, we will only have an effective program if we know that these engines maintain their certified emission level throughout their operating lives.

The burden for certification testing is generally based on conducting two engine tests for each engine family, then using that test data for several years. The manufacturer's application for certification involves an extensive effort the first year, followed by relatively little effort in subsequent years. We estimate that manufacturers will conduct new certification testing every five years; the costs have been estimated on an annual average basis. In addition to testing, manufacturers must prepare the application for certification and maintain appropriate records. The burden for production-line testing is based on an industry-wide calculation. Rebuilders, including operators of marine vessels with Category 3 engines, must keep records as needed to show that rebuilt engines continue to meet emission standards, consistent with the manufacturer's original design. In addition, owners and operators of marine vessels with Category 3 engines must record information about their location when rebuilding engines or making other adjustments and send minimal annual notification to EPA to show that engine maintenance and adjustments have not caused engines to be noncompliant. In total, we estimate that 12 engine manufacturers and 200 engine rebuilders will together face an estimated compliance burden of 3,012 hours per year, which corresponds with annual costs of $191,759 per year. Burden is defined at 5 CFR 1320.3(b).

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations in 40 CFR are listed in 40 CFR part 9. EPA will amend the table in 40 CFR part 9 to add OMB control number associated with the new regulations in 40 CFR part 1043 once those are approved.

C. Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of this rule on small entities, small entity is defined as: (1) a small business that is primarily engaged in manufacture of large diesel marine engines as defined by NAICS code 333618 with 1,000 or fewer employees (based on Small Business Administration size standards) or a small business primarily engaged in shipbuilding and repairing as defined by NAICS code 336611 with 1,000 or fewer employees (based on Small Business Administration size standards); (2) a small business that is primarily engaged in freight or passenger transportation, either on the Great Lakes or in coastal areas as defined by NAICS codes 483113 and 483114 with 500 or fewer employees (based on Small Business Administration size standards); (3) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (4) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of this final rule on small entities, I certify that this action will not have a significant economic impact on a substantial number of small entities. Since publication of the proposed rulemaking, we have learned that the small entities directly regulated by this final rule include shipping companies that use fuel subject to the requirements in this rulemaking. We have identified four small U.S. companies that are operating Category 3 engines that currently burn residual fuel, and have estimated the compliance burden for each of these four small companies based on available information about the companies and their vessels. Our analysis indicates that two companies will have an estimated compliance burden representing less than 1 percent of their operating revenues, one company will have an estimated compliance burden representing between 1 and 3 percent of their operating revenues, and one company will have an estimated compliance burden representing slightly over 6 percent of their operating revenues.

Although this final rule will not have a significant economic impact on a substantial number of small entities, EPA nonetheless has tried to reduce the impact of this rule by adopting provisions to reduce the regulatory burden for these companies. For example, if we would apply the fuel requirements to steamships, a total of five small businesses would have an estimated compliance burden representing over 1 percent of their operating revenues, with the values for some companies reaching 20 percent or higher. However, we have decided to adopt provisions allowing us to waive the fuel-related requirements for these companies if it can be demonstrated that a compliant residual fuel is not available, or that the compliance burden will jeopardize the solvency of the company. This analysis also does not include cost savings from increased durability and reliability or decreased maintenance that occurs when using distillate fuel instead of residual fuel. Our estimated burden for these companies therefore overestimates the costs these companies will actually face when complying with the rule.

Additionally, in some areas, we consider port areas to be internal waters even though they are directly accessed by vessels that operate in coastal and international service on the oceans (such as Puget Sound). We believe it would not be realistic to expect companies operating such vessels to use distillate fuel as they approach U.S. ports and then convert the engines to operate on residual fuel for that portion of their operation that is considered internal waters. Since it would take about an hour of operation to transition back to the residual fuel, we believe this would not be commonly practiced whether or not fuel requirements apply in internal waters. Nevertheless, we have analyzed this scenario for potential small business impacts. We found that one U.S. small business with coastal operations would be affected by this rule, but that they will have costs representing less than one percent of their revenues. As a result, we have concluded that all small businesses that own or operate these coastal vessels will see no significant economic impact in complying with this rule.

D. Unfunded Mandates Reform Act

This rule does not contain a Federal mandate that may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year. While the costs of the coordinated strategy exceed the $100 million per year threshold for the private sector, the costs of the components of that strategy that are the subject of this rule are less than $100 million per year, as explained in Section VII. Therefore, this action is not subject to the requirements of Sections 202 or 205 of the UMRA. This action is also not subject to the requirements of Section 203 of UMRA because it contains no regulatory requirements that might significantly or uniquely affect small governments.

E. Executive Order 13132: Federalism

This action does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. This action will be implemented at the Federal level and impose compliance obligations only on private industry. Thus, Executive Order 13132 does not apply to this rule.

Although Section 6 of Executive Order 13132 does not apply to this rule, EPA did consult with representatives of various State and local governments in developing this rule. EPA consulted with representatives from the National Association of Clean Air Agencies (NACAA, formerly STAPPA/ALAPCO), the Northeast States for Coordinated Air Use Management (NESCAUM), and the California Air Resources Board (CARB).

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

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

This action does not have tribal implications, as specified in Executive Order 13175 (65 FR 67249, November 9, 2000). The rule will be implemented at the Federal level and impose compliance costs only on manufacturers of marine engines and marine vessels. Tribal governments will be affected only to the extent they purchase and use the regulated engines and vehicles. Thus, Executive Order 13175 does not apply to this action.

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

This action is not subject to EO 13045 (62 FR 19885, April 23, 1997) because it is not economically significant as defined in EO 12866, and because the Agency does not believe the environmental health or safety risks addressed by this action present a disproportionate risk to children. This action's health and risk assessments are contained in Section II.A and Section VIII in this document and in Chapter 2 of the RIA, which has been placed in the public docket under Docket ID number EPA–HQ–OAR–2007–0121.

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

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use" (66 FR 28355 (May 22, 2001)), requires EPA to prepare and submit a Statement of Energy Effects to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for certain actions identified as "significant energy actions." Section 4(b) of Executive Order 13211 defines "significant energy actions" as "any action by an agency (normally published in the Federal Register) that promulgates or is expected to lead to the promulgation of a final rule or regulation, including notices of inquiry, advance notices of proposed rulemaking, and notices of proposed rulemaking: (1)(i) that is a significant regulatory action under Executive Order 12866 or any successor order, and (ii) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (2) that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action." We have prepared a Statement of Energy Effects for this action as follows.

This rule's potential effects on energy supply, distribution, or use have been analyzed and are discussed in detail in Section 4.6 of the RIA. In summary, while we project that this rule would result in an energy effect that exceeds the 10,000 barrel per day change in crude oil production threshold noted in E.O. 13211, this rule does not significantly affect the energy use, production, or distribution beyond what is required by Annex VI of the International Convention for the Prevention of Pollution from Ships.

I. National Technology Transfer Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 ("NTTAA"), Public Law No. 104-113, 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

The rulemaking involves technical standards. Therefore, the Agency conducted a search to identify potentially applicable voluntary consensus standards. The only test procedures outside of EPA that are written for Category 3 marine diesel engines are in the NO_X Technical Code as part of MARPOL Annex VI. These test procedures have been adopted by the International Maritime Organization under the auspices of the United Nations. As such, they are not technically voluntary consensus standards. We have adopted test procedure specifications for Category 3 marine diesel engines in 40 CFR part 1042, which rely on the EPA test procedures in 40 CFR part 1065. We have written the part 1065 test procedures to apply broadly to all sizes and types of engines. We have coordinated these efforts with a wide range of manufacturers from every industry over nearly the last ten years. As a result of this effort, we have reached a point that the test procedures have been very widely referenced and adopted for use in various countries and for various applications. We believe that part 1065 is the best path toward global harmonization of emission test procedures for highway, nonroad, and stationary engines. Nevertheless, we have included a provision allowing manufacturers to rely on the procedures specified in the NO_X Technical Code. We believe this appropriately maintains part 1065 as the primary path for adopting standardized and harmonized test procedures, without precluding the possibility of testing according to the other widely accepted protocol for testing Category 3 marine diesel engines.

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

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

EPA has determined that this final rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations because it increases the level of environmental protection for all affected populations without having any disproportionately high and adverse human health or environmental effects on any population, including any minority or low-income population.

Together, this final rule which addresses emissions from domestic-flagged vessels and the joint U.S./Canada ECA application to the IMO which addresses emissions from foreign-flagged vessels (referred to as the “coordinated strategy”) will achieve significant reductions of various emissions from Category 3 marine diesel engines, including NO_X, SO_X, and direct PM. Exposure to these pollutants raises concerns regarding environmental health for the U.S. population in general including the minority populations and low-income populations that are the focus of the environmental justice executive order.

The emission reductions from the new standards in the coordinated strategy will have large beneficial effects on communities in proximity to port, harbor, and waterway locations, including low-income and minority communities. In addition to exhaust emission standards for freshly manufactured and remanufactured engines, the coordinated strategy will further reduce emissions from regulated engines that directly impact low-income and minority communities.

EPA recently updated its initial screening-level analysis of selected marine port areas to better understand the populations, including minority and low-income populations, that are exposed to diesel PM emission sources from these facilities.[174,175] This screening-level analysis is an inexact tool and should only be considered for illustrative purposes to help understand potential impacts. The analysis included all emission sources as well as ocean-going marine diesel engines, and focused on a representative selection of national marine ports (45 ports total).[176,177] Considering only ocean-going marine engine diesel PM emissions, the results indicate that 6.5 million people are exposed to ambient diesel PM levels that are 2.0 $\mu g/m^3$ and 0.2 $\mu g/m^3$ above levels found in areas further from these facilities. This population includes a disproportionate number of low-income households, African-Americans, and Hispanics. The results from all emission sources show that nearly 18 million people are exposed to higher levels of diesel PM from all sources at the marine port areas than urban background levels. Because those living in the vicinity of marine ports are more likely to be low-income households and minority residents, these populations would receive a significant benefit from the combined coordinated strategy. See Section VIII of this preamble and Chapter 6 of the RIA for a discussion on the benefits of this rule, including the benefits to minority and low-income communities.

K. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 et seq., as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the Federal Register. A Major rule cannot take effect until 60 days after it is published in the Federal Register. This action is not a "major rule" as defined by 5 U.S.C. 804(2). This rule will be effective [INSERT DATE 60 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER].

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[174] ICF International. December 1, 2008. Estimation of diesel particulate matter concentration isopleths near selected harbor areas with revised emissions (revised). Memorandum to EPA under Work Assignment Number 1-9, Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR-2007–0121.

[175] ICF International. December 10, 2008. Estimation of diesel particulate matter population exposure near selected harbor areas with revised harbor emissions (revised). Memorandum to EPA under Work Assignment Number 2-9, Contract Number EP-C-06-094. This memo is available in Docket EPA-HQ-OAR-2007-0121.

[176] 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.

[177] The Agency selected a representative sample from the top 150 U.S. ports including coastal, inland and Great Lake ports.

XI. Statutory Provisions and Legal Authority

Statutory authority for the controls in this final rule can be found in sections 203-209, 211, 213 (which specifically authorizes controls on emissions from nonroad engines and vehicles), 216, and 301 of the Clean Air Act (CAA), 42 U.S.C. 7414, 7522, 7523, 7424, 7525, 7541, 7542, 7543, 7545, 7547, 7550, and 7601.

List of Subjects

40 CFR Part 80

Environmental protection, Administrative practice and procedure, Air pollution control, Confidential business information, Diesel Fuel, Fuel Additives, Imports, Labeling, Penalties, Reporting and recordkeeping requirements.

40 CFR Part 85

Confidential business information, Imports, Labeling, Motor vehicle pollution, Reporting and recordkeeping requirements, Research, Warranties.

40 CFR Part 86

Environmental protection, Administrative practice and procedure, Air pollution control, Reporting and recordkeeping requirements, Motor vehicle.

40 CFR Part 94

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

40 CFR Part 1027

Environmental protection, Administrative practice and procedure, Air pollution control, Imports, Reporting and recordkeeping requirements.

40 CFR Part 1033

Environmental protection, Administrative practice and procedure, Confidential business information, Incorporation by reference, Labeling, Penalties, Railroads, Reporting and recordkeeping requirements.

40 CFR Part 1039

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

40 CFR Part 1042

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

40 CFR Part 1043

Environmental protection, Administrative practice and procedure, Air pollution control, Imports, Incorporation by reference, Vessels, Reporting and recordkeeping requirements.

40 CFR Parts 1045, 1048, 1051, 1054, and 1060

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

40 CFR Parts 1065

Environmental protection, Administrative practice and procedure, Incorporation by reference, Reporting and recordkeeping requirements, Research.

40 CFR Part 1068

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

Dated:

Lisa P. Jackson,

Administrator.