Federal Register

Thursday,
January 18, 2001

Part V

Environmental Protection Agency

40 CFR Parts 69, 80, and 86

Control of Air Pollution From New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 69, 80, and 86

[AMS–FRL–6923–7]

RIN 2060–AI69

Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: The pollution emitted by diesel engines contributes greatly to our nation's continuing air quality problems. Even with more stringent heavy-duty highway engine standards set to take effect in 2004, these engines will continue to emit large amounts of nitrogen oxides and particulate matter, both of which contribute to serious public health problems in the United States. These problems include premature mortality, aggravation of respiratory and cardiovascular disease, aggravation of existing asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function. Numerous studies also link diesel exhaust to increased incidence of lung cancer. We believe that diesel exhaust is likely to be carcinogenic to humans by inhalation and that this cancer hazard exists for occupational and environmental levels of exposure.

We are establishing a comprehensive national control program that will regulate the heavy-duty vehicle and its fuel as a single system. As part of this program, new emission standards will begin to take effect in model year 2007, and will apply to heavy-duty highway engines and vehicles. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. Because these devices are damaged by sulfur, we are also reducing the level of sulfur in highway diesel fuel significantly by mid-2006. The program provides substantial flexibility for refiners, especially small refiners, and for manufacturers of engines and vehicles. These options will ensure that there is widespread availability and supply of the low sulfur diesel fuel from the very beginning of the program, and will provide engine manufacturers with the lead time needed to efficiently phase-in the exhaust emission control technology that will be used to achieve the emissions benefits of the new standards.

We estimate that heavy-duty trucks and buses today account for about one-third of nitrogen oxides emissions and one-quarter of particulate matter emissions from mobile sources. In some urban areas, the contribution is even greater. This program will reduce particulate matter and oxides of nitrogen emissions from heavy duty engines by 90 percent and 95 percent below current standard levels, respectively. In order to meet these more stringent standards for diesel engines, the program calls for a 97 percent reduction in the sulfur content of diesel fuel. As a result, diesel vehicles will achieve gasoline-like exhaust emission levels. We are also finalizing more stringent standards for heavy-duty gasoline vehicles, based in part on the use of the low sulfur gasoline that will be available when the standards go into effect.

The clean air impact of this program will be dramatic when fully implemented. By 2030, this program will reduce annual emissions of nitrogen oxides, nonmethane hydrocarbons, and particulate matter by a projected 2.6 million, 115,000 and 109,000 tons, respectively. We project that these reductions and the resulting significant environmental benefits of this program will come at an average cost increase of about $2,000 to $3,200 per new vehicle in the near term and about $1,200 to $1,900 per new vehicle in the long term, depending on the vehicle size. In comparison, new vehicle prices today can range well over $100,000 for larger heavy-duty vehicles. We estimate that when fully implemented the sulfur reduction requirement will increase the cost of producing and distributing diesel fuel by about five cents per gallon.

DATES: This rule will become effective March 19, 2001. The incorporation by reference of certain publications listed in this rule is approved by the Director of the Office of Federal Register as of March 19, 2001.

ADDRESSES: *Comments:* All comments and materials relevant to today's action have been placed in Public Docket No. A–99–06 at the following address: U.S. Environmental Protection Agency (EPA), Air Docket (6102), Room M–1500, 401 M Street, SW, Washington, DC 20460 (on the ground floor in Waterside Mall) from 8:00 a.m. to 5:30 p.m., Monday through Friday, except on government holidays. You can reach the Air Docket by telephone at (202) 260–7548 and by facsimile at (202) 260–4400. We may charge a reasonable fee for copying docket materials, as provided in 40 CFR part 2.

FOR FURTHER INFORMATION CONTACT: Margaret Borushko, U.S. EPA, National Vehicle and Fuel Emissions Laboratory, 2000 Traverwood, Ann Arbor MI 48105; Telephone (734) 214–4334, FAX (734) 214–4816, E-mail borushko.margaret@epa.gov

SUPPLEMENTARY INFORMATION:

Regulated Entities

This action will affect you if you produce or import new heavy-duty engines which are intended for use in highway vehicles such as trucks and buses, or produce or import such highway vehicles, or convert heavy-duty vehicles or heavy-duty engines used in highway vehicles to use alternative fuels, or produce or import light-duty highway diesel vehicles. It will also affect you if you produce, import, distribute, or sell highway diesel fuel, or sell nonroad diesel fuel.

The following table gives some examples of entities that may have to follow the regulations. But because these are only examples, you should carefully examine the regulations in 40 CFR parts 69, 80, and 86. If you have questions, call the person listed in the **FOR FURTHER INFORMATION CONTACT** section of this preamble:

Category	NAICS Codes [a]	SIC Codes [b]	Examples of potentially regulated entities
Industry	336112 336120	3711	Engine and Truck Manufacturers
Industry	811112 811198	7533 7549	Commercial Importers of Vehicles and Vehicle Components
Industry	324110	2911	Petroleum Refiners
Industry	422710 422720	5171 5172	Diesel Fuel Marketers and Distributors
industry	484220	4212	Diesel Fuel Carriers

Category	NAICS Codes [a]	SIC Codes [b]	Examples of potentially regulated entities
	484230	4213	

[a] North American Industry Classifications System (NAICS).
[b] Standard Industrial Classification (SIC) system code.

Access to Rulemaking Documents Through the Internet

Today's final rule is available electronically on the day of publication from the Environmental Protection Agency Internet Web site listed below. Electronic copies of the preamble, regulatory language, Regulatory Impact Analysis, and other documents associated with today's final rule are available from the EPA Office of Transportation and Air Quality (formerly the Office of Mobile Sources) Web site listed below shortly after the rule is signed by the Administrator. This service is free of charge, except any cost that you incur for connecting to the Internet.

Environmental Protection Agency Web Site: *http://www.epa.gov/fedrgstr/* (Either select a desired date or use the Search feature.)

Office of Transportation and Air Quality (OTAQ) Web Site: *http://www.epa.gov/otaq/* (Look in ''What's New'' or under the ''Heavy Trucks/Busses'' topic.)

Please note that due to differences between the software used to develop the document and the software into which document may be downloaded, changes in format, page length, etc. may occur.

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I. Overview

This rule covers the second of two phases in a comprehensive nationwide program for controlling emissions from heavy-duty engines (HDEs) and vehicles. It builds upon the phase 1 program we recently finalized (65 FR 59896, October 6, 2000). That action affirmed the 50 percent reduction in emissions of oxides of nitrogen (NO_X) from 2004 model year highway diesel engines, set in 1997 (62 FR 54693, October 21, 1997), and set new emission standards for heavy-duty gasoline-fueled engines and vehicles for 2005.

This second phase of the program looks beyond 2004, based on the use of high-efficiency exhaust emission control devices and the consideration of the vehicle and its fuel as a single system. In developing this rule, we took into consideration comments received in response to the advance notice of proposed rulemaking (64 FR 26142, May 13, 1999) and the notice of proposed rulemaking (NPRM) (65 FR 35430, June 2, 2000), including comments provided at five public hearings last June.

This program will result in particulate matter (PM) and NO_X emission levels that are 90 percent and 95 percent below the standard levels in effect today, respectively. In order to meet these more stringent standards for diesel engines, the rule mandates a 97 percent reduction in the sulfur content of diesel fuel. The heavy-duty engine standards will be effective starting in the 2007 model year and the low sulfur diesel fuel needed to facilitate the standards will be widely available in September 2006. As a result, diesel vehicles will achieve gasoline-like exhaust emission levels, in addition to their inherent advantages over gasoline vehicles with respect to fuel economy, lower greenhouse gas emissions, and lower evaporative hydrocarbon emissions. The rule also includes more stringent standards for heavy-duty gasoline vehicles. In addition to its impact on heavy-duty vehicle emissions, this rule will make clean diesel fuel available in time for implementation of the light-duty Tier 2 standards.

The standards will result in substantial benefits to public health and welfare and the environment through significant reductions in emissions of NO_X, PM, nonmethane hydrocarbons (NMHC), carbon monoxide (CO), sulfur oxides (SO_X), and air toxics. We project that by 2030, this phase 2 program will reduce annual emissions of NO_X, NMHC, and PM by 2.6 million, 115,000 and 109,000 tons, respectively. These emission reductions will prevent 8,300 premature deaths, over 9,500 hospitalizations, and 1.5 million work days lost. All told the benefits of this rule equal $70.3 billion. A sizeable part of the benefits in the early years of this program come from large reductions in the amount of direct and secondary PM caused by the existing fleet of heavy-duty vehicles. These reductions are due to the use of the higher quality diesel fuel in these vehicles.

A. What Requirements Are Being Set?

There are two basic parts to this program: (1) New exhaust emission standards for heavy-duty highway engines and vehicles, and (2) new quality standards for highway diesel fuel. The systems approach of combining the engine and fuel standards into a single program is critical to the success of our overall efforts to reduce emissions, because the emission standards will not be feasible without the fuel change. The feasibility of the emission standards is based on the use of high-efficiency exhaust emission control devices that would be damaged by sulfur in the fuel. This rule, by providing extremely low sulfur diesel fuel, will also enable cleaner diesel passenger vehicles and light-duty trucks. This is because the same pool of highway diesel fuel also services these light-duty diesel vehicles, and these vehicles can employ technologies similar to the high-efficiency heavy-duty exhaust emission control technologies that will be enabled by the fuel change. We believe these technologies are needed for diesel vehicles to comply with our Tier 2 emissions standards for light-duty highway vehicles (65 FR 6698, February 10, 2000).

We believe that this systems approach is a comprehensive way to enable effective new technologies for clean diesel, affecting all sizes of highway diesel engines, and may translate to future reductions from diesel engines used in nonroad applications too. The fuel change, in addition to enabling new technologies, will also produce emissions and maintenance benefits in the existing fleet of highway diesel vehicles. These benefits will include reduced sulfate PM and sulfur oxides emissions, reduced engine wear and less frequent oil changes, and longer-lasting exhaust gas recirculation (EGR) components on engines equipped with EGR. Heavy-duty gasoline vehicles will also be expected to have much lower emissions due to the transfer of recent technology developments for light-duty applications, and the recent action taken to reduce sulfur in gasoline as part of the Tier 2 rule.

The basic elements of the rule are outlined below. Detailed provisions and justifications for our rule are discussed in subsequent sections.

1. Heavy-Duty Emission Standards

We are finalizing a PM emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower-hour (g/bhp-hr), to take full effect for diesels in the 2007 model year.[1] We are also finalizing standards for NO_X and NMHC of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These NO_X and NMHC standards will be phased in together between 2007 and 2010, for diesel engines. The phase-in will be on a percent-of-sales basis: 50 percent from 2007 to 2009 and 100 percent in 2010. This phase-in schedule differs somewhat from the proposed schedule for reasons explained in Section III. Gasoline engines will be subject to these standards based on a phase-in requiring 50 percent compliance in the 2008 model year and 100 percent compliance in the 2009 model year. This phase-in schedule also differs from that proposed for reasons explained in Section III. In addition, we are finalizing our proposal to include turbocharged diesels in the existing crankcase emissions prohibition, effective in 2007.

Standards for complete HDVs will be implemented on the same schedule as for gasoline engine standards. For certification of complete vehicles between 8500 and 10,000 pounds gross vehicle weight rating (GVWR), the standards are 0.2 grams per mile (g/mi) for NO_X, 0.02 g/mi for PM, 0.195 g/mi for NMHC, and 0.032 g/mi for formaldehyde.[2] For vehicles between

[1] Note that throughout this preamble we refer to diesel and gasoline vehicles and engines. We tend to use those terms given the preponderance of vehicles using diesel fuel or gasoline fuel in the U.S. heavy-duty highway market. However, when we refer to a diesel engine, we generally mean any engine using the diesel cycle. When we refer to a gasoline engine or vehicle, we generally mean any Otto-cycle vehicle or engine. Therefore, the emission standards discussed throughout this preamble apply equally to engines and vehicles fueled by alternative fuels, unless otherwise specified in the regulatory text accompanying today's rule.

[2] Vehicle weight ratings in this rule refer to GVWR (the curb weight of the vehicle plus its maximum recommended load of passengers and cargo) unless noted otherwise.

10,000 and 14,000 pounds, the standards are 0.4 g/mi for NO_X, 0.02 g/mi for PM, 0.230 g/mi for NMHC, and 0.040 g/mi for formaldehyde. These standards levels are roughly comparable to the engine-based standards in these size ranges. Note that these standards will not apply to vehicles above 8500 pounds that we classify as medium-duty passenger vehicles as part of our Tier 2 program.

Finally, we are adopting new evaporative emissions standards for heavy-duty engines and vehicles, effective on the same schedule as the gasoline engine and vehicle exhaust emission standards. The new standards for 8500 to 14,000 pound vehicles are 1.4 and 1.75 grams per test for the 3-day diurnal and supplemental 2-day diurnal tests, respectively. Standards levels of 1.9 and 2.3 grams per test will apply for vehicles over 14,000 pounds. These standards represent more than a 50 percent reduction in the numerical standards as they exist today.

The program includes flexibility provisions to facilitate the transition to the new standards and to encourage the early introduction of clean technologies, and adjustments to various testing and compliance requirements to address differences between the new technologies and existing engine-based technologies. These provisions are described in Sections III and VI.

2. Fuel Quality Standards

This rule specifies that, beginning June 1, 2006, refiners must begin producing highway diesel fuel that meets a maximum sulfur standard of 15 parts per million (ppm). All 2007 and later model year diesel-fueled vehicles must be refueled with this new low sulfur diesel fuel. This sulfur standard is based on our assessment of the impact of sulfur on advanced exhaust emission control technologies, and a corresponding assessment of the feasibility of low sulfur fuel production and distribution.

Today's program includes a combination of flexibilities available to refiners to ensure a smooth transition to low sulfur highway diesel fuel. First, refiners can take advantage of a temporary compliance option, including an averaging, banking and trading component, beginning in June 2006 and lasting through 2009, with credit given for early compliance before June 2006. Under this temporary compliance option, up to 20 percent of highway diesel fuel may continue to be produced at the existing 500 ppm sulfur maximum standard. Highway diesel fuel marketed as complying with the 500 ppm sulfur standard must be segregated from 15 ppm fuel in the distribution system, and may only be used in pre-2007 model year heavy-duty vehicles. Second, we are providing additional hardship provisions for small refiners to minimize their economic burden in complying with the 15 ppm sulfur standard. Third, we are providing additional flexibility to refiners subject to the Geographic Phase-in Area (GPA) provisions of the Tier 2 gasoline sulfur program, which will allow them the option of staggering their gasoline and diesel investments. Finally, we are adopting a general hardship provision for which any refiner may apply on a case-by-case basis under certain conditions. These hardship provisions, coupled with the temporary compliance option, will provide a ''safety valve'' allowing up to 25 percent of highway diesel fuel produced to remain at 500 ppm for these transitional years to minimize any potential for highway diesel fuel supply problems.

In addition, today's program includes unique provisions for implementing the low sulfur diesel fuel program in the State of Alaska, given that it is exempt from the current 500 ppm standard. Certain U.S. territories are excluded from both the new engine standards and highway diesel fuel standards.

The compliance provisions for ensuring diesel fuel quality are essentially consistent with those that have been in effect since 1993 under the existing 500 ppm sulfur standard (55 FR 34120, August 21, 1990). Additional compliance provisions have been established primarily during the transition years of the program to verify refiners' compliance with the temporary compliance option to ensure the two grades of highway diesel fuel remain segregated, and to discourage misfueling of model year 2007 and later diesel vehicles.

B. Why is EPA Taking This Action?

1. Heavy-Duty Vehicles Contribute to Serious Air Pollution Problems

As discussed in detail in Section II, emissions from heavy-duty vehicles contribute greatly to a number of serious air pollution problems, and would have continued to do so into the future absent further controls to reduce these emissions. First, heavy-duty vehicles contribute to the health and welfare effects of ozone, PM, NO_X, SO_X, and volatile organic compounds (VOCs), including toxic compounds such as formaldehyde. These adverse effects include premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days), changes in lung function and increased respiratory symptoms, changes to lung tissues and structures, altered respiratory defense mechanisms, chronic bronchitis, and decreased lung function. Ozone also causes crop and forestry losses, and PM causes damage to materials and soiling of commonly used building materials and culturally important items such as statues and works of art. Second, NO_X, SO_X and PM contribute to substantial visibility impairment in many parts of the U.S. Third, NO_X emissions from heavy-duty trucks contribute to the acidification, nitrification and eutrophication of water bodies. Fourth, the Agency has concluded, and the Clean Air Scientific Advisory Committee has approved in public session, that diesel exhaust is likely to be carcinogenic to humans.

Millions of Americans live in areas with unhealthful air quality that currently endangers public health and welfare. Without emission reductions from the standards for heavy-duty vehicles, there is a significant risk that an appreciable number of 45 areas with 128 million people across the country will violate the 1-hour ozone national ambient air quality standard (NAAQS) during the period when these standards will take effect. Furthermore, our analysis shows that PM_{10} concentrations in 10 areas with a population of 28 million people face a significant risk of exceeding the PM_{10} NAAQS without significant additional controls between 2007 and 2030. Under the mandates and authorities in the Clean Air Act, Federal, state, and local governments are working to bring ozone and particulate levels into compliance with the 1-hour ozone and PM_{10} NAAQS through State Implementation Plan (SIP) attainment and maintenance plans, and to ensure that future air quality reaches and continues to achieve these health-based standards. The reductions in this rulemaking will play a critical part in these important efforts to attain and maintain the NAAQS. In addition, reductions from this action will also reduce public health and welfare effects associated with ozone and fine PM at concentrations that do not constitute a violation of the 1-hour ozone and PM_{10} NAAQS.

Emissions from heavy-duty vehicles account for substantial portions of the country's ambient PM and NO_X levels. (NO_X is a key precursor to ozone formation). By 2007, we estimate that heavy-duty vehicles will account for 28 percent of mobile source NO_X emissions and 20 percent of mobile source PM emissions. These proportions are even higher in some urban areas, such as in Sacramento, Atlanta, and Washington, DC, where HDVs contribute over 34 percent of the mobile source NO_X emissions, and in Santa Fe, Los Angeles, and Hartford, where heavy-duty vehicle PM emissions account for 38, 25 and 30 percent of the mobile source PM emissions inventory, respectively. Over time, the relative contribution of diesel engines to air quality problems will go even higher if diesel-equipped light-duty vehicles become more popular, as is expected by some automobile manufacturers. The PM and NO_X standards for heavy-duty vehicles in this rule will have a substantial impact on emissions. By 2030, NO_X emissions from heavy-duty vehicles under today's standards will be reduced by 2.6 million tons, and PM emissions will decline by about 109,000 tons, dramatically reducing this source of NO_X and PM emissions. Urban areas, which include many poorer neighborhoods, can be disproportionately impacted by HDV emissions, and these neighborhoods will thus receive a relatively larger portion of the benefits expected from new HDV emissions controls.

In addition to its contribution to PM inventories, diesel exhaust PM is of special concern because it has been implicated in an increased risk of lung cancer and respiratory disease. The EPA draft Health Assessment Document for Diesel Exhaust (Draft Assessment) was reviewed in public session by the Clean Air Scientific Advisory Committee (CASAC) on October 12–13, 2000.[3] The Agency has concluded, and the CASAC approved at this session, that diesel exhaust is likely to be carcinogenic to humans. State and local governments, in their efforts to protect the health of their citizens and comply with requirements of the Clean Air Act (CAA or ''the Act''), have recognized the need to achieve major reductions in diesel PM emissions, and have been seeking Agency action in setting stringent new standards to bring this about.[4]

2. Technology-Based Solutions

Although the air quality problems caused by diesel exhaust are challenging, we believe they can be resolved through the application of high-efficiency emissions control technologies. As discussed in detail in Section III, the development of diesel emissions control technology has advanced in recent years so that very large emission reductions (in excess of 90 percent) are possible, especially through the use of catalytic emission control devices installed in the vehicle's exhaust system and integrated with the engine controls. These devices are often referred to as ''exhaust emission control'' or ''aftertreatment'' devices. Exhaust emission control devices, in the form of the well-known catalytic converter, have been used in gasoline-fueled automobiles for 25 years, but have had only limited application in diesel vehicles.

Based on the Clean Air Act requirements discussed in Section I.B.3, we are setting stringent new emission standards that will result in the use of these diesel exhaust emission control devices (see Section III). We are also finalizing changes to diesel fuel quality standards in order to enable these high-efficiency technologies (Section IV). Heavy-duty gasoline engines will also be able to reach the significantly lower emission levels envisioned in this rule by relying on the transfer of recent technology developments for light-duty applications, given the recent action taken to reduce sulfur in gasoline (65 FR 6698, February 10, 2000).

To meet the new standards, application of high-efficiency exhaust emission controls for both PM and NO_X will be needed. High-efficiency PM exhaust emission control technology has been available for several years, although engine manufacturers have generally not needed this technology in order to meet our PM emission standards. This technology has continued to improve over the years, especially with respect to durability and robust operation in use. It has also proven extremely effective in reducing exhaust hydrocarbon emissions. Thousands of such systems are now in use in fleet programs, especially in Europe. However, as discussed in detail in Section III, these systems are very sensitive to sulfur in the fuel. For the technology to be viable and capable of meeting the standards, we believe that it will require diesel fuel with sulfur content capped at the 15 ppm level.

Similarly, high-efficiency NO_X exhaust emission control technology will be needed if heavy-duty vehicles are to attain the new standards. We believe this technology, like the PM technology, is dependent on the 15 ppm maximum diesel fuel sulfur levels being adopted in this rule to be feasible and capable of achieving the standards. Similar high-efficiency NO_X exhaust emission control technology has been quite successful in gasoline direct injection engines that operate with an exhaust composition fairly similar to diesel exhaust. However, as discussed in Section III, application of this technology to diesels has some additional engineering challenges. In that section we discuss the current status of this technology. We also discuss the major development issues still to be addressed and the development steps that can be taken to address these issues. With the lead time available and the certainty of low-sulfur diesel fuel established by today's action, the evidence leaves us confident that the application of this technology to diesels will proceed at a reasonable rate of progress and will result in systems capable of achieving the standards.

The need to reduce the sulfur in diesel fuel is driven by the requirements of the exhaust emission control technology that we project will be needed to meet the standards. The challenge in accomplishing the sulfur reduction is driven by the feasibility of needed refinery modifications, and by the costs of making the modifications and running the equipment. Today, a number of refiners are acting to provide low sulfur diesel to some markets. In consideration of the impacts that sulfur has on the efficiency, reliability, and fuel economy impact of diesel engine exhaust emission control devices, we believe that controlling the sulfur content of highway diesel fuel to the 15 ppm level is necessary and feasible, and, in the context of this rule's overall program, cost effective.

3. Basis For Action Under the Clean Air Act

Section 202(a)(1) of the Act directs us to establish standards regulating the emission of any air pollutant from any class or classes of new motor vehicles or engines that, in the Administrator's judgment, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. Section 202(a)(3) requires that EPA set standards for heavy-duty trucks that reflect the greatest degree of emission reduction achievable through the application of technology which we determine will be available for the model year to which the standards apply. We are to give appropriate consideration to cost, energy, and safety factors associated with the application of such technology. We may revise such technology-based standards, taking costs into account, on the basis of information concerning the effects of air pollution from heavy-duty vehicles or engines and other sources of mobile source related

[3] EPA (2000) Review of EPA's Health Assessment Document for Diesel Exhaust (EPA 600/8–90/057E). Review by the Clean Air Scientific Advisory Committee (CASAC) December 2000. EPA–SAB–CASAC–01–003.

[4] For example, see letter dated July 13, 1999 from John Elston and Richard Baldwin on behalf of the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (docket A–99–06, item II–D–78).

pollutants on the public health and welfare. Section 202(a)(3)(C) requires that promulgated standards apply for no less than three years and go into effect no less than 4 years after promulgation. This rule conforms with these statutory requirements.

We believe the evidence provided in Section III and the Regulatory Impact Analysis (RIA) indicates that the stringent emission standards finalized today are feasible and reflect the greatest degree of emission reduction achievable in the model years to which they apply. We have given appropriate consideration to costs in choosing these standards. Our review of the costs and cost-effectiveness of these standards indicate that they will be reasonable and comparable to the cost-effectiveness of other emission reduction strategies that have been required or could be required in the future. We have also reviewed and given appropriate consideration to the energy factors of this rule in terms of fuel efficiency and effects on diesel fuel supply, production, and distribution, as discussed below, as well as any safety factors associated with these standards.

The information regarding air quality and the contribution of heavy-duty engines to air pollution in Section II and the RIA provides strong evidence that emissions from such engines significantly and adversely impact public health or welfare. First, there is a significant risk that several areas will fail to attain or maintain compliance with the NAAQS for 1-hour ozone concentrations or PM_{10} concentrations during the period that these new vehicle and engine standards will be phased into the vehicle population, and that heavy-duty engines contribute to such concentrations, as well as to concentrations of other NAAQS-related pollutants. This risk will be significantly reduced by the standards adopted today; however, the evidence indicates that some risk remains even after the reductions achieved by these new controls on heavy-duty vehicles and diesel fuel. Second, EPA believes that diesel exhaust is likely to be carcinogenic to humans. The risk associated with exposure to diesel exhaust includes the particulate and gaseous components. Some of the toxic air pollutants associated with emissions from heavy-duty vehicles and engines include benzene, formaldehyde, acetaldehyde, dioxin, acrolein, and 1,3-butadiene. Third, emissions from heavy-duty engines contribute to regional haze and impaired visibility across the nation, as well as acid deposition, POM deposition, eutrophication and nitrification, all of which are serious environmental welfare problems.

Based on this evidence, EPA believes that, for purposes of section 202(a)(1), emissions of NO_X, VOCs, SO_x and PM from heavy-duty trucks can reasonably be anticipated to endanger the public health or welfare. In addition, this evidence indicates that it will not be appropriate to modify the technology-based standards pursuant to section 202(a)(3)(B). EPA believes that it is required under section 202(a)(3)(A) to set technology-based standards that meet the criteria of that provision, and is not required to make an affirmative determination under section 202(a)(1). Instead EPA is authorized to take air quality into consideration under section 202(a)(3)(B) in deciding whether to modify or not set standard under section 202(a)(3)(A). In this case, however, EPA believes the evidence fully supports a determination under section 202(a)(1) to set standards, and a determination not to modify such standards under section 202(a)(3)(B).

In addition, there is significant evidence that emissions from heavy-duty trucks contribute to levels of ozone such that large segments of the national population are expected to experience prolonged exposure over several hours at levels that present serious concern for the public health and welfare. The same is true for exposure to fine PM. These public health and welfare problems are expected to occur in many parts of the country, including areas that are in compliance with the 1-hour ozone and PM_{10} NAAQS (PM_{10} is particulate matter that is 10 microns or smaller). This evidence is an additional reason why the controls finalized today are justified and appropriate under the Act. While EPA sees this as additional support for this action, EPA also believes that the evidence of air pollution problems summarized above and described in greater detail elsewhere is an adequate justification for this rule independent of concern over prolonged exposure to ozone and fine PM levels.

Section 211(c) of the CAA allows us to regulate fuels where emission products of the fuel either: (1) Cause or contribute to air pollution that reasonably may be anticipated to endanger public health or welfare, or (2) will impair to a significant degree the performance of any emission control device or system which is in general use, or which the Administrator finds has been developed to a point where in a reasonable time it will be in general use were such a regulation to be promulgated. This rule meets each of these criteria. The discussion of the first test is substantially the same as the above discussion for the heavy-duty engine standards, because SO_x and sulfate PM emissions from heavy-duty diesel vehicles are due to sulfur in diesel fuel. The substantial adverse effect of high diesel sulfur levels on diesel control devices or systems expected to be used to meet the heavy-duty standards is discussed in depth in Section III.F and in the RIA. In addition, our authority under section 211(c) is discussed in more detail in Appendix A to the RIA.

C. Putting This Rule In Perspective

There are several helpful perspectives to establish in understanding the context for this rule: the growing popularity of diesel engines, past progress and new developments in diesel emissions control, Tier 2 light-duty emission standards and other related EPA initiatives (besides the above-discussed rulemaking for highway heavy-duty engine emission standards in 2004), and recent actions and plans to control diesel emissions by the States and in other countries.

1. Diesel Popularity

The diesel engine is increasingly becoming a vital workhorse in the United States, moving much of the nation's freight, and carrying out much of its farm, construction, and other labor. Diesel engine sales have grown significantly over the last decade, so that now about a million new diesel engines are put to work in the U.S. every year. Unfortunately, these diesel engines emit large quantities of harmful pollutants annually.

Furthermore, although diesel emissions in this country come mostly from heavy-duty trucks and nonroad equipment, an additional source may grow out of auto manufacturers' plans to greatly increase the sales of diesel-powered light-duty vehicles (LDVs) and especially of light-duty trucks (LDTs), a category that includes the fast-selling sport-utility vehicles, minivans, and pickup trucks. These plans reflect the continuation of an ongoing dieselization trend, a trend recently most evident in the growing popularity of diesel-powered light heavy-duty trucks (8500 to 19,500 pounds). Diesel market penetration is working its way from larger to smaller highway applications and to a broader array of nonroad equipment applications. Finally, especially in Europe where diesels have already gained a broad consumer acceptance, the diesel engine is increasingly viewed as an attractive technology option for reducing emissions of gases that contribute to global warming, because it has greater operating efficiency than a gasoline engine.

2. Past Progress and New Developments

Since the 1970's, highway diesel engine designers have employed numerous strategies to meet our emissions standards, beginning with smoke controls, and focusing in the 1990's on increasingly stringent NO_X, hydrocarbon, and PM standards. These strategies have generally focused on reducing engine-out emissions and not on exhaust emission controls, although relatively low-efficiency oxidation catalysts have been applied in some designs to reduce PM, with the recognition that their effectiveness is limited by sulfur in the fuel. On the fuel side, we set quality standards that provided emissions benefits by limiting the amount of sulfur and aromatics in highway diesel fuel beginning in 1993 (55 FR 34120, August 21, 1990). Our most recent round of standard setting for heavy-duty highway diesels occurred in 1997 (62 FR 54693, October 21, 1997), effective with the 2004 model year. These standards were recently reviewed in a final rulemaking (65 FR 59896, October 6, 2000). These actions will result in engines that emit only a fraction of the NO_X, hydrocarbons, and PM produced by engines manufactured just a decade ago. We consider this an important first phase of our current initiative to reconcile the diesel engine with the environment.

Nevertheless, certain characteristics inherent in the way diesel fuel combustion occurs have prevented achievement of emission levels comparable to those of today's gasoline-fueled vehicles. Although diesel engines provide advantages in terms of fuel economy, durability, and evaporative emissions, and have inherently low exhaust emissions of hydrocarbons and carbon monoxide, controlling NO_X emissions is a greater challenge for diesel engines than for gasoline engines, primarily because of the ineffectiveness of three-way catalysis in the oxygen-rich and relatively cool diesel exhaust environment. Similarly, PM emissions, which are inherently low for properly operating gasoline engines, are more difficult to control in diesel engines, because the diesel combustion process tends to form soot particles. The challenge is somewhat complicated by the fact that historical diesel NO_X control approaches tend to increase PM, and vice versa, but both are harmful pollutants that need to be controlled.

Considering the air quality impacts of diesel engines and the potential for growth of diesels in the lighter-duty portion of the market, it is imperative that progress in diesel emissions control continue. Significant progress has already been made in the design of exhaust emission control devices for diesel applications, driven in part by the challenge presented by the stringent Tier 2 standards for light-duty vehicles. As discussed in detail in Section III, new exhaust emission control technologies for NO_X, PM, and hydrocarbon reduction will allow a major advancement in diesel emissions control of a magnitude comparable to that ushered in by the automotive catalytic converter in the 1970's. However, changes in diesel fuel quality will be needed to enable these high-efficiency exhaust emission control devices.

3. Tier 2 Emissions Standards

Auto manufacturers' design plans for new light-duty diesel vehicle models will be greatly affected by our recent adoption of stringent new emission standards for light-duty highway vehicles (referred to as "Tier 2" standards) that will phase in between 2004 and 2009. These Tier 2 standards will require significant improvements in electronic engine controls and catalysts on gasoline vehicles. We anticipate that these advances will be transferred over to heavy-duty gasoline vehicles in meeting the standards finalized in this rule. The Tier 2 NO_X and PM standards, that apply equally to gasoline and diesel vehicles, will also require the use of high-efficiency emission control technologies on light-duty diesel vehicles. The low sulfur highway diesel fuel brought about by this rule will make it possible for designers to employ these high-efficiency exhaust emission control technologies in these light-duty applications. The timing of the fuel change provides for the use of these devices in time to satisfy Tier 2 phase-in requirements.

The Tier 2 program phases in interim and final standards over a number of years, providing manufacturers the option of delaying some of their production of final Tier 2 designs until later in the phase-in. For vehicles up to 6000 lbs GVWR (LDVs) and light light-duty trucks (LLDTs)), the interim standards begin in 2004 and phase out by 2007, as they are replaced by the final Tier 2 standards. For vehicles between 6000 and 8500 lbs (heavy light-duty trucks (HLDTs)), the interim standards begin in 2004 and phase out by 2009 as they are replaced by the final Tier 2 standards. A new category of vehicles between 8,500 and 10,000 lbs, medium-duty passenger vehicles (MDPVs), will follow the same phase-in schedule as HLDTs.

Our assessment in the Tier 2 final rule is that the interim standards are feasible for diesel vehicles without a need for fuel quality changes. Manufacturers can take advantage of the flexibilities provided in the Tier 2 program to delay the need for light-duty diesels to meet the final Tier 2 levels until late in the phase-in period (as late as 2007 for LDVs and LLDTs, and 2009 for HLDTs and MDPVs). However, low sulfur fuel is expected to be needed for diesel vehicles designed to meet the final NO_X and PM standards, because these vehicles are likely to employ light-duty versions of the sulfur-sensitive exhaust emission control technologies discussed in Section III. The gasoline quality changes and light-duty gasoline engine developments that will result from the Tier 2 rule will also help make it feasible for heavy-duty gasoline engines to meet the standards in this rule.

4. Mobile Source Air Toxics Rulemaking

Passenger cars, on-highway trucks, and nonroad equipment emit hundreds of different compounds and elements. Several of these are considered to be known, likely, or possible human carcinogens. These include diesel exhaust, plus several VOCs such as acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and acrolein. Trace metals may also be present in heavy-duty diesel engine emissions, resulting from metals in fuels and lubricating oil, and from engine wear. Several of these metals have carcinogenic and mutagenic effects.

Important reductions in these and other mobile source air toxics have occurred under existing programs established under Clean Air Act Sections 202(a) (on-highway engine requirements), 211 (the fuel requirements), and 213 (nonroad engine requirements). Although these programs are primarily designed for control of criteria pollutants, especially ozone and PM_{10}, they also achieve important reductions in diesel PM and gaseous air toxics through VOC and hydrocarbon controls.

In addition to these programs, Section 202(l)(2) of the Act directs us to consider additional controls to reduce emissions of hazardous air pollutants from motor vehicles, their fuels, or both. Those standards are to reflect the greatest degree of emission reduction achievable through the application of technology which will be available, taking into account existing standards, costs, noise, energy, and safety factors. We published a proposed rule on mobile source air toxics on August 4, 2000 (65 FR 48058). This MSAT final rule was signed on December 20, 2000. Interested parties should refer to the final rule if interested in the ultimate form of the regulation.

The mobile source air toxics (MSATs) rule consists of four parts. First, we identify a list of 21 MSATs that are known to be emitted from motor vehicles or their fuels and are considered by the Agency to pose potential adverse human health risks. Diesel exhaust is included on this MSAT list because, as discussed in Section II, human epidemiological studies have suggested that diesel exhaust is associated with increased risk of adverse respiratory effects and lung cancer. Second, the MSAT rule considers the contribution of mobile sources to the nation's air toxics inventory and evaluates the toxics benefits of existing mobile source emission control programs. The benefits of the program as proposed are included in this analysis. Third, the MSAT final rule considers whether additional controls are appropriate at this time, given technological feasibility, cost, and the other criteria specified in the Act. The final rule includes a toxics performance standard applicable to reformulated gasoline and anti-dumping standards that apply to conventional gasoline. With regard to additional vehicle-based controls, we proposed that it is not appropriate at this time to set more stringent standards than the technology forcing standards found in this rule and our recently adopted Tier 2 rulemaking. Finally, because of our concern about the potential future health impacts of exposure to the public of air toxics from the remaining emissions from mobile sources in the future, we continue our toxics-related research activities and to conduct a future rulemaking to evaluate whether, based on the additional data, additional mobile source air toxics controls should be adopted. This rulemaking would be completed no later than 2004.

EPA also intends to rely on today's rule to satisfy in part its obligations under section 202(l) of the Clean Air Act. In the mobile source air toxics NPRM, the Agency proposed a list of mobile source air toxics, including diesel exhaust, as well as a number of specific constituents of heavy-duty vehicle exhaust (gasoline and diesel).[5] The emissions standards established in today's action result in the greatest achievable reductions of diesel PM and heavy-duty vehicle NMHC. The Agency is scheduled to finalize the mobile source air toxics rulemaking on or before December 20, 2000.

5. Nonroad Engine Standards and Fuel

Although this rule covers only highway diesel engines and fuel, it is clear that potential requirements for nonroad diesel engines and fuel are related. It is expected that nonroad diesel fuel quality, currently unregulated, may need to be controlled in the future in order to reduce the large contribution of nonroad engines to NO_X and PM inventories. Refiners, fuel distributors, states, environmental organizations, and others have asked that we provide as much information as possible about the future specifications for both types of fuel as early as possible.

We do plan to give further consideration to additional control of nonroad engine emissions. As discussed below in Section VIII, an effective control program for these engines requires the resolution of several major issues relating to engine emission control technologies and how they are affected by fuel sulfur content. The many issues connected with any rulemaking for nonroad engines and fuel warrant serious attention, and we believe it is premature for us to take any action on this initiative in this rule. We plan to initiate action in the future to formulate proposals that would address both nonroad diesel fuel and engines.

6. State Initiatives

The California Air Resources Board (ARB) and local air quality management districts within California are also pursuing measures to better control diesel emissions. Key among these efforts is work resulting from the Board's designation of particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC) on August 27, 1998. TACs are air pollutants that may cause or contribute to an increase in death or serious illness or may pose a present or future hazard to human health. The TAC designation was based on research studies showing that emissions from diesel-fueled engines may cause cancer in animals and humans, and that workers exposed to higher levels of emissions from diesel-fueled engines are more likely to develop lung cancer.

In September 2000 the ARB approved a Diesel Risk Reduction Plan developed by its staff following an extensive public process.[6] This plan includes several California measures related to highway diesel vehicles, including the major elements of the program we are establishing on a nationwide basis in this final rule. Because truck travel from other states has a large effect on California's air quality, the plan and the Board's resolution further encourages the EPA adopt this nationwide program, as well as other diesel-related emissions reduction programs.

The ARB has also adopted stringent new emission requirements for urban transit buses and is considering similar requirements for school buses.[7] This program is aimed at encouraging the use of clean alternative fuels and high-efficiency diesel emission control technologies. Their program includes requirements for zero-emissions buses, fleet average NO_X levels, and retrofits for PM control, as well as model year 2007 NO_X and PM standards levels of 0.2 and 0.01 g/bhp-hr, respectively (equal to the levels finalized in this rule). It also requires that all diesel fuel used by transit agencies after July 1, 2002 must meet a cap of 15 ppm sulfur. This is a much earlier schedule than that finalized in this rule, to support the ARB's proposed transit bus fleet program.

Other states, most notably Texas, have taken steps toward adopting programs for cleaner diesel fuel and cleaner diesel engines. On December 6, 2000, the Texas Natural Resource Conservation Commission adopted a program that, among other things, would require the capping of diesel fuel sulfur levels in many counties to 15 ppm by June 2006.[8] This proposal exemplifies the importance that states with air quality problems have attached to clean diesel fuel, and specifically to the 15 ppm maximum sulfur requirement in 2006 being set in this rule

7. Retrofit Programs

Many States facing air quality improvement challenges have expressed strong interest in programs that will reduce emissions from existing highway and nonroad diesel engines through the retrofitting of these engines with improved emission control devices. The urban transit bus program adopted by the California ARB includes such a retrofit requirement as one of its major components (see Section I.C.6). In March 2000 we announced our own Diesel Retrofit Initiative to support and

[5] 65 FR 48058, August 4, 2000.

[6] State of California Air Resources Board Resolution 00–30, September 28, 2000.

[7] "Notice of Public Hearing To Consider the Adoption of a Public Transit Bus Fleet Rule and Emission Standards For New Urban Buses", California ARB, November 30, 1999, and ARB Resolution 00–2, dated February 24, 2000.

[8] Title 30, Texas Administrative Code, Chapter 114, Subchapter H, Division 2. Also see Texas Natural Resource Conservation Commission website www.tnrcc.state.tx.us.

encourage fleet operators, air quality planners, and retrofit manufacturers in creating effective retrofit programs. These programs are appealing because the slow turnover of the diesel fleet to the new low-emitting engines makes it difficult to achieve near-term air quality goals through new engine programs alone. Some of the exhaust emission control technologies discussed in this rule are especially appealing for use in retrofits because they can be fitted to an existing vehicle as add-on devices without major engine modifications, although some of the more sophisticated systems that require careful control of engine parameters may be more challenging.

Because of the uncertainty at this time in how and when such programs may be implemented, our analysis for today's rule does not calculate any benefits from them. Nevertheless, we believe that this program can enable the viability of these retrofit technologies. We expect that large emission benefits from the existing fleet could be realized as a result of the fuel changes we are finalizing here, combined with retrofit versions of the technologies that will be developed in response to the finalized engine standards. These benefits will be especially important in the early years of the program when new vehicles standards are just beginning to have an impact, and when States and local areas need to gain large reductions to attain air quality goals.

8. Actions In Other Countries

There is substantial activity taking place in many countries related to the regulation of diesel fuel and engines. The large light-duty vehicle market share enjoyed by diesels in many European countries has helped to stir innovation in dealing with diesel emissions problems. Advanced emissions control technologies are being evaluated there in the in-use fleet and experience gained from these trials is helping to inform the diesel emissions control discussion in the U.S. In addition, several European countries have low sulfur diesel fuel, with maximum sulfur levels varying from 10 to 50 ppm, and so experience gained from the use of these fuels, though not completely transferable to the U.S. situation, also provides valuable experience. European Union countries will limit sulfur in diesel fuel to 50 ppm by 2005, and even more aggressive plans are being discussed or implemented. The United Kingdom made a rapid conversion to 50 ppm maximum sulfur diesel fuel in 1999 by offering tax incentives. This change occurred with much smaller refinery investments than had been predicted, and some refinery production there is actually at levels well below the 50 ppm cap. Germany is moving forward with plans to introduce a 10 ppm sulfur cap for diesel fuel by 2003, also via tax incentives, and is attempting to get the 50 ppm specification that was adopted by the European Commission revised downward to the 10 ppm cap level. The Commission is reviewing the implications of moving to this level.

One European country has had extensive experience with the transition to low sulfur diesel fuel. In the early 1990's, Sweden decided to take advantage of the environmental benefits of 10 ppm sulfur/low aromatics fuel by introducing it with a reduction in the diesel fuel tax. The program has been quite successful, and in excess of 90 percent of the highway diesel fuel used there is of this 10 ppm maximum sulfur class.[9]

The government of Canada has expressed its intent to harmonize its fuel regulations with the U.S. fuels standards being adopted today.[10] This would simplify the operation of new-technology vehicles that cross the U.S-Canada border. However, the success of the U.S. program does not depend on harmonized diesel fuel standards, and Section VI.H discusses how differences between the future fuel specifications in the U.S. and those in Canada and Mexico may be accommodated.

II. The Air Quality Need and Projected Benefits

A. Overview

Heavy-duty vehicle emissions contribute to air pollution with a wide range of adverse health and welfare impacts. Emissions of VOC, CO, NO_X, SO_x, and PM from HD vehicles contribute a substantial percentage of the precursors or direct components of ambient concentrations of ozone, PM, sulfur and nitrogen compounds, aldehydes, and substances known or considered likely to be carcinogens. Emissions of VOCs include some specific substances known or suspected to cause cancer. Of particular concern is human epidemiological evidence linking diesel exhaust to an increased risk of lung cancer, and the Agency is also concerned about the noncancer health effects of diesel exhaust We have finalized on December 20, 2000 a rule which lists diesel particulate matter and diesel exhaust organic gases as a mobile source air toxic under section 202(l) of the Clean Air Act, and the particulate matter standard finalized today reflects the greatest degree of emissions reductions achievable under section 202(l) for on-highway heavy-duty vehicle PM emissions. Heavy-duty vehicle emissions also cause adverse environmental effects including visibility reductions, acid rain, nitrification and eutrophication of water bodies.

Emissions from heavy-duty vehicles, which are predominantly diesel-powered, account for substantial portions of the country's ambient PM and ground-level ozone levels. By 2007, we estimate that heavy-duty vehicles will account for 28 percent of mobile source NO_X emissions (including highway and non-road), and 20 percent of mobile source PM emissions. These proportions are even higher in some urban areas, such as Atlanta and Los Angeles. Urban areas, which include many poorer neighborhoods, can be disproportionately impacted by HDV emissions because of heavy traffic in and out of densely populated urban areas.

The Agency developed new emissions inventories and conducted new air quality modeling for this rule to determine the risk of exposure to unhealthy ambient concentrations of ozone and particulate matter in 2007, 2020 and 2030. This analysis, supplemented with local air quality modeling and other information on emissions and air quality trends, indicates that an appreciable number of the 45 areas with a total population of 128 million people face a significant risk of violating the 1-hour ozone standard between 2007 and 2030. Ten PM_{10} nonattainment areas with 28 million people face a significant risk of experiencing particulate matter levels that violate the PM_{10} standard during the same period.

Under the mandates and authorities in the Clean Air Act, federal, state, and local governments are working to bring ozone and particulate levels into compliance with the 1-hour ozone and PM_{10} NAAQS through SIP attainment plans. Areas that reach attainment without reductions from this rule are likely to need additional reductions to ensure that future air quality continues to achieve ozone and PM standards, and areas that seek redesignation to attainment may use the reductions from this rule in future maintenance plans.

The heavy-duty vehicle and engine emission standards, along with the diesel fuel sulfur standard finalized today, will have a dramatic impact in

[9] Memo from Thomas M. Baines to Docket A–99–06, October 29, 1999, Docket #A–99–06, Item II–G–12.

[10] "Process Begins to Develop Long term Agenda to Reduce Air Pollution from Vehicles and Fuels", Environment Canada press release, May 26, 2000.

reducing the large contribution of HDVs to air pollution. These standards will result in substantial benefits to public health and welfare through significant annual reductions in emissions of NO_X, PM, NMHC, carbon monoxide, sulfur dioxide, and air toxics. For example, we project a 1.8 million ton reduction in NO_X emissions from HD vehicles in 2020, which will increase to 2.6 million tons in 2030 when the current HD vehicle fleet is completely replaced with newer HD vehicles that comply with these emission standards. When coupled with the emission reductions projected to result from the Phase 1 (model year 2004) HDV standards, the emission reductions from heavy-duty vehicles are projected to be as large as the substantial reductions the Agency expects from light-duty vehicles as a result of its recently promulgated Tier 2 rulemaking.

In sum, the Agency's air quality modeling and other evidence demonstrates that ambient concentrations of ozone, particulate matter, sulfur and nitrogen compounds, VOCs, air toxics, CO and diesel exhaust are anticipated to endanger public health, welfare and the environment in the time period between 2007 and 2030. Emission reductions expected from today's action are predicted to lessen future ambient concentrations of ozone and particulate matter and associated adverse public health and welfare effects.

B. Public Health and Welfare Concerns

1. Health and Welfare Concerns Raised During Public Hearings

The Agency received a significant number of comments on this section during the public hearings and in written comments from interested parties. Comments are addressed in this section as well as in the Response to Comment document that accompanies this action.

Throughout the five public hearings held around the country on the proposed heavy-duty engine and diesel fuel rule, the Agency received strong public support at each venue for increasing the stringency of heavy-duty truck and bus emission standards, and for further controls on sulfur in diesel fuel, in order to enable the necessary exhaust emission control. In addition to the 55,000 comments received from citizens in support of the Agency proposal to clean diesel fuel by mid-2006 and reduce emissions from diesel engines in 2007, we received 8,500 comments from citizens urging the Agency to act prior to 2007.

Public officials and representatives of environmental, public health, or community-based organizations testified regularly about the link between public health ailments, such as asthma and lung cancer, and air pollution caused by diesel exhaust and particulate matter. In different ways, many noted that the impact of diesel soot is compounded by the fact that it is discharged at street level where people live and breathe. A regular complaint was the close proximity of bus depots, transfer terminals, and heavily-trafficked roadways to homes and apartment buildings, and in particular, to hospitals, playgrounds and schools. A common theme revolved around the notion that since asthma is an incurable disease, it was of utmost importance to help reduce the severity and frequency of attacks by reducing environmental triggers such as ozone, particulate matter and diesel exhaust.

Major industries represented during these public hearings were the heavy-duty vehicle engine manufacturers, the oil industry, and the commercial truckers. While each had a different perspective, most supported the underlying intent of the proposal to improve public health and welfare, and some also supported the specific requirements as proposed. For those who objected to the proposal, the main thrust of their concerns related to the stringency and public health necessity of the new standards and the diesel fuel sulfur requirement. Largely in their written comments, these industries raised questions about the need for additional reductions in order to meet existing ozone and PM national ambient air quality standards and took exception with the Agency's characterization of diesel exhaust as a human carcinogen at environmental levels of exposure. Some industry commenters also challenged the Agency's reliance on public welfare and environmental effects such as visibility impairment and eutrophication of water bodies because the Agency had insufficiently quantified the benefits that would result from new standards on heavy-duty vehicles and diesel fuel.

The following subsections present the available information on the air pollution situation that is likely to exist without this rule for each ambient pollutant. We also present information on the improvement that is expected to result from this rule.

2. Ozone and Its Precursors

a. Health and Welfare Effects From Short-Term Exposures to Ozone

NO_X and VOC are precursors in the photochemical reaction which forms tropospheric ozone. A large body of evidence shows that ozone can cause harmful respiratory effects including chest pain, coughing, and shortness of breath, which affect people with compromised respiratory systems most severely. When inhaled, ozone can cause acute respiratory problems; aggravate asthma; cause significant temporary decreases in lung function of 15 to over 20 percent in some healthy adults; cause inflammation of lung tissue; produce changes in lung tissue and structure; may increase hospital admissions and emergency room visits; and impair the body's immune system defenses, making people more susceptible to respiratory illnesses. Children and outdoor workers are likely to be exposed to elevated ambient levels of ozone during exercise and, therefore, are at greater risk of experiencing adverse health effects. Beyond its human health effects, ozone has been shown to injure plants, which has the effect of reducing crop yields and reducing productivity in forest ecosystems.

There is strong and convincing evidence that exposure to ozone is associated with exacerbation of asthma-related symptoms. Increases in ozone concentrations in the air have been associated with increases in hospitalization for respiratory causes for individuals with asthma, worsening of symptoms, decrements in lung function and increased medication use. Studies have also indicated that exposure to particulate matter can be associated with altered lung function and increased respiratory symptoms, and asthmatic children are considered to be particularly sensitive to these effects. In addition, exposures to particulate matter or ozone have been shown to have a priming effect for responsiveness to allergens, with the pollutant exposure leading to heightened responses to allergens among allergic asthmatics. It is not believed, based on the current evidence, that exposure to outdoor pollutants such as ozone or particulate matter is a cause of asthma.

Asthma is one of the most common and costly diseases in the United States. According to the President's Task Force on Environmental Health Risks and Safety Risks to Children, America is in the midst of an asthma epidemic.[11]

[11] *Asthma and the Environment: A Strategy to Protect Children, President's Task Force on*

Since 1980, the number of asthma sufferers in the United States has more than doubled from 6.7 million to 17.3 million in 1998.[12] Today, more than 5 percent of the US population has asthma. On average, 15 people died every day from asthma in 1995, and the death rate has nearly tripled since 1975. In 1998, the cost of asthma to the U.S. economy was estimated to be $11.3 billion, with hospitalizations accounting for the single largest portion of the cost.[13] A recent report by the Pew Environmental Health Commission at Johns Hopkins School of Public Health estimates that by 2010, 22 million Americans will suffer from asthma, or one in 14 Americans and one in every five families.[14] At present, asthma cannot be cured, only controlled.

To address this growing public health problem, the President's Task Force on Environmental Health Risks and Safety Risks to Children ranked asthma as its highest priority. The President's Task Force created and charged the Asthma Priority Area Workgroup, co-chaired by EPA and the Department of Health and Human Services, with reviewing current Federal efforts to address the issue, and to make recommendations. In May, 2000, the Task Force issued a strategy that focused on developing a greater understanding of the role environmental factors associated with the onset of asthma; and triggers of asthma. The report found that ''children with asthma have long been recognized as particularly sensitive to outdoor air pollution,'' The report noted that ''25 percent of children in America live in areas that regularly exceed EPA limits for ozone.'' The first guiding principle was to focus efforts to ''eliminate the disproportionate impact of asthma in minority populations and those living in poverty.'' Testimony received during the Agency's five public hearings on this rule contained numerous references and detailed personal accounts as to the severe and sometimes fatal impact of asthma on the lives of American citizens.

b. Current and Future Nonattainment Status With the 1-Hour Ozone NAAQS

Today, ground level ozone remains a pervasive pollution problem in the United States. As of July, 2000, 102 million people (1999 census) lived in 31 metropolitan areas designated nonattainment under the 1-hour ozone NAAQS.[15] This is a sharp decline from the 101 nonattainment areas originally identified under the Clean Air Act Amendments of 1990, but elevated ozone concentrations remain a serious public health concern throughout the nation.

Over the last decade, declines in ozone levels were found mostly in urban areas, where emissions are heavily influenced by controls on mobile sources and their fuels.[16] Twenty-three metropolitan areas have realized a decline in ozone levels since 1989, but at the same time, ozone levels in 11 metropolitan areas with 7 million people have increased.[17] Regionally, California and the Northeast have recorded significant reductions in peak ozone levels, while four other regions (the Mid-Atlantic, the Southeast, the Central and Pacific Northwest) have seen ozone levels increase.

The highest ambient concentrations are currently found in suburban areas, consistent with downwind transport of emissions from urban centers. Concentrations in rural areas have risen to the levels previously found only in cities. Over the last decade, ozone levels at 17 of our National Parks have increased, and in 1998, ozone levels in two parks were 30 to 40 percent higher than the ozone NAAQS.

i. Results of Photochemical Ozone Modeling and Analysis of Emissions Inventories

In conjunction with this rulemaking, the Agency performed ozone air quality modeling for nearly the entire Eastern U.S covering metropolitan areas from Texas to the Northeast.[18] This ozone air quality modeling was based upon the same modeling system as was used in the Tier 2 air quality analysis, with the addition of updated inventory estimates for 2007 and 2030.[19] This modeling supports the conclusion that there is a broad set of areas with predicted ozone concentrations in 2007 and 2030 at or above 0.125 ppm, in the baseline scenarios without additional emission reductions. EPA established the 1-hour standard at 0.12 parts per million (ppm) daily maximum 1-hour average concentration not to be exceeded more than once per year on average. Compliance with the 1-hour standard is judged on the basis of the most recent three years of ambient air quality monitoring data.

We have compared and supplemented our own ozone modeling with other modeling studies, submitted to us as state implementation plan (SIP) revisions, or brought to our attention through our consultations with states on SIP revisions that are in development. The ozone modeling in the SIP revisions has the advantage of using emission inventories that are more specific to the area being modeled, and of using meteorological conditions selected specifically for each area. Also, the SIP revisions included other evidence and analysis, such as analysis of air quality and emissions trends, observation-based models that make use of data on concentrations of ozone precursors, alternative rollback analyses, and information on the responsiveness of the air quality model. For some areas, we decided that the predictions of 1-hour ozone exceedances from our modeling were less reliable than conclusions that could be drawn from this additional evidence and analysis. For example, in some areas our episodes did not capture the meteorological conditions that have caused high ozone, while local modeling did so. Thus, these local analyses are considered to be more extensive than our own modeling for estimating whether there would be NAAQS nonattainment without further emission reductions, when interpreted by a weight of evidence method which meets our guidance for such modeling.

Photochemical ozone modeling conducted for this rulemaking was based in part on updated national emissions inventories for all sources. National emission trends for NO_X

Environmental Health Risks and Safety Risks to Children, January 28, 1999, Revised May, 2000.

[12] *Asthma Prevention Program of the National Center for Environmental Health,* Centers for Disease Control and Prevention, ''At-A-Glance, 1999; Centers for Disease Control and Prevention, CDC, *Surveillance for Asthma—United States, 1960–1995,*'' MMWR 47 (No. SS-1) (April 1998).

[13] Asthma Statistics, National Institutes of Health, National, Heart, Lung, and Blood Institute, January, 1999.

[14] *Attack Asthma: Why America Needs A Public Health Defense System to Battle Environmental Threats,* Pew Environmental Health Commissions at the Johns Hopkins School of Public Health, June, 2000.

[15] Memorandum to Air Docket, September 18, 2000. Information on ozone nonattainment areas and populations as of July 31, 2000 from US EPA website www.epa.gov/airs/nonattn.html, USA Air Quality Nonattainment Areas, Office of Air Quality Planning and Standards.

[16] National Emissions Trends database.

[17] National Air Quality and Emissions Trends Report, 1998, March, 2000, at 28.

[18] EPA also performed ozone air quality modeling for the western United States but, as described further in the air quality technical support document, model predictions were well below corresponding ambient concentrations. Because of poor model performance for this region of the country, the results of western ozone modeling were not relied on for this rule.

[19] Consistent with a commitment expressed in the proposal, the Agency released the emissions inventory inputs for, and a description of, ozone modeling into the public record (docket number A–99–06), and also onto a website developed expressly for this purpose, on a continuous basis as they were developed. Further discussion of this modeling, including evaluations of model performance relative to predicted future air quality, is provided in the air quality modeling Technical Support Document (TSD).

predict a significant decline from 1996 to 2007, a leveling off of the downward trend between 2007 to 2020, and an increase in NO_X inventories from 2020 to 2030. By 2030, national NO_X levels are estimated to reach levels that are within ten percent of 2007 levels. Predictions of national VOC emissions indicate a reduction from 1996 to 2007, followed by an increase between 2007 and 2030 resulting in 2030 levels that are estimated to be 10 percent greater than VOC emissions levels in 2007. In metropolitan ozone nonattainment areas, such as Charleston, Chicago and Houston, NO_X or VOC emissions in 2030 are predicted to reach or exceed 2007 levels. These estimated national and metropolitan area emissions inventories of ozone precursors are consistent with the conclusions reached by analysis of ozone modeling conducted for this rule that additional reductions are needed in order to enable areas to reach and maintain attainment of the ozone standard between 2007 and 2030.

The Agency conducted ozone modeling based on inventories developed with and without reductions from this rulemaking for three future years: 2007, 2020 and 2030. The year 2007 was chosen because it is also the first year of implementation for the new standards adopted in today's action. It is also the year that nine major urban areas with a history of persistent and elevated ozone concentrations must demonstrate attainment, and is also relevant to the South Coast Air Basin of California (South Coast) with an attainment date of 2010. In addition, modeling was performed for 2030 when the full benefits of the rule are expected to be realized and for 2020 which represents an intermediate year between the start of the program and full turnover of the affected vehicle fleet. The year 2020 is also representative of the period when areas that have come into attainment may need additional reductions in order to maintain the standard.

Today's rule will provide a substantial reduction in emissions of ozone precursors, particularly NO_X. These emissions reductions will greatly lower ozone concentrations which will help federal and State efforts to bring about attainment of the current 1-hour ozone standard. As described in the Air Quality Modeling Technical Support Document for this rule, EPA performed regional scale ozone modeling for the Eastern U.S. to assess the impacts of the controls in this rule on predicted 1-hour ozone exceedances. The results of this modeling were examined for those 37 areas in the East for which EPA's modeling predicted exceedances in 2007, 2020 and/or 2030 and current 1-hour design values are above the standard or within 10 percent of the standard. The results for these areas combined indicate that there will be substantial reductions in the number of exceedances and the magnitude of high ozone concentrations in both 2020 and 2030 due to this rule. The modeling also indicates that without the rule, exceedances would otherwise increase by 37 percent between 2020 and 2030 as growth in emissions offsets the reductions from Tier 2 and other current control programs.

For all areas combined, the rule is forecast to provide a 33 percent reduction in exceedances in 2020 and a 38 percent reduction in 2030. The total amount of ozone above the standard is expected to decline by nearly 37 percent in 2020 and 44 percent in 2030. Also, daily maximum ozone exceedances are lowered by 5 ppb on average in 2020 and nearly 7 ppb in 2030. The modeling forecasts an overall net reduction of 39 percent in exceedances from 2007, which is close to the start of this program, to 2030 when controls will be fully in place. In addition, the results for each individual area indicates that all areas are expected to have fewer exceedances in 2030 with the HDV controls than without this rule.

During the public comment period on the proposed rule, EPA received several comments that expressed concern about potential increases in ozone that might result from this rule. As indicated above, the air quality modeling results indicate an overall reduction in ozone levels in 2007 and 2030 during the various episodes modeled. Examining individual areas, nearly the entire country is projected to benefit substantially from the reductions in this rule.[20] There is a metropolitan area that EPA modeled as having exceedances with the one-hour ozone standard under baseline conditions in 2007 through 2030, which the Agency's modeling for the HDV rule estimated could have less than a 3 percent increase in its peak ozone levels in 2020 and 2030 and small net increase (i.e., less than 1 ppb) in levels above the 1-hour standard in 2030. However, EPA's air quality modeling did not predict an increase in the number of exceedances in this CMSA/MSA in 2020 and a decrease in exceedances occurred in 2030. In another CMSA/MSA in another State, in 2030 there was less than a one percent increase in the summer peak level. Yet, this area had fewer exceedances and lower ozone above the 1-hour standard in both 2020 and 2030 under the rule. EPA expects that the States will have State Implementation Plans that will consider federal controls and complement them with State actions to provide attainment and will work with the States to ensure this occurs.

Considering all of EPA's air quality modeling results, it is clear that the significant ozone reductions from this rule outweigh the limited ozone increases that may occur in the future assuming no additional reductions from federal or local controls. Additional details on this are provided in the Response to Comments document and in EPA's Heavy Duty Rule Air Quality Modeling Technical Support Document. Furthermore, EPA's Regulatory Impact Analysis for this rule shows significant health and welfare benefits occurring from the ozone reductions that the rule provides (see details on the benefits in Section V.F.5 of the preamble and Chapter VII of the RIA).

ii. Areas At Risk of Exceeding the 1-Hour Ozone Standard in the Future

This section presents the Agency's conclusions about the risk of future nonattainment for 45 areas listed in Table II.B–1 based on photochemical ozone modeling conducted for this rule and other evidence such as local air quality modeling.[21] The areas listed in Table II.B–1 are separated into two broad groups: (1) Those areas with attainment dates in 2007 or 2010 that will benefit from reductions from this rule to attain and maintain the standard; and (2) those areas with attainment dates prior to 2007 that will benefit from reductions from this rule to maintain the standard after their attainment dates. Because ozone concentrations causing violations of the 1-hour ozone standard are well established to endanger public health and welfare, this indicates that it is appropriate for the Agency to set new standards for heavy-duty vehicles. The following discussion follows these groupings from top to bottom. A more detailed discussion is found in the Regulatory Impact Analysis (RIA).

Ten metropolitan areas contained within designated ozone nonattainment areas have statutorily-defined attainment dates of 2007 or 2010, or

[20] The air quality modeling was performed for the Eastern region of the United States, but EPA also expects the rule to benefit nonattainment areas throughout the entire nation, including California.

[21] In the proposal, we relied on photochemical ozone modeling performed for recently promulgated standards on light duty vehicles, or Tier 2. The results presented in this final rulemaking for heavy-duty vehicles and diesel fuel are largely consistent with the findings presented in the proposal, with small differences due to updated emissions inventories. As stated in the proposal, the ozone modeling methodologies used in the proposal and presented here in the final rule are identical.

have requested attainment date extensions to 2007. These 10 areas are listed at the top of Table II.B–1, and are New York City, Houston, Hartford, New London, Chicago, Milwaukee, Dallas, Beaumont-Port Arthur, Los Angeles, and Southeast Desert.

Each of these areas needs additional emission reductions in order to reach attainment by 2007, and to maintain the standards in the future. Some of these areas have emission reduction shortfalls that are identified in their attainment demonstrations (*i.e.,* South Coast Air Basin, New York and Houston), and reductions from this rule will assist State efforts to reach attainment.[22] Three other areas—Southeast Desert, Hartford, New London—are subject to ozone transport from upwind areas with identified shortfalls (South Coast and New York), and depend upon attainment from these upwind areas to reach attainment themselves. We have received attainment plans for two areas in Texas (Dallas and Beaumont-Port Arthur), and the Agency is likely to consider the reductions from this rule in its proposed approval of these attainment plans in **Federal Register** notices. Finally, there are two areas in the Midwest—Chicago and Milwaukee—that have incorporated reductions from this rule into their regional ozone modeling, and plan to rely on reductions from this rule to support their 2007 attainment demonstration.[23]

For all ten areas, even if all shortfalls were filled by the States, there is some risk that at least some of the areas will not attain the standards by their attainment dates of 2007, or 2010 for Los Angeles. In that event, the reductions associated with this program, which increase substantially after 2007, will help assure that any residual failures to attain are remedied. Finally, there is also some risk that the areas will be unable to maintain attainment after 2007. Considered collectively, there is a significant risk that some areas will not be in attainment throughout the period when the new standards will reduce heavy-duty vehicle emissions.

The rest of the areas have required attainment dates prior to 2007, or have no attainment date but are subject to a general obligation to have a SIP that provides for attainment and maintenance. These 34 areas, according to our modeling, are at risk of exceeding the ozone NAAQS between 2007 and 2030. These areas will be able to rely on reductions from this rule to continue to maintain the standard after attainment is reached, and will be able to take credit for this program in their maintenance plans when they seek redesignation to attainment of the ozone standard. If any of these areas reach attainment, and then fall back into nonattainment, or fail to reach attainment by 2007, reductions from this rule will assist these areas in achieving the ozone standard. If an area does not choose to seek redesignation, the continuing reductions from this rulemaking will help ensure maintenance (*i.e.,* prevent future exceedances) with the 1-hour standard after initial attainment is reached.

Areas with attainment dates prior to 2007 are presented in two groupings in the table at the end of this section: a group of 20 areas in the middle of Table II.B–1, and a group of 15 areas at the bottom of Table II.B–1. For the middle group of 20 areas, EPA and the States are pursuing the established statutory processes for attaining and maintaining the ozone standard, or have already redesignated these areas to attainment with a maintenance plan (*e.g.,* Cincinnati). EPA has re-instated the 1-hour ozone standard to some of these areas, restoring the applicability of these processes to them. The Agency believes that there is a significant risk that future air quality in a number of these areas will exceed the ozone standard at some time in the 2007 and later period. This belief is based on three factors: (1) Recent exceedances in 1997–1999, (2) predicted exceedances in 2007, 2020 or 2030 after accounting for existing mobile source requirements and other local or regional controls currently in place or required, and (3) our assessment of the magnitude of recent violations, the year-to-year variability of meteorological conditions conducive to ozone formation, transport from areas with later attainment dates, and other variables inherent in predicting future attainment such as the potential for some areas to experience unexpectedly high economic growth rates, growth in vehicle miles traveled, varying population growth from area to area, and differences in vehicle choice.

Only a subset of these 20 areas have yet adopted specific control measures that have allowed the Agency to fully approve an attainment plan. For some of these areas, we have proposed a finding, based on all the available evidence, that the area will attain by its applicable attainment date. We have approved a 10-year maintenance plan for Cincinnati, OH from 1999 to 2009. However, in many cases, these proposals depend on the State adopting additional emission reduction measures. The RIA provides more information on our recent proposals on attainment demonstrations and maintenance plans.[24] Until the SIPs for these areas are actually submitted, reviewed and approved by EPA, there is some risk that these areas will not adopt fully approvable SIPs.

Finally, there are 15 additional metropolitan areas for which the available ozone modeling and other evidence is less clear regarding the need for additional reductions (see Table II.B–1). Our ozone modeling predicted these areas to need further reductions to avoid exceedances in 2007, 2020 or 2030. The recent air quality monitoring data for these areas shows ozone levels with less than a 10 percent margin below the NAAQS. We believe there is a risk that future ozone levels will be above the NAAQS because of the year-to-year variability of meteorological conditions conducive to ozone formation, or because local emissions inventories may increase faster than national inventories.

iii. Conclusion

In sum, without these reductions, there is a significant risk that an appreciable number of the 45 areas, with a population of 128 million people in 1999, will violate the 1-hour ozone standard during the time period when these standards will apply to heavy-duty vehicles. The evidence summarized in this section, and presented in more detail in the air quality modeling TSD and the RIA, supports the Agency's belief that emissions of NO_X and VOC from heavy-duty vehicles in 2007 and later will contribute to a national ozone air pollution problem that warrants regulatory action under section 202(a)(3) of the Act.

[22] The South Coast's "additional measures" which rely on new technologies, are located in its 1994 SIP.

[23] Technical Support Document, Midwest Subregional Modeling: 1-Hour Attainment Demonstration for Lake Michigan Area and Emissions Inventory, Illinois Environmental Protection Agency, Indiana Department of Environmental Management, Michigan Department of Environmental Quality, Wisconsin Department of Natural Resources, September 27, 2000, at 14 and at 8.

[24] We have recently proposed favorable action, in some cases with a condition that more emission reductions be obtained, on attainment demonstrations in these areas with attainment dates prior to 2007: Philadelphia, Washington-Baltimore, Atlanta, and St. Louis.

TABLE II.B–1 [a]

[Areas and 1999 Populations at Risk of Exceeding the Ozone Standard between 2007 and 2030]

MSA/CMSA/State	1999 Population (in millions)
Areas with 2007/2010 Attainment Dates (Established or Requested)	
Beaumont-Port Arthur, TX	0.4
Chicago-Gary-Kenosha, IL–IN–WI	8.9
Dallas-Fort Worth, TX	4.9
Hartford, CT	1.1
Houston-Galveston-Brazoria, TX	4.5
Los Angeles-Riverside-Orange County, CA	16.0
Milwaukee-Racine, WI	1.6
New London-Norwich, CT–RI	0.3
New York-Northern New Jersey-Long Island, NY–NJ–CT–PA	20.2
Southeast Desert, CA	0.5
10 areas	58.4
Areas with Pre-2007 Attainment Dates or No Specific Attainment Date, with a Recent History of Nonattainment.	
Atlanta, GA	3.9
Baton Rouge, LA	0.6
Birmingham, AL	0.9
Boston-Worcester-Lawrence, MA–HN–ME–CT	5.7
Charlotte-Gastonia-Rock Hill, NC–SC	1.4
Detroit-Ann Arbor-Flint, MI MSA	5.5
Huntington-Ashland, WV–KY–OH	0.3
Louisville, KY–IN	1.0
Macon, GA MSA	0.3
Memphis, TN–AR–MS	1.1
Nashville, TN	1.2
Philadelphia-Wilmington-Atlantic City, PA–NJ–DE–MD	6
Richmond-Petersburg, VA	1
Sacramento-Yolo, CA	1.7
San Diego, CA	2.8
San Francisco-Oakland-San Jose, CA	6.9
San Joaquin Valley, CA	3.2
St. Louis, MO–IL	2.6
Ventura County, CA	0.7
Washington, DC—Baltimore, DC, MD, VA MSA	7.4
20 Areas	54.2
Areas with Pre-2007 Attainment Dates and Recent Concentrations within 10 percent of an Exceedance.	
Barnstable-Yarmouth, MA	0.2
Benton Harbor, MI	0.2
Biloxi-Gulfport-Pascagoula, MS MSA	0.4
Charleston, WV MSA	0.3
Cincinnati-Hamilton, OH–KY–IN	2.0
Cleveland-Akron, OH CMSA	2.9
Grand Rapids-Muskegon-Holland, MI MSA	1.1
Houma, LA	0.2
Lake Charles, LA	0.2
New Orleans, LA MSA	1.3
Norfolk-Virginia Beach-Newport News, VA–NC MSA	1.6
Orlando, FL MSA	1.5
Pensacola, FL MSA	0.4
Providence-Fall River-Warwick, RI–MA	1.1
Tampa-St. Petersburg-Clearwater, FL MSA	2.3
15 areas	15.7
Total Areas: 45	Population: 128

[a] In order to determine the reliability of model predictions the Agency ran the ozone model for current ozone concentrations and compared those predictions with actual ozone levels recorded by ozone monitors. The results of the model's performance are presented in the RIA for this rule.

c. Public Health and Welfare Concerns from Prolonged and Repeated Exposures to Ozone

A large body of scientific literature regarding health and welfare effects of ozone has associated health effects with certain patterns of ozone exposures that do not necessarily include any hourly ozone concentration above the 0.12 parts per million (ppm) level of the 1-hour NAAQS. The science indicates that there are health effects attributable to prolonged and repeated exposures to lower ozone concentrations. Studies of 6 to 8 hour exposures showed health effects from prolonged and repeated exposures at moderate levels of exertion to ozone concentrations as low as 0.08 ppm. Prolonged and repeated ozone concentrations at these levels are common in areas throughout the country, and are found in areas that are exceeding, and areas that are not exceeding, the 1-hour ozone standard. For example, 153 million people, or 87 percent of the total population in counties evaluated (176 million), lived in areas with 2 or more days with concentrations of 0.09 ppm or higher in 1998, including areas currently violating the 1-hour NAAQS. In the 2007, before the application of emission reductions resulting from this rule, we estimated that 116 million, or 93 percent of the total population considered in the analysis, are predicted to live in areas with at least 2 days with model-adjusted 8-hour average concentrations of 0.08 ppm or higher. By 2030, the number of people (139 million) and the relative percentage (91 percent) of the total population considered in the analysis is projected to grow significantly without reductions from this rule. Since prolonged exposures at moderate levels of ozone are more widespread than exceedances of the 1-hour ozone standard, and given the continuing nature of the 1-hour ozone problem described above, adverse health effects from this type of ozone exposure can reasonably be anticipated to occur in the future in the absence of this rule. Adverse welfare effects can also be anticipated, primarily from damage to vegetation. See the RIA for further details.

Studies of acute health effects have shown transient pulmonary function responses, transient respiratory symptoms, effects on exercise performance, increased airway responsiveness, increased susceptibility to respiratory infection, increased hospital and emergency room visits, and transient pulmonary respiratory inflammation. Such acute health effects have been observed following prolonged exposures at moderate levels of exertion at concentrations of ozone well below the current standard of 0.12 ppm. The effects are more pronounced at concentrations above 0.09 ppm, affecting more subjects or having a greater effect on a given subject in terms of functional changes or symptoms. A more detailed discussion may be found in the RIA.

With regard to chronic health effects, the collective data have many ambiguities, but provide suggestive evidence of chronic effects in humans. There is a biologically plausible basis for considering the possibility that repeated inflammation associated with exposure to ozone over a lifetime, as can occur with prolonged exposure to moderate ozone levels below peak levels, may result in sufficient damage to respiratory tissue that individuals later in life may experience a reduced quality of life, although such relationships remain highly uncertain.

Ozone has many welfare effects, with damage to plants being of most concern. Plant damage affects crop yields, forestry production, and ornamentals. The adverse effect of ozone on forests and other natural vegetation can in turn cause damage to associated ecosystems, with additional resulting economic losses, as well as aesthetic impacts which may not be fully quantifiable in economic terms. Ozone concentrations of 0.10 ppm can be phytotoxic to a large number of plant species, and can produce acute injury and reduced crop yield and biomass production. Ozone concentrations at or below 0.10 ppm have the potential over a longer duration of creating chronic stress on vegetation that can result in reduced plant growth and yield, shifts in competitive advantages in mixed populations, decreased vigor, and injury from other environmental stresses.

Section 202(a) provides EPA with authority to promulgate standards applicable to motor vehicle emissions that ''in the Administrator's judgment, cause or contribute to air pollution reasonably anticipated to endanger public health and welfare.'' The evidence in the RIA regarding the occurrence of adverse health effects due to prolonged and repeated exposure to ozone concentrations in the range discussed above, and regarding the populations that are expected to receive exposures at these levels, along with the welfare effects described above, supports a conclusion that emissions of NO_X and VOC from heavy-duty vehicles in 2007 and later will be contributing to a national air pollution problem that warrants regulatory action under section 202(a) of the Act.

3. Particulate Matter

a. Health and Welfare Effects

Particulate matter (PM) represents a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. All particles equal to and less than 10 microns are called PM_{10}. Fine particles can be generally defined as those particles with an aerodynamic diameter of 2.5 microns or less (also known as $PM_{2.5}$), and coarse fraction particles are those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns. The health and environmental effects of PM are strongly related to the size of the particles.

The emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters of fine and coarse particles are distinct. Fine particles are directly emitted from combustion sources and are formed secondarily from gaseous precursors such as sulfur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulfate, nitrate, chloride and ammonium compounds; organic and elemental carbon; and metals. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. In contrast, coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometers, while coarse particles deposit to the earth within minutes to hours and within tens of kilometers from the emission source.

Diesel particles are a component of both coarse and fine PM, but fall mostly in the fine and ultrafine size range.[25] Diesel PM contains small quantities of numerous mutagenic and carcinogenic compounds. While representing a very small portion (less than one percent) of the national emissions of metals, and a small portion of diesel particulate matter (one to five percent), we note that several toxic trace metals of potential

[25] Fine particulate matter includes particles with a diameter less than 2.5 micrometers. Ultrafine particulate matter include particles with a diameter less than 100 nanometers.

toxicological significance are also emitted by diesel engines including chromium, manganese, mercury and nickel. In addition, small amounts of dioxins have been measured in diesel exhaust, some of which may partition into the particle phase, though the impact of these emissions on human health is not clear.

Particulate matter, like ozone, has been linked to a range of serious respiratory health problems. Scientific studies suggest a likely causal role of ambient particulate matter (which is attributable to a number of sources including diesel) in contributing to a series of health effects. The key health effects categories associated with ambient particulate matter include premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days), aggravated asthma, acute respiratory symptoms, including aggravated coughing and difficult or painful breathing, chronic bronchitis, and decreased lung function that can be experienced as shortness of breath. Observable human noncancer health effects associated with exposure to diesel PM include some of the same health effects reported for ambient PM such as respiratory symptoms (cough, labored breathing, chest tightness, wheezing), and chronic respiratory disease (cough, phlegm, chronic bronchitis and suggestive evidence for decreases in pulmonary function). Symptoms of immunological effects such as wheezing and increased allergenicity are also seen. Studies in rodents, especially rats, show the potential for human inflammatory effects in the lung and consequential lung tissue damage from chronic diesel exhaust inhalation exposure. Both fine and coarse particles can accumulate in the respiratory system. Exposure to fine particles is most closely associated with such health effects as premature mortality or hospital admissions for cardiopulmonary disease. For additional information on health effects, see the RIA. PM also causes damage to materials and soiling of commonly used building materials and culturally important items such as statutes and works of art. It is a major cause of substantial visibility impairment in many parts of the U.S.

Heavy-duty vehicles contribute to particle formation through a number of pollutants. The contribution to PM fine varies by region of the country. Sulfate plays a major role in the composition of fine particulate across the country, but typically makes up over half the fine particles found in the Eastern United States. Organic carbon accounts for a large portion of fine particle mass, with a slightly higher fraction in the west. Diesel engines are the principal source of elemental carbon, which makes up about 5–6 percent of particle mass. Nationally, nitrate plays a relatively small role in the make up of fine particles, but ammonium nitrate plays a far larger role in southern California. Ammonium nitrate–formed secondarily from NO_X and ammonia emissions—is one of the most significant components of particulate matter pollution in California. During some of the worst episodes of elevated particle levels in the South Coast, ammonium nitrate can account for about 65–75 percent of the $PM_{2.5}$ mass. Reducing ammonium nitrate through controls on NO_X sources is a critical part of California's particulate matter strategy. Nationally, the standards finalized in this rule will significantly reduce HDV emissions of SO_X, NO_X, VOCs and elemental carbon, and thus contribute to reductions in ambient concentrations of PM_{10} and $PM_{2.5}$.

b. Attainment and Maintenance of the PM_{10} NAAQS

Under the CAA, we are to regulate HDV emissions if they contribute to air pollution that can reasonably be anticipated to endanger public health and welfare. We have already addressed the question of what concentration patterns of PM endanger public health, in setting the NAAQS for PM_{10} in 1987. The PM NAAQS were revised in 1997, largely by adding new standards for fine particles ($PM_{2.5}$) and modifying the form of the daily PM_{10} standard. On judicial review, the revised standards were remanded for further proceedings, and the revised PM_{10} standards were vacated. The Supreme Court is currently reviewing that decision. Oral arguments were held on November 7, 2000 and a decision by the Court is expected in 2001. Pending final resolution of the litigation, the 1987 PM_{10} standard is the applicable NAAQS for PM_{10}.

Commenters questioned the need for additional PM_{10} reductions in order to achieve attainment with the PM_{10} NAAQS, and questioned the Agency's statement that, unlike ozone, PM_{10} emissions are projected to increase in the future. Commenters are correct that significant progress has occurred over the last decade,[26] but the Agency's statement was based on projected PM_{10} inventory increases in the future between 1996 and 2030. During this period, inventory trends for current PM_{10} nonattainment areas, or those with concentrations within 10 percent of the standard, are predicted to increase significantly. For example, from 1996 to 2030, increases are predicted in Clark County (Las Vegas) of 41 percent, Harris County (Houston) of 37 percent, and Phoenix of 24 percent. A more detailed discussion is provided in the RIA.

i. Current PM_{10} Nonattainment

The most recent PM_{10} monitoring data indicates that 14 designated PM_{10} nonattainment areas with a projected population of 23 million violated the PM_{10} NAAQS in the period 1997–1999. Table II.B–3 lists the 14 areas, and also indicates the PM_{10} nonattainment classification and 1999 projected population for each PM_{10} nonattainment area. The projected population in 1999 was based on 1990 population figures which were then increased by the amount of population growth in the relevant county from 1990 to 1999.

TABLE II.B–3.—PM_{10} NONATTAINMENT AREAS VIOLATING THE PM_{10} NAAQS IN 1997–99

Area	Classification	1999 Population (projected, in millions)
Hayden/Miami, AZ	Moderate	0.004
Phoenix, AZ	Serious	2.977
Nogales, AZ	Moderate	0.025
San Joaquin Valley, CA	Serious	3.214
Imperial Valley, CA	Moderate	0.122

[26] Ambient concentrations of PM_{10} and PM_{10} emissions have declined over the last ten years by 25 percent and 19 percent, respectively. National Air Quality and Emissions Trends Report, 1998, US EPA, March, 2000.

TABLE II.B–3.—PM_{10} NONATTAINMENT AREAS VIOLATING THE PM_{10} NAAQS IN 1997–99—Continued

Area	Classification	1999 Population (projected, in millions)
Owens Valley, CA	Serious	0.018
Searles Valley, CA	Moderate	0.029
Coachella Valley, CA	Serious	0.239
South Coast Air Basin	Serious	14.352
Las Vegas, NV	Serious	1.200
Reno, NV	Moderate	0.320
Anthony, NM [b]	Moderate	0.003
El Paso, TX [a]	Moderate	0.611
Wallula, WA [b]	Moderate	0.052
Total Areas: 14		23.167

[a] EPA has determined that continuing PM_{10} nonattainment in El Paso, TX is attributable to international transport under section 179(B).
[b] The violation in this area has been determined to be attributable to natural events under section 188(f) of the Act.

In addition to the 14 PM_{10} nonattainment areas that are currently violating the PM_{10} NAAQS, there are 25 unclassifiable areas that have recently recorded ambient concentrations of PM_{10} above the PM_{10} NAAQS. EPA adopted a policy in 1996 that allows areas with PM_{10} exceedances that are attributable to natural events to retain their designation as unclassifiable if the State is taking all reasonable measures to safeguard public health regardless of the sources of PM_{10} emissions. Areas that remain unclassifiable areas are not required under the Clean Air Act to submit attainment plans, but we work with each of these areas to understand the nature of the PM_{10} problem and to determine what best can be done to reduce it. With respect to the monitored violations reported in 1997–99 in the 25 areas designated as unclassifiable, we have not yet excluded the possibility that factors such as a one-time monitoring upset or natural events, which ordinarily would not result in an area being designated as nonattainment for PM_{10}, may be responsible for the problem. Emission reductions from today's action will assist these currently unclassifiable areas to achieve ambient PM_{10} concentrations below the current PM_{10} NAAQS.

ii. Risk of Future Exceedances of the PM_{10} Standard

The new standards for heavy-duty vehicles will benefit public health and welfare through reductions in direct diesel particles and NO_X, VOCs, and SO_X which contribute to secondary formation of particulate matter. Because ambient particle concentrations causing violations of the PM_{10} standard are well established to endanger public health and welfare, this information supports the new standards for heavy-duty vehicles. The reductions from today's rule will assist States as they work with the Agency through implementation of local controls including development and adoption of additional controls as needed to move their areas into attainment by the applicable deadline, and maintain the standards thereafter.

The Agency's PM inventory analysis performed for this rulemaking predicts that without additional reductions 10 areas face a significant risk of failing to meet or to maintain the PM_{10} NAAQS even with federal, State and local controls currently in place.[27] Table II.B–4 presents information about these 10 areas and subdivides them into two groups. The first group of 6 areas are designated PM_{10} nonattainment areas which had recent monitored violations of the PM_{10} NAAQS in 1997–1999 and increasing inventories of PM_{10} from 2007 to 2030 (see Table II.B–3 for predicted increases in emissions). These areas have a population of 19 million. Included in the group are the nonattainment areas that are part of the Los Angeles, Phoenix and Las Vegas (Clark County) metropolitan areas, where traffic from heavy-duty vehicles is substantial. These six areas will benefit from the reductions in emissions that will occur from the new standards for heavy-duty vehicles, as will other areas impacted by heavy-duty vehicle emissions.

The second group of four counties listed in Table II.B–4 with a total of nine million people in 1999 also had predicted exceedances of the PM_{10} standard. While these four areas registered, in either 1997 or 1998, single-year annual average monitored PM_{10} levels of at least 90 percent of the PM_{10} NAAQS, these areas did not exceed the formal definition of the PM_{10} NAAQS over the three-year period ending in 1999. For each of these four areas (i.e., Cuyahoga, Harris, New York, and San Diego), inventories of total PM_{10} are predicted to increase between 1996, when these areas recorded values within 10 percent of the PM_{10} standard, and 2030 when this rule will take full effect. Additionally, EPA is in the process of taking final action on a request by the State of Ohio to redesignate Cuyahoga County as attainment. This action is based on locally developed information and is consistent with the requirements of the CAA which include, among other requirements a 10-year plan for maintenance of the PM_{10} standard.

For some of these areas, total PM_{10} inventories are predicted to decline or stay relatively constant from 1996 to 2007, and then increase after 2007. Based on inventory projections, the small margin of attainment which the four areas currently enjoy will likely erode between 1996 and 2030, and for some areas before 2007, if additional actions to reduce the growth of future emissions are not taken. We therefore consider these four areas to each individually have a significant risk of exceeding the PM_{10} standard between 2007 and 2030 without further emission reductions. The emission reductions from the new standards for heavy-duty vehicles will help these areas attain and maintain the PM_{10} NAAQS in conjunction with other processes that

[27] EPA has evaluated projected emissions for this analysis rather than future air quality because REMSAD, the model EPA has used for analyses related to this rule, was designed principally to estimate long-term average concentrations of fine particulate matter and its ability to predict short-term PM_{10} concentrations has not been satisfactorily demonstrated. In contrast with ozone, which is the product of complex photochemical reactions and therefore difficult to directly relate to precursor emissions, ambient PM_{10} concentrations are more heavily influenced by direct emissions of particulate matter and can therefore be correlated more meaningfully with emissions inventories.

are currently moving these areas towards attainment.

TABLE II.B–4—AREAS WITH SIGNIFICANT RISK OF EXCEEDING THE PM_{10} NAAQS WITHOUT FURTHER EMISSION REDUCTIONS BETWEEN 2007 AND 2030

Area	Percent increases in PM_{10} emissions (1996–2030)	1999 Population (projected) (millions)
Areas currently exceeding the PM_{10} standard:		
Clark Co., NV (Las Vegas)	41	1.217
El Paso, TX [a]	14	0.611
Hayden/Miami, AZ	4	0.004
Los Angeles South Coast Air Basin, CA	14	14.352
Nogales, AZ	3	0.025
Phoenix, AZ	24	3.012
Subtotal for 6 Areas	....	19.22
Areas within 10% of exceeding the PM_{10} standard:		
Cuyahoga Co., OH (Cleveland)	28	1.37
Harris, Co., TX (Houston)	37	3.26
New York Co., NY	14	1.55
San Diego Co., CA	13	2.83
Subtotal for 4 Areas	....	9.01
10 Areas	....	28.23

[a] EPA has determined that PM_{10} nonattainment in this area is attributable to international transport. While reductions in heavy-duty vehicle emissions cannot be expected to result in attainment, they will help reduce the degree of PM_{10} nonattainment.

EPA recognizes that the SIP process is ongoing and that nonattainment areas are in the process of implementing, or will be adopting and implementing, additional control measures to achieve the PM_{10} NAAQS in accordance with their attainment dates under the Clean Air Act. EPA believes, however, that as in the case of ozone, there are uncertainties inherent in any demonstration of attainment that is premised on forecasts of emission levels in future years. Even if these areas adopt and submit SIPs that EPA is able to approve as demonstrating attainment of the PM_{10} standard, and attain the standard by the appropriate attainment dates, the inventory analysis conducted for this rule and the history of PM_{10} levels in these areas indicates that there is still a significant risk that these areas will need the reductions from the heavy-duty vehicle standards adopted today to maintain the PM_{10} standards in the long term (ie, between 2007 and 2030). In addition, this list does not fully consider the possibility that there are other areas which are now meeting the PM_{10} NAAQS that have at least a significant probability of requiring further reductions to continue to maintain it.

c. Public Health and Welfare Concerns From Exposure to Fine PM

Many epidemiologic studies have shown statistically significant associations of ambient PM levels with a variety of human health endpoints in sensitive populations, including mortality, hospital admissions and emergency room visits, respiratory illness and symptoms measured in community surveys, and physiologic changes in mechanical pulmonary function. These effects have been observed in many areas with ambient PM levels at or below the current PM_{10} NAAQS. The epidemiologic science points to fine PM as being more strongly associated with some health effects, such as premature mortality, than coarse PM.

Associations of both short-term and long-term PM exposure with most of the above health endpoints have been consistently observed. The general internal consistency of the epidemiologic data base and available findings have led to increasing public health concern, due to the severity of several studied endpoints and the frequent demonstration of associations of health and physiologic effects with ambient PM levels at or below the current PM_{10} NAAQS. The weight of epidemiologic evidence suggests that ambient PM exposure has affected the public health of U.S. populations. Specifically, increased mortality associated with fine PM was observed in cities with longer-term average fine PM concentrations in the range of 16 to 21 $\mu g/m^3$.

Current 1999 $PM_{2.5}$ monitored values, which cover about a third of the nation's counties, indicate that at least 40 million people live in areas where long term ambient fine particulate matter levels are at or above 16 $\mu g/m^3$ (37 percent of the population in the areas with monitors), which is the low end of the range of long term average $PM_{2.5}$ concentrations in cities where statistically significant associations were found with serious health effects, including premature mortality (EPA, 1996).[28]

The Agency used the Regulatory Model System for Aerosols and Desposition (REMSAD) to model baseline and post-control ambient PM concentrations. For a description of the REMSAD model, the reader is referred to Chapter VII of the RIA.

Our REMSAD modeled predictions allow us to also estimate the affected population for the counties which do not currently have $PM_{2.5}$ monitors. According to our national modeled predictions, there were a total of 76

[28] EPA (1996) Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information OAQPS Staff Paper. EPA–452/R–96–013.

million people (1996 populations) living in areas with modeled annual average $PM_{2.5}$ concentrations at or above 16 μg/m^3 (29 percent of the population).[29]

The REMSAD model also allows us to estimate future $PM_{2.5}$ levels. However, the most appropriate method of making these projections relies on the model to predict changes between current and future states. Thus, we have estimated future conditions only for the areas with current $PM_{2.5}$ monitored data (which, as just noted, covers about a third of the nation's counties). For these counties, REMSAD predicts the current level of 37 percent of the population living in areas where fine PM levels are at or above 16 μg/m^3 to increase to 59 percent in 2030.

It is reasonable to anticipate that sensitive populations exposed to similar or higher levels, now and in the 2007 and later time frame, will also be at increased risk relative to the general population of premature mortality associated with exposures to fine PM. In addition, statistically significant relationships have also been observed in U.S. cities between PM levels and increased respiratory symptoms and decreased lung functions in children.

Since EPA's examination in the mid-1990s of the epidemiological and toxicological evidence of the health effects of PM, many new studies have been published that reevaluate or extend the initial research. The Agency is currently reviewing these new studies to stay abreast of the literature and adjust as necessary its assessment of PM's health effects. It is worth noting that within this new body of scientific literature, there are two new studies funded by the Health Effects Institute, a EPA-industry jointly funded group, that have generally confirmed the mid-1990s findings of the Agency about the association of fine particles and premature mortality and various other respiratory and cardiovascular effects. HEI's *National Morbidity, Mortality and Air Pollution Study* (NMMAPS), evaluated associations between air pollutants and mortality in 90 U.S. cities, and also evaluated associations between air pollutants and hospital admissions among the elderly in 14 U.S. cities.[30] In HEI's *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality,* data were obtained from the original investigators for two previous studies.[31] [32], The extensive analyses included replication and validation of the previous findings, as well as sensitivity analyses using alternative analytic techniques, including different methods of covariate adjustment, exposure characterization, and exposure-response modeling.[33]

Section 202(a) provides EPA with independent authority to promulgate standards applicable to motor vehicle emissions that ''in the Administrator's judgment, cause or contribute to air pollution reasonably anticipated to endanger public health and welfare.'' The body of health evidence is supportive of our view that PM exposures are a serious public health concern. This concern exists for current exposures as well as exposures that can reasonably be anticipated to occur in the future. The risk is significant from an overall public health perspective because of the large number of individuals in sensitive populations that we expect to be exposed to ambient fine PM in the 2007 and later time frame, as well as the importance of the negative health effects. This information warrants a requirement to reduce emissions from heavy-duty vehicles, to address elevated levels of fine PM. This evidence supports EPA's conclusion that emissions from heavy-duty vehicles that lead to the formation of fine PM in 2007 and later will be contributing to a national air pollution problem that warrants action under section 202(a)(3).

d. Other Welfare Effects Associated with PM

The deposition of airborne particles reduces the aesthetic appeal of buildings, and promotes and accelerates the corrosion of metals, degrades paints, and deteriorates building materials such as concrete and limestone. This materials damage and soiling are related to the ambient levels of airborne particulates, which are emitted by heavy-duty vehicles. Although there was insufficient data to relate materials damage and soiling to specific concentrations, and thereby to allow the Agency to establish a secondary PM standard for these impacts, we believe that the welfare effects are real and that heavy-duty vehicle PM, NO_X, SO_X, and VOC contribute to materials damage and soiling.

e. Conclusions Regarding PM

There is a significant risk that, despite statutory requirements and EPA and State efforts towards attainment and maintenance, some areas of the U.S. will violate the PM_{10} NAAQS in 2007 and thereafter. Heavy-duty vehicles contribute substantially to PM_{10} levels, as shown in Section II.C below.

It is also reasonable to anticipate that concentrations of fine PM, as represented for example by $PM_{2.5}$ concentrations, will also endanger public health and welfare even if all areas attain and maintain the PM_{10} NAAQS. Heavy-duty vehicles contribute to this air pollution problem.

There are also important environmental impacts of PM_{10}, such as regional haze which impairs visibility. Furthermore, while the evidence on soiling and materials damage is limited and the magnitude of the impact of heavy-duty vehicles on these welfare effects is difficult to quantify, these welfare effects support our belief that this action is necessary and appropriate.

Finally, in addition to its contribution to PM inventories, diesel exhaust PM is of special concern because it has been implicated in an increased risk of lung cancer and respiratory disease in human studies, and an increased risk of noncancer health effects as well. The information provided in this section shows that there will be air pollution that warrants regulatory action under section 202(a)(3) of the Act.

4. Diesel Exhaust

Diesel emissions are of concern to the agency beyond their contribution to ambient PM. As discussed in detail in the draft RIA, there have been health studies specific to diesel exhaust emissions which indicate potential hazards to human health that appear to be specific to this emissions source. For chronic exposure, these hazards included respiratory system toxicity and carcinogenicity. Acute exposure also causes transient effects (a wide range of physiological symptoms stemming from irritation and inflammation mostly in the respiratory system) in humans though they are highly variable depending on individual human susceptibility. The chemical

[29] REMSAD modeling for $PM_{2.5}$ annual average concentrations. Total 1996 population in all REMSAD grid cells is 263 million.

[30] Samet JM, Zeger SL, Dominici F, Curriero F, Coursac I, Dockery DW, Schwartz J, Zanobetti A. 2000. The National Morbidity, Mortality and Air Pollution Study: Part II: Morbidity, Mortality and Air Pollution in the United States. Research Report No. 94, Part II. Health Effects Institute, Cambridge MA, June 2000.

[31] Dockery, D.W., Pope, C.A., III, Xu, X., Spengler, J.D., Ware, J.H., Fay, M.E., Ferris, B.G., Speizer, F.E. (1993) An association between air pollution and mortality in six U.S. cities. N. Engl. J. Med. 329:1753–1759.

[32] Pope, C. A., III, Thun, M. J., Namboodiri, M. M., Dockery, D. W., Evans, J. S., Speizer, F. E., 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.

[33] Krewski D, Burnett RT, Goldbert MS, Hoover K, Siemiatycki J, Jarrett M, Abrahamowicz M, White WH. (2000) Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality. Special Report to the Health Effects Institute, Cambridge MA, July 2000.

composition of diesel exhaust includes several hazardous air pollutants, or air toxics. In our Mobile Source Air Toxic Rulemaking under section 202(l) of the Act discussed above, EPA determined that diesel particulate matter and diesel exhaust organic gases be identified as a Mobile Source Air Toxic (MSAT). The purpose of the MSAT list is to provide a screening tool that identifies compounds emitted from motor vehicles or their fuels for which further evaluation of emissions controls is appropriate. As discussed in chapter 3 on engine technology, the particulate matter standard finalized today reflects the greatest degree of emissions reductions achievable under section 202(l) for on-highway heavy-duty vehicle PM emissions.

a. Potential Cancer Effects of Diesel Exhaust

The EPA has concluded that diesel exhaust is likely to be carcinogenic to humans by inhalation at occupational and environmental levels of exposure.[34] The draft Health Assessment Document for Diesel Exhaust (draft Assessment), was reviewed in public session by the Clean Air Scientific Advisory Committee (CASAC) on October 12–13, 2000.[35] The CASAC found that the Agency's conclusion that diesel exhaust is likely to be carcinogenic to humans is scientifically sound. CASAC concurred with the draft Assessment's findings with the proviso that EPA provide modifications and clarifications on certain topics. The Agency expects to produce the finalized Assessment in early 2001. Information presented here is consistent with that to be provided in the final Assessment.

In its review of the published literature, EPA found that about 30 individual epidemiologic studies show increased lung cancer risk associated with diesel emissions. In the draft Assessment EPA evaluated 22 studies that were most relevant for risk assessment, 16 of which reported significant increased lung cancer risks, ranging from 20 to 167 percent, associated with diesel exhaust exposure. Published analytical results of pooling many of the 30 studies showed that on average, the risks were increased by 33 to 47 percent. Questions remain about the influence of other factors (e.g., effect of smoking, other particulate sources), the quality of the individual epidemiologic studies, exposure levels, and consequently the precise magnitude of the increased risk of lung cancer. From a weight of evidence perspective, EPA concludes that the epidemiologic evidence, as well as supporting data from certain animal and mode of action studies, support the Agency's conclusion that exposure to diesel exhaust is likely to pose a human lung cancer hazard to occupationally exposed individuals as well as to the general public exposed to typically lower environmental levels of diesel exhaust.

Risk assessments in the peer-reviewed literature have attempted to assess the lifetime risk of lung cancer in workers occupationally exposed to diesel exhaust. These estimates suggest that lung cancer risk may range from 10^{-4} to 10^{-2}.[36 37 38] The Agency recognizes the significant uncertainties in these studies, and has not used these estimates to assess the possible cancer unit risk associated with ambient exposure to diesel exhaust.

While available evidence supports EPA's conclusion that diesel exhaust is likely to be a human lung carcinogen, and thus is likely to pose a cancer hazard to humans, EPA has concluded that the available data are not sufficient to develop a confident estimate of cancer unit risk. The absence of a cancer unit risk for diesel exhaust limits our ability to quantify, with confidence, the potential impact of the hazard (magnitude of risk) on exposed populations. In the draft Assessment, EPA acknowledged this limitation and provided a discussion of the possible environmental cancer risk consistent with the majority of the occupational epidemiological findings of increased lung cancer risk and the exposure differences between the occupational and environmental settings.[39] The Agency concluded in developing its perspective on risk that there is a reasonable potential that environmental lifetime cancer risks (''environmental risk range'') from diesel exhaust may exceed 10^{-5} and could be as high as 10^{-3}.[40]

The environmental risk estimates included in the Agency's risk perspective are meant only to gauge the possible magnitude of risk to provide a means to understand the potential significance of the lung cancer hazard. The estimates are not to be construed as cancer unit risk estimates and are not suitable for use in analyses which would estimate possible lung cancer cases in exposed populations.

EPA recognizes that, as in all such risk assessments, there are uncertainties in this assessment of the environmental risk range including limitations in exposure data, uncertainty with respect to the most accurate characterization of the risk increases observed in the epidemiological studies, chemical changes in diesel exhaust over time, and extrapolation of the risk from occupational to ambient environmental exposures. As with any such risk assessment for a carcinogen, despite EPA's thorough examination of the available epidemiologic evidence and exposure information, at this time EPA can not rule out the possibility that the lower end of the risk range includes zero.[41] However, it is the Agency's best scientific judgement that the assumptions and other elements of this analysis are reasonable and appropriate for identifying the risk potential based on the scientific information currently available.

The Agency believes that the risk estimation techniques that were used in the draft Assessment to gauge the potential for and possible magnitude of risk are reasonable and the CASAC

[34] U.S. EPA (2000) Health Assessment Document for Diesel Exhaust: SAB Review Draft. EPA/600/8–90/057E Office of Research and Development, Washington, D.C. The document is available electronically at www.epa.gov/ncea/dieslexh.htm.

[35] EPA (2000) Review of EPA's Health Assessment Document for Diesel Exhaust (EPA 600/8–90/057E). Review by the Clean Air Scientific Advisory Committee (CASAC) December 2000. EPA–SAB–CASAC–01–003.

[36] California Environmental Protection Agency, Office of Health Hazard Assessment (CAL–EPA, OEHHA) (1998) Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Appendix III Part B Health Risk Assessment for Diesel Exhaust. April 22, 1998.

[37] Harris, J.E. (1983) Diesel emissions and Lung Cancer. Risk Anal. 3:83–100.

[38] Stayner, L.S., Dankovic, D., Smith, R., Steenland, K. (1998) Predicted Lung Cancer Risk Among Miners Exposed to Diesel Exhaust Particles. Am. J. of Indus. Medicine 34:207–219.

[39] See Chapter 8.4 and 9.5.2 of the U.S. EPA (2000) Health Assessment Document for Diesel Emissions: SAB Review Draft. EPA/600/8–90/057E Office of Research and Development, Washington, D.C. The document is available electronically at www.epa.gov/ncea/dieselexh.htm.

[40] As used in this rule, environmental risk is defined as the risk (i.e. a mathematical probability) that lung cancer would be observed in the population after a lifetime exposure to diesel exhaust. Exposure levels may be occupational lifetime or environmental lifetime exposures. An environmental risk in the magnitude of 10^{-5} translates as the probability of lung cancer being evidenced in one person in a population of one hundred thousand having a lifetime exposure.

[41] EPA's scientific judgment (which CASAC has supported) is that diesel exhaust is likely to be carcinogenic to humans. Notably, similar scientific judgements about the carcinogenicity of diesel exhaust have been recently made by the National Toxicology Program of the Department of Health and Human Services, NIOSH, WHO, and OEHA of the State of California. In the risk perspective discussed above, EPA recognizes the possibility that the lower end of the environmental risk range includes zero. The risks could be zero because (1) some individuals within the population may have a high tolerance level to exposure from diesel exhaust and therefore are not susceptible to the cancer risks from environmental exposure and (2) although EPA has not seen evidence of this, there could be a threshold of exposure below which there is no cancer risk.

panel has concurred with the Assessment's discussion of the possible environmental risk range with an understanding that some clarifications and caveats would be added to the final version of the Assessment. Details of the technical approach used in estimating the possible range of environmental risks and uncertainties are provided in the RIA.

In the draft Assessment, the Agency also provided a discussion of the potential overlap and/or relatively small difference between some occupational settings where increased lung cancer risk is reported and ambient environmental exposures. The potential for small exposure differences underscores the concern that some degree of occupational risk may also be present in the environmental setting and that extrapolation of occupational risk to ambient environmental exposure levels should be more confidently judged to be appropriate. The relevant exposure information is presented in the RIA.

In the absence of having a unit cancer risk to assess environmental risk, EPA has considered the relevant epidemiological studies and principles for their assessment, the relative risk from occupational exposure as assessed by others, and relative exposure differences between occupational and ambient environmental levels of diesel exhaust exposure.

While uncertainty exists in estimating the possible magnitude of the environmental risk range, the likely hazard to humans together with the potential for significant environmental risks leads the Agency to believe that diesel exhaust emissions should be reduced in order to protect the public's health. We believe that this is a prudent measure in light of:

- The designation that diesel exhaust is likely to be carcinogenic to humans,
- The exposure of the entire population to various levels of diesel exhaust,
- The consistent observation of significantly increased lung cancer risk in workers exposed to diesel exhaust, and
- The potential overlap and/or relatively small difference between some occupational settings where increased lung cancer risk is reported and ambient exposures.

In the late 1980s, the International Agency for Research on Cancer (IARC) determined that diesel exhaust is ''probably carcinogenic to humans'' and the National Institute for Occupational Safety and Health classified diesel exhaust a ''potential occupational carcinogen.''[42] [43] Based on IARC findings, the State of California identified diesel exhaust in 1990 as a chemical known to the State to cause cancer. In 1996, the International Programme on Chemical Safety of the World Health Organization listed diesel exhaust as a ''probable'' human carcinogen.[44] In 1998, the California Office of Environmental Health Hazard Assessment (OEHHA, California EPA) identified diesel PM as a toxic air contaminant due to the noncancer and cancer hazard and because of the potential magnitude of the cancer risk.[45] Most recently, the U.S. Department of Health and Human Services National Toxicology Program designated diesel exhaust particles as ''reasonably anticipated to be a human carcinogen'' in its Ninth Report on Carcinogens.[46] The concern for a carcinogenicity hazard resulting from diesel exhaust exposures is longstanding and widespread.

b. Noncancer Effects of Diesel Exhaust

The acute and chronic exposure-related noncancer effects of diesel exhaust emissions are also of concern to the Agency. Acute exposure to diesel exhaust can result in physiologic symptoms consistent with irritation and inflammation, and evidence of immunological effects including increased reaction to allergens and some symptoms associated with asthma. The acute effects data, however, lack sufficient detail to permit the calculation of protective levels for human exposure.

For chronic diesel exhaust exposure, EPA is completing the development of an inhalation reference concentration (RfC). The RfC is an estimate of the continuous human inhalation exposure (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer effects during a lifetime. While the limited amount of human data are suggestive of respiratory distress, animal test data are quite definitive in providing a basis to anticipate a hazard to the human lung based on the irritant and inflammatory reactions in test animals. Thus, EPA believes that chronic diesel exhaust exposure, at sufficient exposure levels, increases the hazard and risk of an adverse health effect. Based on CASAC advice regarding the use of the animal data to derive the RfC, the Agency will provide in the final Assessment in 2001 an RfC based on diesel exhaust effects in test animals of approximately 5 μg/m^3.

In addition, it is also instructive to recognize that diesel exhaust particulate matter is part of ambient fine PM. A qualitative comparison of adverse effects of exposure to ambient fine PM and diesel exhaust particulate matter shows that the respiratory system is adversely affected in both cases, though a wider spectrum of adverse effects has been identified for ambient fine PM. Relative to the diesel PM database, there is a wealth of human data for fine PM noncancer effects. Since diesel exhaust PM is a component of ambient fine PM, the fine PM health effects data base can be informative. The final Assessment will discuss the fine PM health effects data and its relation to evaluating health effects associated with diesel exhaust.

5. Other Criteria Pollutants

The standards being finalized today will help reduce levels of three other pollutants for which NAAQS have been established: carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). As of July, 2000, every area in the United States has been designated to be in attainment with the NO_2 NAAQS. There were 28 areas designated as nonattainment with the SO_2 standard, and 17 areas designated CO nonattainment areas.

A health threat of carbon monoxide at outdoor levels occurs for those who suffer from cardiovascular disease, such as angina petoris, where it can exacerbate the effects. Studies also show that outdoor levels can lower peak performance from individuals that are exercising and lower exercise tolerance of sensitive individuals. EPA believes that epidemiological evidence suggests that there is a risk of premature mortality and lowered birth weight from CO exposure.[47] The Carbon Monoxide Criteria Document was finalized in

[42] National Institute for Occupational Safety and Health (NIOSH) (1988) Carcinogenic effects of exposure to diesel exhaust. NIOSH Current Intelligence Bulletin 50. DHHS, Publication No. 88–116. Centers for Disease Control, Atlanta, GA.

[43] International Agency for Research on Cancer (1989) Diesel and gasoline engine exhausts and some nitroarenes, Vol. 46. Monographs on the evaluation of carcinogenic risks to humans. World Heath Organization, International Agency for Research on Cancer, Lyon, France.

[44] World Health Organization (1996) Diesel fuel and exhaust emissions: International program on chemical safety. World Health Organization, Geneva, Switzerland.

[45] Office of Environmental Health Hazard Assessment (1998) Health risk assessment for diesel exhaust, April 1998. California Environmental Protection Agency, Sacramento, CA.

[46] U.S. Department of Health and Human Services (2000) Ninth report on carcinogens. National Toxicology Program, Research Triangle Park, NC. ehis.niehs.nih.gov/roc/toc9.html.

[47] U.S. Environmental Protection Agency, Air Quality Criteria for Carbon Monoxide, June 2000.

August 2000 and made available to the public at that time.

6. Other Air Toxics

In addition to NO_X and particulates, heavy-duty vehicle emissions contain several other substances that are known or suspected human or animal carcinogens, or have serious noncancer health effects. These include benzene,1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and dioxin. For some of these pollutants, heavy-duty engine emissions are believed to account for a significant proportion of total nation-wide emissions. Although these emissions will decrease in the short term, they are expected to increase between 2010 and 2020 without the emission limits, as the number of miles traveled by heavy-duty trucks increases. In the RIA, we present current and projected exposures to benzene, 1,3-butadiene, formaldehyde, and acetaldehyde from all on-highway motor vehicles.

By reducing hydrocarbon and other organic emissions, both in gas phase and bound to particles, the emission control program in today's action will also reduce the direct emissions of air toxics from HDVs. Today's action will reduce exposure to hydrocarbon and other organic emissions and therefore help reduce the impact of HDV emissions on cancer and noncancer health effects.

a. Benzene

Highway mobile sources account for 42 percent of nationwide emissions of benzene and HDVs account for 7 percent of all highway vehicle benzene emissions.[48] The EPA has recently reconfirmed that benzene is a known human carcinogen by all routes of exposure (including leukemia at high, prolonged air exposures), and is associated with additional health effects including genetic changes in humans and animals and increased proliferation of bone marrow cells in mice.[49] [50] [51] EPA believes that the data indicate a causal relationship between benzene exposure and acute lymphocytic leukemia and suggest a relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia. Respiration is the major source of human exposure and at least half of this exposure is attributable to gasoline vapors and automotive emissions. A number of adverse noncancer health effects including blood, disorders, such as preleukemia and aplastic anemia, have also been associated with low-dose, long-term exposure to benzene.

b. 1,3-Butadiene

Highway mobile sources account for 42 percent of the annual emissions of 1,3-butadiene and HDVs account for 15 percent of the highway vehicle portion. Today's program will play an important role in reducing in the mobile contribution of 1,3-butadiene. Reproductive and/or developmental effects have been observed in mice and rats following inhalation exposure to 1,3-butadiene.[52] No information is available on developmental/reproductive effects in humans following exposure to 1,3-butadiene. In the EPA1998 draft Health Risk Assessment of 1,3-Butadiene, that was reviewed by the SAB, EPA proposed that 1,3-butadiene is a known human carcinogen based on human epidemiologic, laboratory animal data, and supporting data such as the genotoxicity of 1,3-butadiene metabolites.[53] The Environmental Health Committee of EPA's Scientific Advisory Board (SAB), reviewed the draft document in August 1998 and recommended that 1,3-butadiene be classified as a probable human carcinogen, stating that designation of 1,3-butadiene as a known human carcinogen should be based on observational studies in humans, without regard to mechanistic or other information.[54] In applying the 1996 proposed Guidelines for Carcinogen Risk Assessment, the Agency relies on both observational studies in humans as well as experimental evidence demonstrating causality and therefore the designation of 1,3-butadiene as a known human carcinogen remains applicable.[55] The Agency has revised the draft Health Risk Assessment of 1,3-Butadiene based on the SAB and public comments. The draft Health Risk Assessment of 1,3-Butadiene will undergo the Agency consensus review, during which time additional changes may be made prior to its public release and placement on the Integrated Risk Information System (IRIS).

c. Formaldehyde

Highway mobile sources contribute 24 percent of the national emissions of formaldehyde, and HDVs account for 36 percent of the highway portion. EPA has classified formaldehyde as a probable human carcinogen based on evidence in humans and in rats, mice, hamsters, and monkeys.[56] Epidemiological studies in occupationally exposed workers suggest that long-term inhalation of formaldehyde may be associated with tumors of the nasopharyngeal cavity (generally the area at the back of the mouth near the nose), nasal cavity, and sinus. Formaldehyde exposure also causes a range of noncancer health effects, including irritation of the eyes (tearing of the eyes and increased blinking) and mucous membranes. Sensitive individuals may experience these adverse effects at lower concentrations than the general population and in persons with bronchial asthma, the upper respiratory irritation caused by formaldehyde can precipitate an acute asthmatic attack. The agency is currently conducting a reassessment of risk from inhalation exposure to formaldehyde.

d. Acetaldehyde

Highway mobile sources contribute 29 percent of the national acetaldehyde emissions and HDVs are responsible for approximately 33 percent of these highway mobile source emissions. Acetaldehyde is classified as a probable human carcinogen and is considered moderately toxic by the inhalation, oral, and intravenous routes. The primary acute effect of exposure to acetaldehyde vapors is irritation of the eyes, skin, and respiratory tract. At high concentrations, irritation and pulmonary effects can occur, which could facilitate the uptake of other contaminants. The agency is currently conducting a reassessment of

[48] U.S. EPA (2000) 1996 National Toxics Inventory. http://www.epa.gov/ttn/uatw/nata. Inventory values for 1,3 butadiene, formaldehyde, acetaldehyde, and acrolein discussed below also come from this source.

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

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

[51] Environmental Protection Agency, Carcinogenic Effects of Benzene: An Update, National Center for Environmental Assessment, Washington, DC. 1998.

[52] Environmental Protection Agency. Draft Health Risk Assessment of 1,3-Butadiene, National Center for Environmental Assessment, Office of Research and Development, U.S. EPA, EPA/600/P–98/001A, February 1998.

[53] An SAB Report: Review of the Health Risk Assessment of 1,3-Butadiene. EPA-SAB-EHC–98, August, 1998.

[54] Scientific Advisory Board. 1998. An SAB Report: Review of the Health Risk Assessment of 1,3-Butadiene. EPA-SAB-EHC–98, August, 1998.

[55] [55]: EPA 1996. Proposed guidelines for carcinogen risk assessment. **Federal Register** 61(79):17960–18011.

[56] Environmental Protection Agency, Assessment of Health Risks to Garment Workers and Certain Home Residents from Exposure to Formaldehyde, Office of Pesticides and Toxic Substances, April 1987.

risk from inhalation exposure to acetaldehyde.

e. Acrolein

Highway mobile sources contribute 16 percent of the national acrolein emissions and HDVs are responsible for approximately 39 percent of these highway mobile source emissions. Acrolein is extremely toxic to humans when inhaled, with acute exposure resulting in upper respiratory tract irritation and congestion. The Agency has developed a reference concentration for inhalation (RfC) of acrolein of 0.02 micrograms/m^3.[57] Although no information is available on its carcinogenic effects in humans, based on laboratory animal data, EPA considers acrolein a possible human carcinogen.

f. Dioxins

Recent studies have confirmed that dioxins are formed by and emitted from heavy-duty diesel trucks and are estimated to account for 1.2 percent of total dioxin emissions in 1995. In the environment, the pathway of immediate concern is the food pathway (*e.g.*, human ingestion of certain foods, *e.g.* meat and dairy products contaminated by dioxin) which may be affected by deposition of dioxin from the atmosphere. EPA classified dioxins as probable human carcinogens in 1985. Recently EPA has proposed, and the Scientific Advisory Board has concurred, to classify one dioxin compound, 2,3,7,8-tetrachlorodibenzo-p-dioxin as a human carcinogen and the complex mixtures of dioxin-like compounds as likely to be carcinogenic to humans using the draft 1996 carcinogen risk assessment guidelines.[58] Using the 1986 cancer risk assessment guidelines, the hazard characterization for 2,3,7,8-tetrachlorodibenzo-p-dioxin is ''known'' human carcinogen and the hazard characterization for complex mixtures of dioxin-like compounds is ''probable'' human carcinogens. Acute and chronic noncancer effects have also been reported for dioxin.

7. Other Welfare and Environmental Effects

Some commenters challenged the Agency's use of adverse welfare and environmental effects associated with emissions from heavy-duty vehicles as a partial basis for this rulemaking. Other commenters went to great lengths to support the Agency's inclusion of these welfare and environmental effects. Additional information has been added since the proposal in order to update and clarify the available information on welfare and environmental impacts of heavy-duty vehicle emissions. The following section presents information on four categories of public welfare and environmental impacts related to heavy-duty vehicle emissions: acid deposition, eutrophication of water bodies, POM deposition, and impairment of visibility.

a. Acid Deposition

Acid deposition, or acid rain as it is commonly known, occurs when SO_2 and NO_X react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds that later fall to earth in the form of precipitation or dry deposition of acidic particles.[59] It contributes to damage of trees at high elevations and in extreme cases may cause lakes and streams to become so acidic that they cannot support aquatic life. In addition, acid deposition accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. To reduce damage to automotive paint caused by acid rain and acidic dry deposition, some manufacturers use acid-resistant paints, at an average cost of $5 per vehicle—a total of $61 million per year if applied to all new cars and trucks sold in the U.S.

Acid deposition primarily affects bodies of water that rest atop soil with a limited ability to neutralize acidic compounds. The National Surface Water Survey (NSWS) investigated the effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams. It found that acid deposition was the primary cause of acidity in 75 percent of the acidic lakes and about 50 percent of the acidic streams, and that the areas most sensitive to acid rain were the Adirondacks, the mid-Appalachian highlands, the upper Midwest and the high elevation West. The NSWS found that approximately 580 streams in the Mid-Atlantic Coastal Plain are acidic primarily due to acidic deposition. Hundreds of the lakes in the Adirondacks surveyed in the NSWS have acidity levels incompatible with the survival of sensitive fish species. Many of the over 1,350 acidic streams in the Mid-Atlantic Highlands (mid-Appalachia) region have already experienced trout losses due to increased stream acidity. Emissions from U.S. sources contribute to acidic deposition in eastern Canada, where the Canadian government has estimated that 14,000 lakes are acidic. Acid deposition also has been implicated in contributing to degradation of high-elevation spruce forests that populate the ridges of the Appalachian Mountains from Maine to Georgia. This area includes national parks such as the Shenandoah and Great Smoky Mountain National Parks.

A recent study of emissions trends and acidity of waterbodies in the Eastern United States by the General Accounting Office (GAO) found that sulfates declined in 92 percent of a representative sample of lakes from 1992 to 1999, and nitrate levels increased in 48 percent of the lakes sampled.[60] The decrease in sulfates is consistent with emissions trends, but the increase in nitrates is inconsistent with the stable levels of nitrogen emissions and deposition. The study suggests that the vegetation and land surrounding these lakes have lost some of their previous capacity to use nitrogen, thus allowing more of the nitrogen to flow into the lakes and increase their acidity. Recovery of acidified lakes is expected to take a number of years, even where soil and vegetation have not been ''nitrogen saturated,'' as EPA called the phenomenon in a 1995 study.[61] This situation places a premium on reductions of SO_X and especially NO_X from all sources, including HDVs, in order to reduce the extent and severity of nitrogen saturation and acidification of lakes in the Adirondacks and throughout the United States.

The SO_X and NO_X reductions from today's action will help reduce acid rain and acid deposition, thereby helping to reduce acidity levels in lakes and streams throughout the country and help accelerate the recovery of acidified lakes and streams and the revival of ecosystems adversely affected by acid deposition. Reduced acid deposition levels will also help reduce stress on forests, thereby accelerating reforestation efforts and improving timber production. Deterioration of our

[57] U.S. EPA (1993) Environmental Protection Agency, Integrated Risk Information System (IRIS), National Center for Environmental Assessment, Cincinnati, OH.

[58] U.S. EPA (2000) Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Part III: Integrated Summary and Risk Characterization for 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. External Review Draft. EPA/600/P–00/001Ag.

[59] Much of the information in this subsection was excerpted from the EPA document, Human Health Benefits from Sulfate Reduction, written under Title IV of the 1990 Clean Air Act Amendments, U.S. EPA, Office of Air and Radiation, Acid Rain Division, Washington, DC 20460, November 1995.

[60] Acid Rain: Emissions Trends and Effects in the Eastern United States, US General Accounting Office, March, 2000 (GOA/RCED–00–47).

[61] Acid Deposition Standard Feasibility Study: Report to Congress, EPA 430R–95–001a, October, 1995.

historic buildings and monuments, and of buildings, vehicles, and other structures exposed to acid rain and dry acid deposition also will be reduced, and the costs borne to prevent acid-related damage may also decline. While the reduction in sulfur and nitrogen acid deposition will be roughly proportional to the reduction in SO_X and NO_X emissions, respectively, the precise impact of today's action will differ across different areas.

b. Eutrophication and Nitrification

Eutrophication is the accelerated production of organic matter, particularly algae, in a water body. This increased growth can cause numerous adverse ecological effects and economic impacts, including nuisance algal blooms, dieback of underwater plants due to reduced light penetration, and toxic plankton blooms. Algal and plankton blooms can also reduce the level of dissolved oxygen, which can also adversely affect fish and shellfish populations.

In 1999, NOAA published the results of a five year national assessment of the severity and extent of estuarine eutrophication. An estuary is defined as the inland arm of the sea that meets the mouth of a river. The 138 estuaries characterized in the study represent more than 90 percent of total estuarine water surface area and the total number of US estuaries. The study found that estuaries with moderate to high eutrophication conditions represented 65 percent of the estuarine surface area. Eutrophication is of particular concern in coastal areas with poor or stratified circulation patterns, such as the Chesapeake Bay, Long Island Sound, or the Gulf of Mexico. In such areas, the ''overproduced'' algae tends to sink to the bottom and decay, using all or most of the available oxygen and thereby reducing or eliminating populations of bottom-feeder fish and shellfish, distorting the normal population balance between different aquatic organisms, and in extreme cases causing dramatic fish kills.

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

In recent decades, human activities have greatly accelerated nutrient inputs, such as nitrogen and phosphorous, causing excessive growth of algae and leading to degraded water quality and associated impairments of freshwater and estuarine resources for human uses.[62] Since 1970, eutrophic conditions worsened in 48 estuaries and improved in 14. In 26 systems, there was no trend in overall eutrophication conditions since 1970.[63] On the New England coast, for example, the number of red and brown tides and shellfish problems from nuisance and toxic plankton blooms have increased over the past two decades, a development thought to be linked to increased nitrogen loadings in coastal waters. Long-term monitoring in the United States, Europe, and other developed regions of the world shows a substantial rise of nitrogen levels in surface waters, which are highly correlated with human-generated inputs of nitrogen to their watersheds.

On a national basis, the most frequently recommended control strategies by experts surveyed by National Oceanic and Atmospheric Administration (NOAA) between 1992–1997 were agriculture, wastewater treatment, urban runoff, and atmospheric deposition.[64] In its Third Report to Congress on the Great Waters, EPA reported that atmospheric deposition contributes from 2 to 38 percent of the nitrogen load to certain coastal waters.[65] A review of peer reviewed literature in 1995 on the subject of air deposition suggests a typical contribution of 20 percent or higher.[66] Human-caused nitrogen loading to the Long Island Sound from the atmosphere was estimated at 14 percent by a collaboration of federal and state air and water agencies in 1997.[67] The National Exposure Research Laboratory, US EPA, estimated based on prior studies that 20 to 35 percent of the nitrogen loading to the Chesapeake Bay is attributable to atmospheric deposition.[68] The mobile source portion of atmospheric NO_X contribution to the Chesapeake Bay was modeled at about 30 percent of total air deposition.[69]

Deposition of nitrogen from heavy-duty vehicles contributes to elevated nitrogen levels in waterbodies. In the Chesapeake Bay region, modeling shows that mobile source deposition occurs in relatively close proximity to highways, such as the 1–95 corridor which covers part of the Bay surface. The new standards for heavy-duty vehicles will reduce total NO_X emissions by 2.6 million tons in 2030. The NO_X reductions will reduce the airborne nitrogen deposition that contributes to eutrophication of watersheds, particularly in aquatic systems where atmospheric deposition of nitrogen represents a significant portion of total nitrogen loadings.

c. Polycyclic Organic Matter Deposition

EPA's Great Waters Program has identified 15 pollutants whose deposition to water bodies has contributed to the overall contamination loadings to the these Great Waters.[70] One of these 15 pollutants, a group known as polycyclic organic matter (POM), are compounds that are mainly adhered to the particles emitted by mobile sources and later fall to earth in the form of precipitation or dry deposition of particles. The mobile source contribution of the 7 most toxic POM is at least 62 tons/year and represents only those POM that adhere to mobile source particulate emissions.[71] The majority of these emissions are produced by diesel engines.

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[62] Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June, 2000.

[63] Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June, 2000. Great Waters are defined as the Great Lakes, the Chesapeake Bay, Lake Champlain, and coastal waters. The first report to Congress was delivered in May, 1994; the second report to Congress in June, 1997.

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

[65] Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June, 2000.

[66] Valigura, Richard, et al., Airsheds and Watersheds II: A Shared Resources Workshop, Air Subcommittee of the Chesapeake Bay Program, March, 1997.

[67] The Impact of Atmospheric Nitrogen Deposition on Long Island Sound, The Long Island Sound Study, September, 1997.

[68] Dennis, Robin L., Using the Regional Acid Deposition Model to Determine the Nitrogen Deposition Airshed of the Chesapeake Bay Watershed, SETAC Technical Publications Series, 1997.

[69] Dennis, Robin L., Using the Regional Acid Deposition Model to Determine the Nitrogen Deposition Airshed of the Chesapeake Bay Watershed, SETAC Technical Publications Series, 1997.

[70] Deposition of Air Pollutants to the Great Waters—Third Report to Congress, June, 2000, Office of Air Quality Planning and Standards Deposition of Air Pollutants to the Great Waters—Second Report to Congress, Office of Air Quality Planning and Standards, June 1997, EPA–453/R–97–011.

[71] The 1996 National Toxics Inventory, Office of Air Quality Planning and Standards, October 1999.

POM is generally defined as a large class of chemicals consisting of organic compounds having multiple benzene rings and a boiling point greater than 100 degrees C. Polycyclic aromatic hydrocarbons are a chemical class that is a subset of POM. POM are naturally occurring substances that are byproducts of the incomplete combustion of fossil fuels and plant and animal biomass (e.g., forest fires). Also, they occur as byproducts from steel and coke productions and waste incineration. Evidence for potential human health effects associated with POM comes from studies in animals (fish, amphibians, rats) and in human cells culture assays. Reproductive, developmental, immunological, and endocrine (hormone) effects have been documented in these systems. Many of the compounds included in the class of compounds known as POM are classified by EPA as probable human carcinogens based on animal data.

Evidence for potential human health effects associated with POM comes from studies in animals (fish, amphibians, rats) and in human cells culture assays. Reproductive, developmental, immunological, and endocrine (hormone) effects have been documented in these systems. Many of the compounds included in the class of compounds known as POM are classified by EPA as probable human carcinogens based on animal data.

The particulate reductions from today's action will help reduce not only the particulate emissions from highway diesel engines but also the deposition of the POM adhering to the particles, thereby helping to reduce health effects of POM in lakes and streams, accelerate the recovery of affected lakes and streams, and revive the ecosystems adversely affected.

d. Visibility and Regional Haze

Visibility impairment, also called regional haze, is a complex problem caused by a variety of sources, both natural and anthropogenic (e.g., motor vehicles). Regional haze masks objects on the horizon and reduces the contrast of nearby objects. The formation, extent, and intensity of regional haze are functions of meteorological and chemical processes, which sometimes cause fine particle loadings to remain suspended in the atmosphere for several days and to be transported hundreds of kilometers from their sources (NRC, 1993).

Visibility has been defined as the degree to which the atmosphere is transparent to visible light (NRC, 1993). Visibility impairment is caused by the scattering and absorption of light by particles and gases in the atmosphere. Fine particles (0.1 to 2.5 microns in diameter) are more effective per unit mass concentration at impairing visibility than either larger or smaller particles (NAPAP, 1991). Most of the diesel particle mass emitted by diesel engines falls within this fine particle size range. Light absorption is often caused by elemental carbon, a product of incomplete combustion from activities such as burning diesel fuel or wood. These particles cause light to be scattered or absorbed, thereby reducing visibility.

Heavy-duty vehicles contribute a significant portion of the emissions of direct PM, NO_X, and SO_X that result in ambient PM that contributes to regional haze and impaired visibility. The Grand Canyon Visibility Transport Commission's report found that heavy-duty diesel vehicles contribute 41 percent of fine elemental carbon or soot, 20 percent of NO_X, 7 percent of fine organic carbon, and 6 percent of SO_X. The report also found that reducing total mobile source emissions is an essential part of any program to protect visibility in the Western U.S. The Commission identified mobile source pollutants of concern as VOC, NO_X, and elemental and organic carbon. The Western Governors Association, in later commenting on the Regional Haze Rule and on protecting the 16 Class I areas on the Colorado Plateau, stated that the federal government, and particularly EPA, must do its part in regulating emissions from mobile sources that contribute to regional haze in these areas. As described more fully later in this section, today's action will result in large reductions in these pollutants. These reductions are expected to provide an important step towards improving visibility across the nation. Emissions reductions being achieved to attain the 1-hour ozone and PM_{10} NAAQS will assist in visibility improvements. Moreover, the timing of the reductions from the standards fits very well with the goals of the regional haze program. We will work with the regional planning bodies to make sure they have the information to take account of the reductions from this final rule in their planning efforts.

The Clean Air Act contains provisions designed to protect national parks and wilderness areas from visibility impairment. In 1999, EPA promulgated a rule that will require States to develop plans to dramatically improve visibility in national parks. Although it is difficult to determine natural visibility levels, we believe that average visual range in many Class I areas in the United States is significantly less (about 50–66 percent of natural visual range in the West, about 20 percent of natural visual range in the East) than the visual range that will exist without anthropogenic air pollution. The final Regional Haze Rule establishes a 60-year time period for planning purposes, with several near term regulatory requirements, and is applicable to all 50 states. One of the obligations is for States to representative conduct visibility monitoring in mandatory Class I Federal areas and determine baseline conditions using data for year 2000 to 2004. Reductions of particles, NO_X, sulfur, and VOCs from this rulemaking will have a significant impact on moving all states towards achieving long-term visibility goals, as outlined in the 1999 Regional Haze Rule.

C. Contribution from Heavy-Duty Vehicles

Nationwide, heavy-duty vehicles are projected to contribute about 15 percent of the total NO_X inventory, and 28 percent of the mobile source inventory in 2007. Heavy-duty NO_X emissions also contribute to fine particulate concentrations in ambient air due to the transformation in the atmosphere to nitrates. The NO_X reductions resulting from today's standards will therefore have a considerable impact on the national NO_X inventory. All highway vehicles account for 34 percent and heavy-duty highway vehicles account for 20 percent of the mobile source portion of national PM_{10} emissions in 2007. The heavy-duty portion of the inventory is often greater in the cities, and the reductions in this rulemaking will have a relatively greater benefit in those areas.

1. NO_X Emissions

Heavy-duty vehicles are important contributors to the national inventories of NO_X emissions. Without NO_X reductions from this rule, HDVs are expected to contribute approximately 18 percent of annual NO_X emissions in 1996. The HDV contribution is predicted to fall to 15 percent in 2007 and 14 percent in 2020 due to reductions from the 2004 heavy-duty rulemaking, and then rise again to 16 percent of total NO_X inventory by 2030 (Table II.C–1). Annual NO_X reductions from this rule are expected to total 2.6 million tons in 2030.

TABLE II.C–1—NO_X EMISSIONS FROM HDVS WITH AND WITHOUT REDUCTIONS FROM THIS RULE

Year	Without this rule (base case)		With this rule (control case)
	HDV annual NO_X tons	HDV annual NO_X tons as a percent of total NO_X	Reductions in annual HDV NO_X tons
1996	4,810,000	18	n/a
2007	3,040,000	15	58,000
2020	2,560,000	14	1,820,000
2030	2,960,000	16	2,570,000

The contribution of heavy-duty vehicles to NO_X inventories in many MSAs is significantly greater than that reflected in the national average. For example, HDV contributions to total annual NO_X is greater than the national average in the eight metropolitan statistical areas listed in Table II.C–2. Examples of major cities with a history of persistent ozone violations that are heavily impacted by NO_X emissions from HDVs include: Los Angeles, Washington, DC, San Diego, Hartford, Atlanta, Sacramento. As presented in the table below, HDV's contribute from 22 percent to 33 percent of the total NO_X inventories in these selected cities. NO_X emissions also contribute to the formation of fine particulate matter, especially in the West. In all areas, NO_X also contributes to environmental and welfare effects such as regional haze, and eutrophication and nitrification of water bodies.

TABLE II.C–2—HEAVY-DUTY VEHICLE PERCENT CONTRIBUTION TO NO_X INVENTORIES IN SELECTED URBAN AREAS IN 2007

MSA, CMSA / State	HDV NO_X as portion of total NO_X (%)	HDV NO_X as portion of mobile source NO_X (%)
National	*15*	*28*
Sacramento, CA	33	37
Hartford, CT	28	38
San Diego, CA	25	28
San Francisco, CA	24	29
Atlanta, GA	22	34
Los Angeles	22	26
Dallas	22	28
Washington-Baltimore, MSA	22	36

2. PM Emissions

Nationally, we estimate that primary emissions of PM_{10} to be about 33 million tons/year in 2007. Fugitive dust, other miscellaneous sources and crustal material (wind erosion) constitute approximately 90 percent of the 2007 PM_{10} inventory. However, there is evidence from ambient studies that emissions of these materials may be overestimated and/or that once emitted they have less of an influence on monitored PM concentration than this inventory share would suggest. Mobile sources account for 22 percent of the PM_{10} inventory (excluding the contribution of miscellaneous and natural sources) and highway heavy-duty engines, the subject of today's action, account for 20 percent of the mobile source portion of national PM_{10} emissions in 2007.

The contribution of heavy-duty vehicle emissions to total PM emissions in some metropolitan areas is substantially higher than the national average. This is not surprising, given the high density of these engines operating in these areas. For example, in Los Angeles, Atlanta, Hartford, San Diego, Santa Fe, Cincinnati, and Detroit, the estimated 2007 highway heavy-duty vehicle contribution to mobile source PM_{10} ranges from 25 to 38 percent, while the national percent contribution to mobile sources for 2007 is projected to be about 20 percent. As illustrated in Table II.C–3, heavy-duty vehicles operated in El Paso, Indianapolis, San Francisco, and Minneapolis also account for a higher portion of the mobile source PM inventory than the national average. These data are based on updated inventories developed for this rulemaking. Importantly, these estimates do not include the contribution from secondary PM, which is an important component of diesel PM.

TABLE II.C–3—2007 HEAVY-DUTY VEHICLE CONTRIBUTION TO URBAN MOBILE SOURCE PM INVENTORIES

MSA, State	HDV PM Contribution to mobile source PMG[a]
National (48 State)	*20*
Atlanta, GA MSA	25
Cincinnati-Hamilton, OH–KY–IN CMSA	26
Detroit-Ann Arbor-Flint, MI CMSA	25
El Paso, TX MSA	23
Hartford, CT MSA	30
Indianapolis, IN MSA	23
Los Angeles-Riverside-Orange County, CA CMSA	25
Minneapolis-St. Paul, MN–WI MSA	23
San Diego, CA MSA	27
San Francisco-Oakland-San Jose, CA CMSA	24
Santa Fe, NM MSA	38

[a] Direct exhaust emissions only; excludes secondary PM.

The city-specific emission inventory analysis and investigations of ambient $PM_{2.5}$ summarized in the RIA indicate that the contribution of diesel engines to PM inventories in several urban areas around the U.S. is much higher than indicated by the national PM emission inventories only. One possible explanation for this is the concentrated use of diesel engines in certain local or regional areas which is not well represented by the national, yearly average presented in national PM emission inventories. Another reason may be underestimation of the in-use diesel PM emission rates. Our current modeling incorporates deterioration only as would be experienced in properly maintained, untampered vehicles. We are currently in the process of reassessing the rate of in-use deterioration of diesel engines and vehicles which could significantly increase the contribution of HDVs to diesel PM.

3. Environmental Justice

Environmental justice is a priority for EPA. The Federal government stated its concern, in part, over this issue through issuing Executive Order 12898, Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations (February 11, 1994). This Order requires that federal agencies make achieving environmental justice part of their mission. Similarly, the EPA created an Office of Environmental Justice (originally the Office of Environmental Equity) in 1992, commissioned a task force to address environmental justice issues, oversees a Federal Advisory Committee addressing environmental justice issues (the National Environmental Justice Advisory Council), and has developed an implementation strategy as required under Executive Order 12898.

Application of environmental justice principles as outlined in the Executive Order advances the fair treatment of people of all races, income, and culture with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no person or group of people should shoulder a disproportionate share of any negative environmental impacts resulting from the execution of this country's domestic and foreign policy programs.

For the last several years, environmental organizations and community-based citizens groups have been working together to phase out diesel buses in urban areas. For example, the Natural Resources Defense Council initiated a ''Dump Dirty Diesel'' campaign in the 1990s to press for the phase out of diesel buses in New York City. Other environmental organizations operating in major cities such as Boston, Newark, and Los Angeles have joined this campaign. The Coalition for Clean Air worked with NRDC and other experts to perform exposure monitoring in communities located near distribution centers where diesel truck traffic is heavy. These two organizations concluded that facilities with heavy truck traffic are exposing local communities to diesel exhaust concentrations far above the average levels in outdoor air. The report states: ''These affected communities, and the workers at these distribution facilities with heavy diesel truck traffic, are bearing a disproportionate burden of the health risks.'' [72] Other diesel ''hot spots'' identified by the groups are bus terminals, truck and bus maintenance facilities, retail distribution centers, and busy streets and highways.

While there is currently a limited understanding of the relationship of environmental exposures to the onset of asthma, the environmental triggers of asthma attacks for children with asthma have become increasingly well characterized.[73] Asthma's burden falls hardest on the poor, inner city residents, and children. Among children up to 4 years of age, asthma prevalence increased 160 percent since 1980.[74] African-American children have an annual rate of hospitalization three times that for white children, and are four times as likely to seek care at an emergency room.[75] In 1995, the death rate from asthma in African-American children, 11.5 per million, was over four times the rate in white American children, 2.6 per million.[76]

Local community groups and private citizens testified at public hearings held for this rule that the residents of their communities suffer greatly, and disproportionally, from air pollution in general, and emissions from heavy-duty vehicles in particular. For example, a testifier in New York pointed out that ''since Northern Manhattan and the South Bronx experience asthma mortality and morbidity rates at three to five times greater than the citywide average, New York City's problem is Northern Manhattan's crisis.'' [77]

The new standards established in this rulemaking are expected to improve air quality across the country and will provide increased protection to the public against a wide range of health effects, including chronic bronchitis, respiratory illnesses, and aggravation of asthma symptoms. These air quality and public health benefits could be expected to mitigate some of the environmental justice concerns related to heavy-duty vehicles since the rule will provide relatively larger benefits to heavily impacted urban areas.

D. Anticipated Emissions Benefits

This subsection presents the emission benefits we anticipate from heavy-duty vehicles as a result of our new NO_X, PM, and NMHC emission standards for heavy-duty engines. The graphs and tables that follow illustrate the Agency's projection of future emissions from heavy-duty vehicles for each pollutant. The baseline case represents future emissions from heavy-duty vehicles at present standards (including the MY2004 standards). The controlled case quantifies the future emissions of heavy-duty vehicles once the new standards in this FRM are implemented.

We use the same baseline inventory as is used in the county-by-county, hour-by-hour air quality analyses associated with this rule. However, we made a slight modification to the controlled inventory to incorporate the changes between the proposed and final standards. Because the detailed air quality analyses took several months to perform, we had to use the proposed standards for the air quality analysis. Since beginning this analysis, we updated the control case emission inventories to reflect the final phase-in of the NO_X standard, slight changes to the timing of the HDGV standards, a temporary compliance option for introducing the low sulfur fuel requirements, and various hardship provisions for refiners in our emission inventory projections. The emission inventory calculations are presented in detail in the Regulatory Impact Analysis.

1. NO_X Reductions

The Agency expects substantial NO_X reductions on both a percentage and a tonnage basis from the new standards. The RIA provides additional projections between 2007 and 2030. As stated previously, HDVs contribute about 15 percent to the national NO_X inventory for all sources in 2007. Figure II.D–1 shows our national projections of total NO_X emissions with and without the engine controls finalized today. Table II.D–1 presents the total reductions.[78] This includes both exhaust and crankcase emissions.[79] The standards

[72] *Exhausted by Diesel: How America's Dependence on Diesel Engines Threatens Our Health,* Natural Resources Defense Council, Coalition for Clean Air, May 1998.

[73] *Asthma and the Environment: A Strategy to Protect Children, President's Task Force on Environmental Health Risks and Safety Risks to Children,* January 28, 1999, Revised May, 2000.

[74] Asthma Statistics, National Institutes of Health, National Heart, Lung and Blood Institute, January, 1999.

[75] *Asthma and the Environment: A Strategy to Protect Children, President's Task Force on Environmental Health Risks and Safety Risks to Children,* January 28, 1999, Revised May, 2000. The Task Force was formed in conjunction with Executive Order 13045 (April 21, 1997), is co-chaired by Department of Health and Human Services and EPA, and is charged with recommending strategies for protecting children's environmental health and safety. In April, 1998, the Task Force identified childhood asthma as one of its top four priorities for immediate attention.

[76] *Id.*

[77] Testimony by Peggy Shepard, Executive Director, West Harlem Environmental Action, June 19th, 2000.

[78] The baseline used for this calculation is the 2004 HDV standards (64 FR 58472). These reductions are in addition to the NO_X emissions reductions projected to result from the 2004 HDV standards.

[79] We include in the NO_X projections excess emissions, developed by the EPA's Office of Enforcement and Compliance, that were emitted by many model year 1998–98 diesel engines. This is described in more detail in Chapter 2 of the RIA.

should result in close to a 90 percent reduction in NO_X from new engines.

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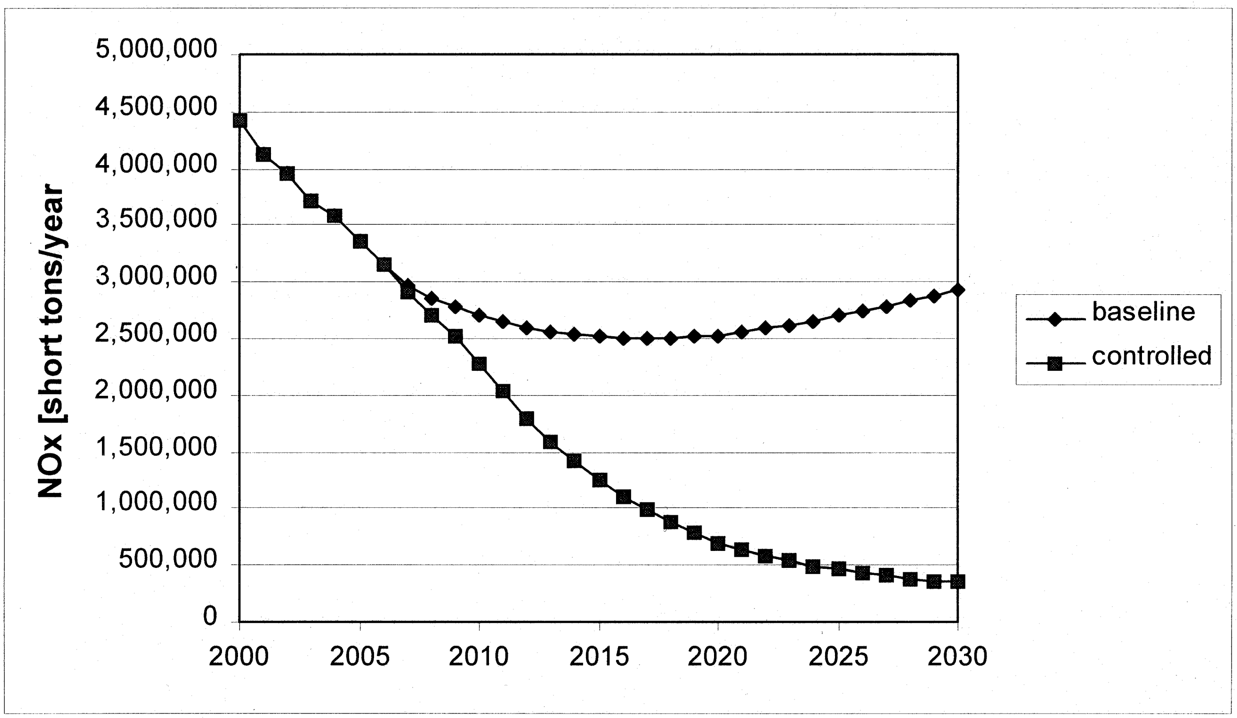

Figure II.D-1: Projected Nationwide Heavy-Duty Vehicle NOx Emissions

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TABLE II.D–1.—ESTIMATED REDUCTIONS IN NO_X

Calendar year	NO_X reduction [thousand short tons]
2007	58
2010	419
2015	1,260
2020	1,820
2030	2,570

2. PM Reductions

As stated previously, HDVs will contribute about 20 percent to the 2007 national PM_{10} inventory for mobile sources. The majority of the projected PM reductions are directly a result of the exhaust PM standard. However, a modest amount of PM reductions will come from reducing sulfur in the fuel. For the existing fleet of heavy-duty vehicles, a small fraction of the sulfur in diesel fuel is emitted directly into the atmosphere as direct sulfate, and a portion of the remaining fuel sulfur is transformed in the atmosphere into sulfate particles, referred to as indirect sulfate. Reducing sulfur in the fuel decreases the amount of direct sulfate PM emitted from heavy-duty diesel engines and the amount of heavy-duty diesel engine SOx emissions that are transformed into indirect sulfate PM in the atmosphere.[80] For engines meeting the new standards, we consider low sulfur fuel to be necessary to enable the PM control technology. In other words, we do not claim an additional benefit beyond the new exhaust standard for reductions in direct sulfate PM for new engines. However, once the low sulfur fuel requirements go into effect, many pre-2007 model year engines would also be using low sulfur fuel. Because these pre-2007 model year engines are certified with higher sulfur fuel, they will achieve reductions in PM beyond their certification levels.

Figure II.D–2 shows our national projections of total HDV PM (TPM) emissions with and without the new engine controls. This figure includes brake and tire wear, crankcase emissions and the direct sulfate PM (DSPM) benefits due to the use of low sulfur fuel by the existing fleet. These direct sulfate PM benefits from the existing fleet are also graphed separately. The new standards will result in about a 90 percent reduction in exhaust PM from new heavy-duty diesel engines. The low sulfur fuel should result in more than a 95 percent reduction in direct sulfate PM from pre-2007 heavy-duty diesel engines. Due to complexities of the conversion and removal processes of sulfur dioxide, we do not attempt to quantify the indirect sulfate reductions that would be derived from this rulemaking in the inventory analysis. Nevertheless, we recognize that these indirect sulfate PM reductions contribute significant additional benefits to public health and welfare, and we include this effect in our more detailed air quality analysis.

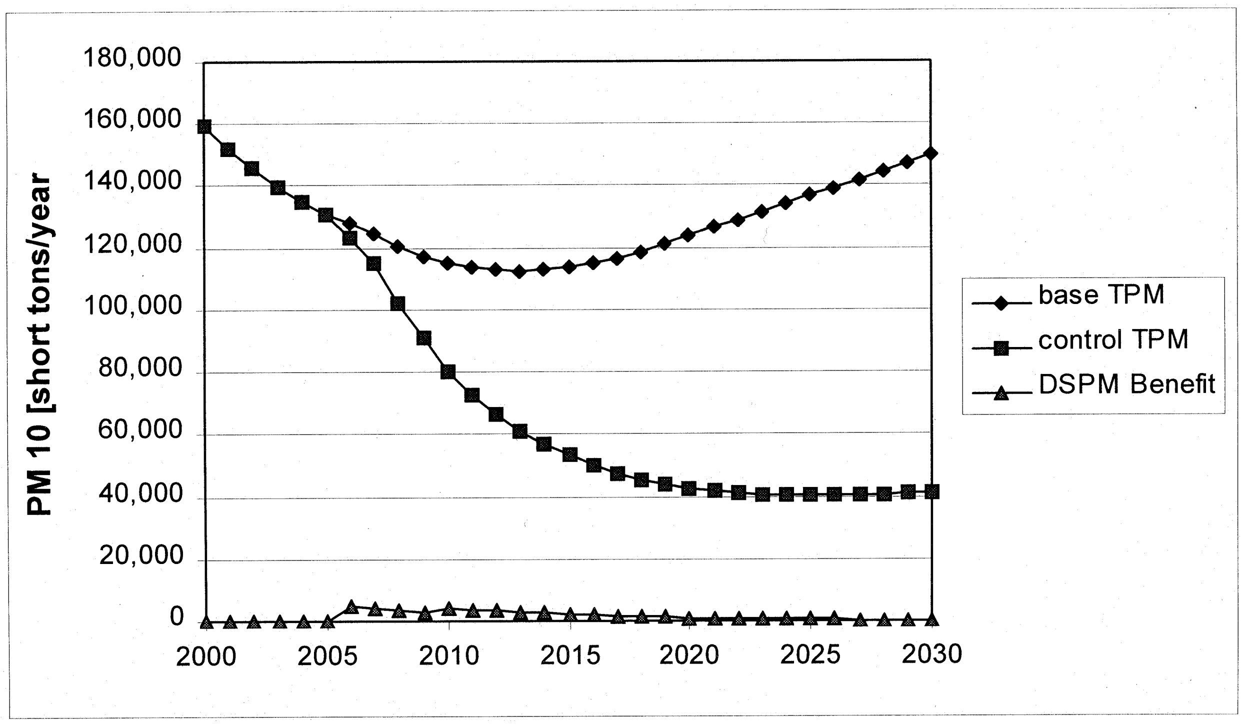

Figure II.D-2: Projected Nationwide Heavy-Duty Vehicle PM Emissions and Direct Sulfate Emission Reductions

[80] Sulfate forms a significant portion of total fine particulate matter in the Northeast Chemical speciation data in the Northeast collected in 1995 shows that the sulfate fraction of fine particulate matter ranges from 20 and 27 percent of the total fine particle mass. *Determination of Fine Particle and Concentrations and Chemical Composition in the Northeastern United States. 1995.* NESCAUM, prepared by Cass, et al., September 1999.

TABLE II.D–2.—ESTIMATED REDUCTIONS IN PM

Calendar year	PM reduction [thousand short tons]
2007	11
2010	36
2015	61
2020	82
2030	109

3. NMHC Reductions

The standards described in Section III are designed to be feasible for both gasoline and diesel heavy-duty vehicles. Although the standards give manufacturers the same phase-in for NMHC as for NO_X, we model the NMHC reductions for diesel vehicles to be fully in place in 2007 due to the application of particulate control technology. We believe the use of aftertreatment for PM control will cause the NMHC levels to be below the standards as soon as the PM standard goes into effect in 2007.

HDVs account for about 3 percent of national VOC and 8 percent from mobile sources in 2007. Figure II.D–3 shows our national projections of total NMHC emissions with and without the new engine controls. This includes both exhaust emissions and evaporative emissions. Table II.D–3 presents the projected reductions of NMHC due to the new standards.

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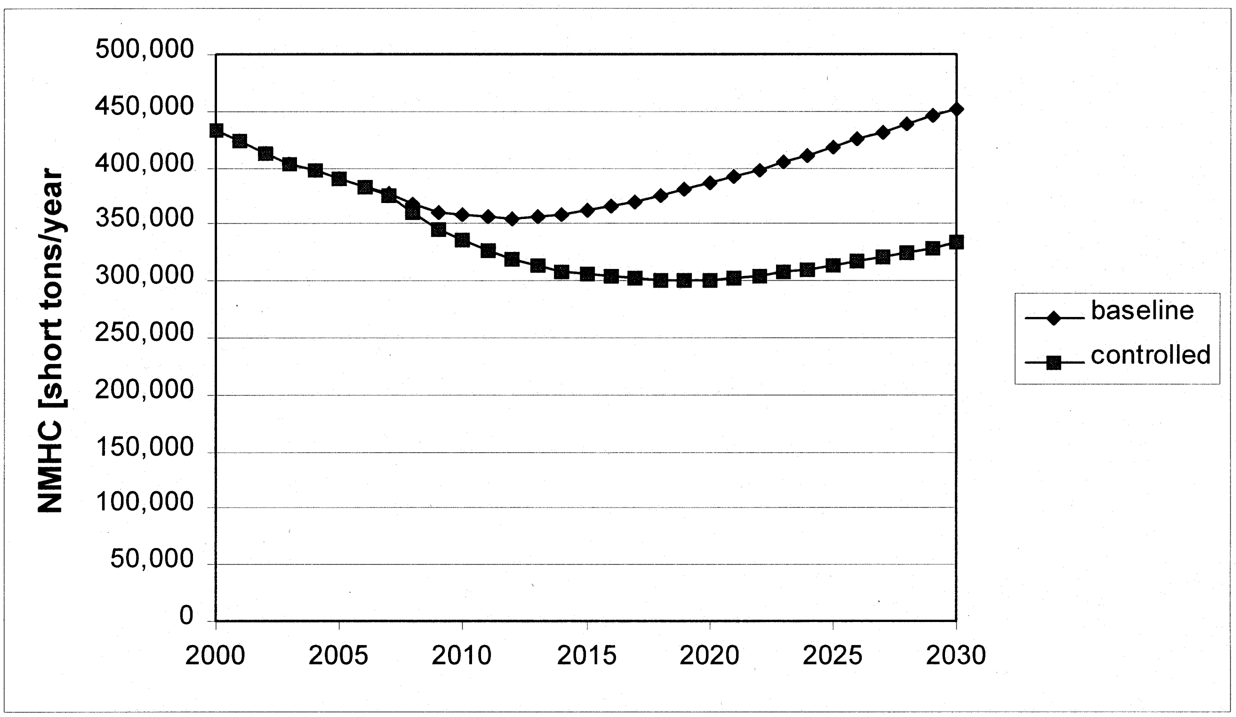

Figure II.D-3: Projected Nationwide Heavy-Duty Vehicle NMHC Emissions

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TABLE II.D–3.—ESTIMATED REDUCTIONS IN NMHC

Calendar year	NMHC reduction [thousand short tons]
2007	2
2010	21
2015	54
2020	83
2030	115

4. Additional Emissions Benefits

This subsection looks at tons/year emission inventories of CO, SO_X, and air toxics from HDEs. Although we are not including stringent standards for these pollutants in this action, we believe the standards will result in reductions in CO, SO_X, and air toxics. Here, we present our anticipated benefits.

a. CO Reductions

In 2007, HDVs are projected to contribute to approximately 5 percent of national CO and 9 percent of CO from mobile sources. Although it does not include new CO emission standards, today's action would nevertheless be expected to result in a considerable reduction in CO emissions from heavy-duty vehicles. CO emissions from heavy-duty diesel vehicles, although already very low, would likely be reduced by an additional 90 percent due to the operation of emissions control systems that will be necessary to achieve today's new standards for hydrocarbons and particulate matter. CO emissions from heavy-duty gasoline vehicles would also likely decline as the NMHC emissions are decreased. Table II.D–4 presents the projected reductions in CO emissions from HDVs.

TABLE II.D–4.—ESTIMATED REDUCTIONS IN CO

Calendar year	CO reduction [thousand short tons]
2007	56
2010	317
2015	691
2020	982
2030	1,290

b. SO_X Reductions

HDVs are projected to emit approximately 0.5 percent of national SO_X and 8 percent of mobile source SO_X in 2007. We are requiring significant reductions in diesel fuel sulfur to enable certain emission control devices to function properly. We expect SO_X emissions to decline as a direct benefit of low sulfur diesel fuel. The majority of these benefits will be from heavy-duty highway diesel vehicles; however, some benefits will also come from highway fuel burned in other applications such as light-duty diesel vehicles and nonroad engines. As discussed in greater detail in the section on PM reductions, the amount of sulfate particles (direct and indirect) formed as a result of diesel exhaust emissions will decline for all HD diesel engines operated on low sulfur diesel fuel, including the current on-highway HD diesel fleet, and those non-road HD diesel engines that may operate on low sulfur diesel fuel in the future. Table II.D–5 presents our estimates of SO_X reductions resulting from the low sulfur fuel.

TABLE II.D–5.—ESTIMATED REDUCTIONS IN SO_X DUE TO LOW SULFUR FUEL

Calendar year	SO_X reduction [thousand short tons]
2007	79
2010	107
2015	117
2020	126
2030	142

c. Air Toxics Reductions

This FRM establishes new non-methane hydrocarbon standards for all heavy-duty vehicles and a formaldehyde standard for complete heavy-duty vehicles. Hydrocarbons are a broad class of chemical compounds containing carbon and hydrogen. Many forms of hydrocarbons, such as formaldehyde, are directly hazardous and contribute to what are collectively called ''air toxics.'' Air toxics are pollutants known to cause or suspected of causing cancer or other serious human health effects or ecosystem damage. The Agency has identified at least 20 compounds emitted from on-road gasoline vehicles that have toxicological potential, 19 of which are emitted by diesel vehicles, as well as an additional 20 compounds which have been listed as toxic air contaminants by California ARB.[81] [82] This action also will reduce emissions of diesel exhaust and diesel particulate matter (see Section II.B for a discussion of health effects).

Our assessment of heavy-duty vehicle (gasoline and diesel) air toxics focuses on the following compounds with cancer potency estimates that have significant emissions from heavy-duty vehicles: benzene, formaldehyde, acetaldehyde, and 1,3-butadiene. These compounds are an important, but limited, subset of the total number of air toxics that exist in exhaust and evaporative emissions from heavy-duty vehicles. The reductions in air toxics quantified in this section represent only a fraction of the total number and amount of air toxics reductions expected from the new hydrocarbon standards.

For this analysis, we estimate that air toxic emissions are a constant fraction of hydrocarbon exhaust emissions from future engines. Because air toxics are a

[81] National Air Quality and Emissions Trends Report, 1997, (EPA 1998), p. 74.

[82] California Environmental Protection Agency (1998) Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Appendix III, Part A: Exposure Assessment. April 1998.

subset of hydrocarbons, and new emission controls are not expected to preferentially control one type of air toxic over another, the selected air toxics chosen for this analysis are expected to decline by the same percentage amount as hydrocarbon exhaust emissions. We have not performed a separate analysis for the new formaldehyde standard since compliance with the hydrocarbon standard should result in compliance with the formaldehyde standard for all petroleum-fueled engines. The RIA provides more detail on this analysis. Table II.D–6 shows the estimated air toxics reductions associated with the reductions in hydrocarbons.

TABLE II.D–6.—ESTIMATED REDUCTIONS IN AIR TOXICS (SHORT TONS)

Calendar year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene
2007	24	181	67	14
2010	356	1,670	608	135
2015	965	4,720	1,720	384
2020	1,340	7,080	2,600	567
2030	1,960	10,200	3,730	823

E. Clean Heavy-Duty Vehicles and Low-Sulfur Diesel Fuel are Critically Important for Improving Human Health and Welfare

Despite continuing progress in reducing emissions from heavy-duty engines, emissions from these engines continue to be a concern for human health and welfare. Ozone continues to be a significant public health problem, and affects not only people with impaired respiratory systems, such as asthmatics, but healthy children and adults as well. Ozone also causes damage to plants and has an adverse impact on agricultural yields. Particulate matter, like ozone, has been linked to a range of serious respiratory health problems, including premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, and chronic bronchitis. Importantly, EPA has concluded that diesel exhaust is likely to be carcinogenic to humans by inhalation at occupational and environmental levels of exposure.

Today's action will reduce NO_X, VOC, CO, PM, and SO_X emissions from these heavy-duty vehicles substantially. These reductions will help reduce ozone levels nationwide and reduce the frequency and magnitude of predicted exceedances of the ozone standard. These reductions will also help reduce PM levels, both by reducing direct PM emissions and by reducing emissions that give rise to secondary PM. The NO_X and SO_X reductions will help reduce acidification problems, and the NO_X reductions will help reduce eutrophication problems. The PM and NO_X standard enacted today will help improve visibility. All of these reductions are expected to have a beneficial impact on human health and welfare by reducing exposure to ozone, PM, diesel exhaust and other air toxics and thus reducing the cancer and noncancer effects associated with exposure to these substances.

III. Heavy-Duty Engine and Vehicle Standards

In this section, we describe the vehicle and engine standards we are finalizing today to respond to the serious air quality needs discussed in Section II. Specifically, we discuss:

- The CAA and why we are finalizing new heavy-duty standards.
- The technology opportunity for heavy-duty vehicles and engines.
- Our new HDV and HDE standards, and our phase-in of those standards.
- Why we believe the stringent standards being finalized today are feasible in conjunction with the low sulfur gasoline required under the recent Tier 2 rule and the low sulfur diesel fuel being finalized today.
- The effects of diesel fuel sulfur on the ability to meet the new standards, and what happens if high sulfur diesel fuel is used.
- Plans for future review of the status of heavy-duty diesel NO_X emission control technology.

A. Why Are We Setting New Heavy-Duty Standards?

We are finalizing new heavy-duty vehicle and engine standards and related provisions under section 202(a)(3) of the CAA, which authorizes EPA to establish emission standards for new heavy-duty motor vehicles. (See 42 U.S.C. 7521(a)(3).) Section 202(a)(3)(A) requires that such standards ''reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety factors associated with the application of such technology.'' Section 202(a)(3)(B) allows EPA to take into account air quality information in revising such standards. Because heavy-duty engines contribute greatly to a number of serious air pollution problems, especially the health and welfare effects of ozone, PM, and air toxics, and because millions of Americans live in areas that exceed the national air quality standards for ozone or PM, we believe the air quality need for tighter heavy-duty standards is well founded. This, and our belief that a significant degree of emission reduction from heavy-duty vehicles and engines is achievable, giving appropriate consideration to cost, energy, and safety factors, through the application of new diesel emission control technology, further refinement of well established gasoline emission controls, and reductions of diesel fuel sulfur levels, leads us to believe that new emission standards are warranted.

B. Emission Control Technologies for Heavy-Duty Vehicles and Engines

For the past 30 or more years, emission control development for gasoline vehicles and engines has concentrated most aggressively on exhaust emission control devices. These devices currently provide as much as or more than 95 percent of the emission control on a gasoline vehicle. In contrast, the emission control development work for diesels has concentrated on improvements to the engine itself to limit the emissions leaving the combustion chamber.

However, during the past 15 years, more development effort has been put into diesel exhaust emission control devices, particularly in the area of PM control. Those developments, and recent developments in diesel NO_X control devices, make the widespread commercial use of diesel exhaust emission controls feasible. Through use of these devices, we believe emissions control similar to that attained by gasoline applications will be possible with diesel applications. However, without low sulfur diesel fuel, these technologies cannot be implemented on heavy-duty diesel applications. Low sulfur diesel fuel will at the same time also allow these technologies to be implemented on light-duty diesel applications.

As discussed at length in the preamble to our proposal, several exhaust emission control devices have been or are being developed to control harmful diesel exhaust pollutants. Of these, we believe that the catalyzed diesel particulate trap and the NO_X adsorber are the most likely candidates to be used to meet the very low diesel exhaust emission standards adopted today on the variety of applications in the heavy-duty diesel market. While other technologies exist that have the potential to provide significant emission reductions, such as selective catalytic reduction systems for NO_X control, and development of these technologies is being pursued to varying degrees, we believe that the catalyzed diesel particulate trap and the NO_X adsorber will be the only likely broadly applicable technology choice by the makers of engines and vehicles for the national fleet in this timeframe. However, as discussed in detail in the Final RIA, we strongly believe that none of these technologies can be brought to market on diesel engines and vehicles unless the kind of low sulfur diesel fuel adopted in this rule is available.

As for gasoline engines and vehicles, improvement continues to be made to gasoline emissions control technology. This includes improvement to catalyst designs in the form of improved washcoats and improved precious metal dispersion. Much effort has also been put into improved cold start strategies that allow for more rapid catalyst light-off. This can be done by retarding the spark timing to increase the temperature of the exhaust gases, and by using air-gap manifolds, exhaust pipes, and catalytic converter shells to decrease heat loss from the system.

These improvements to gasoline emission controls will be made in response to the California LEV–II standards and the federal Tier 2 standards.[83] These improvements should transfer well to the heavy-duty gasoline segment of the fleet. With such migration of light-duty technology to heavy-duty vehicles and engines, we believe that considerable improvements to heavy-duty gasoline emissions can be realized, thus allowing vehicles to meet the much more stringent standards adopted today.

The following discussion provides more detail on the technologies we believe are most capable of meeting very stringent heavy-duty emission standards. The goal of this discussion is to describe the emission reduction capability of these emission control technologies and their critical need for diesel fuel sulfur levels as low as those being finalized today. But first, we present the details of the new emission standards being finalized today.

C. What Engine and Vehicle Standards Are We Finalizing?

1. Heavy-Duty Engine Exhaust Emissions Standards

a. FTP Standards[84]

The emission standards finalized today for heavy-duty engines are summarized in Table III.C–1. For reasons explained below, the phase-in schedule for these standards differs from the proposed schedule. We are also finalizing an incentive provision to encourage the early introduction of engines meeting these new standards. This incentive provision is explained in section III.D. In addition, we have altered our Averaging, Banking, and Trading (ABT) provisions from what was proposed. The final ABT provisions are discussed in detail in section VI.

TABLE III.C–1.—FULL USEFUL LIFE HEAVY-DUTY ENGINE EXHAUST EMISSIONS STANDARDS AND PHASE-INS FOR INCOMPLETE VEHICLES

		Standard (g/bhp-hr)	Phase-In by Model Year[a]			
			2007	2008	2009	2010
Diesel	NO_X	0.20	50%	50%	50%	100%
	NMHC	0.14	50%	50%	50%	100%
	PM	0.01	100%	100%	100%	100%
Gasoline	NO_X	0.20	0%	50%	100%	100%
	NMHC	0.14	0%	50%	100%	100%
	PM	0.01	0%	50%	100%	100%

[a] Percentages represent percent of sales.

With respect to PM, this new standard represents a 90 percent reduction for most heavy-duty diesel engines from the current PM standard. The current PM standard for most heavy-duty engines, 0.10 g/bhp-hr, was implemented in the 1994 model year; the PM standard for urban buses implemented in that same year was 0.05 g/bhp-hr; these standards are not changing when other standards change in the 2004 model year timeframe. The new PM standard of 0.01 g/bhp-hr being finalized today is projected to require the addition of highly efficient PM traps to diesel engines, including those diesel engines used in urban buses; it is not expected to require the addition of any new hardware for gasoline engines.

With respect to NMHC and NO_X, these new standards represent significant reductions from the 2004 diesel engine standard which is either 2.4 g/bhp-hr NO_X+NMHC, or 2.5 g/bhp-hr NO_X+NMHC with a cap on NMHC of 0.5 g/bhp-hr. We generally expect that 2004 diesel engines will meet those standards with emission levels around 2.2 g/bhp-hr NO_X and 0.2 g/bhp-hr NMHC. Like the PM standard, the new NO_X standard is projected to require the addition of a highly efficient NO_X emission control system to diesel engines which, with help from the PM trap, will need to be optimized to control NMHC emissions. For gasoline

[83] See Chapter IV.A of the final Tier 2 Regulatory Impact Analysis, contained in Air Docket A–97–10, and McDonald, Joseph, and Jones, Lee, ''Demonstration of Tier 2 Emission Levels for Heavy Light-Duty Trucks,'' SAE 2001–01–1957.

[84] The Phase 1 heavy-duty rule recently promulgated by EPA specified two supplemental sets of standards for heavy-duty diesel engines. (See 65 FR 59896, October 6, 2000.) Manufacturers of heavy-duty diesel engines must meet these supplemental standards, the Supplemental Emission Test (SET, formerly referred to as the Supplemental Steady-State (SSS) test) and the Not-to-Exceed (NTE) standards, beginning in model year 2007, in addition to meeting the preexisting standards, which must be met using the preexisting federal test procedure (FTP). For the purposes of this preamble, we refer to the standards met using the preexisting FTP as the FTP standards, though the SET and NTE test procedures have now been added to the regulations establishing the various federal test procedures for heavy-duty diesel engines.

engines, the 2005 model year standard recently finalized in the Phase 1 heavy-duty rule is 1.0 g/bhp-hr NO_X+NMHC. (See 65 FR 59896, October 6, 2000.) There is a direct trade off between NO_X and NMHC emissions with a gasoline engine, but we would generally expect NO_X levels over 0.5 g/bhp-hr and NMHC levels below that. Regardless of the NO_X and NMHC split, today's standards represent significant reductions for 2008 and later engines that will require substantial improvement in the effectiveness of heavy-duty gasoline emission control technology.

We proposed a new formaldehyde standard of 0.016 g/bhp-hr for both heavy-duty diesel and gasoline engines. However, we have decided not to finalize those standards. We proposed the formaldehyde (HCHO) standard because it is a hazardous air pollutant that is emitted by heavy-duty engines and other mobile sources. In the proposal, we stated our belief that formaldehyde emissions from gasoline and diesel engines are and will remain inherently low, but having the standard would ensure that excess emissions would not occur. Several commenters took issue with our proposed standard claiming that the benefits were nonexistent, that we should address toxic emissions in our toxics rulemaking, and that we had shown neither its technological feasibility nor its measurability. After further consideration we do believe that the proposed formaldehyde standard is not necessary because the NMHC standard we are promulgating today will almost certainly result in formaldehyde emissions well below our proposed formaldehyde standard. As a result, other comments on this issue such as those concerning technological feasibility and measurability are no longer relevant to this rule. We will continue to evaluate this issue to ensure that formaldehyde emissions do not become a problem in the future and may take action to consider standards if warranted.

We believe a phase-in of the diesel NO_X standard is appropriate. With a phase-in, manufacturers are able to introduce the new technology on a portion of their engines, thereby gaining valuable experience with the technology prior to implementing it on their entire fleet. Also, we are requiring that the NO_X, and NMHC standards be phased-in together for diesel engines. That is, engines will be expected to meet both of these new standards, not just one or the other. We are requiring this because the standard finalized in the Phase 1 heavy-duty rule is a combined NMHC+NO_X standard. With separate NO_X and NMHC phase-ins, say 50/50/50/100 for NO_X and 100 percent in 2007 for NMHC, the 2.5 gram engines being phased-out would have a 2.5 gram NO_X+NMHC standard and a new 0.14 gram NMHC standard with which to comply. While this could be done, we believe that it introduces unnecessary compliance complexity to the program.

In our NPRM, we requested comment on a range of possible phase-in schedules for NO_X including anything from our primary proposal of 25/50/75/100 percent phase-in to a possible requirement for 100 percent compliance in the 2007 model year. We have determined that a 50/50/50/100 percent phase-in schedule is the most appropriate schedule for several reasons.

Some commenters argued that we should require 100 percent compliance in the 2007 model year because of the 0.20 gram standard was both technologically feasible and critical given the nation's air quality needs. Other commenters were concerned that 100 percent compliance to the 0.20 gram NO_X standard in the first year of the program was ill advised as it would provide little opportunity for industry to ''field test'' new NO_X control technologies. These commenters also expressed concern over workload burdens on industry members needing to redesign all of their new engines and vehicles in one year. Some commenters were concerned that a 25/50/75/100 percent phase-in schedule would introduce competitiveness issues whereby those vehicles equipped with new NO_X control technology may be less attractive to some buyers than vehicles without the technology, making them difficult for manufacturers to sell.

We set standards and implementation schedules based on many factors including technological feasibility, cost, energy, and safety. Considering these factors, we believe that industry should be provided the flexibility of having a phase-in of the new NO_X standard. As discussed in section III.E below, we believe the 0.20 gram NO_X standard is feasible in the 2007 time frame. However, we believe a phase-in is appropriate for a couple of reasons. First, the phase-in will provide industry with the flexibility to roll out the NO_X control technology on only a portion of their fleet. This will allow them to focus their resources on that half of their fleet being brought into compliance in 2007. This ability to focus their efforts will increase both the efficiency and the effectiveness of those efforts. Second, a phase-in allows industry the ability to introduce the new technology on those engines it believes are best suited for a successful implementation which, in turn, provides a valuable opportunity to refine that technology on only a portion of their product line prior to the next push toward full implementation.

Another concern with respect to our proposed phase-in schedule was raised by several commenters and pertains to its interaction with the final implementation schedule for the new supplemental requirements (the Supplemental Emission Test, SET, and the Not-to-Exceed, NTE). These requirements, finalized in the Phase 1 heavy-duty final rule, will be implemented in the 2007 model year on all heavy-duty diesel engines. (See 65 FR 59896, October 6, 2000.) Under a 25/50/75/100 percent phase-in schedule of new diesel engine emission requirements, 25 percent of engines in the 2007 model year would meet 0.20 and 0.01 g/bhp-hr NO_X and PM, while 75 percent would meet 2.5 and 0.01 g/bhp-hr NO_X and PM. Further, all of those engines would be required, beginning in the 2007 model year, to meet the supplemental requirements based on the FTP emission standards to which they were certified. A 25/50/75/100 percent phase-in schedule would change the supplemental requirements for those 25 percent of engines in the 2008 model year that would have to change to meet the new 50 percent compliance requirement. This change would be required even though the supplemental requirements on those 25 percent of engines were first implemented only one model year earlier, in model year 2007. Commenters have questioned whether this is consistent with section 202(a)(3)(c) of the Clean Air Act, which requires that standards for heavy-duty vehicles and engines apply for no less than three model years without revision. Under this argument, the supplemental requirements implemented in the 2007 model year must be allowed three model years of stability, meaning that no changes can be required to those standards until the 2010 model year.

The final phase-in schedule, 50/50/50/100 percent, addresses any concerns about violating the stability requirement of the Act and addresses the technology and lead time benefits of a phase-in as discussed above.[85] While this phase-in does not provide certain commenters with their goal of 100 percent implementation of very low NO_X engines in 2007, we believe it is

[85] EPA need not determine, at this time, whether the 25/50/75/100 percent phase-in schedule violates section 202(a)(3)(c), as the 50/50/50/100 percent phase-in schedule clearly does not and is available to all manufacturers.

appropriate for the technology, cost, and other reasons described above. This 50/50/50/100 percent phase-in schedule does provide a more rapid implementation of low NO_X engines and, more importantly, provides more air quality benefits in 2007 than would our proposed phase-in schedule. We are also finalizing provisions that would encourage manufacturers to introduce clean technology, both diesel and gasoline, earlier than required in return for greater flexibility during the later years of our phase-in. These optional early incentive provisions are analogous to those included in our light-duty Tier 2 rule and are discussed in more detail in section III.D. We have also revised our Averaging, Banking, and Trading program to increase flexibility as discussed further in section VI.

For gasoline engines, we proposed 100 percent compliance in the 2007 model year. However, since the proposal was published, we have set new standards for heavy-duty gasoline engines that take effect in the 2005 model year. Therefore, the three year stability requirement of the CAA requires that today's new standards not apply until the 2008 model year at the earliest. Further, while we had not proposed a phase-in for gasoline standards, based on comments received we believe that a phase-in should be provided. The phase-in will allow manufacturers to implement improved gasoline control technologies on their heavy-duty gasoline engines in the same timeframe as they implement those technologies on their Tier 2 medium-duty passenger vehicles (MDPV). This consistency with Tier 2 is discussed in more detail below in section III.C.2 on vehicle standards. Note that the gasoline engine phase-in schedule is the same as but separate from the gasoline vehicle phase-in schedule discussed below. As we have done for diesel engines, we have also revised our Averaging, Banking, and Trading program for gasoline engines to increase flexibility as discussed further in section VI.

For a discussion of why we believe these standards are technologically feasible in the time frame required, refer to section III.E below and for a more detailed discussion refer to the RIA contained in the docket. The averaging, banking, and trading (ABT) provisions associated with today's standards are discussed in Section VI of this preamble. The reader should refer to that section for more details.

b. Supplemental Provisions for HD Diesel Engines (SET & NTE)

In addition to the new FTP standards for HD diesel engines contained in today's final action, we are also finalizing the supplemental emission standards we proposed to apply to the new HDDEs, with a number of changes as discussed in this section. The supplemental provisions will help ensure that HD diesel engines achieve the expected in-use emission reductions over a wide range of vehicle operation and a wide range of ambient conditions, not only the test cycle and conditions represented by the traditional FTP. The Agency has historically relied upon the FTP and the prohibition of defeat devices to ensure that HDDE emission control technologies which operate during the laboratory test cycle continue to operate in-use. The supplemental provisions are a valuable addition to the FTP and the defeat device prohibition to ensure effective in-use emission control. The supplemental provisions for HD diesel engines consist of two principal requirements, the supplemental emission test and associated standards (SET),[86] and the not-to-exceed test and associated standards (NTE). The supplemental emission standards finalized today for heavy-duty diesel engines are summarized in Table III.C–2.

TABLE III.C–2.—FULL USEFUL LIFE HEAVY-DUTY DIESEL ENGINE SUPPLEMENTAL EXHAUST EMISSIONS STANDARDS

Supplemental test	Requirements for NO_X, NMHC, PM
Supplemental emission test.	1.0 × FTP standard (or FEL).
Not-to-exceed test	1.5 × FTP standard (or FEL).

The SET and NTE test procedures were recently adopted for 2007 on-highway HD diesel engines. (See 65 FR 59896, October 6, 2000.) In the recent HD Phase 1 rulemaking which promulgated the SET and NTE, the supplemental provisions were finalized in the context of the emission control technology expected to be used to meet the 2004 FTP standards, *i.e.,* injection timing strategies and cooled EGR. In this final action, we are finalizing a number of changes to the supplemental provisions to address specific technical issues raised by commenters and which result from the expected application of high efficiency exhaust emission control devices on HD diesel engines and vehicles to meet today's new standards. These changes are minor in nature and will not impact the emission reductions we expect from the Phase 2 standards. These changes are discussed in the following sections. Additional discussion regarding the supplemental provisions for HDDEs is contained in the RIA and the Response to Comments (RTC) for this final rule, as well as in Section III.E of this preamble (''Feasibility of the New Engine and Vehicle Standards'').

i. Supplemental Emission Test

We are finalizing supplemental emission test provisions for HD diesel engines and vehicles certified to the new FTP standards contained in this final rule. The SET emission standard is equal to 1.0 times the FTP standard or FEL for HD diesel engines. Emission results from this test must meet the numerical standards for the FTP. The SET requirements are phased-in beginning with the 2007 model year, consistent with the phase-in of the new FTP standards. The supplemental emission test duty cycle consists of 13 modes of speed and torque, primarily covering the typical highway cruise operating range of heavy-duty diesel engines. The emission results from each of the modes are weighted by defined factors in the regulations, and the final weighted emission value for each pollutant must meet the SET standard. In addition, several of the 13 individual modes are in the NTE control zone, and must meet the applicable NTE requirements. The SET test is a laboratory test performed using an engine dynamometer under the same conditions which apply to the FTP, as specified in the regulations. (See 40 CFR 86.1360.)

The regulations for the SET in model year 2007 as they apply to the 2004 FTP emission standards contain additional steady-state test point emission limits. The Phase 1 supplemental requirements define a ''Maximum Allowable Emission Limit'' (MAEL) which the engines must comply with. The Phase 1 regulations allowed EPA to randomly select up to three steady-state test points prior to certification which the manufacturer would test to show compliance with the MAEL. These test points are referred to as ''mystery points''. In this final rule we have eliminated the MAEL for engines certified to the Phase 2 standards. The MAEL assures that an engine is calibrated to maintain emission control similar to the SET test under steady state conditions across the engine map, not just at the pre-defined 13 test points

[86] In the Phase 1 rulemaking, the Supplemental Emission Test was referred to as the supplemental steady state test. As discussed in the Phase 1 rule, the supplemental steady state test is based on and is consistent with the European Commissions ''EURO III ESC'' test. (See 65 FR 59915.) In this final rule we have renamed the supplemental steady state test the Supplemental Emission Test (SET).

which comprise the SET test. For Phase 1 engines the MAEL was necessary to ensure this potential for gaming did not occur because the difference between the FTP standard and the NTE standard could be large, for example, 0.625 g/bhp-hr for NMHC + NO_X. However, for Phase 2 engines the NTE requirements are a mere 0.10 g/bhp-hr NO_X greater than the FTP standard. Considering this small increment, we have eliminated the MAEL for Phase 2 engines because it is redundant with the NTE. For the same reasons, we have eliminated the certification ''mystery points'' for engines complying with today's diesel engine standards.

ii. Not-to-Exceed

We are also finalizing revisions to the not-to-exceed emission standards for HD diesel engines certified to the Phase 2 FTP standards contained in this final rule. These NTE procedures apply under engine operating conditions within the range specified in the NTE test procedure that could reasonably be expected to be seen in normal vehicle operation and use. (See 40 CFR 86.1370.) The NTE procedure defines limited and specific engine operating regions (*i.e.,* speed and torque conditions) and ambient operating conditions (*i.e.,* altitude, temperature, and humidity conditions) which are subject to the NTE emission standards. Emission results from this test procedure must be less than or equal to 1.5 times the FTP standards (or FEL) for NO_X, NMHC, and PM. The new NTE requirements are phased-in starting with the 2007 model year, consistent with the new FTP standards.

The Not-To-Exceed (NTE) provisions were recently finalized for HDDEs certified to the 2004 FTP emission standards with implementation beginning in model year 2007. (See 65 FR 59896, October 6, 2000.) The NTE approach establishes an area (the ''NTE control area'') under the torque curve of an engine where emissions must not exceed a specified value for any of the regulated pollutants.[87] The NTE requirements would apply under engine operating conditions that could reasonably be expected to be seen in normal vehicle operation and use which occur during the conditions specified in the NTE test procedure. (See 40 CFR 86.1370.) This test procedure covers a specific range of engine operation and ambient operating conditions (*i.e.,* temperature, altitude, and humidity). The NTE control area, emissions standards, ambient conditions and test procedures for HDDEs are described in the regulations.

The NTE multiplier promulgated in the previous final rulemaking for HD diesel engines certified to the 2004 FTP standards is 1.25 × FTP standard (*e.g.,* 1.25 × 2.5g/bhp-hr NMHC+NO_X and 1.25 × 0.1 g/bhp-hr PM). We believe the NTE cap finalized today (1.5 × the Phase 2 FTP standards or FEL) allows sufficient headroom above the FTP standard to accommodate the technical challenges necessary to meet the NTE standard which must be met over a broader range of ambient conditions, a shorter time period, and a wider variety of operating conditions, than the FTP or the SET. While the 1.5 NTE multiplier we are finalizing is greater than what we proposed, in absolute terms the NTE requirement for Phase 2 engines is much smaller than for Phase 1 engines (*i.e.,* the magnitude of the cap in g/bhp-hr emissions), and the Phase 2 NTE cap will help ensure the emission reductions we expect from the Phase 2 standards will occur in-use. The NTE requirements have been modified from what we proposed based on our assessment of the emission performance of the exhaust emission control devices that will be used to meet the new FTP standards (*e.g.,* catalyzed particulate traps and NO_X adsorbers). Under the program finalized today, an NTE limit of 1.5 × the NO_X FEL would apply to 2007 and later model year engines certified with FELs less than 1.5 g/bhp-hr NO_X. As discussed throughout this notice, the stringent 2007 PM standard, 0.01 g/bhp-hr, can be met with the use of catalyzed particulate traps. Because of the very low particulate matter emissions which will be emitted by engines meeting the PM standard, this final rule also establishes a minimum PM NTE requirement for engines certified with FELs below 0.01 g/bhp-hr at 1.5 × the FTP standard, not the FEL. Based on our assessment of the expected exhaust emission control devices and their performance, the NTE standard of 1.5 × FTP standard is both technologically feasible and appropriate. A detailed discussion of the feasibility of the NTE requirements is contained in the RIA for this final rule.

Today's action allows the NTE deficiency provisions we recently finalized for 2007 HDDEs meeting the 2004 FTP standards to be used by HDDEs meeting the standards contained in today's final rule (See 40 CFR 86.007–11(a)(4)(iv) in the regulations, and 65 FR 59914 of the Phase 1 rule for a detailed discussion of the NTE deficiencies.). These deficiency provisions are similar to the deficiency provisions which currently apply to LD and HD on-board diagnostic systems. This will allow the Administrator to accept a HDDE as compliant with the NTE even though some specific requirements are not fully met. This provision will be available for manufacturers through 2013, though it will be more limited after 2009 as described below. In the Phase 1 rule, the Agency finalized deficiency provisions which were allowed through model year 2009. In this rule, it is appropriate to extend the availability of the NTE deficiency provisions beyond 2009. Given the nature of the phase-in requirements in this rule, manufacturers may be introducing new engine families certified to the Phase 2 NO_X and NMHC standards as late as model year 2010, and these families may need limited access to a NTE deficiency for a few years after their introduction. Therefore, we have extended the availability of deficiencies through model year 2013, but with one constraint. Given the considerable lead time available, we have limited the number of deficiencies to three per engine family for 2010 through 2013.

In addition, we have made a number of changes to the NTE requirements to address specific technical issues which arise from the application of high efficiency exhaust emission control devices to HDDEs. These provisions will only be summarized here. A detailed discussion is contained in the RIA and the RTC for this final rule. These changes include: engine start-up provisions; exhaust emission control device warm-up provisions; modifications of the NTE control zone; and adjustments to the NTE minimum emissions sample time.

Under this final rule, the NTE requirements will not apply during engine start-up conditions. EPA intended to include the provision excluding start-up provisions from the NTE requirements under the Phase 1 rulemaking, and it was discussed in the preamble for both the Phase 1 proposal and final rule. However, this provision was inadvertently left out of the regulations. We have corrected this in today's rule for both Phase 1 and Phase 2 engines. In addition, with the application of advanced exhaust emission control devices, an exhaust emission control device warm-up provision is a necessary criterion for the NTE. Specifically, until the exhaust gas temperature on the outlet side of the exhaust emission control device(s)

[87] Torque is a measure of rotational force. The torque curve for an engine is determined by an engine ''mapping'' procedure specified in the Code of Federal Regulations. The intent of the mapping procedure is to determine the maximum available torque at all engine speeds. The torque curve is merely a graphical representation of the maximum torque across all engine speeds.

achieves 250 degrees Celsius, the engine is not subject to the NTE. Additional discussion of this provision is contained in the RIA.

We have made three changes to the NTE engine control zone. First, we have expanded the NTE engine control zone for engines certified to the new 0.01 g/bhp-hr PM standard. The NTE requirements as specified in the regulations for engines certified to the 2004 FTP standards provide specific ''PM carve-outs'' to the NTE control zone. These carve-outs define an area of the engine operating regime (speed and torque area) to which the NTE does not apply for PM emissions. (See 65 FR 59961.) The PM only carve-outs were specified because, under certain engine operating regions, the NTE requirements for PM could not be met with the technology projected to be used to meet the 2004 FTP standards. However, as discussed in the RIA, the advanced PM trap technology that will be used to meet the PM standard contained in today's final rule is very efficient at controlling PM emissions across the entire NTE control zone. Due to the high PM reduction capabilities of catalyzed PM traps, there is no need for the PM specific carve-outs. Therefore, we have eliminated the NTE PM carve-outs for Phase 2 engines. Second, we have added a provision which would allow a manufacturer to exclude defined regions of the NTE engine control zone from NTE compliance if the manufacturer could demonstrate that the engine, when installed in a specified vehicle(s), is not capable of operating in such regions. Finally, we have added a provision which would allow a manufacturer to petition the Agency to limit testing in a defined region of the NTE engine control zone during NTE testing. This optional provision would require the manufacturer to provide the Agency with in-use operation data which the manufacturer could use to define a single, continuous region of the NTE control zone. This single area of the control zone must be specified such that operation within the defined region accounts for 5 percent or less of the total in-use operation of the engine, based on the supplied data. Further, to protect against gaming by manufacturers, the defined region must generally be elliptical or rectangular in shape, and share a boundary with the NTE control zone. If approved by EPA, the regulations then disallow testing with sampling periods in which operation within the defined region constitutes more than 5.0 percent of the time-weighted operation within the sampling period.

We have also changed the minimum emissions sample time approach for NTE testing to address technical issues specific to the advanced exhaust emission control devices anticipated to be used to meet the NTE requirements. We proposed that the minimum emission sample time for the NTE was 30 seconds, which is what we recently finalized for engines certified to the Phase 1 standards. This short sample time was sufficient to ensure that momentary spikes in emissions (*e.g.,* such as could occur in a two or three second time frame) could not be isolated for determining compliance with the NTE (*e.g.,* an NTE test must be no shorter than a 30 second average). However, the use of highly efficient exhaust emission control devices complicates the minimum sample time requirements because of the potential for short-duration emission increases during regeneration events. We have adjusted the minimum sample time requirements to address this issue as follows (a detailed discussion of the need for this change is contained in the RIA). The regulations specify that the NTE sample time can be as short as 30 seconds provided no regeneration events occur within the sample period. However, if a regeneration event is included in the sample time, the sample time must include the period of time from the start of one regeneration event to the start of the next regeneration event, for each regeneration included in the sample. A regeneration event is determined by the engine manufacturer. This second provision regarding the minimum NTE sample time also cannot be shorter than 30 seconds. This sample time provision applies to any HDDE engine equipped with an exhaust emission control device which requires discreet regeneration events, regardless of the nature of the regeneration (*e.g.,* NO_X regeneration, desulfation).

c. Crankcase Emissions Control

Crankcase emissions are the pollutants that are emitted in the gases that are vented from an engine's crankcase. These gases are also referred to as ''blowby gases'' because they result from engine exhaust from the combustion chamber ''blowing by'' the piston rings into the crankcase. These gases are vented to prevent high pressures from occurring in the crankcase. Our emission standards have historically prohibited crankcase emissions from all highway engines except turbocharged heavy-duty diesel engines. The most common way to eliminate crankcase emissions has been to vent the blowby gases into the engine air intake system, so that the gases can be recombusted. We made the exception for turbocharged heavy-duty diesel engines in the past because of concerns about fouling that could occur by routing the diesel particulates (including engine oil) into the turbocharger and aftercooler. Our concerns are now alleviated by newly developed closed crankcase filtration systems, specifically designed for turbocharged heavy-duty diesel engines. These new systems (discussed more fully in Section III.E below and in Chapter III of the Final RIA) are already required for new on-highway diesel engines under the EURO III emission standards.

In today's action, we are eliminating the exception for turbocharged heavy-duty diesel engines starting in the 2007 model year. Manufacturers will be required to control crankcase emissions from these engines, preferably by routing them back to the engine intake or to the exhaust stream upstream of the exhaust emission control devices. However, in response to the manufacturers' comments, we are finalizing the crankcase control requirement to allow manufacturers to treat crankcase emissions from these engines the same as other exhaust emissions (*i.e.,* we provide a performance requirement and leave the design to the manufacturer). Under this allowance, manufacturers could potentially discharge some or all of the crankcase emissions to the atmosphere, but only if they were able to keep the combined total of the crankcase emissions and the other exhaust emissions below the applicable exhaust emission standards. They could do this by routing the crankcase gases into the exhaust stream downstream of the exhaust emission control devices, or by continuing the current practice of venting the gases to the engine compartment. But, they could take either of these approaches only if they make sure that the combined total of the crankcase emissions and the other exhaust emissions are below the applicable exhaust emission standards. Also, the manufacturer would have to ensure that the crankcase emissions were readily measurable during laboratory and in-use field testing.[88] Despite this allowance made at the request of commenters, given the low levels of today's final standards we believe that manufacturers will have to close the crankcases of all of their

[88] During laboratory testing, the crankcase emissions would need to be vented in a controlled manner so that they could be routed into the dilution tunnel to ensure their proper measurement and inclusion in the tested emission level.

engines by either routing the crankcase emissions into the engine intake or by routing them into the exhaust upstream of the exhaust emission control devices.

d. On-Board Diagnostics (OBD)

The Phase 1 heavy-duty final rule put into place OBD requirements for heavy-duty diesel and gasoline engines weighing 14,000 pounds or less. (See 65 FR 59896, October 6, 2000.) In that rule, the OBD thresholds for malfunction identification are based on multiples of the applicable FTP emission standards to which the engine is certified. Given the structure of the 2004 FTP emission standards (2005 FTP emission standards for gasoline engines), which are combined NMHC+NO_X standards, the OBD thresholds are based on a multiple of the combined FTP standards. However, the structure of the 2007 FTP standards (2008 for gasoline engines) finalized today is not a combined NMHC+NO_X standard, but is instead a separate NO_X and a separate NMHC standard.

Therefore, today's final rule is revising the existing section of the regulations to link OBD thresholds to whatever the appropriate standards are whether they are the combined FTP standards or the new separate FTP standards finalized today. This is consistent with the intent of our OBD requirements since inception—that the OBD thresholds be based on the FTP standards to which the vehicle or engine has been certified.

We are also revising the phase-in for the OBD requirements finalized in the Phase 1 rule. (See 65 FR 59896.) In that rule, OBD systems were required to phase-in on a schedule of 60/80/100 percent beginning in the 2005 model year. At least one commenter claimed that the OBD phase-in may require multiple changes to OBD systems in consecutive years, because OBD systems are tied to the FTP standards to which they are certified.[89] We have decided, for diesel engine OBD systems, to revise the 60/80/100 percent phase-in to 50/50/100 percent beginning in the 2005 model year. This revised phase-in not only alleviates the commenter's concerns, but also makes the OBD phase-in consistent with the implementation of new emission standards.

In addition, we have decided, for gasoline engine OBD systems, to revise the 60/80/100 percent phase-in to 60/80/80/100 percent beginning in the 2005 model year.[90] As with the new diesel OBD phase-in, this gasoline engine OBD phase-in alleviates the commenter's concerns, and it also makes the gasoline OBD phase-in more consistent with the implementation of new emission standards while maximizing the percentage of gasoline engines designed to meet the OBD requirements.

We also received comments suggesting that we commit to making any necessary changes to the OBD requirements based on the outcome of future rulemaking efforts by the California Air Resources Board (ARB). While we cannot make any such commitment, nor do we believe the commenter truly would want us to commit to making changes solely because ARB made changes, we do intend to continue our normal practice of working closely with ARB and harmonizing our OBD requirements where appropriate. Of course, any changes to our OBD requirements could only be done via rulemaking.[91]

2. Heavy-Duty Vehicle Exhaust Emissions Standards[92]

a. FTP Standards

The emission standards being finalized today for heavy-duty gasoline vehicles are summarized in Table III.C–3. We have already required that all complete heavy-duty gasoline vehicles, whether for transporting passengers or for work, be chassis certified. (See 65 FR 59896, October 6, 2000.) Current federal regulations do not require that complete diesel vehicles over 8,500 pounds be chassis certified; instead, our regulations have traditionally required certification of their engines. Today's final rule allows, as an option, chassis certification of complete heavy-duty diesel vehicles under 14,000 pounds. This option is discussed in more detail later in this section.

The Tier 2 final rule created a new vehicle category called ''medium-duty passenger vehicles.''[93] These vehicles, both gasoline and diesel, are required to meet requirements of the Tier 2 program, which carries with it a chassis certification requirement. As a result, diesel medium-duty passenger vehicles must certify using the chassis certification test procedure.[94] Today's heavy-duty vehicle based standards, or chassis standards, for 2008 and later model year heavy-duty gasoline vehicles would apply to the remaining complete gasoline vehicles under 14,000 pounds and those complete diesel vehicles under 14,000 pounds choosing the chassis certification option; these complete vehicles are typically used for commercial, non-passenger applications. The standards shown in Table III.C–3 are, we believe, comparable in stringency to the diesel and gasoline engine standards shown in Table III.C–1.

[89] EPA does not believe there would be any legal stability concern even if we had kept the OBD phase-in as finalized in the Phase 1 rule. However, EPA agrees with the commenter that the phase-in as finalized in the Phase 1 rule would have complicated compliance unnecessarily.

[90] For those manufacturers choosing compliance Options 1 or 2 as part of the Phase 1 program, the gasoline engine OBD phase-in will become 40/60/80/80/100 percent beginning in model year 2004. (See 65 FR 59896, October 6, 2000.)

[91] This comment also pertained to gasoline vehicle-based OBD systems. Our statements made here pertain to those requirements as well but are not repeated below in section III.2.c.

[92] As noted above, vehicle and engine standards apply to all vehicles and engines, even if they are alternative fueled vehicles and engines.

[93] Medium-duty passenger vehicles are defined as any complete vehicle between 8,500 and 10,000 pounds GVWR designed primarily for the transportation of persons. The definition specifically excludes any vehicle that (1) has a capacity of more than 12 persons total or, (2) is designed to accommodate more than 9 persons in seating rearward of the driver's seat or, (3) has a cargo box (*e.g.,* pick-up box or bed) of six feet or more in interior length. (See the Tier 2 final rulemaking, 65 FR 6698, February 10, 2000.)

[94] The Tier 2 final rule did make a limited allowance for engine certification of diesel MDPVS through the 2007 model year. The reader should refer to the Tier 2 final rule for details on that allowance. (See 65 FR 6750, February 10, 2000.)

TABLE III.C–3.—FULL USEFUL LIFE HEAVY-DUTY VEHICLE EXHAUST EMISSIONS STANDARDS AND PHASE-INS FOR COMPLETE VEHICLES [a]

[Grams/mile]

Weight range (GVWR)		Standard (g/mi)	Phase-in by model year [b]	
			2008	2009
8,500 to 10,000 lbs	NO_X	0.2		
	NMHC	0.195		
	HCHO	0.032		
	PM	0.02		
10,001 to 14,000 lbs	NO_X	0.4	50%	100%
	NMHC	0.230		
	HCHO	0.040		
	PM	0.02		

[a] Does not include medium-duty passenger vehicles.
[b] Percentages represent percent of sales.

These NO_X standards represent a 78 percent reduction and a 60 percent reduction from the standards for 8,500–10,000 pound and 10,000–14,000 pound vehicles, respectively, finalized for the 2005 model year. The 2005 model year standards are equivalent to the California LEV–I NO_X standards of 0.9 g/mi and 1.0 g/mi, respectively. The NO_X standards shown in Table III.C–3 are consistent with the CARB LEV–II NO_X standards for low emission vehicles (LEVs) in each respective weight range. The NO_X standard is slightly higher for the 10,000 to 14,000 pound vehicles for several reasons: these vehicles are tested at a heavier payload; they generally have a larger frontal area which creates more drag on the engine and requires it to work harder; and their in-use duty cycle tends to be more severe. The increased weight results in using more fuel per mile than vehicles tested at lighter payloads; therefore, they tend to emit slightly more grams of pollutant per mile than lighter vehicles.[95]

The NMHC standards finalized today represent a 30 percent reduction from the 2005 standards for 8500–10,000 and 10,000–14,000 pound vehicles. The 2005 model year standards require such vehicles to meet NMHC standard levels of 0.28 g/mi and 0.33 g/mi, respectively (equal to the California LEV–I nonmethane organic gases (NMOG) standard levels). These new NMHC standards are consistent with the CARB LEV–II NMOG standards for LEVs in each respective weight class. The NMHC standard for 10,000–14,000 pound vehicles is higher than for 8,500–10,000 pound vehicles for the same reason as stated above for the higher NO_X standard for such vehicles.

The formaldehyde (HCHO) standards shown in Table III.C–3 are not the standards we proposed. The standards we are finalizing are equivalent to the California LEV–II LEV category standards. This approach is being taken to maintain consistency with the approach taken on NO_X and NMHC standards. Although we are not finalizing formaldehyde standards for engine certified systems, because all the exhaust emission standards for complete vehicles are consistent with the CARB LEV II standards, we believe it is appropriate to maintain the formaldehyde standard for gasoline vehicles. Formaldehyde is a hazardous air pollutant that is emitted by heavy-duty vehicles and other mobile sources, and we are finalizing these formaldehyde standards to prevent excessive formaldehyde emissions. These standards are especially important for any methanol-fueled vehicles because formaldehyde is chemically similar to methanol and is one of the primary byproducts of incomplete combustion of methanol. Formaldehyde is also emitted by vehicles using petroleum fuels (i.e., gasoline or diesel fuel), but to a lesser degree than is typically emitted by methanol-fueled vehicles. We expect that petroleum-fueled vehicles able to meet the NMHC standards should comply with the formaldehyde standards with large compliance margins. Based upon our analysis of the similar Tier 2 standards for passenger vehicles, we believe that formaldehyde emissions from petroleum-fueled vehicles when complying with the new PM, NMHC and NO_X standards should be as much as 90 percent below the standards.[96] Thus, to reduce testing costs, we are finalizing a provision that permits manufacturers of petroleum-fueled vehicles to demonstrate compliance with the formaldehyde standards based on engineering analysis. This provision requires manufacturers to make a demonstration in their certification application that vehicles having similar size and emission control technology have been shown to exhibit compliance with the applicable formaldehyde standard for their full useful life. This demonstration is expected to be similar to that required to demonstrate compliance with the Tier 2 formaldehyde standards.

The PM standard is 80 percent lower than the CARB LEV–II LEV category PM standard of 0.12 g/mi, which actually applies only to diesel vehicles. Note that the PM standard shown in Table III.C–3 represents not only a stringent PM level, but a new standard for federal HDVs where none existed before. Both the California LEV II program for heavy-duty diesel vehicles and the federal Tier 2 standards for over 8,500 pound gasoline and diesel vehicles designed for transporting passengers contain PM standards. The PM standard finalized today is consistent with the light-duty Tier 2 bins 7 and 8 level of 0.02 g/mi.

The timing for our final gasoline vehicle standards differs from what we had proposed. Our proposal had no phase-in, requiring 100 percent compliance in the 2007 model year. However, since the proposal was published, we have set new standards for heavy-duty gasoline complete vehicles that take effect in the 2005 model year. Therefore, the three year stability requirement of the CAA requires that today's new standards not apply until the 2008 model year at the earliest. Further, based on comments

[95] Engine standards, in contrast, are stated in terms of grams per unit of work rather than grams per mile. Therefore, engine emission standards need not increase with weight because heavier engines do not necessarily emit more per unit of work produced. In contrast, heavier vehicles, due to their greater mass, tend to emit more per mile due to the increased load placed on the engine which requires the engine to do more work to travel each mile.

[96] See the Tier 2 Response to Comments document contained in Air Docket A–97–10.

received, we believe that a phase-in should be provided. The phase-in will allow manufacturers to implement improved gasoline control technologies on their heavy-duty gasoline vehicles in the same timeframe as they implement those technologies on their Tier 2 medium-duty passenger vehicles (MDPV). The MDPVs generally use the same engines and emission control systems as do the heavy-duty versions of those vehicles. MDPVs must comply with our light-duty Tier 2 program at 50 percent beginning in the 2008 model year and then 100 percent in the 2009 model year. As a result of this MDPV phase-in, and the stability requirements of the CAA, and because we believe it provides the greatest emission control considering costs, we are finalizing a gasoline phase-in of 50/100 percent beginning in the 2008 model year. Commenters suggested a 40/80/100 percent phase-in beginning in the 2008 model year, but we believe that a 50/100 percent phase-in allows appropriate leadtime and synergy with the MDPV requirements of our Tier 2 program. It is worth clarifying that this phase-in excludes California complete heavy-duty vehicles, which are already required to be certified to the California emission standards. It also excludes vehicles sold in any state that has adopted California emission standards for complete heavy-duty vehicles. It would be inappropriate to allow manufacturers to ''double-count'' the vehicles by allowing them to count those vehicles both as part of their compliance with this phase-in and for compliance with California requirements. We would handle heavy-duty engines similarly if California were to adopt different emission standards than those being established by this rule.

We are also finalizing provisions that would encourage manufacturers to introduce clean technology earlier than required in return for greater flexibility during the later years of our phase-in. These optional early incentive provisions are analogous to those included in our light-duty Tier 2 rule and are discussed in more detail in section III.D.

As we have done for diesel and gasoline engines, we have revised our Averaging, Banking, and Trading program for gasoline vehicles and engines to increase flexibility as discussed further in section VI. The reader should refer to that section for more details. Note that the gasoline vehicle phase-in schedule is the same as but separate from the gasoline engine phase-in schedule discussed above. For a discussion of why we believe these standards are technologically feasible in the time frame required, refer to section III.E below, and for a more detailed discussion refer to the RIA contained in the docket.

We are also allowing complete heavy-duty diesel vehicles under 14,000 pounds to certify to the heavy-duty vehicle standards. The issue of chassis certification of diesels was raised as part of the Phase 1 rule. At that time, manufacturers expressed little interest in such a provision. Because the heavy-duty diesel industry is largely not a vertically-integrated industry, in that one company makes the engine and another makes the vehicle, chassis certification is not an immediately attractive or practical option for diesel engine manufacturers. Nonetheless, some manufacturers have begun to express interest in diesel chassis certification.[97] Also, the California Air Resources Board allows complete diesel vehicles to chassis certify. We like the idea of diesel chassis certification because it allows us to more easily evaluate such vehicles in-use. A chassis certified diesel could be acquired easily by EPA and tested in its vehicle configuration without the need to remove the engine for an engine test.

Therefore, while we fully expect that manufacturers will continue to certify the engines intended for complete diesel vehicles to the engine standards, we will allow the option to chassis certify such vehicles. Any chassis-certified complete diesel vehicles must meet the applicable Phase 2 emission standards for complete vehicles (i.e., this option is not available to diesels certified to the Phase 1 standards). In addition, while complete diesel vehicles would count against the phase-in requirements for diesel engines, they would not be allowed in the Averaging, Banking, and Trading program. Therefore, a chassis-certified diesel vehicle can neither use nor earn ABT credits, but counts as part of the 50 percent phase-in. Further, complete diesels choosing the chassis certification option would be required to comply with our federal OBD vehicle-based requirements for monitoring of exhaust emission control devices, even if choosing the option to demonstrate OBD compliance using the California OBD II requirements. Lastly, diesel vehicles choosing this option would be certified under subpart S which applies to chassis certified complete vehicles, but the evaporative emissions provisions of that subpart would not apply for diesel vehicles.

[97] See memorandum from Todd Sherwood to Air Docket A–99–06, dated December 6, 2000, Item #IV–E–47.

b. Supplemental Federal Test Procedure

We did not propose new supplemental FTP (SFTP) standards for heavy-duty vehicles. The SFTP standards control off-cycle emissions in a manner somewhat analogous to the NTE requirements for engines. We believe that the SFTP standards are an important part of our light-duty program just as we believe the NTE requirements will be an important part of our heavy-duty diesel engine program. Although we did not propose SFTP standards for heavy-duty vehicles, we stated an intention to do so via a separate rulemaking. We requested comment on such an approach, and on appropriate SFTP levels for heavy-duty vehicles along with supporting data.

We received unanimous support from industry commenters to address SFTP standards for heavy-duty vehicles in a separate rulemaking. In our Tier 2 final rule, we stated that we are currently contemplating a new SFTP rulemaking that would consider ''Tier 2'' SFTP standards for all Tier 2 vehicles, including MDPVs. California is also interested in developing more stringent SFTP standards within the context of their LEV II program and we are coordinating with California on these new SFTP standards. Given our concern over ''off cycle'' emissions, we believe it is appropriate that SFTP standards apply to all chassis certified vehicles, heavy-duty and light-duty. As part of the SFTP rule being contemplated, we expect to examine not only those issues stated in the Tier 2 rule (e.g., the SFTP test cycles and different SFTP standards for different vehicles sizes) but also the issue of heavy-duty SFTP standards.

c. On-Board Diagnostics (OBD)

The Phase 1 heavy-duty rule finalized OBD requirements for heavy-duty diesel engines, heavy-duty gasoline engines, and heavy-duty complete vehicles weighing 14,000 pounds or less. (See 65 FR 59896, October 6, 2000.) In that rulemaking, the final regulatory language stated the OBD catalyst thresholds for complete vehicles as multiples of a combined NMHC+NO_X emission standard. However, the emission standards for complete vehicles are not combined, as are the engine standards in that final rule. Therefore, the OBD catalyst thresholds for complete vehicles were not stated properly in the applicable sections of the regulations.

Today's final rule corrects that regulatory error by revising the appropriate regulatory language to link the OBD thresholds to a separate, rather than combined, set of FTP exhaust emission standards. This is consistent with the Phase 1 heavy-duty proposal which correctly linked the proposed OBD thresholds to the separate FTP exhaust emission standards. (See 64 FR 58472, October 29, 1999.) It is also consistent with the preamble to the Phase 1 final rule, which stated the catalyst monitor threshold correctly. This change makes the OBD thresholds for complete vehicle certifications consistent with the structure used since implementation of the federal OBD requirements. (See 58 FR 9468, February 19, 1993.)

Consistent with the changes already discussed in section III.C.1, we are also revising the phase-in for complete vehicle OBD requirements finalized in the Phase 1 rule. (See 65 FR 59896.) In that rule, OBD systems were required to phase-in on a schedule of 60/80/100 percent beginning in the 2005 model year. At least one commenter pointed out that the OBD phase-in may require multiple changes to OBD systems in consecutive years because OBD systems are tied to the FTP standards to which they are certified. We have decided, for gasoline vehicle OBD systems, to revise the 60/80/100 percent phase-in to 60/80/80/100 percent beginning in the 2005 model year.[98] This revised OBD phase-in alleviates the commenter's concerns, and it makes the gasoline OBD phase-in more consistent with the implementation of new emission standards while maximizing the percentage of gasoline vehicles designed to meet the OBD requirements.

3. Heavy-Duty Evaporative Emissions Standards

We are finalizing new evaporative emission standards for heavy-duty vehicles and engines. The new standards are shown in Table III.C–4. These standards will apply to heavy-duty gasoline-fueled vehicles and engines, and methanol-fueled heavy-duty vehicles and engines. Consistent with existing standards, the standard for the two day diurnal plus hot soak test sequence would not apply to liquid petroleum gas (LPG) fueled and natural gas fueled HDVs.

TABLE III.C–4.—NEW HEAVY-DUTY EVAPORATIVE EMISSIONS STANDARDS [a]

[Grams per test]

Category	3 day diurnal + hot soak	Supplemental 2 day diurnal + hot soak [b]
8,500–14,000 lbs	1.4	1.75
>14,000 lbs	1.9	2.3

[a] To be implemented on the same schedule as the gasoline engine and vehicle exhaust emission standards shown in Tables III.C–1 and III.C–3. These new standards do not apply to medium-duty passenger vehicles, and do not apply to diesel fueled vehicles and engines.

[b] Does not apply to LPG or natural gas fueled HDVs.

These new standards represent more than a 50 percent reduction in the numerical standards as they exist today. The Phase 1 heavy-duty rule made no changes to the numerical value of the standard, but it did put into place new evaporative emission test procedures for heavy-duty complete gasoline vehicles.[99] (See 65 FR 59896, October 6, 2000.) For establishing evaporative emission levels from complete heavy-duty vehicles, the standards shown in Table III.C–4 presume the test procedures required in the Phase 1 heavy-duty rule.

The new standards for 8,500 to 14,000 pound vehicles are consistent with the Tier 2 standards for medium-duty passenger vehicles (MDPV). MDPVs are of consistent size and have essentially identical evaporative emission control systems as the remaining work-oriented HDVs in the 8,500 to 10,000 pound weight range. Therefore, the evaporative emission standards should be equivalent. We are requiring those same standards for the 10,000 to 14,000 pound HDVs because, historically, the evaporative emission standards have been consistent throughout the 8,500 to 14,000 pound weight range. We believe that the HDVs in the 10,000 to 14,000 pound range are essentially equivalent in evaporative emission control system design as the lighter HDVs; therefore, continuing this historical approach is appropriate.

We are finalizing slightly higher evaporative emission standards for the over 14,000 pound HDVs because of their slightly larger fuel tanks and for non-fuel emissions related to larger vehicle sizes. This is consistent with past evaporative emission standards. The levels chosen for the over 14,000 pound HDVs maintains the same ratio relative to the 8,500 to 14,000 pound HDVs as exists with current evaporative standards. To clarify, the current standards for the 3 day diurnal test are 3 and 4 grams/test for the 8,500 to 14,000 and the over 14,000 pound categories, respectively. The ratio of 3:4 is maintained for the new 2008 standards, 1.4:1.9.

The new standard levels are slightly higher than the California LEV-II standard levels. The California standard levels are 1.0 and 1.25 for the 3-day and the 2-day tests, respectively. However, federal vehicles are certified using the higher-volatility federal test fuel.[100] Arguably, the federal and California evaporative emission standards are equivalent in stringency despite the difference in standard levels. We believe that our standards are appropriate for federal heavy-duty vehicles.

We are requiring that the new evaporative emission standards be implemented on the same schedule as the gasoline engine and vehicle exhaust standards shown in Tables III.C–1 and III.C–3. This will allow manufacturers to plan any needed changes to new vehicles at the same time, although it is not necessary that the exhaust and evaporative standards be phased-in on the same vehicles and engines. Also, we are finalizing the revised durability provisions finalized in the Tier 2 rulemaking, which require durability demonstration using fuel containing at least 10 percent alcohol. Alcohol can break down the materials used in evaporative emission control systems. Therefore, a worst case durability demonstration would include a worst case alcohol level in the fuel (10 percent) because in some areas of the country there is widespread use of alcohol fuels.

D. Incentives for Early Introduction of Clean Engines and Vehicles

In our proposal, we requested comment on alternative phase-in approaches that could provide attractive implementation options to

[98] For those manufacturers choosing compliance Options 1 or 2 as part of the Phase 1 program, the gasoline vehicle OBD phase-in will become 40/60/80/80/100 percent beginning in model year 2004. (See 65 FR 59896.)

[99] The test procedure changes codify a commonly approved waiver allowing heavy-duty gasoline vehicles to use the light-duty driving cycle for demonstrating evaporative emission compliance. The urban dynamometer driving schedule (UDDS) used for heavy-duty vehicles is somewhat shorter than that used for light-duty vehicles, both in terms of mileage covered and minutes driven. This results in considerably less time for canister purge under the heavy-duty procedure than under the light-duty procedure. We recognize this discrepancy and have routinely provided waivers under the enhanced evaporative program that allow the use of the light-duty procedures for heavy-duty certification testing. This is consistent with CARB's treatment of equivalent vehicles.

[100] The federal test fuel specification for fuel volatility, the Reid Vapor Pressure, is 8.7 to 9.2 psi. The California test fuel specification is 6.7 to 7.0 psi.

manufacturers without compromising air quality. We requested comment on a ''declining standard'' approach and a ''cumulative phase-in'' approach. We received only limited comment on those approaches with no commenters expressing particularly strong support for them. We did receive numerous comments suggesting that we provide some form of incentive for manufacturers to introduce clean technology engines earlier than required by the base program. We are finalizing the approach discussed here as an incentive for manufacturers to introduce clean diesel engines earlier than the 2007 model year (or the 2008 model year for gasoline engines and vehicles).

In our Tier 2 rule, we stated our belief that providing inducements to manufacturers to certify vehicles early to very low levels is appropriate. We believe that such inducements may help pave the way for greater and/or more cost effective emission reductions from future vehicles. We believe the program discussed here provides a strong incentive for manufacturers to maximize their development and introduction of the best available vehicle and engine emission control technology. This, in turn, provides a stepping stone to the broader introduction of this technology soon thereafter. Early production of cleaner vehicles enhances the early benefits of our program. If a manufacturer can be induced to certify to the new standards by the promise of reasonable extra credits, the benefits of that decision to the program may last for many years.

The incentive program finalized today is analogous to the provisions set forth in the final Tier 2 rule. We are finalizing provisions that permit manufacturers to take credit for diesel engines certified to this rule's final standards prior to the 2007 model year (prior to the 2008 model year for gasoline engines or vehicles) in exchange for making fewer diesel engines certified to these standards in or after the 2007 model year (2008 for gasoline engines or vehicles). In other words, a clean engine sold earlier than required displaces the requirement to sell a similar engine later. Note that the emission standards must be met to earn the early introduction credit. That is, emission credits earned under averaging, banking, and trading cannot be used to demonstrate compliance. Therefore, the early introduction engine credit is an alternative to the ABT program in that any early engines or vehicles can earn either the engine credit or the ABT emission credit, but not both. The purpose of the incentive is to encourage introduction of clean technology engines earlier than required in exchange for added flexibility during the phase-in years.

Any early engine credits earned for a diesel-fueled engine would, of course, be predicated on the assurance by the manufacturer that the engine would indeed be fueled with low sulfur diesel fuel in the marketplace. We expect this would occur through selling such engines into fleet applications, such as city buses, school buses, or any such well-managed centrally-fueled fleet. For this reason, we believe that any engines sold within this early incentive program would be sold primarily in urban areas where more centrally-fueled fleets exist. Because of the difficulty associated with low sulfur diesel fuel availability prior to mid-2006, we believe it is necessary and appropriate to provide a greater incentive for early introduction of clean diesel technology. Therefore, we will count one early diesel engine as 1.5 diesel engines later. This extra early credit for diesel engines means that fewer clean diesel engines than otherwise would be required may enter the market during the years 2007 and later. But, more importantly, it means that emission reductions would be realized earlier than under our base program. We believe that providing incentives for early emission reductions is a worthwhile goal for this program. Therefore, we are finalizing these provisions for manufacturers willing to make the early investment in cleaner engines. For gasoline engines and vehicles, the early engine credit will be a one-for-one credit because the gasoline needed by the engine or vehicle will be readily available.

We are providing this early introduction credit to diesel engines that meet all of today's final standards (0.20 g/bhp-hr NO_X, 0.14 g/bhp-hr NMHC, and 0.01 g/bhp-hr PM). We are also providing this early introduction credit to diesel engines that pull-ahead compliance with only the 0.01 g/bhp-hr PM standard. However, a PM-only early engine can offset only PM compliant engines during the phase-in years, not NO_X, NMHC, and PM compliant engines.

An important aspect of the early incentive provision is that it must be done on an engine or vehicle count basis. That is, a diesel engine meeting new standards early counts as 1.5 such diesel engines later and a gasoline engine or vehicle early counts as one gasoline engine or vehicle later. This contrasts with a provision done on an engine percentage basis which would count one percent of diesel engines early as 1.5 percent of diesel engines later. Basing the incentive on an engine count will alleviate any possible influence of fluctuations in engine and vehicle sales in different model years.

Another important aspect of this program is that it is limited to engines sold prior to the 2007 model year (2008 for gasoline). In other words, diesel engines sold in the 2007 through 2009 model years that exceed the required 50 percent phase-in will not be considered ''early'' introduction engines and will, therefore, receive no early introduction credit. The same is true for gasoline engines and vehicles sold in the 2008 model year. However, such engines and vehicles will still be able to generate ABT credits. Note that early gasoline vehicles can count for later gasoline vehicles, and early gasoline engines can count for later gasoline engines, but early gasoline vehicles cannot be traded for later gasoline engines and vice versa.

Table III.D–1 shows an example for a diesel engine manufacturer and how it might use this incentive provision on an assumed fleet of 100 engine sales growing at one percent per year beginning in the 2004 model year.

TABLE III.D–1.—EXAMPLE ENGINE INTRODUCTION UNDER OUR EARLY INCENTIVE PROGRAM

	2004	2005	2006	2007	2008	2009	2010
Total Sales	100	101	102	103	104	105	106
Clean Engines under Base program	0	0	0	52	52	53	106
Clean Engines under Incentive Program	4	4	4	46	46	47	106

The four engines sold early in each of model years 2004 through 2006 generate a total credit of 18 engines ($4 \times 3 \times 1.5 = 18$). This allows the manufacturer to reduce its compliant engine count in each of model years 2007 through 2009 by six engines (18/3=6). This helps the manufacturer by reducing total costs through requiring fewer total engines at the low-emitting, clean engine level. But, more importantly, it introduces clean technology engines early and, by 2010 in this example, generates from four to six years of emission reductions that otherwise would not have occurred.

As further incentive to introduce clean engines and vehicles early, we are also finalizing a provision that would give manufacturers an early introduction credit equal to two engines during the phase-in years. This ''Blue Sky'' incentive would apply for diesel engines meeting one-half of today's final NO_X standard while also meeting the NMHC and PM standards. For gasoline engines, the same early introduction double engine credit would be available to engines sold prior to 2008 and meeting one-half the NO_X standard while also meeting the NMHC, PM, and evaporative emission standards. For gasoline vehicles, the double engine credit would be available to those vehicles certified early to the California SULEV levels and today's PM and evaporative emission standards.[101] Due to the extremely low emission levels to which these Blue Sky series engines and vehicles would need to certify, we believe that the double engine count credit is appropriate. Table III.D–2 shows the emission levels that would be required prior to the 2007 model year for diesel engines and the 2008 model year for gasoline vehicles and engines to earn any early introduction engine credits.

TABLE III.D–2.—EMISSION LEVELS AND CREDITS AVAILABLE FOR EARLY INTRODUCTION ENGINES

Category	Must meet[a]	Early engine credit[b]
Early Diesel PM-only[c]	Phase 2 PM & Phase 1 NO_X + NMHC	1.5-to-1
Early Diesel Engine[c]	All Phase 2 Standards	1.5-to-1
Early Gasoline Engine or Vehicle—Exhaust	Phase 2 Exhaust Standards	1-to-1
Early Gasoline Engine or Vehicle—Evap	Phase 2 Evaporative Standards	1-to-1
Blue Sky Series Diesel[c] or Gasoline Engine	0.10 g/bhp-hr NO_X & All other Phase 2 Standards[d]	2-to-1
Blue Sky Series Gasoline Vehicle	0.02 g/mi PM & California SULEV Level Standards[d]	2-to-1

[a] Phase 1 refers to standards required by 65 FR 59896, October 6, 2000; Phase 2 refers to today's final standards.
[b] Engine count credits must be earned prior to the phase-in years of 2007 for diesel and 2008 for gasoline.
[c] Early diesel engines must also meet the Phase 2 crankcase emissions requirements.
[d] For gasoline engines and vehicles, these must also meet the Phase 2 evaporative emission standards.

Alternative fueled vehicles and engines can also play a significant role in this incentive program. Any alternative fueled diesel-cycle engine certified to today's final standards prior to the 2007 model year can generate a 1.5 diesel-cycle engine count credit during the diesel phase-in years. Likewise, any alternative fueled Otto-cycle engine certified to today's final standards prior to the 2008 model year can generate one Otto-cycle engine count credit. Many commenters suggested that EPA should do more than was put forward in our proposal to encourage the introduction of alternative fuel technologies. To the extent that alternative fueled vehicles and engines are cleaner than diesels and gasolines, they may have an advantage within today's program. We believe that this program and its structure provides significant incentives for manufacturers to introduce alternative fueled vehicles and engines.

One final aspect of the incentive program is its interaction with our Tier 2 program. The Tier 2 final rule allows some MDPVs to be equipped with engine-certified diesel engines through the 2007 model year. Any such engines are required to comply with the diesel engine standards that apply during the given model year. Given that they are certified as heavy-duty diesel engines, any such engines that meet today's final diesel standards prior to the 2007 model year would be allowed within today's incentive program provided they in no way generate any emission or engine count credits within the Tier 2 program. Further, any MDPVs, whether gasoline or diesel, certified on a chassis dynamometer and being counted in any way as part of the Tier 2 program, cannot be used as part of today's incentive program because they are not considered heavy-duty vehicles.

E. Feasibility of the New Engine and Vehicle Standards

For more detail on the information and analyses supporting our assessment of the technological feasibility of today's standards, please refer to the Final RIA in the docket for this rule. The following discussion summarizes the more detailed discussion found in the Final RIA and in the Summary and Analysis of Comments document.

1. Feasibility of Stringent Standards for Heavy-Duty Diesel

The designers and manufacturers of diesel engines have made substantial progress over the last 20 years reducing NO_X emissions by 60 percent and PM emissions by almost 90 percent through better engine design. We believe that, in response to our Phase 1 heavy-duty rule, industry will have implemented all promising engine-based emission reduction technologies in order to meet the 2.5 g/bhp-hr NO_X+NMHC standard and the 0.1 g/bhp-hr PM standard. To get the substantial PM and NO_X reductions from diesel engines needed to solve the air quality problems identified in section II, we believe a new technology solution will be required. That solution is the application of high efficiency exhaust emission control technologies (catalysts) to diesel engines, analogous to the application of catalyst technologies to passenger cars in the 1970s. These high efficiency catalyst technologies, enabled by the use of diesel fuel with sulfur content at or below 15 ppm, can reduce NO_X and PM emissions by more than 90 percent. This dramatic reduction in emissions will

[101] The California SULEV levels are, for 8,500 to 10,000 pound vehicles, 0.1 g/mi NO_X, 0.100 g/mi NMOG, 0.008 g/mi HCMO, and 0.06 g/mi PM; and for 10,000 to 14,000 pound vehicles, 0.2 g/mi NO_X, 0.117 g/mi NMOG, 0.010 g/mi HCHO, and 0.06 g/mi PM. With the exception of the PM standards, these emission levels are half or roughly half of this rule's final gasoline vehicle standards.

enable diesel powered vehicles to reach emission levels well below today's gasoline emission levels. As detailed in the sections below, these technologies are rapidly being developed and will be available for application to diesel powered vehicles by, or even before, the 2007 model year provided the low sulfur diesel fuel required today is widely available.

a. Meeting the PM Standard

Diesel PM consists of three primary constituents: Unburned carbon particles (soot), which make up the largest portion of the total PM; the soluble organic fraction (SOF), which consists of unburned hydrocarbons that have condensed into liquid droplets or have condensed onto unburned carbon particles; and sulfates, which result from oxidation of fuel and oil derived sulfur in the engine's exhaust. Several exhaust emission control devices have been developed to control harmful diesel PM constituents—the diesel oxidation catalyst (DOC), and the many forms of diesel particulate filters, sometimes called PM traps. DOCs have been shown to be durable in use, but they effectively control only the SOF portion of the total PM which, on a modern diesel engine constitutes only 10 to 30 percent of the total PM. Therefore, the DOC on its own would only offer a modest reduction in PM emissions, and would not be able to meet the PM standard set here.

Diesel particulate filters were first investigated some twenty years ago as a means to capture solid particles in diesel exhaust. A variety of approaches to this technology have been developed most of which provide excellent mechanical filtration of the solid particles that make up the bulk of diesel PM (60 to 80 percent). The collected PM, mostly carbon particles, must then be ''burned off'' of the filter before the filter becomes plugged. This burning off of collected PM (oxidation of the stored PM, releasing CO_2) is referred to as ''regeneration,'' and can occur either:

- On a periodic basis by using base metal catalysts (including fuel-borne base metal catalysts) or an active regeneration system such as an electrical heater, a fuel burner, or a microwave heater; or,
- On a continuous basis by using precious metal catalysts.

Diesel particulate traps that regenerate on a periodic basis (referred to here as either uncatalyzed or base metal catalytic PM traps) demonstrated high PM trapping efficiencies many years ago, but the level of the applicable PM standard was such that it could be met through less costly ''in-cylinder'' control techniques. Un-catalyzed diesel particulate filters will not be able to meet the 0.01 g/bhp-hr PM standard finalized today as they are only moderately effective at controlling the SOF fraction of the particulate. In addition, they require active regeneration technology which must be engaged frequently making the systems expensive to operate (increasing fuel consumption) and less reliable.

We believe the kind of PM trap that would be able to meet the PM standard in a reliable, durable, cost effective manner, and the type of trap that will prove to the be the industry's technology of choice, is one capable of regenerating on an essentially continuous basis. In addition these PM traps will be able to achieve very low PM emissions because:

- They are highly efficient at controlling the solid carbon portion of PM;
- Unlike uncatalyzed filters, they are highly efficient at oxidizing the SOF of diesel PM;
- They employ precious metals to produce conditions that reduce the temperature at which regeneration occurs, thereby allowing for passive regeneration under normal operating conditions typical of a diesel engine; [102]
- Because they regenerate continuously, they have lower average backpressure thereby reducing potential fuel economy impacts; and,
- Because of their passive regeneration characteristics, they need no extra burners or heaters like what would be required by an active regeneration system, thereby reducing potential failures and fuel economy impacts.

These catalyzed PM traps are able to provide in excess of 90 percent control of diesel PM when operated on diesel fuel with sulfur levels at or below 15 ppm. However, as discussed in detail in the RIA, the catalyzed PM trap cannot regenerate properly with current fuel sulfur levels, as such sulfur levels poison the catalytic function of the PM trap inhibiting the necessary NO to NO_2 reaction to the point of stopping trap regeneration.[103] Also, because SO_2 is so readily oxidized to SO_3, the 0.01 g/bhp-hr PM standard cannot be achieved with fuel sulfur levels above 15 ppm because of the resultant increase in sulfate PM emissions (''sulfate make'').[104]

More than one exhaust emission control manufacturer is known to have or be developing these precious metal catalyzed, passively regenerating PM traps and to have them in broad field test programs in areas where low sulfur diesel fuel is currently available. In field trials since 1994, they have demonstrated highly efficient PM control and good durability with some units accumulating in excess of 360,000 miles of field use.[105] The experience gained in these field tests also helps to clarify the need for low sulfur diesel fuel. In Sweden, where below 10 ppm diesel fuel sulfur is readily available, more than 3,000 catalyzed diesel particulate filters have been introduced into retrofit applications without a single failure. These retrofit applications include intercity trains, airport buses, mail trucks, city buses and garbage trucks.[106] The field experience in areas where sulfur is capped at 50 ppm has been less definitive. In regions without extended periods of cold ambient conditions, such as the United Kingdom, field tests on 50 ppm sulfur cap fuel have been positive, matching the durability at 10 ppm, but would be unable to meet a 0.01 g/bhp-hr PM standard due to a substantial increase in sulfate PM. However, field tests on 50 ppm sulfur fuel in Finland where colder winter conditions are often encountered (similar to northern parts of the United States) have experienced a failure rate of 10 percent, due to trap plugging. This 10 percent failure rate has been attributed to insufficient trap regeneration due to fuel sulfur in combination with low ambient temperatures.[107] Other possible reasons for the high failure rate in Finland when contrasted with the Swedish experience appear to be unlikely. The Finnish and Swedish fleets were substantially similar, with both fleets consisting of transit buses powered by Volvo and Scania engines in the 10 to 11 liter range. Further, the buses were operated in city areas and none of the vehicles were operated in northern extremes such as north of the

[102] For PM trap regeneration without precious metals, exhaust metals, exhaust temperatures in excess of 650°C must be obtained. At such high temperatures, carbon will burn (oxidize to CO_2) provided sufficient oxygen is present. Although the largest heavy-duty diesels may achieve exhaust temperatures of 650°C under some operating conditions, smaller diesel engines, particularly light-duty and light heavy-duty diesel engines, will rarely achieve such high temperatures. For example, exhaust temperatures on the HDE Federal Test Procedure cycle typically range from 100°C to 450°C. Precious metal catalyzed traps use platinum to oxidize NO in the exhaust to No_2, which is capable of oxidizing carbon at temperatures as low as 250°C to 300°C.

[103] Cooper and Thoss, Johnson Matthey, SAE 890404.

[104] See the RIA for more detail on the relationship of fuel sulfur to sulfate make.

[105] Allansson, *et al.* SAE 2000–01–0480.

[106] Allansson, *et al.* SAE 2000–01–0480.

[107] Letter from Dr. Barry Cooper to Don Kopinski, US EPA, Air Docket A–99–06.

Arctic Circle.[108] Given that the fleets in Sweden and Finland were substantially similar, and given that ambient conditions in Sweden are expected to be similar to those in Finland, we believe that the increased failure rates noted here are due to the higher fuel sulfur level in a 50 ppm cap fuel versus a 10 ppm cap fuel.[109] Testing on an even higher fuel sulfur level of 200 ppm was conducted in Denmark on a fleet of 9 vehicles. In less than six months all of the vehicles in the Danish fleet had failed due to trap plugging.[110] We believe that this real world testing clearly indicates that increasing diesel fuel sulfur levels limit trap regeneration, leading to plugging of the PM trap even at fuel sulfur levels as low as 50 ppm.

From these results, we can further conclude that lighter applications (such as large pick-up trucks and other light heavy-duty applications), having lower exhaust temperatures than heavier applications, may experience similar failure rates even in more temperate climates and would, therefore, need lower sulfur fuel even in the United Kingdom. These results are understood to be due to the effect of sulfur on the trap's ability to create sufficient NO_2 to carry out proper trap regeneration. Without the NO_2, the trap continues to trap the PM at high efficiency, but it is unable to oxidize, or regenerate, the trapped PM. The possible result is a plugged trap. This vulnerability of the catalyzed diesel particulate filter due to sulfur in the fuel and the consequences of trap plugging are discussed fully in section III.F and the RIA.

Several commenters raised concerns with our use of the extensive fleet experience in Europe, to draw conclusions about the necessary sulfur reductions required in order to ensure PM trap durability. Their concerns focused generally around the fact that these fleets were made up of retrofit applications, and that the nature of the fleet operation did not represent a controlled experiment (ideally all things would have been equal except for the fuel sulfur level). While we acknowledge these limitations in the data, we believe they still provide reasonable evidence of the need for low sulfur diesel fuel. The diversity of applications, climates, fuel properties, NO_X emission levels, and sulfur levels help to show the relative robustness of the technology. Further, we believe the PM trap manufacturer's analysis of the failure mode (*i.e.,* that cold ambient conditions coupled with diminished NO to NO_2 conversion due to sulfur led to the failures that were experienced) is the most likely explanation of the observed phenomena. Sulfur in diesel fuel is known to inhibit the oxidation of NO to NO_2 (as described in section III.F) leading to reduced ability to regenerate the PM filter, especially under low ambient conditions. For our detailed response to comments surrounding catalyzed diesel particulate filter durability refer to the RTC document.

Several progressive refineries have begun to produce diesel fuel with sulfur content less than 15 ppm for limited markets in the United States. The availability of this low sulfur diesel fuel makes it possible to introduce diesel particulate filters into these limited markets today. International Truck and Engine Corporation (''International'') has announced its intent to commercialize its Green Diesel Engine Technology™ in 2001 coupled with less than 15 ppm sulfur fuel to achieve our proposed MY 2007 NMHC and PM emissions standards six years in advance of the requirement. International's ability to bring a catalyzed diesel particulate filter technology to commercialization in such a short period highlights the advanced state of this technology.[111]

Modern catalyzed PM traps have been shown to be very effective at reducing PM mass. In addition, recent data show that they are also very effective at reducing the overall number of emitted particles when operated on low sulfur fuel. Hawker, *et. al.,* found that a modern catalyzed PM trap reduced particle count by over 95 percent, including some of the smallest measurable particles (<50 nm), at most of the tested conditions. The lowest observed efficiency in reducing particle number was 86 percent. No generation of particles by the PM trap was observed under any tested conditions.[112] Kittelson, *et al.,* confirmed that ultrafine particles can be reduced by a factor of ten by oxidizing volatile organics, and by an additional factor of ten by reducing sulfur in the fuel. Catalyzed PM traps efficiently oxidize nearly all of the volatile organic PM precursors, and elimination of as much fuel sulfur as possible will substantially reduce the number of ultrafine PM emitted from diesel engines. The combination of catalyzed PM traps with low sulfur fuel is expected to result in very large reductions in both PM mass and the number of ultrafine particles.

The data currently available show that catalyzed particulate filters can provide significant reductions in PM. Catalyzed particulate filters, in conjunction with low sulfur fuel, have been shown to be more than 90 percent efficient over the FTP and at most SET modes.[113] Testing completed as part of the Diesel Emission Control Sulfur Effects (DECSE) program has demonstrated that a heavy duty diesel engine can achieve less than 0.01 g/bhp-hr PM emissions over the supplemental emission test when equipped with a catalyzed diesel particulate filter and operated on diesel fuel with sulfur content less than 15 ppm.[114] Further testing at NVFEL has demonstrated that FTP PM emissions can likewise be controlled below 0.01 g/bhp-hr provided less than 15 ppm sulfur diesel fuel is used with a catalyzed PM trap.[115] Based upon these test results, extensive field experience throughout the world and International Truck and Engine Corporation's commitment to produce vehicles with this technology in 2001, we conclude that the 0.01 g/bhp-hr FTP PM standard is feasible and that it represents the lowest emission level possible having given consideration to cost, energy and safety factors.

With regard to the NTE PM requirements, there is the potential for sulfate production during some operating modes covered by the NTE which would likely exceed the FTP PM standard. However, the NTE PM standard is equal to $1.5 \times$ FTP standard. Even though the FTP standard of 0.01 g/bhp-hr PM is very low, the small additional head room provided by a

[108] Telephone conversation between Dr. Barry Cooper, Johnson Matthey, and Todd Sherwood, EPA, Air Docket A–99–06.

[109] The average temperatrue in Helsinki, Finland, for the month of January is 21°F. The average temperature in Stockholm, Sweden, for the month of January is 26°F. The average temperature at the University of Michigan in Ann Arbor, Michigan, for the month of January is 24°F. The temperature reported here are from *www.worldclimate.com* based upon the Global Historical Climatology Network (GHCN) produced jointly by the National Climatic Data Center and Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory (ORNL).

[110] Letter from Dr. Barry Cooper to Don Kopinski US EPA, Air Docket A–99–06.

[111] International Truck and Engine Corporation's comments on the proposed 2007 heavy duty vehicle standards, Air Docket A–99–06, page 2.

[112] Hawker, P., *et al.,* Effect of a Continuously Regenerating Diesel Particulate Filter on Non-Regulated Emissions and Particle Size Distribution, SAE 980189.

[113] Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Low Emission Levels, Manufacturers of Emissions Controls Association, June 1999.

[114] Testing for the DECSE program was conducted on 3 ppm and 30 ppm diesel fuel. A straight-line fit to the results between 3 ppm and 30 ppm shows that a 15 ppm cap fuel would have emissions less than 0.01 g/bhp-hr. Diesel Emission Control Sulfur Effects (DECSE) Program, Phase I Interim Data Report No. 4: Diesel Particulate Filters—Final Report, January 2000.

[115] Memorandum from Charles Schenk, EPA, to Air Docket A–99–06, ''Summary of EPA PM Efficiency Data,'' May 8, 2000.

NTE multiplier of 1.5 will be sufficient to enable PM trap equipped HDDEs to meet the NTE provisions, even when operated on 15 ppm sulfur fuel. This is supported by data generated as part of the DECSE test program, as well as data generated at our own laboratory, as discussed in greater detail in the RIA.[116] As discussed in the RIA, the expanded ambient condition requirements of the NTE test procedure will have little effect on the PM reduction capabilities of a PM trap. The SET PM requirements have also been demonstrated in our laboratory and are supported by the DECSE test program. A detailed discussion is contained in the RIA. Based on this information and assessment, we conclude that the PM supplemental requirements will be feasible in the 2007 time frame.

b. Meeting the NO_X Standard

NO_X emissions from gasoline-powered vehicles are controlled to extremely low levels through the use of the three-way catalyst technology first introduced in the 1970s. Today, an advancement upon this well-developed three-way catalyst technology, the NO_X adsorber, has shown that it too can make possible extremely low NO_X emissions from lean-burn engines such as diesel engines. The potential of the NO_X adsorber catalyst is limited only by its need for careful integration with the total vehicle system (as was done for three-way catalyst equipped passenger cars in the 1980s and 1990s) and by poisoning of the catalyst from sulfur in the fuel. Just as the Tier 2 rulemaking enables advanced three-way catalyst equipped vehicles to meet ultra low NO_X emission levels through the use of low sulfur gasoline, today's rulemaking will enable NO_X adsorbers through substantial reductions in diesel fuel sulfur levels. The NO_X adsorber has already been commercially introduced in a number of stationary and mobile source applications.

NO_X Adsorbers in Power Generation

NO_X adsorber catalysts were first introduced in the power generation market less than five years ago. Since then, NO_X adsorber systems in stationary source applications have enjoyed considerable success. In 1997, the South Coast Air Quality Management District of California determined that a NO_X adsorber system provided the ''Best Available Control Technology'' NO_X limit for gas turbine power systems.[117] Average NO_X control for these power generation facilities is in excess of 92 percent.[118] A NO_X adsorber catalyst applied to a natural gas fired powerplant has demonstrated better than 99 percent reliability for more than 21,000 hours of operation while controlling NO_X by more than 90 percent.[119]

NO_X Adsorbers in Lean-Burn Gasoline Vehicles

The NO_X adsorber's ability to control NO_X under oxygen rich (fuel lean) operating conditions has led the industry to begin applying NO_X adsorber technology to lean-burn engines in mobile source applications. NO_X adsorber catalysts have been developed and are now in production for lean-burn gasoline vehicles in Japan, including several vehicle models sold by Toyota Motor Corporation.[120] The 2000 model year saw the first U.S. application of this technology with the introduction of the Honda Insight, certified to the California LEV–I ULEV category standard. These lean burn gasoline applications are of particular interest because they are similar to diesel vehicle applications in terms of NO_X storage under lean exhaust conditions and the need for periodic NO_X regeneration under transient driving conditions. The substantial experience already gained and continuing to be gained from NO_X adsorber use in lean-burn gasoline vehicles provides a firm basis from which diesel NO_X adsorber development is proceeding.

NO_X Adsorbers in Light-Duty Diesel Vehicles

This rapid development pace of the NO_X adsorber technology is not limited to gasoline applications but includes markets where low sulfur diesel fuel is already available or has been mandated to coincide with future emission standards. In Japan, Toyota Motor Corporation has recently announced that it will begin introducing vehicles using its Diesel Particulate— NO_X Reduction (DPNR) system in 2003. This system uses a NO_X adsorber catalyst applied on the surface of a diesel particulate filter, providing greater than 80 percent reductions in both PM and NO_X. Toyota notes however, that DPNR requires fuel with low sulfur content in order to maintain high efficiency for a long duration.[121] In Europe, both Daimler Chrysler and Volkswagen, driven by a need to meet stringent Euro IV emission standards, have published results showing how they would apply the NO_X adsorber technology to their diesel-powered passenger cars. Volkswagen reports that it has already demonstrated NO_X emissions of 0.137 g/km (0.22 g/mi), a 71 percent reduction, on a diesel powered Passat passenger car equipped with a NO_X adsorber catalyst.[122]

US DOE Research Programs

The U.S. Department of Energy (DOE) has funded several test programs at national laboratories and in partnership with industry to investigate NO_X adsorber technology. At Oak Ridge National Laboratory, DOE researchers have shown that a NO_X adsorber and a laboratory regeneration system can reduce NO_X by more than 90 percent when used on a diesel powered Mercedes A-class passenger car. Following 600 miles of driving with 150 ppm sulfur fuel, the system performance degraded considerably.[123] While the system was not production ready, it does demonstrate that very high efficiencies are achievable with advanced emission control systems operating on low sulfur fuel.[124] With additional system development over the next several years we are confident that the remaining design challenges such as long-term durability will be solved.

EPA NVFEL Current Technology Evaluation Program

As part of an effort to evaluate the rapidly developing state of this technology, the Manufacturers of Emission Control Association (MECA) provided four different NO_X adsorber catalyst formulations to EPA for

[116] Diesel Emission Control Sulfur Effects (DECSE) Program—Phase II Interim Data Report No. 4, Diesel Particulate Filters—Final Report, January 2000, Table C1, www.ott.doe.gov/decse.

[117] Letter from Barry Wallerstein, Acting Executive Officer, SCAQMD, to Robert Danziger, Goal Line Environmental Technologies, dated December 8, 1997, www.glet.com.

[118] Reyes and Cutshaw, $SCONO_X$ Catalytic Absorption System, December 8, 1998, www.glet.com.

[119] Danziger, R. *et al.* 21,000 Hour Performance Report on SCONOX, 15 September 2000, Air Docket A–99–06.

[120] Toyota requires that their lean burn gasoline engines equipped with NO_X adsorbers are fueled on premium gasoline in Japan, which has an average sulfur content of 6 ppm. (See Item IV–E–31 in Air Docket A–99–06.)

[121] Revolutionary Diesel Aftertreatment System Simultaneously Reduces Diesel Particulate Matter and Nitrogen Oxides, Toyota Motor Corporation press release, July 25, 2000, contained in Air Docket A–99–06.

[122] Pott, E., *et al.,* ''Potential of NO_X-Trap Catalyst Application for DI–Diesel Engines,'' Air Docket A–99–06.

[123] Diesel Vehicle Emission Control Sulfur Effects Project at Oak Ridge National Laboratory, Phase 1 Overview. Pete Devlin, DOE Office of Transportation Technologies, March 29, 2000, Air Docket A–99–06.

[124] Diesel Emission Control Sulfur Effects (DECSE) Program Phase II Summary Report: NO_X Adsorber Catalysts, October 2000, Air Docket A–99–06.

evaluation. Testing of these catalysts at NVFEL revealed that all four formulations were capable of reducing NO_X emissions by more than 90 percent over the broad range of operation in the supplemental emission test (SET) procedure as summarized in Figure III–1. At operating conditions representative of ''road-load'' operation for a heavy duty on-highway truck, the catalysts showed NO_X reductions as high as 99 percent resulting in NO_X emissions well below 0.1 g/bhp-hr from an engine-out level of nearly 5 g/bhp-hr.[125] Testing on the FTP has shown similarly good results, with hot start FTP NO_X emissions reduced by more than 90 percent. These results demonstrate that significant NO_X reductions are possible over a broad range of operating conditions with current NO_X adsorber technology, as typified by the FTP and the SET.

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[125] For more information on testing conducted at NVFEL, refer to the in-depth discussion given in the RIA, and to the initial test report contained in Air Docket A–99–06, Item IV–A–29.