To: Interested Parties
From: Michael P. Walsh
Date: May 17, 2000
Subject: EPA Proposal Regarding Heavy Duty Engines & Diesel Fuel

EPA announced today its long awaited proposal to substantially reduce emissions from heavy duty vehicles and engines and to reduce the sulfur content in diesel fuel. The purpose of this memo is to summarize the most important provisions of the proposal.

OVERVIEW: Diesel engines contribute considerable pollution to the US'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.

Diesel engine sales have grown over the last decade, so that now about a million new diesel engines are sold in the U.S. every year. Diesels overwhelmingly dominate the bus and large truck markets and have been capturing a growing share of the light heavy-duty vehicle market over the last decade.
EPA has proposed a comprehensive national control program that would regulate the heavy-duty vehicle and its fuel as a single system. New emission standards would begin to take effect in 2007, and would apply to heavy-duty highway engines and vehicles. These proposed 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, EPA has also proposed to reduce the level of sulfur in highway diesel fuel significantly by the middle of 2006.

If this program is implemented as proposed, diesel trucks and buses will have dramatically reduced emission levels. This proposed program will bring heavy-duty diesel emissions on par with new cars and would, for the first time, result in the widespread introduction of exhaust emission control devices on diesel engines.

By 2007, EPA estimates that heavy-duty trucks and buses will account for as much as 30 percent of nitrogen oxides emissions from transportation sources and 14 percent of particulate matter emissions. In some urban areas, the contribution will be even greater. The standards for heavy-duty vehicles proposed in this rule would have a substantial impact on the mobile source inventories of oxides of nitrogen and particulate matter. Beginning the program in the 2007 model year ensures that emission reductions start early enough to counter the upward trend in heavy-duty vehicle emissions that would otherwise occur because of the increasing number of vehicle miles traveled each year.

The proposed program would result in particulate matter and oxides of nitrogen emission levels that are 90% and 95% below current standards levels, respectively. In order to meet these more stringent standards for diesel engines, the proposal calls for a 97% reduction in the sulfur content of diesel fuel. EPA is also proposing more stringent standards for heavy-duty gasoline vehicles.

The clean air impact of this program would be dramatic when fully implemented. By 2030, this program would reduce annual emissions of nitrogen oxides, nonmethane hydrocarbons, and particulate matter by a projected 2.8 million, 305,000 and 110,000 tons, respectively. This would come at an average cost increase of about $1,700 to $2,800 per new vehicle in the near term and about $1000 to $1600 per new vehicle in the long term, depending on the vehicle size. In comparison, new vehicle prices today can range up to $250,000 for larger heavy-duty vehicles. The cost of reducing the sulfur content of diesel fuel would result in an estimated increase of approximately four cents per gallon.

1. Heavy-Duty Engine Emission Standards

EPA is proposing a PM emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower-hour (g/bhp-hr), to take full effect in the 2007 HDE model year. They are also proposing standards for NOx and NMHC of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively, to be phased in together between 2007 and 2010, for diesel engines. The phase-in would be on a percent-of-sales basis: 25 percent in 2007, 50 percent in 2008, 75 percent in 2009, and 100 percent in 2010. Because of the more advanced state of gasoline engine emissions control technology, gasoline engines would be fully subject to these standards in the 2007 model year. In addition, EPA is proposing a formaldehyde (HCHO) emissions standard of 0.016 g/bhp-hr for all heavy-duty engines, to be phased in with the NOx and NMHC standards, and the inclusion of turbocharged diesels in the existing crankcase emissions prohibition, effective in 2007.

Proposed standards for complete HDVs would be implemented on the same schedule as for engine standards. For certification of complete vehicles between 8500 and 10,000 pounds gross vehicle weight rating (GVWR), the proposed standards are 0.2 grams per mile (g/mi) for NOx, 0.02 g/mi for PM, 0.195 g/mi for NMHC, and 0.016 g/mi for formaldehyde.[1] For vehicles between 10,000 and 14,000 pounds, the proposed standards are 0.4 g/mi for NOx, 0.02 g/mi for PM, 0.230 g/mi for NMHC, and 0.021 g/mi for formaldehyde. These standards levels are roughly comparable to the proposed engine-based standards in these size ranges.

Finally, EPA is proposing to revise the evaporative emissions standards for heavy-duty engines and vehicles, effective on the same schedule as the gasoline engine and vehicle exhaust emission standards. The proposed 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. Slightly higher standards levels of 1.9 and 2.3 grams per test would apply for vehicles over 14,000 pounds. These proposed standards represent more than a 50 percent reduction in the numerical standards as they exist today.

The emission standards for heavy-duty engines are summarized below.

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

Proposed Full Useful Life Heavy-Duty Engine Emission Standards and Phase-Ins

		Standard (g/bhp-hr)	Phase-In by Model Year			
			2007	2008	2009	2010
Diesel	NOx	0.20	25%	50%	75%	100%
	NMHC	0.14				
	HCHO	0.016				
Gasoline	NOx	0.20	100%			
	NMHC	0.14				
	HCHO	0.016				
Diesel & Gasoline	PM	0.01	100%			

The proposed PM standard of 0.01 g/bhp-hr is projected to require the addition of a highly efficient PM trap to diesel engines, including urban buses; it is not expected to require the addition of any new hardware for gasoline engines.

Like the PM standard, the proposed NOx standard is projected to require the addition of highly efficient NOx aftertreatment to diesel engines. For gasoline engines, the standard proposed in the 2004 heavy-duty rule is 1.0 g/bhp-hr NMHC+NOx. Therefore, for gasoline engines, the standards proposed today would represent roughly an additional 70 percent reduction.

With respect to formaldehyde, the standards are comparable in stringency to the formaldehyde standards recently finalized in the Tier 2 rule for passenger vehicles; they are also consistent with the CARB LEV II formaldehyde standards. These standards would be especially important for methanol-fueled engines because formaldehyde is chemically similar to methanol and is one of the primary byproducts of incomplete combustion of methanol. Formaldehyde is also emitted by engines using petroleum fuels (i.e., gasoline or diesel fuel), but to a lesser degree than is typically emitted by methanol-fueled engines. Based upon the analysis of similar standards recently finalized for passenger vehicles, EPA believes that formaldehyde emissions from petroleum-fueled engines when complying with the PM, NMHC, and NOx standards should be as much as 90 percent below the standards. Thus, to reduce testing costs, EPA is proposing a provision that would permit manufacturers of petroleum-fueled engines to demonstrate compliance with the formaldehyde standards based on engineering analysis. This provision would require manufacturers to make a demonstration in their certification application that engines 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 would be similar to that recently finalized for light-duty vehicles to demonstrate compliance with the Tier 2 formaldehyde standards.

Because the NOx exhaust emission control technology EPA expects would be required to meet the proposed NOx standard is at an early stage of development, EPA believes a phase-in of the NOx standard is appropriate. With a phase-in, manufacturers are able to introduce the new technology on a limited number of engines, thereby gaining valuable experience with the technology prior to implementing it on their entire fleet. Also, EPA is proposing that the NOx, HCHO, and NMHC standards be phased-in together for diesel engines, i.e, engines would be expected to meet each of these proposed new standards, not just one or the other. EPA proposes this because the standard as proposed in the 2004 heavy-duty rule would be a combined NMHC+NOx standard. Separating the phase-ins for NMHC and NOx would create a problem because it would not be clear to what NMHC standard an engine would certify were it to certify to the proposed NOx standard independent of certifying to the proposed NMHC standard (and vice versa for engines certifying to the proposed NMHC standard independent of the proposed NOx standard).[2] EPA request s comment on the phase-in for diesel engines of these proposed NOx, HCHO, and NMHC standards and the requirement that they be phased-in together. They also request comment on alternative phase-in schedules and percentages, such as a phase-in over three years (2007-2009), a phase-in over two years (2007-2008), and no phase-in (100% in 2007). EPA is not proposing a phase-in for gasoline engines because it wants to maintain consistency with the proposed heavy-duty gasoline vehicle standards which are not phased-in. Nonetheless, EPA requests comment on possible alternative phase-ins for the proposed gasoline engine standards, such as a phase-in consistent with the proposed phase-in for diesel engine standards, or a phase-in consistent with that used for heavy light-duty trucks and medium-duty passenger vehicles under the light-duty highway Tier 2 program.

2. Not-to-Exceed and Supplemental Steady-State Test

To help ensure that heavy-duty engine emissions are controlled over the full range of speed and load combinations commonly experienced in use, EPA has previously proposed to apply Not-To-Exceed (NTE) limits to heavy-duty diesel engines. As proposed, the NTE approach establishes an area (the "NTE zone") under the torque curve of an engine where emissions must not exceed a specified value for any of the regulated pollutants. As proposed, the specified value under which emissions must remain is 1.25 times the FTP standards. The NTE standard would apply under any conditions that could reasonably be expected

[2] Note that, despite the concurrent phase-in of NOx and NMHC standards for diesel engines, the NMHC standards should be easily met through use of a PM trap. Since the PM standards would be implemented on 100 percent of new engines in the 2007 model year, all new engines would have a PM trap and would, therefore, control NMHC emissions to levels below the proposed standards. Therefore, while the NMHC standard is phased-in with NOx due to the 2004 combining of the NOx and NMHC standards, the proposed NMHC standards would be met by all new engines in the 2007 model year.

to be seen by that engine in normal vehicle operation and use. In addition, EPA has proposed that the whole range of real ambient conditions be included in NTE testing.

Similarly, to help ensure that heavy-duty engine emissions are controlled during steady-state type driving (such as a line-haul truck operating on a freeway), EPA has previously proposed a new supplemental steady-state test consisting of 13 steady-state modes, each weighted according to the amount of time that might be expected at each mode during typical real world conditions. As proposed, the supplemental steady-state test has emission limits of 1.0 times the FTP standards.

Today's notice proposes to apply the heavy-duty diesel NTE and supplemental steady-state test provisions intended to be finalized as part of the 2004 standards rulemaking. The October 29, 1999, proposal for that rule contained the description of these provisions. EPA expects that a number of modifications will be made to those provisions in the FRM for that rule based on feedback received during the comment period. While the details of the final provisions are not yet available, EPA will provide the necessary information in the docket for this rule as soon as it becomes available in order to allow for comment.

EPA has not proposed that the NTE requirements, or the supplemental steady-state test, apply to heavy-duty gasoline engines. However, it is working with several industry members to pursue a proposal in a separate action with the intention of having NTE requirements in place for heavy-duty gasoline engines beginning in the 2004 model year. Today's proposal intends that those provisions, when developed, would apply to the gasoline engines subject to today's proposed standards as well. EPA currently have no intention of pursuing supplemental steady-state test requirements for heavy-duty gasoline engines.

EPA requests comment and data on the feasibility of technology meeting the proposed emission standards in the context of the NTE and supplemental steady-state tests as proposed in the 2004 heavy-duty rule, and the potential changes to the supplemental tests should changes be made from what was proposed.

3. 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. The existing emission standards prohibit crankcase emissions from all highway engines except turbocharged heavy-duty diesel engines. EPA made the exception for turbocharged heavy-duty diesel engines because of concerns in the past about fouling that could occur by routing the diesel particulates (including engine oil) into the turbocharger and aftercooler. These concerns are now alleviated by newly developed closed crankcase filtration systems, specifically designed for turbocharged heavy-duty diesel engines. These new systems are already required for new on-highway diesel engines under the EURO III emission standards.

EPA is proposing to eliminate the exception for turbocharged heavy-duty diesel engines starting in the 2007 model year. This is an environmentally significant proposal since most heavy-duty diesel trucks use turbocharged engines, and a single engine can emit over 100 pounds of NOx, NMHC, and PM from the crankcase over the lifetime of the engine.

4. Heavy-Duty Vehicle Exhaust Standards

The emission standards being proposed today for heavy-duty vehicles are summarized in the Table below. EPA has already proposed that all complete heavy-duty gasoline vehicles, whether for transporting passengers or for work, be chassis certified. Current federal regulations do not require that complete diesel vehicles over 8,500 pounds be chassis certified, instead requiring certification of their engines. Today's proposal does not make changes to those requirements.

The Tier 2 final rule created a new vehicle category called "medium-duty passenger vehicles".[3] 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, applicable complete diesel vehicles must certify using the chassis certification test procedure. Today's proposed chassis standards for 2007 and later model year heavy-duty gasoline vehicles would apply to the remaining (work-oriented) complete gasoline vehicles under 14,000 pounds.

Proposed 2007+ Full Useful Life Heavy-Duty Vehicle Exhaust Emission Standards for Complete Gasoline Vehicles* (grams/mile)

Weight Range (GVWR)	NOx	NMHC	HCHO	PM
8500 to 10,000 lbs	0.2	0.195	0.016	0.02
10,000 to 14,000 lbs	0.4	0.230	0.021	0.02

* does not include medium-duty passenger vehicles

These NOx 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, proposed in the 2004 heavy-duty rule. The 2004 heavy-duty rule would require such vehicles to meet the California LEV-I NOx standards

[3] 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.

of 0.9 g/mi and 1.0 g/mi, respectively. The proposed NOx standards shown in the Table are consistent with the CARB LEV-II NOx standard for low emission vehicles (LEVs). EPA has proposed, and CARB has put into place in their LEV-II program, a slightly higher NOx standard for 10,000 to 14,000 pound vehicles because these vehicles are tested at a heavier payload. The increased weight results in using more fuel per mile than vehicles tested at lighter payloads; therefore, they tend to emit slightly more grams per mile than lighter vehicles.[4]

The NMHC standards represent a 30 percent reduction from the proposed 2004 standards for 8500-10,000 and 10,000-14,000 pound vehicles. The 2004 heavy-duty rule would 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). The proposed 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 NOx standard for such vehicles.

The formaldehyde standards are comparable in stringency to the formaldehyde standards recently finalized in the Tier 2 rule for passenger vehicles; they are also consistent with today's proposed engine standards and the CARB LEV II formaldehyde standards. Formaldehyde is a hazardous air pollutant that is emitted by heavy-duty vehicles and other mobile sources, and we are proposing these formaldehyde standards to prevent excessive formaldehyde emissions. These standards would be especially important for 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. EPA recognizes that petroleum-fueled vehicles able to meet the proposed NMHC standards should comply with the formaldehyde standards with large compliance margins. Based upon the analysis of similar standards recently finalized for passenger vehicles, EPA believes that formaldehyde emissions from petroleum-fueled vehicles when complying with the PM, NMHC and NOx standards should be as much as 90 percent below the standards. Thus, to reduce testing costs, EPA is are proposing a provision that would permit manufacturers of petroleum-fueled vehicles to demonstrate compliance with the formaldehyde standards based on engineering analysis. This provision would require 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 would be similar to that recently finalized for light-duty vehicles to demonstrate compliance with the Tier 2 formaldehyde standards.

The PM standard represents over an 80 percent reduction from the CARB LEV-II LEV category PM

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[4] Engine standards, in contrast, are stated in terms of grams per unit power rather than grams per mile. Therefore, engine emission standards need not increase with weight because heavier engines do not necessarily emit more per horsepower even though they tend to emit more per mile.

standard of 0.12 g/mi. Note that the PM standard shown in the Table represents not only a stringent PM level, but a new standard for federal HDVs where none existed before. The California LEV-II program for heavy-duty vehicles, and the federal Tier 2 standards for over 8,500 pound vehicles designed for transporting passengers, both contain PM standards. The PM standard proposed today is consistent with the Tier 2 bin 8 level of 0.02 g/mi.

EPA believes that the vehicle standards proposed are comparable in stringency to the proposed diesel and gasoline engine standards.

EPA is not proposing a phase-in for the HDV standards. As proposed, the HDV standards would apply only to complete gasoline vehicles, consistent with current regulations. EPA believes that emission control technology for gasoline engines is in an advanced enough state to justify a simple implementation requirement in the 2007 model year.

Consistent with current regulations, EPA is not proposing to allow complete heavy-duty diesel vehicles to certify to the heavy-duty vehicle standards. Instead, manufacturers would be required to certify the engines intended for such vehicles to the engine standards. However, EPA requests comment on whether complete heavy-duty diesel vehicles should be allowed, or perhaps should be required, to certify to the vehicle standards. Any comments on this topic should also address whether a phase-in, consistent with the phase-in of engine standards, would be appropriate.

5. Supplemental Federal Test Procedure For Heavy Duty Vehicles

EPA is not proposing new supplemental FTP (SFTP) standards for heavy-duty vehicles. The SFTP standards control off-cycle emissions in a manner analogous to the NTE requirements for engines. EPA believes that the SFTP standards are an important part of the light-duty program just as it believes the NTE requirements will be an important part of the heavy-duty diesel engine program. Although they are not proposing SFTP standards for heavy-duty vehicles, they intend to do so via a separate rulemaking. They request comment on such an approach, and on appropriate SFTP levels for heavy-duty vehicles along with supporting data.

6. Heavy-Duty Evaporative Emission Standards

We are proposing new evaporative emission standards for heavy-duty vehicles and engines. The proposed standards are shown in the Table below. These standards would apply to heavy-duty gasoline-fueled vehicles and engines, and methanol-fueled heavy-duty vehicles and engines. Consistent with existing standards, only the standard for the three day diurnal test sequence would apply to liquid petroleum gas (LPG) fueled and natural gas fueled HDVs.

Proposed Heavy-Duty Evaporative Emission Standards*
(grams per test)

Category	3 Day Diurnal + Hot Soak	Supplemental 2 Day Diurnal + Hot Soak**
8,500 - 14,000 lbs	1.4	1.75
>14,000 lbs	1.9	2.3

* Proposed to be implemented on the same schedule as the proposed gasoline engine and vehicle exhaust emission standards. These proposed standards would not apply to medium-duty passenger vehicles, and would not apply to diesel fueled vehicles.
** Does not apply to LPG or natural gas fueled HDVs.

These proposed standards represent more than a 50 percent reduction in the numerical standards as they exist today. The 2004 heavy-duty rule proposed no changes to the numerical value of the standard, but it did propose new evaporative emission test procedures for heavy-duty complete gasoline vehicles.[5] Those test procedures would effectively increase the stringency of the standards, even though the numerical value was not proposed to change. For establishing evaporative emission levels from complete heavy-duty vehicles, the standards presume the test procedures proposed in the 2004 heavy-duty rule.

The proposed 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. EPA is proposing 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. EPA believes 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.

EPA is proposing slightly higher evaporative emission standards for the over 14,000 pound HDVs because

[5] The proposed test procedure changes sought to 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. EPA recognizes 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. They do not believe that this approach impacts the stringency of the standards. Further, it is consistent with CARB's treatment of equivalent vehicles.

of their slightly larger fuel tanks and 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 proposed 2007 standards, 1.4:1.9.

The proposed standards levels are slightly higher than the California LEV-II standards levels. The California standards levels are 1.0 and 1.25 for the 3-day and the 2-day tests, respectively. EPA believes that its standards are appropriate for federal vehicles certified on the higher-volatility federal test fuel.

EPA is proposing that the evaporative emission standards be implemented on the same schedule as the proposed gasoline engine and vehicle exhaust standards. Also, they are proposing 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) as some areas of the country use alcohol fuels to improve their air quality.

7. Diesel Fuel Sulfur Standards

EPA is proposing to require that all highway diesel fuel produced or imported by refiners and importers be subject to a maximum sulfur level of 15 ppm by weight. There are five key factors which, when taken together, lead EPA to propose that a diesel fuel sulfur cap of 15 ppm is both necessary to enable the NOx and PM exhaust emission control technology (and thereby allow the proposed emission standards to be met), and appropriate, taking into consideration the challenges involved in providing low-sulfur fuel. These factors are the implications that sulfur levels in excess of 15 ppm would have for the efficiency, reliability, and fuel economy impacts of the exhaust emission control systems, and the feasibility and costs of producing low-sulfur diesel fuel.

The efficiency of emission control technologies at reducing harmful pollutants is directly impacted by sulfur in diesel fuel. Initial and long term conversion efficiencies for NOx, NMHC, CO and diesel PM emissions are significantly reduced by catalyst poisoning and catalyst inhibition due to sulfur. NOx conversion efficiencies with the NOx adsorber technology in particular are dramatically reduced in a very short time due to sulfur poisoning of the NOx storage bed. In addition total PM control efficiency is negatively impacted by the formation of sulfate PM. The formation of sulfate PM is likely to be in excess of the total PM standard proposed today, unless diesel fuel sulfur levels are below 15 ppm.

The reliability of the emission control technologies to continue to function as required under all operating conditions for the life of the vehicle is also directly impacted by sulfur in diesel fuel. Sulfur in diesel fuel can prevent proper operation and regeneration of both NOx and PM control technologies leading to permanent loss in emission control effectiveness and even catastrophic failure of the systems. EPA believes that diesel fuel with sulfur levels less than 15 ppm will be required to provide a level of reliability for these technologies to allow their introduction into the marketplace.

The sulfur content of diesel fuel will also affect the fuel economy of vehicles equipped with NOx and PM exhaust emission control technologies. NOx adsorbers are expected to consume diesel fuel in order to cleanse themselves of stored sulfates and maintain efficiency. The larger the amount of sulfur in diesel fuel, the greater this impact on fuel economy. As sulfur levels increase above 15 ppm the fuel economy impact transitions from merely noticeable to levels most diesel vehicle operators would consider unacceptable. Likewise PM trap regeneration is inhibited by sulfur in diesel fuel. This leads to increased PM loading in the diesel particulate filter, increased exhaust backpressure, and poorer fuel economy. Thus for both NOx and PM technologies the lower the fuel sulfur level the better the fuel economy of the vehicle.

As a result of these factors, EPA believes that 15 ppm represents an upper threshold of diesel fuel sulfur levels that would make these technologies viable, and is therefore proposing to cap in-use sulfur levels there. However, EPA has analyzed the impacts on technology enablement, costs, and benefits from controlling fuel sulfur to a 15 ppm average level with a 25 ppm cap, as well as from capping fuel sulfur at 5 ppm and 50 ppm. These levels have been put forward by various stakeholders as either necessary (in the case of a 5 ppm cap) or adequate (in the case of a 50 ppm cap) for enabling high-efficiency diesel exhaust emission controls. EPA requests comment on the appropriate level of the highway diesel fuel sulfur standard, and on its assessment of alternative standards.

8. Timing of New Diesel Sulfur Standard

Since the need for low-sulfur diesel is dictated by the implementation of new engine standards, the proposed sulfur standard would become effective commensurate with the introduction of the first heavy-duty engines meeting the proposed standards. The phase-in of the engine standards is proposed to begin with the 2007 model year. Since light-heavy-duty trucks might be introduced as early as January 2 of the previous calendar year but are often introduced beginning about July 1, EPA is proposing that all highway diesel fuel sold at retail stations and wholesale purchaser-consumers meet the proposed sulfur standard by June 1, 2006. EPA believes that this one month lead time will be sufficient to provide confidence that the fuel available for purchase on July 1 will comply with the proposed sulfur cap. EPA is also proposing that highway diesel fuel at the terminal level be required to meet the proposed sulfur standard as of May 1, 2006, and that highway diesel fuel produced by refiners (and imported) meet the proposed sulfur standard by April 1, 2006. EPA believes these earlier compliance requirements at terminals and refineries would be necessary to provide an orderly transition to low-sulfur fuel and to avoid the market disruptions that occurred when the sulfur level of diesel fuel was lowered to 500 ppm in 1993 with only a retail compliance date. The three months between April and July should allow sufficient time for fuel to move through the distribution system, for existing tankage to transition down to the lower sulfur level that would be required. It would also ensure that all fuel is complying with the proposed sulfur standard and is available for use in heavy-duty engines when 2007 model year engines are introduced to the market. EPA requests comment on this proposed approach.

9. Need For & Benefits of Proposal

Emissions from heavy-duty vehicles contribute greatly to the health and welfare effects of ozone, PM, NOx, SOx, 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, while PM also causes damage to materials, and soiling. Second, both NOx and PM contribute to substantial visibility impairment in many parts of the U.S. Third, NOx emissions from heavy-duty trucks contribute to the acidification, nitrification and eutrophication of water bodies.

Millions of Americans live in areas with unhealthful air quality that currently endangers public health and welfare. Without emission reductions from the proposed standards for heavy-duty vehicles, there is a significant risk that an appreciable number of areas 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, EPA's analysis shows that PM_{10} concentrations in 10 areas with a combined population of 27 million people face a significant risk of exceeding the PM_{10} NAAQS without significant additional controls in 2007 or thereafter.

Urban areas, which include many poorer neighborhoods, can be disproportionately impacted by HDV emissions, and these neighborhoods would thus receive a relatively larger portion of the benefits expected from new HDV emissions controls. 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.

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. The EPA draft Health Assessment Document for Diesel Emissions is currently being revised based on comments received from the Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board. The current EPA position is that diesel exhaust is a likely human carcinogen and that this cancer hazard applies to environmental levels of exposure.[6] In the draft Health Assessment Document for Diesel Emissions, EPA provided a qualitative perspective that the upper bounds on environmental cancer risks may exceed 10^{-6} and could be as high as 10^{-3}. Several other agencies and governing bodies have designated diesel exhaust or diesel PM as a "potential" or "probable" human carcinogen. In addition, diesel PM poses nonmalignant

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[6] Environmental Protection Agency (1999) Health Assessment Document for Diesel Emissions: SAB Review Draft. EPA/600/8-90/057D Office of Research and Development, Washington, D.C. The document is available electronically at www.epa.gov/ncea/diesel.htm

respiratory hazards to humans, not unlike, in some respects, hazards from exposure to ambient $PM_{2.5}$, to which diesel PM contributes.

a. NOx Emissions

Heavy-duty vehicles are important contributors to the national inventories of NOx emissions, and they contribute moderately to national VOC pollution. HDVs are expected to contribute approximately 15 percent of annual NOx emissions in 2007.

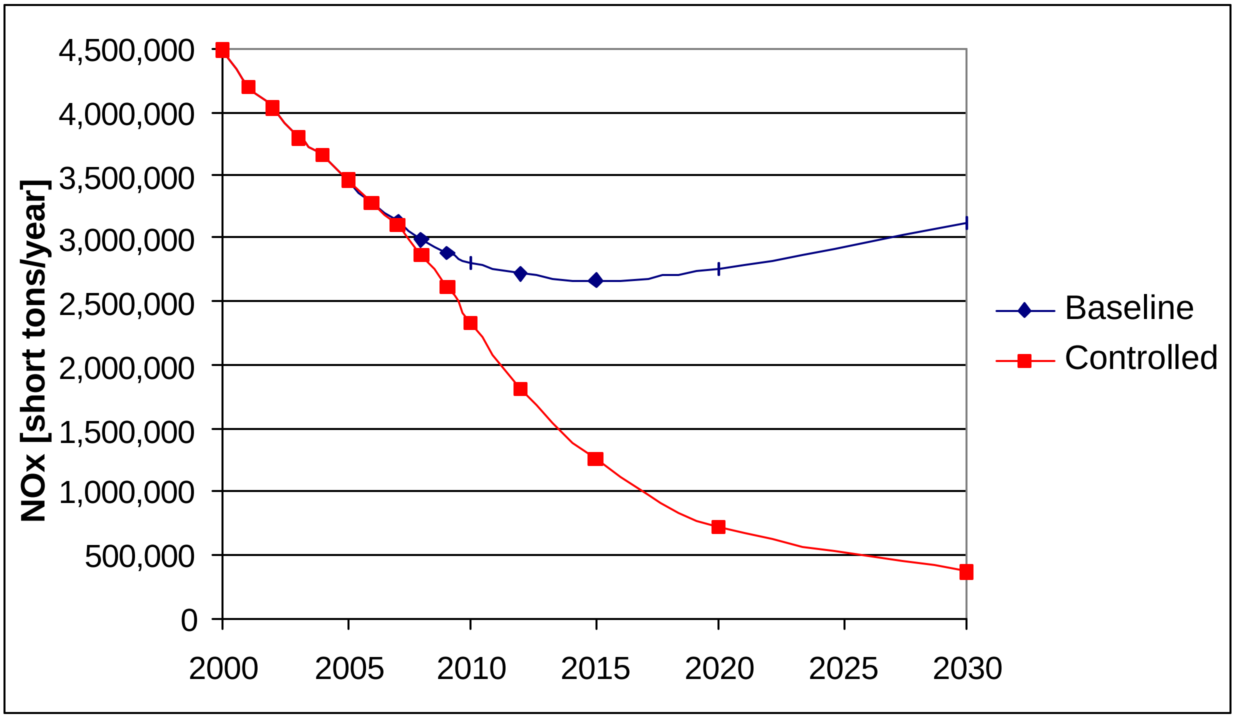
2007 Heavy-Duty Vehicle Contribution to Urban NOx Inventories

Metropolitan Statistical Area	Portion of Total NOx	Portion of Mobile Source NOx
National	*15%*	*29%*
Albuquerque	25%	38%
Atlanta	23%	36%
San Francisco	23%	29%
Spokane	23%	29%
Seattle	22%	26%
Dallas	22%	28%
Charlotte	21%	34%
Washington	20%	37%
Los Angeles	20%	26%
San Antonio	20%	31%
New York	19%	30%
Miami	18%	23%
Phoenix	18%	28%
Philadelphia	18%	30%
Cleveland	17%	30%
St. Louis	16%	34%

The contribution of heavy-duty vehicles to NOx inventories in many MSAs is significantly greater than that reflected in the national average. For example, HDV contributions to NOx in Albuquerque, Atlanta, San Francisco, Spokane, Seattle, and Dallas are projected to be 22 to 25 percent of the MSA-specific inventories in 2007, which is significantly higher than the national average.

The Agency expects substantial NOx reductions on both a percentage and a tonnage basis from this proposal. As illustrated in the following graph, the air quality benefit expected from this proposal is a reduction in NOx emissions from HDVs of 2.0 million tons in 2020.[7] The Figure shows EPA's national projections of total NOx emissions with and without the proposed engine controls. The proposed standards should result in about a 90 percent reduction in NOx from new engines.[8]

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



b. PM Emissions

Nationally, EPA estimates primary emissions of PM_{10} to be about 33.2 million tons/year in 2007. Fugitive dust, other miscellaneous sources and crustal material (wind erosion) comprise 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 24 percent of the PM_{10} inventory (excluding the contribution of miscellaneous and natural sources) and highway heavy-duty engines account for 14 percent of the mobile source portion of national PM_{10} emissions.

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

[8] EPA includes in the NOx projections excess emissions that were emitted from many model year 1988-98 diesel engines.

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 Albuquerque, Pittsburgh, St. Louis, and Atlanta, the estimated 2007 highway heavy-duty vehicle contribution to mobile source PM_{10} ranges from 16 to 21 percent, and the national percent contribution to mobile sources for 2007 is projected to be about 14 percent. As illustrated below, heavy-duty vehicles operated Washington, Fairbanks, Billings, and Detroit also account for a slightly higher portion of the mobile source PM inventory than the national average. Importantly, these estimates do not include the contribution from secondary PM which is an important component of diesel PM.

2007 Heavy-Duty Vehicle Contribution to Urban Mobile Source PM Inventories

Metropolitan Statistical Area	PM_{10} Contribution from HDVs
National	*14%*
Albuquerque	21%
Pittsburgh	18%
St. Louis	17%
Atlanta	16%
Washington	15%
Fairbanks	15%
Billings	15%
Detroit	15%

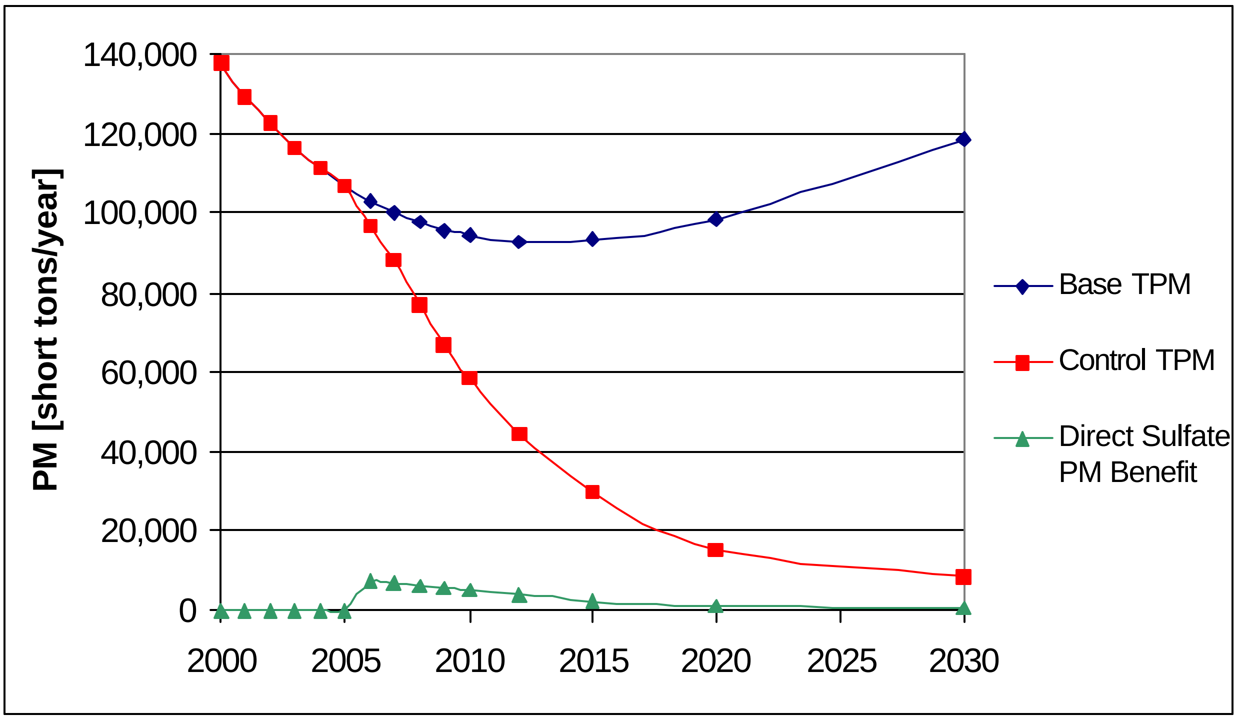
In addition to the national inventories, investigations have been conducted in certain urban areas which provide information about the contribution of HD diesel vehicles and engines to ambient $PM_{2.5}$ concentrations. This is particularly relevant as diesel PM, for the most part, is composed of fine particles under 2.5 microns.

The city-specific emission inventory analysis and independent investigations of ambient $PM_{2.5}$ summarized here 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. EPA's current modeling incorporates deterioration only as would be experienced in properly maintained, untampered vehicles.

Moreover, heavy-duty vehicles will have a more important contributing role in ambient $PM_{2.5}$ concentrations than in ambient PM_{10} concentrations. In addition, the absolute contribution from heavy-duty vehicles is larger in relationship to the numerically lower $PM_{2.5}$ standard, making them more important to attainment and maintenance.

The Figure below shows EPA's national projections of total HDV PM emissions with and without the proposed engine controls. This figure includes crankcase emissions and the direct sulfate PM 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 proposed standards should result in about a 90 percent reduction in total PM from new engines. The proposed low sulfur fuel should result in about a 95 percent reduction in direct sulfate PM from pre-2007 engines. Due to complexities of the conversion and removal processes of sulfur dioxide, EPA does not attempt to quantify the indirect sulfate reductions that would be derived from this rulemaking. Nevertheless, the Agency believes that these indirect sulfate PM reductions are likely to contribute significant additional benefits to public health and welfare. The air quality benefit of the new PM standards and low sulfur diesel fuel as presented in the Figure indicate an 83,000 ton direct PM reduction in 2020.

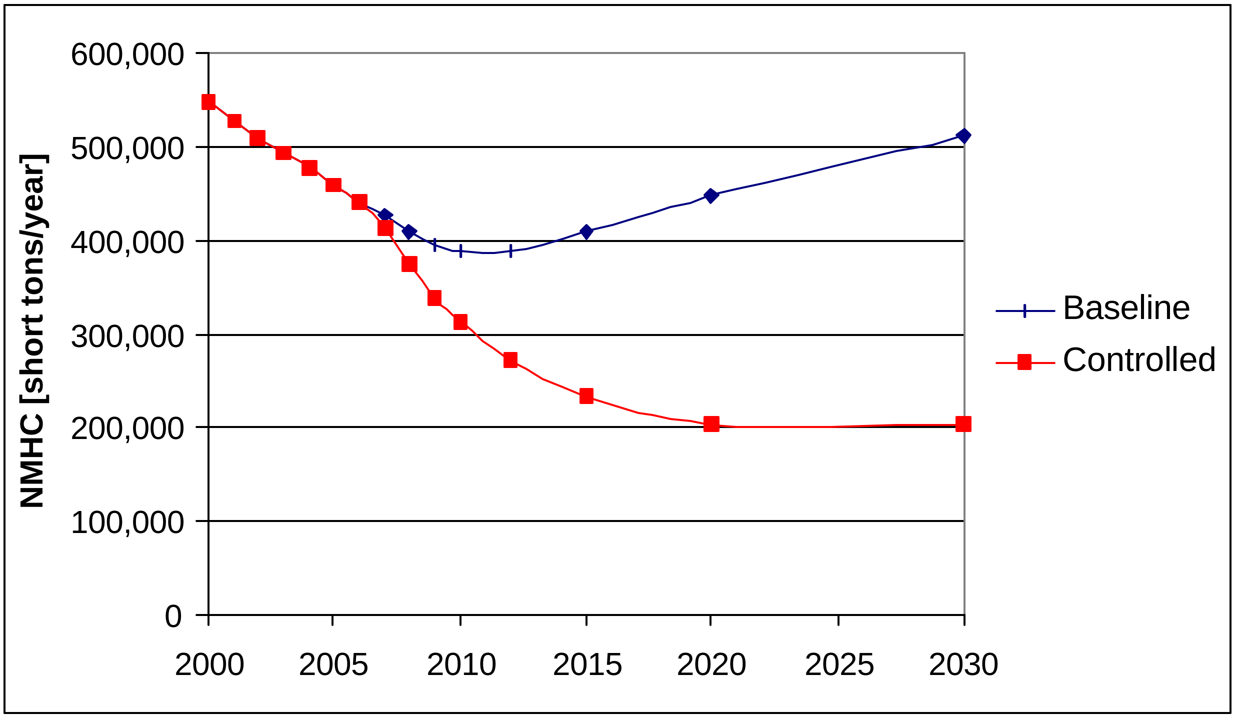
Figure II.D-2: Projected Nationwide Heavy-Duty Vehicle PM Emissions and Direct Sulfate Emission Reductions



c. NMHC Reductions

The Figure below shows EPA's national projections of total NMHC emissions with and without the proposed engine controls. This includes both exhaust emissions and evaporative emissions. As presented in the Figure, the Agency projects a reduction of 230,000 tons of NMHC in 2020 due to the proposed standards.

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



d. Additional Emissions Benefits

i. CO Reductions

The Table below presents the projected reductions in CO emissions from HDVs.

Estimated Reductions in CO

Calendar Year	CO Benefit [thousand short tons]
2007	71
2010	405
2015	911
2020	1,250
2030	1,640

ii. SOx Reductions

The Table below presents EPAs estimates of SOx reductions resulting from the proposed low sulfur fuel.

Estimated Reductions In SOx Due To Low Sulfur Fuel

Calendar Year	SOx Benefit [thousand short tons]
2007	101
2010	106
2015	115
2020	124
2030	139

iii. Air Toxics Reductions

The proposal establishes new hydrocarbon and formaldehyde standards for 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 as 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.[9][10] This proposal also seeks to reduce emissions of diesel exhaust and diesel particulate matter.

EPA's 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 proposed new hydrocarbon standards.

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

[10] 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.

For this analysis, EPA estimates that air toxic emissions are a constant fraction of hydrocarbon exhaust emissions. Because air toxics are a 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. The Table below shows the estimated air toxics reductions associated with the anticipated reductions in hydrocarbons.

Estimated Reductions In Air Toxics (short tons)

Calendar Year	Benzene	Formaldehyde	Acetaldehyde	1,3-Butadiene
2007	153	831	318	65
2010	932	4,750	1,870	382
2015	2,080	11,400	4,460	909
2020	2,780	15,800	6,120	1,250
2030	3,510	20,500	7,850	1,600

10. Heavy Duty Control Technology

Several exhaust emission control devices have been developed to control harmful diesel PM constituents -- the diesel oxidation catalyst (DOC), and the many forms of particulate filters, or traps. DOCs have been shown to be durable in use, but they control only a relatively small fraction of the total PM and, consequently, do not address EPAs PM concerns sufficiently. Uncatalyzed diesel particulate traps demonstrated high efficiencies many years ago, but the level of the PM standard was such that it could be met through less costly “in-cylinder” control techniques. Catalyzed diesel particulate traps have the potential to provide major reductions in diesel PM emissions and provide the durability and dependability required for diesel applications. Therefore, at this time EPA believes the catalyzed PM trap will be the control technology of choice for future control of diesel PM emissions. However, EPA believes that catalyzed PM traps cannot be brought to market on diesel applications unless low-sulfur diesel fuel is available.

Diesel NOx control is arguably at an earlier stage of development than is diesel PM control. Even so, several exhaust emission control technologies are being developed to control NOx emissions, and the industry seems focused on a couple of these as the most promising technologies for enabling lower NOx emission standards. Diesel selective catalytic reduction, or SCR, has been developed to the point of nearing market introduction in Europe. SCR has significant NOx control potential, but it also has many roadblocks to marketability in this country. These roadblocks include infrastructure issues that EPA believes would prove exceedingly difficult and potentially costly to overcome. Because of that, EPA believes that the NOx adsorber is the best technology for delivering significant diesel NOx reductions while also providing market and operating characteristics necessary for the U.S. market.[11] However, the NOx adsorber, like the catalyzed PM trap, cannot be brought to market on diesel applications unless low-sulfur diesel fuel is available.

Improvements have also been made to gasoline emission control technology during the past few years, even the past 12 months. Such improvements include those 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 control have been made in response to the California LEV-II standards and the federal Tier 2 standards. Some of this development work was contributed by EPA in a very short timeframe and with very limited resources in support of its Tier 2 program. 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, EPA believes that considerable improvements to heavy-duty emissions can be realized, thus enabling much more stringent standards.

11. Emission Control Systems for 2007 and Net Fuel Economy Impacts

EPA anticipates that, in order to meet the stringent NOx and PM emission standards proposed today, the manufacturers would integrate engine-based emission control technologies and post-combustion emission control technologies into a single systems-based approach that would fundamentally shift historic trade-offs between emissions control and fuel economy. Individual components in this system would introduce new constraints and opportunities for improvements in fuel efficient control of emissions. Having considered the many opportunities to fundamentally improve these relationships, EPA believes that it is unlikely that fuel economy will be lower than today's levels and, in fact, may improve through the application of these new technologies and this new systems approach. Therefore, for its analysis of economic impacts, no penalty or benefit for changes to fuel economy are considered. EPA requests comment onits analysis of the likely fuel economy offsets of the NOx and PM emission control technologies that would be needed in order to meet today's proposed standards.

12. Future Reassessment of Diesel NOx Control Technology

EPA is considering conducting a future reassessment of diesel NOx control technologies and associated fuel sulfur requirements, and requests comment on the need for such a reassessment. Given the relative state of development of NOx emission control technology versus PM and NMHC control technologies, EPA

[11] The NOx adsorber was originally developed for stationary source emission control and was subsequently developed for use in the lean operating environment of gasoline direct injection engines.

would expect to focus the control technology reassessment solely on NOx control technologies. They believe that the clear intent of this proposal to provide low-sulfur diesel fuel will allow the development of this technology to progress rapidly, and will result in systems capable of achieving the proposed standards. However, they acknowledge that the proposed NOx standard represents an ambitious target for this technology, and that the degree of uncertainty surrounding the feasibility of high-efficiency NOx control technology would be higher if fuel sulfur levels higher than the proposed level were adopted. They also recognize that technology evolution may affect the sulfur level at which these technologies are enabled.

Therefore, they are evaluating whether or not the proposed program could benefit from a future reassessment of the control effectiveness of diesel NOx exhaust emission control technologies and associated fuel sulfur requirements. They would expect to conduct such a reassessment in the 2003 timeframe. They also welcome comment on the extent to which a review of NOx control technology should also include a review of the appropriate diesel fuel sulfur level for enabling the NOx control technology, including consideration of impacts that a revised fuel requirement would have on PM control technology. Another possible area for consideration during the reassessment could be non-conformance penalties (NCPs) and the role they might play in this program. NCPs would allow engine manufacturers to produce and sell noncomplying engines under limited circumstances in exchange for paying a penalty to the government.

13. Encouraging Innovative Technologies

EPA also encourages comments on approaches that could provide increased incentives for the development and introduction of clean advanced engine technologies. Some such approaches have been suggested by stakeholders or have been a part of other EPA rules. One of these would be to develop a program for providing a special designation for engines or vehicles that are significantly below the standards or use specific innovative propulsion technologies. EPA finalized such a designation, the “Blue Sky Series Engine” program, as a part of the 1998 nonroad diesel standards final rule. Incorporating such a designation could be very valuable for use in programs developed by states, municipalities, or corporations to highlight or reward the purchase and use of especially clean or innovative vehicles and engines. EPA requests comment on how it might structure a program like the “Blue Sky Series” program in the context of today’s proposal, including what criteria they should use to qualify an engine or vehicles for such a designation.