United States
Environmental Protection
Agency

Office of Transportation
and Air Quality

EPA420-R-04-007
May 2004

Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines

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Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

List of Acronyms

ABT	Averaging, Banking, and Trading
AEO	Annual Energy Outlook
AGME	Above-ground mining equipment
APA	Administrative Procedures Act
AT	Aftertreatment
BSFC	Brake Specific Fuel Consumption
CAA	Clean Air Act
CCV	Closed crankcase ventilation
CDPF	Catalyzed diesel particulate filter
CFR	Code of Federal Regulations
CI	Compression-Ignition
CMV	Commercial Marine Vessel
CO	Carbon monoxide
DF	Deterioration Factor
DI	direct injection
DOC	Diesel oxidation catalyst
EF	Emission Factor
EGR	Exhaust gas recirculation
EIA	U. S. Energy Information Administration
EIA	Economic Impact Analysis
FR	Federal Register
FTC	Federal Trade Commission
GPA	Geographic Phase-In Area
GDP	Gross domestic product
HC	Hydrocarbons
HD2007	Heavy-duty 2007 refers to the final rule setting emission standards for 2007 and later engines
hp	Horsepower
IDI	Indirect injection
IRFA	Initial Regulatory Flexibility Analysis
kW	kilowatt
L&M	Locomotive and marine

MPP	marginal physical product
NAICS	North American Industry Classification System
NDEIM	Nonroad Diesel Economic Impact Model
NMHC	Non-methane hydrocarbons
NPV	Net present value
NR	Nonroad
NRLM	Nonroad, Locomotive, and Marine diesel fuel
O&M	operating and maintenance
OMB	Office of Management and Budget
PADD	Petroleum Administration Districts for Defense
PM	Particulate matter
ppm	Parts per million
PSR	Power Systems Research
PTD	Product Transfer Document
R&D	Research and Development
RFA	Regulatory Flexibility Act
RIA	Regulatory Impact Analysis
SBA	Small Business Administration
SBAR	Small Business Advocacy Review
SBREFA	Small Business Regulatory Enforcement Fairness Act
SER	Small Entity Representative
SIC	Standard Industrial Classification
stds	standards
TAF	Transient Adjustment Factor
TPEM	Transition program for engine manufacturers (see 40 CFR 89.102 and the proposed 40 CFR
ULSD	Ultra Low Sulfur Diesel
VMP	value of marginal product
VOC	Volatile organic compounds
ZHL	Zero-Hour Emission Level

Executive Summary

The Environmental Protection Agency (EPA) is adopting requirements to reduce emissions of particulate matter (PM), oxides of nitrogen (NO_X), and air toxics from nonroad diesel engines. This rule includes emission standards for new nonroad diesel engines. The rule also reduces the level of sulfur for diesel fuels used in nonroad engines, locomotive engines, and marine engines. The reduction in sulfur for nonroad diesel fuel will enable the use of advanced emission-control technology that new nonroad diesel engines will use to achieve the emission reductions called for under the engine standards in this final rule. In addition, the reduction in sulfur will provide important public health and welfare benefits by reducing emissions of PM and SO_2 from nonroad, locomotive and marine diesel engines.

This executive summary describes the relevant air-quality issues, highlights the new Tier 4 emission standards and fuel requirements, and gives an overview of the analyses in the rest of this document.

Air Quality Background and Estimated Environmental Impact of the Final Rule

Emissions from nonroad, locomotive, and marine diesel engines contribute greatly to a number of serious air pollution problems and would continue to do so in the future absent further reduction measures. Such emissions lead to adverse health and welfare effects associated with ozone, PM, NO_X, SO_x, and volatile organic compounds, including toxic compounds. In addition, diesel exhaust is of specific concern because it is likely to be carcinogenic to humans by inhalation, as well as posing a hazard from noncancer respiratory effects. Ozone, NO_X, and PM also cause significant public welfare harm, such as damage to crops, eutrophication, regional haze, and soiling of building materials.

Millions of Americans continue to live in areas with unhealthy air quality that may endanger public health and welfare. There are approximately 159 million people living in areas that either do not meet the 8-hour ozone National Ambient Air Quality Standards (NAAQS) or contribute to violations in other counties as noted in EPA's recent nonattainment designations for part or all of 474 counties. In addition, approximately 65 million people live in counties where air quality measurements violate the $PM_{2.5}$ NAAQS. These numbers do not include the tens of millions of people living in areas where there is a significant future risk of failing to maintain or achieve the ozone or $PM_{2.5}$ NAAQS. Federal, state, and local governments are working to bring ozone and PM levels into compliance with the NAAQS attainment and maintenance plans. The reductions included in this final rule will play a critical part in these actions. Reducing regional emissions of SO_x is critical to this strategy for attaining the PM NAAQS and meeting regional haze goals in our treasured national parks. SO_x levels can themselves also pose a respiratory hazard.

In 1996, emissions from land-based nonroad diesel engines, locomotive engines, and marine diesel engines were estimated to be about 40 percent of the total mobile-source inventory of $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter) and 25 percent of the NO_X inventory. Absent this final rule, these contributions would be expected to grow to 44 percent and 47 percent by 2030 for $PM_{2.5}$ and NO_X, respectively. By themselves, land-based nonroad diesel engines are a very large part of the mobile-source $PM_{2.5}$ inventory for diesel engines, contributing about 47 percent in 1996, and growing to 70 percent by 2020 without this final rule.

The requirements in this rule will result in substantial benefits to public health and welfare and the environment through significant reductions in NO_X and PM, as well as nonmethane hydrocarbons (NMHC), carbon monoxide (CO), SO_X and air toxics. By 2030, this program will reduce annual emissions of NO_X and PM by 738,000 and 129,000 tons, respectively. We estimate these annual emission reductions will prevent 12,000 premature deaths, over 8,900 hospitalizations, 15,000 nonfatal heart attacks, and approximately 1 million days that people miss work because of respiratory symptoms. The overall quantifiable benefits will total over $83 billion annually by 2030, with a 30-year net present value of $805 billion.

A comparison of the rule's quantified costs and quantified benefits indicates that estimated benefits (approximately $80 billion per year) are much larger than estimated costs (roughly $2 billion per year). This favorable result was found to be robust in a variety of sensitivity and uncertainty analyses. The favorable net benefits are particularly impressive since there are a substantial number of health and environmental advantages of the rule that could not be quantified. In the final Regulatory Impact Analysis, the Agency has done extensive analysis to identify, describe and quantify the degree of uncertainty in the benefit estimates (see Chapter 9). This analysis suggests that the high end of the uncertainty range for this rule's estimated benefits could exceed the low end of the range by a factor of 20. In addition, illustrative calculations indicate that the uncertainty range could span two orders of magnitude using the preliminary results of an EPA-OMB collaborative study on expert judgment for the relative risk of mortality from PM exposure. Despite the uncertainty inherent in the benefit-cost analysis for this rule, the results strongly support a conclusion that the benefits will substantially exceed costs.

Engine Emission Standards

Tables 1 through 4 show the Tier 4 emission standards and when they apply. For most engines, these standards are similar in stringency to the final standards included in the 2007 highway diesel program and are expected to require the use of high-efficiency aftertreatment systems. As shown in the Table 2, we are phasing in many of the standards over time to address considerations of lead time, workload, and overall feasibility. In addition, the final rule includes other provisions designed to address the transition to meeting the long-term Tier 4 standards.

Table 1—Tier 4 PM Standards (g/bhp-hr) and Schedule

Engine Power	Model Year					
	2008	2009	2010	2011	2012	2013
hp < 25 (kW < 19)	0.30 [a]					
25 ≤ hp < 75 (19 ≤ kW < 56)	0.22 [b]					0.02
75 ≤ hp < 175 (56 ≤ kW < 130)					0.01	
175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560)				0.01		
hp > 750 (kW > 560)	see Table 3					

Notes:

[a] For air-cooled, hand-startable, direct injection engines under 11 hp, a manufacturer may instead delay implementation until 2010 and demonstrate compliance with a less stringent PM standard of 0.45 g/bhp-hr, subject also to additional provisions discussed in section II.A.3.a of the preamble.

[b] A manufacturer has the option of skipping the 0.22 g/bhp-hr PM standard for all 50-75 hp engines. The 0.02 g/bhp-hr PM standard would then take effect one year earlier for all 50-75 hp engines, in 2012.

Table 2—Tier 4 NOx and NMHC Standards and Schedule

Engine Power	**Standard** (g/bhp-hr)		**Phase-in Schedule**[a] (model year)			
	NOx	NMHC	2011	2012	2013	2014
25 ≤ hp < 75 (19 ≤ kW < 56)	3.5 NMHC+NOx [b]				100%	
75 ≤ hp < 175 (56 ≤ kW < 130)	0.30	0.14		50% [c]	50% [c]	100% [c]
175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560)	0.30	0.14	50%	50%	50%	100%
hp > 750 (kW > 560)	see Table 3					

Notes:

[a] Percentages indicate production required to comply with the Tier 4 standards in the indicated model year.

[b] This is the existing Tier 3 combined NMHC+NOx standard level for the 50-75 hp engines in this category. In 2013 it applies to the 25-50 hp engines as well.

[c] Manufacturers may use banked Tier 2 NMHC+NOx credits to demonstrate compliance with the 75-175 hp engine NOx standard in this model year. Alternatively, manufacturers may forego this special banked credit option and instead meet an alternative phase-in requirement of 25/25/25% in 2012, 2013, and 2014 through December 30, with 100% compliance required beginning December 31, 2014. See sections III.A and II.A.2.b of the preamble.

Table 3 – Tier 4 Alternative NOx Phase-in Standards (g/bhp-hr)

Engine Power	NOx Standard (g/bhp-hr)
75 ≤ hp < 175 (56 ≤ kW < 130)	1.7 [a]
175 ≤ hp ≤ 750 (130 ≤ kW ≤ 560)	1.5

Notes:
[a] Under the option identified in footnote b of Table 2, by which manufacturers may meet an alternative phase-in requirement of 25/25/25% in 2012, 2013, and 2014 through December 30, the corresponding alternative NOx standard is 2.5 g/bhp-hr.

Table 4—Tier 4 Standards for Engines Over 750 hp (g/bhp-hr)

engines used in:	2011			2015		
	PM	NOx	NMHC	PM	NOx	NMHC
generator sets ≤1200 hp	0.075	2.6	0.30	0.02	0.50	0.14
generator sets >1200 hp	0.075	0.50	0.30	0.02	no new standard	0.14
all other equipment	0.075	2.6	0.30	0.03	no new standard	0.14

EPA has also taken steps to ensure that engines built to these standards achieve effective real-world emission control including the transient duty cycle (both cold-start and hot-start testing), steady-state duty cycles, and Not-to-Exceed standards and test procedures. The Not-to-Exceed provisions are modeled after the highway program, with which much of the industry has gained some level of experience.

Feasibility of Meeting Tier 4 Emission Standards

For the past 30 or more years, emission-control development for gasoline vehicles and engines has concentrated most aggressively on aftertreatment technologies (i.e., in-exhaust catalyst technologies). 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 highway and nonroad diesel engines has concentrated on improvements to the engine itself to limit the emissions formed in the engine (engine-out control technologies).

During the past 15 years, however, more development effort has been put into catalytic exhaust emission-control devices for diesel engines, particularly in the area of particulate matter (PM) control. Those developments, and recent developments in diesel NOx exhaust emission-control devices, make the widespread commercial use of highly efficient diesel exhaust emission controls feasible. EPA has recently set new emission standards for diesel engines installed in highway vehicles based on the emission-reduction potential of these devices. These devices will also make possible a level of emission control for nonroad diesel engines that is similar to that attained by gasoline catalyst systems. However, without the same ultra-low-sulfur diesel fuel that will be used by highway engines, these technologies cannot be implemented.

The primary focus of the Tier 4 program is the transfer of catalyst based emission control technologies developed for on-highway diesel engines to nonroad engines. This RIA summarizes extensive analyses evaluating the effectiveness of these new emission control technologies and the specific challenges to further develop these technologies for nonroad applications. The RIA concludes that for a very significant fraction of nonroad diesel engines and equipment, the application of advanced catalyst based emission control technology is feasible in the Tier 4 timeframe given the availability of 15 ppm sulfur diesel fuel.

Although the primary focus of the Tier 4 emissions program and the majority of the analyses contained in this RIA are directed at the application of catalytic emission control technologies enabled by 15 ppm sulfur diesel fuel, there are also important elements of the program based upon continuing improvements in engine-out emission controls. Like the advanced catalytic based technologies, these engine-out emission solutions for nonroad diesel engines rely upon technologies already applied to on-highway diesel engines. Additionally, these technologies form the basis for the Tier 3 emission standards for some nonroad diesel engines in other size categories.

Controls on the Sulfur Content of Diesel Fuel

We are finalizing the a two-step sulfur standard for nonroad, locomotive and marine (NRLM) diesel fuel that will achieve significant, cost-effective sulfate PM and SO_2 emission reductions. These emission reductions will, by themselves, provide dramatic environmental and public health benefits which far outweigh the cost of meeting the standards necessary to achieve them. In addition, the final sulfur standards for nonroad diesel fuel will enable advanced high efficiency emission control technology to be applied to nonroad engines. As a result, these nonroad fuel sulfur standards, coupled with our program for more stringent emission standards for new nonroad engines and equipment, will also achieve dramatic NOx and PM emission reductions. Sulfur significantly inhibits or impairs the function of the diesel exhaust emission control devices which will generally be necessary for nonroad diesel engines to meet the emission standards in this final rule. With the 15 ppm sulfur standard for nonroad diesel fuel, we have concluded that this emission control technology will be available for model year 2011 and later nonroad diesel engines to achieve the NOx and PM emission standards adopted in this final rule. The benefits of this final rule also include the sulfate PM and SO2 reductions achieved by establishing the same standard for the sulfur content of locomotive and marine diesel fuel.

The fuel sulfur requirements established under this final rule are similar to the sulfur limits established for highway diesel fuel in prior rulemakings – 500 ppm in 1993 (55 FR 34120, August 21, 1990) and 15 ppm in 2006 (66 FR 5002, January 18, 2001). Beginning June 1, 2007, refiners will be required to produce NRLM diesel fuel with a maximum sulfur content of 500 ppm. Then, beginning June 1, 2010, the sulfur content will be reduced for nonroad diesel fuel to a maximum of 15 ppm. The sulfur content of locomotive and marine diesel fuel will be reduced to 15 ppm beginning June 1, 2012. The program contains certain provisions to ease refiners' transition to the lower sulfur standards and to enable the efficient distribution of all diesel fuels.

The final program also contains provisions to smooth the refining industry's transition to the low sulfur fuel requirements, encourage earlier introduction of cleaner burning fuel, maintain the fuel distribution system's flexibility to fungibly distribute similar products, and provide an outlet for off-specification distillate product. These provisions, which will maintain, and even enhance, the health and environmental benefits of this rule, include the 2012 date for locomotive and marine diesel fuel, early credits for refiners and importers and special provisions for small refiners, transmix processors, and entities in the fuel distribution system.

Feasibility of Meeting Diesel Fuel Sulfur Standards

We conclude that it is feasible for refiners to meet the 500 ppm and 15 ppm sulfur cap standards for nonroad, locomotive and marine diesel fuel (NRLM). We project that refiners will use conventional desulfurization technology for complying with the 500 ppm sulfur standard in 2007, which is the same technology used to produce 500 ppm sulfur highway diesel fuel today. Refiners complying with the 500 ppm sulfur NRLM diesel fuel standard will have about the same amount of lead time refiners had in complying with the highway diesel fuel standard, when it took affect in 1993, and they can draw on their experience gained from complying with the 1993 highway sulfur standard. Thus we conclude that refiners producing 500 ppm NRLM diesel fuel will have sufficient leadtime. For complying with the 15 ppm sulfur cap standards applicable to nonroad diesel fuel in 2010 and to locomotive and marine diesel fuel in 2012, refiners will be able to use the experience gained from complying with the 15 ppm highway diesel fuel standard which begins to take effect in 2006. Furthermore, refiners will have ample lead time of at least six years before they will have to begin to produce 15 ppm sulfur nonroad diesel fuel. For complying with both the 15 ppm sulfur standard for nonroad diesel fuel in 2010 and the locomotive and marine diesel fuel in 2012, we expect many refiners to utilize lower cost advanced desulfurization technologies which have recently been commercialized. Others will rely on extensions of conventional hydrotreating technology which most refiners are planning on using to comply with the 15 ppm cap for highway diesel fuel in 2006. These technologies will enable refiners to achieve the 15 ppm NRLM sulfur standards.

We do not expect any new significant issues regarding the feasibility of distributing NRLM fuels that meet the sulfur standards in this rule. The highway diesel program acknowledged that limiting sulfur contamination during the distribution of 15 ppm diesel fuel would be a significant challenge to industry. Industry is already taking the necessary steps to rise to this challenge to distribute highway diesel fuel meeting a 15 ppm sulfur standard by the 2006 implementation date for this standard. Thus, we believe that any issues regarding limiting sulfur contamination during the distribution of 15 ppm sulfur nonroad, and locomotive/marine diesel fuel will have been resolved a number of years before the implementation of the 15 ppm sulfur standard for these fuels (in 2010 and 2012 respectively).

The fuel program in this rule is structured in such a way to maximize fuel fungibility and minimize the need for additional segregation of products in the fuel distribution system. Thus, this rule will only result in the need for a limited number of additional storage tanks at terminals and bulk plants in the interim, and in the long run will result in a simplified overall product slate that needs to be distributed.

Estimated Costs and Cost-Effectiveness

There are approximately 600 nonroad equipment manufacturers using diesel engines in several thousand different equipment models. There are more than 50 engine manufacturers producing diesel engines for these applications. Fixed costs consider engine research and development, engine tooling, engine certification, and equipment redesign. Variable costs include estimates for new emission-control hardware. Near-term and long-term costs for some example pieces of equipment are shown in Table 5. Also shown in Table 5 are typical prices for each piece of equipment for reference. See Chapter 6 for detailed information related to our engine and equipment cost analysis.

Table 5— Long-Term Costs for Several Example Pieces of Equipment ($2002)[a]

	GenSet	Skid/Steer Loader	Backhoe	Dozer	Agricultural Tractor	Dozer	Off-Highway Truck
Horsepower	9 hp	33 hp	76 hp	175 hp	250 hp	503 hp	1000 hp
Displacement (L)	0.4	1.5	3.9	10.5	7.6	18	28
Incremental Engine & Equipment Cost							
Long Term	$120	$790	$1,200	$2,560	$1,970	$4,140	$4,670
Near Term	$180	$1,160	$1,700	$3,770	$3,020	$6,320	$8,610
Estimated Equipment Price[b]	$4,000	$20,000	$49,000	$238,000	$135,000	$618,000	$840,000

[a] Near-term costs include both variable costs and fixed costs; long-term costs include only variable costs and represent those costs that remain following recovery of all fixed costs.

Our estimated costs related to changing to ultra-low-sulfur fuel take into account all of the necessary changes in both refining and distribution practices. We have estimated the cost of producing 500 ppm sulfur NRLM fuel to be, on average, 2.1 to 3.5 cents per gallon. Average costs for 15 ppm sulfur NR fuel during the years 2010 through 2012 are estimated to be an additional 2.5 cents per gallon for a combined cost of 5.8 cents per gallon. Average costs for 15 ppm sulfur NRLM fuel are estimated to be an additional 1.2 cents per gallon for a combined cost of 7.0 cents per gallon for the years 2014 and beyond. All of these fuel costs are summarized in Table 6. These ranges consider variations in regional issues in addition to factors that are specific to individual refiners. In addition, engines running on low-sulfur fuel will have reduced maintenance expenses that we estimate will be equivalent to reducing the cost of the fuel by 2.9

to 3.2 cents per gallon.

Table 6—Increased Cost of Providing Nonroad, Locomotive and Marine Diesel Fuel (cents per gallon of affected fuel)

Specification	Year	Refining Costs (c/gal)	Distribution & Additive Costs (c/gal)	Total Costs (c/gal)
500 ppm NRLM	2007-10	1.9	0.2	2.1
500 ppm NRLM	2010-12	2.7	0.6	3.3
500 ppm NRLM	2012-14	2.9	0.6	3.5
15 ppm Nonroad	2010-12	5.0	0.8	5.8
15 ppm NRLM	2012-14	5.6	0.8	6.4
15 ppm NRLM	2014+	5.8	1.2	7.0

Chapter 8 describes the analysis of aggregating the incremental fuel costs, operating costs, and the costs for producing compliant engines and equipment, operating costs. Table 7 compares these aggregate costs with the corresponding estimated emission reductions to present cost-per-ton figures for the various pollutants.

Table 7—Aggregate Cost per Ton for the Proposed Two-Step Fuel Program and Engine Program—2004-2036 Net Present Values at 3% Discount Rate ($2002)

Pollutant	Aggregate Discounted Lifetime Cost per ton
NOx+NMHC	$1,010
PM	$11,200
SO_x	$690

Economic Impact Analysis

As described in Chapter 10, we prepared an Economic Impact Analysis (EIA) to estimate the economic impacts of this rule on producers and consumers of nonroad engines and equipment and fuels, and related industries. The EIA has two parts: a market analysis and a welfare analysis. The market analysis explores the impacts of the proposed program on prices and quantities of affected products. The welfare analysis focuses on changes in social welfare and explores which entities will bear the burden of the proposed program. The EIA relies on the Nonroad Diesel Economic Impact Model (NDEIM). The NDEIM uses a multi-market analysis framework that considers interactions between 62 regulated markets and other markets to estimate how compliance costs can be expected to ripple through these markets.

As shown in Table 8, the market impacts of this rule suggest that the overall economic impact on society is expected to be small, on average. According to this analysis, price increases of goods and services produced using equipment and fuel affected by this rule (the application marktets) are expected to average about 0.1 percent per year. Output decrease in the application markets are expected to average less than 0.02 percent for all years. The price increases for engines, equipment, and fuel are expected to be about 20 percent, 3 percent, and 7 percent, respectively (total impact averaged over the relevant years). The number of engines and equipment produced annually is expected to decrease by less than 250 units, and the amount of fuel produced annually is expected to decrease by less than 4 million gallons.

Table 8—Summary of Expected Market Impacts, 2013 and 2020

Market	2013			2036		
	Average engineering cost per unit	Price change	Quantity change	Average engineering cost per unit	Price change	Quantity change
Engines	$1,052	21.4%	-0.014%	$931	18.2%	-0.016%
Equipment	$1,198	2.9%	-0.017%	$962	2.5%	-0.018%
Application markets[a]	—	0.10%	-0.015%	—	0.10%	-0.016%
Nonroad Fuel Markets	$0.06	6.0%	-0.019%	$0.07	7.0%	-0.022%
Loco/Marine Transportation	—	0.01%	-0.007	—	0.01%	-0.008

[a]Commodities in the application markets are normalized; only percentage changes are presented

The welfare analysis predicts that consumers and producers in the application markets are expected to bear the burden of this proposed program. In 2013, the total social costs of the rule are expected to be about $1.5 billion. About 83 percent of the total social costs is expected to be borne by producers and consumers in the application markets, indicating that the majority of the costs associated with the rule are expected to be passed on in the form of higher prices. When these estimated impacts are broken down, 58.5 percent are expected to be borne by consumers in the application markets and 41.5 percent are expected to be borne by producers in the application markets. Equipment manufacturers are expected to bear about 9.5 percent of the total social costs. These are primarily the costs associated with equipment redesign. Engine manufacturers are expected to bear about 2.8 percent; this is primarily the fixed costs for R&D. Nonroad fuel refiners are expected to bear about 0.5 percent of the total social costs. The remaining 4.2 percent is accounted for by locomotive and marine transportation services.

Total social costs continue to increase over time and are projected to be about $2.0 billion by 2030 and $2.2 billion in 2036 ($2002). The increase is due to the projected annual growth in the engine and equipment populations. Producers and consumers in the application markets are expected to bear an even larger portion of the costs, approximately 96 percent. This is consistent with economic theory, which states that, in the long run, all costs are passed on to the consumers of goods and services.

Impact on Small Businesses

Chapter 11 discusses our Final Regulatory Flexibility Analysis, which evaluates the potential impacts of new engine standards and fuel controls on small entities. Before issuing our proposal, we analyzed the potential impacts of this rule on small entities. As a part of this analysis, we interacted with several small entities representing the various affected sectors and convened a Small Business Advocacy Review Panel to gain feedback and advice from these representatives. This feedback was used to develop regulatory alternatives to address the impacts of the rule on small businesses. Small entities raised general concerns related to potential difficulties and costs of meeting the upcoming standards.

The Panel consisted of members from EPA, the Office of Management and Budget, and the Small Business Administration's Office of Advocacy. We either proposed or requested comment on the Panel's recommendations. Chapter 11 discusses the options recommended in the Panel Report, the regulatory alternatives we considered in the proposal, and the provisions we are adopting in the final rule. We have adopted several provisions that give small engine and equipment manufacturers and small refiners several compliance options aimed specifically at educing the burden on these small entities. In general the options are similar to small entity provisions adopted in prior rulemakings where EPA set standards for nonroad diesel engines and controlled the level of sulfur in highway gasoline and diesel fuel. These provisions will reduce the burden on small entities that must meet this rule's requirements.

Alternative Program Options

In the course of developing our final program, we investigated several alternative approaches to both the engine and fuel programs. These alternative program options included variations in:

- The applicability of aftertreatment-based standards for different horsepower categories
- The phase-in schedule for engine standards
- The start date for the diesel fuel sulfur standard
- The use of a single-step instead of a two-step approach to fuel sulfur standards
- The applicability of the very-low fuel sulfur standards to fuel used by locomotives and marine engines

Chapter 12 includes a complete description of twelve alternative program options. The draft RIA contained an assessment of technical feasibility, cost, cost-effectiveness, inventory impact, and health and welfare benefits for each alternative. We refer the reader to the detailed evaluations of the options presented in the Draft Regulatory Impact Analysis.