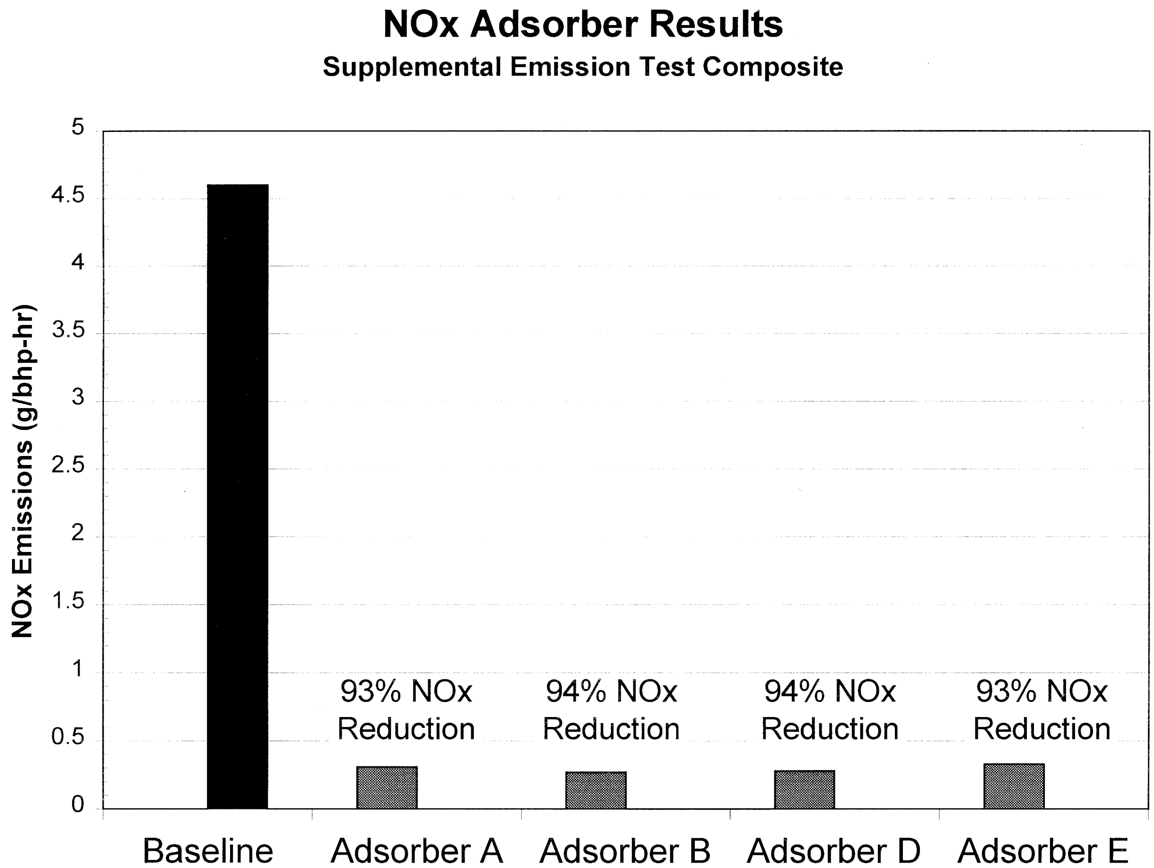


**Figure III-1. NVFEL NOx Adsorber SET Composite Results**

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This large body of evidence that $NO_X$ adsorbers are highly effective, that they can be applied to diesel engines (as further described in the RIA), and that there is a clear and strong prospect for their further development, causes us to conclude that $NO_X$ adsorbers will provide at least one feasible path to the $NO_X$ standards we have set today. Further, we can conclude from this development experience that the 0.20 g/bhp-hr $NO_X$ standard represents the lowest standard achievable by the year 2007, having given appropriate consideration to cost, energy, and safety as described elsewhere in sections III and V of this document and in the RIA.

*Remaining Engineering Development*

The considerable success in demonstrating $NO_X$ adsorber technology in laboratory settings, as outlined above, clearly shows that the technology is currently capable of achieving the $NO_X$ standard level. There are several engineering challenges that will be addressed in going from this level of demonstration to implementation of durable and effective emission control systems on production vehicles. One of these technical challenges involves changes to the way diesel engines will need to operate in order to take full advantage of the $NO_X$ adsorber, representing a shift from current day engine operation. Working within the engine design and operating principles expected for 2004 model year engines, optimization of the total system (matching exhaust temperatures to the operating window of $NO_X$ adsorbers and controlling exhaust air to fuel ratios), will be essential to getting the best performance from the $NO_X$ adsorber. We have estimated in the RIA that diesel engine manufacturers collectively will need to invest $385 million in order to implement this change. In addition to the generic need to optimize operation to match the $NO_X$ adsorber performance, industry will further need to address $NO_X$ adsorber desulfation and its associated issues because some sulfur will still remain in the fuel and the engine's lubricating oil.

Clear engineering paths to address these problems can be described today, several years in advance of when they will need to be applied. The primary thing that must occur is to eliminate most of the sulfur from diesel fuel. The fuel sulfur standard set today in this rulemaking overcomes this obstacle. The second set of system engineering steps needed to accomplish both $NO_X$ regeneration and desulfation are already being laid out in test programs conducted by DOE in the DECSE Phase II program and in our own test program at the National Vehicle and Fuel Emissions Laboratory. The DECSE Phase II program clearly demonstrates that, through changes in ''in-cylinder'' operation, diesel exhaust conditions can be generated that are optimized for $NO_X$ storage (fuel lean operation), $NO_X$ regeneration (fuel rich operation), or desulfation (hot, fuel rich operation). This in-cylinder approach, discussed more fully in the RIA, represents a likely technical solution for light heavy-duty vehicles which are expected to already have the necessary EGR and common rail fuel system technologies need for this approach by the 2004 model year. Testing at NVFEL shows yet another engineering path to optimizing the $NO_X$ control system external to the combustion system. This approach segregates the exhaust into separate streams external to the engine and manipulates exhaust conditions by changing exhaust mass flow (through valves) and by adding supplemental fuel with an electronic fuel injector. This approach means that exhaust temperatures and air to fuel ratios can be controlled external to the engine allowing great flexibility to control and optimize $NO_X$ regeneration and sulfur regeneration events. This approach may prove to be a good solution for heavy heavy-duty vehicles because of the freedom it allows for optimization of both the engine operation and the aftertreatment operation with fewer tradeoffs with regards to fuel consumption and engine durability. A complete description of this approach and its merits is given in the RIA.

Each of the engineering paths described here shows a means for compliance with the $NO_X$ standard given further optimization and development and, given past experiences with the introduction of new technologies, other approaches are likely to be devised as well. Given industry's demonstrated ability to develop solutions to similar issues with gasoline three-way catalysts and gasoline-based $NO_X$ adsorber technologies, we are confident that the $NO_X$ emission control system can be designed for the long life required for heavy-duty diesel operation. We are not alone in this evaluation of $NO_X$ adsorber development, as evidenced by the strong endorsement of the technology by many in the industry.[126] For example, one letter we have received stated, ''We believe all $NO_X$ Adsorber development issues have been identified and the technology is proceeding according to schedule. We have identified development paths leading toward production optimization and do not see insurmountable technical barriers. We are confident in our ability and experience in applying the science of surface chemistry and catalysis to achieve our objective.'' [127]

*NTE $NO_X$ Limits*

The broad $NO_X$ reduction capability of the $NO_X$ adsorbers will also enable the NTE $NO_X$ requirements to be met. As discussed previously, we have established an NTE $NO_X$ standard of 1.5 × FTP standard, or 0.30 g/bhp-hr $NO_X$, which is 0.10 g/bhp-hr above the FTP standard. The NMHC+$NO_X$ NTE standard for 2004 technology HDDEs is 1.25 × 2.5 g/bhp-hr NMHC + $NO_X$, or 3.125 g/bhp-hr, which is 0.625 g/bhp-hr above the 2004 FTP standard. As discussed in the RIA for this final rule, we would expect that the majority of the NTE standard for a 2004 technology engine would be comprised of $NO_X$ emissions, perhaps as much as 3.0 g/bhp-hr (with the remainder, 0.125 g/bhp-hr, being HC). Based on available data, including data from our NVFEL test facility, we believe a $NO_X$ adsorber system will be capable of a 90 percent or greater emission reduction across the entire NTE control zone, for the test conditions covered by the NTE test procedure, by model year 2007. A 90 percent reduction from the ''base'' $NO_X$ NTE level of 3.0 g/bhp-hr would result in a tailpipe emission rate of 0.30 g/bhp-hr, which is 1.5 times the 2007 FTP $NO_X$ standard. As discussed in the RIA, we have demonstrated $NO_X$ reductions on the order of 90 percent or greater across the NTE control zone in our test program at NVFEL. A complete description of the $NO_X$ adsorber testing completed at NVFEL is provided in the final RIA and in the docket associated with this rule. This testing was performed at standard laboratory conditions; however, we do not expect the expanded ambient conditions required for NTE compliance to have a significant impact on the performance of the exhaust emission control systems. Additional discussion of this issue is contained in the RTC and the RIA for this rule.

[126] Letter from Steven Suttle, Corning, Inc., to Margo Oge, EPA, dated October 23, 2000, Item IV–G–59; letter from Martin Lassen, Johnson Matthey, to Margo Oge, EPA, dated October 19, 2000, Item IV–G–55; letter from John Mooney, Engelhard Corporation, to Margo Oge, EPA, dated October 3, 2000, Item IV–G–38; MECA press release dated October 3, 2000, Item IV–G–53; and Department of Energy, dated September 6, 2000, Item IV–G–28; all contained in Docket A–99–06.

[127] Letter from John J. Mooney, Director, Technical Development and Business Groups, Engelhard Corporation, to Margo Oge, Director, OTAQ, EPA, dated October 3, 2000, Item IV–G–38, Docket A–99–06.

*Sulfur Trap*

The preceding discussion of $NO_X$ adsorbers assumes that $SO_X$ ($SO_2$ and $SO_3$) emissions will be ''trapped'' on the surface of the catalyst, effectively poisoning the device and requiring a ''desulfation'' (sulfur removal event) to recover catalyst efficiency. We believe that, at the 15 ppm cap fuel sulfur level, this strategy will allow effective $NO_X$ control with moderately frequent desulfation and with a modest fuel consumption of one percent. We believe this fuel consumption impact will be more than offset by reduced reliance on current, more fuel inefficient $NO_X$ control strategies (see discussion in Section III.G for estimates of overall fuel economy impacts). In the NPRM for this rulemaking, we sought comment on the potential of a separate $SO_X$ trap catalyst to control sulfur poisoning of the $NO_X$ adsorber catalyst. As detailed further in the final RIA and RTC documents, we believe that even if a separate $SO_X$ trap system were used, fuel sulfur levels would have to be 15 ppm or lower in order for the $NO_X$ adsorber technology to function properly over the life of a heavy-duty vehicle.

*Urea SCR Technology*

SCR Technology has been put forward by some as another means of meeting stringent $NO_X$ standards. For reasons discussed below we do not believe that it provides an adequate basis for establishing the feasibility of today's emission standards. Selective Catalytic Reduction (SCR), like the $NO_X$ adsorber technology, was first developed for stationary applications and is currently being refined for the transient operation found in mobile applications. With the SCR system, a urea solution is injected upstream of the catalyst which breaks down the urea into ammonia and carbon dioxide. The ammonia is used as a $NO_X$ reductant across the SCR catalyst producing $N_2$ and water. Catalysts containing precious metals (platinum) can be used at the inlet and outlet of SCR systems designed for mobile applications to improve low temperature $NO_X$ reduction performance and to oxidize any ammonia that may pass through the SCR, respectively. SCR systems using these oxidation catalysts and being developed for mobile applications are more often called ''compact SCR'' systems. Generally, reference to SCR throughout this preamble should be taken to mean compact SCR. The use of these platinum catalysts enables SCR systems to achieve $NO_X$ reductions at lower temperatures (as required for diesel engine applications), but introduces sensitivity to sulfur in much the same way as for diesel particulate filter technologies. Sulfur in diesel fuel inhibits low temperature performance and results in high sulfate-make, leading directly to higher particulate emissions. For a further discussion of SCR system sensitivity to sulfur in diesel fuel, and of its need for low sulfur diesel fuel, refer to Section III.F.

Urea SCR catalysts, like $NO_X$ adsorbers, need low sulfur diesel fuel to achieve high $NO_X$ conversion efficiencies and to control sulfate PM emissions. If low sulfur fuel is required, SCR $NO_X$ control may be possible in some applications by 2007. However we believe there are significant barriers to its general use for meeting the 2007 standards. SCR systems require vehicles to carry a supply of urea. The infrastructure for delivering urea at the diesel fuel pump would need to be in place for these devices to be feasible in the marketplace; and before development of the infrastructure could begin, the industry would have to decide upon a standardized method of delivery for the urea supply.

In addition to this, there would need to be adequate safeguards in place to ensure the urea is used throughout the life of the vehicle since, given the added cost of urea and the fact that urea depletion would not normally affect driveability, there would be an incentive not to refill the urea tank. This could lead to considerable uncertainties regarding the effectiveness of SCR, even if EPA were to promulgate the regulations that likely would be needed to require the regular replenishment of urea. Some commenters have suggested that this is the key issue with regard to urea SCR systems. One commenter further concludes that this issue could be addressed by designing engines with on-board diagnostic systems utilizing a $NO_X$ sensor that would observe a loss of $NO_X$ control. When observed, the engine would be designed to reduce power gradually until a 50 percent loss of power was realized. This power loss would serve to encourage the user to replenish the urea tank.[128] While such an approach may be possible, it raises concerns for public safety as poor engine performance could lead to inadequate power for safe merging onto highways and other related driving situations. We remain hesitant to base a national program on such technology when important issues such as driver training on the need to refill the urea tank and the consequences of failure to do so cannot be appropriately controlled. This approach would seem to suggest a need for EPA-mandated spot checks of individual vehicles to ensure compliance with the $NO_X$ standard. How such a program would work and the burden that it might place on small business entities was not addressed in the comments. In testimony given at the public hearing held for this rulemaking in Los Angeles, the California Trucking Association raised concerns about the appropriateness of putting this regulatory burden on truckers when a simpler technology such as a diesel $NO_X$ adsorber was available instead.[129] Without measures similar to these, we would expect that a substantial number of users would not remember to fill their urea tanks. Since failure to provide urea for a vehicle would lead to a total loss of $NO_X$ control for that vehicle, we would need to model the loss of $NO_X$ control to be expected from an SCR based program. Such a loss in $NO_X$ control most likely would be appreciable and, in effect, the $NO_X$ standard would not be met on a fleetwide basis.

We believe that these significant obstacles would prevent the widespread or general availability of SCR for use as a $NO_X$ control strategy to meet the 0.20 g/bhp-hr $NO_X$ standard. These problems may, however, be resolved in some niche applications; for example, certain well-managed centrally-fueled fleets. Because of the many obstacles to ensure in-use $NO_X$ control with the SCR, we do not believe that feasibility of the 0.20 g/bhp-hr $NO_X$ standard can be based upon SCR technology. For further discussion of urea SCR's need for low sulfur diesel fuel, refer to section III.F of this preamble.

*Summary*

Based on the discussion above, we believe that $NO_X$ exhaust emission control technology, in combination with low sulfur diesel fuel of 15 ppm or lower, is capable of meeting the very stringent $NO_X$ standards finalized today. The certainty provided by this rulemaking that low sulfur diesel fuel will be available in the future, and the emission standards finalized today that necessitate advanced $NO_X$ controls, should lead to rapid development of these technologies. The $NO_X$ adsorber technology has shown remarkable advancement in the last five years, both in stationary source applications and

[128] API Comments on the 2007 Heavy Duty Engine/Diesel Sulfur Proposed Rule, August 14, 2000, Air Docket A–99–06, IV–D–343.

[129] Testimony of Stephanie Williams—Director of Environmental Affairs, California Trucking Association to EPA public hearing June 27, 2000, Air Docket A–99–06, IV–F–190.

lean-burn gasoline applications, and now for heavy-duty diesel engines. Given this rapid progress, the availability of low sulfur diesel fuel, the identification of engineering paths to resolving the technological issues, and the lead time provided by today's rulemaking, we believe that applying $NO_X$ adsorbers to heavy-duty diesel engines will provide the emission reductions needed to comply with the 2007 HD $NO_X$ standards. This can be done in a cost effective way, with little or no fuel economy impact, and no special concerns of safety.

c. Meeting the NMHC Standard

Historically control of non-methane hydrocarbon (NMHC) emissions on diesel engines has been relatively simple, when compared to gasoline engines, due to the net fuel lean (abundant oxygen) operation typical of diesel engines. In fact, due to this operating characteristic, diesel engine NMHC levels have often been significantly below the mandated levels. The introduction of catalytic $NO_X$ control and the subsequent need to operate under alternately net lean and net rich conditions is likely to make NMHC control more difficult.

Meeting the NMHC standards under the lean operating conditions typical of the biggest portion of $NO_X$ adsorber operation should not present any special challenges to diesel manufacturers. Since the devices discussed above—catalyzed particulate filters and $NO_X$ adsorbers, contain platinum and other precious metals to oxidize NO to $NO_2$, they are also very efficient oxidizers of hydrocarbons. NMHC emission reductions of greater than 95 percent have been shown in these devices over the transient FTP and SET modes.[130] Given that typical engine-out NMHC is expected to be in the 0.20 g/bhp-hr range for engines meeting the 2004 standards, this level of NMHC reduction will mean that under lean conditions emission levels will be well below the standard.

However, the $NO_X$ regeneration strategies for the $NO_X$ adsorber technology may prove difficult to control precisely, leading to a possible increase in HC emissions under the rich operating conditions required for $NO_X$ regeneration. Even with precise control of the regeneration cycle, HC slip may prove to be a difficult problem due to the need to regenerate the $NO_X$ adsorber under net rich conditions (excess fuel) rather than the stoichiometric (fuel and air precisely balanced) operating conditions typical of a gasoline three-way catalyst. It seems likely therefore, that in order to meet the HC standards we have set, an additional clean up catalyst may be necessary. A diesel oxidation catalyst, like those applied historically for HC and partial PM control, can reduce HC reductions (including toxic HCs) by more than 80 percent.[131] This amount of additional control along with optimized $NO_X$ regeneration strategies will ensure very low HC emissions. With such a downstream clean-up device to control HC slip during the periodic $NO_X$ regeneration event, the HC standard we have set here can be met. For a complete description of how the clean up catalyst functions in conjunction with the $NO_X$ adsorber technology, please refer to the complete system description given below in section III.E.1.e and to the final RIA.

Given industry's extensive experience with diesel oxidation catalysts, the long lead time provided by this rulemaking and the availability of less than 15 ppm sulfur diesel fuel, we conclude, having given consideration to cost, energy impacts and safety, that the NMHC standard is feasible.

d. Meeting the Crankcase Emissions Requirements

The most common way to eliminate crankcase emissions has been to vent the blow-by gases into the engine air intake system, so that the gases can be recombusted. Until today's rulemaking, we have required that crankcase emissions be controlled only on naturally aspirated diesel engines. We have made an 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. However, this is an environmentally significant exception since most heavy-duty diesel trucks use turbocharged engines, and a single engine can emit over 100 pounds of $NO_X$, NMHC, and PM from the crankcase over its lifetime.

Given the available means to control crankcase emissions, we have eliminated this exception. We anticipate that the heavy-duty diesel engine manufacturers will be able to control crankcase emissions through the use of closed crankcase filtration systems or by routing unfiltered blow-by gases directly into the exhaust system upstream of the emission control equipment. However, the provision has been written such that if adequate control can be had without "closing" the crankcase then the crankcase can remain "open." Compliance would be ensured by adding the emission from the crankcase ventilation system to the emissions from the engine control system downstream of any emission control equipment.

We expect that in order to meet the stringent tailpipe emission standards set here, that manufacturers will have to utilize closed crankcase approaches as described here. Closed crankcase filtration systems work by separating oil and particulate matter from the blow-by gases through single or dual stage filtration approaches, routing the blow-by gases into the engine's intake manifold and returning the filtered oil to the oil sump. These systems are required for new heavy-duty diesel vehicles in Europe starting in 2000. Oil separation efficiencies in excess of 90 percent have been demonstrated with production ready prototypes of two stage filtration systems.[132] By eliminating 90 percent of the oil that would normally be vented to the atmosphere, the system works to reduce oil consumption and to eliminate concerns over fouling of the intake system when the gases are routed through the turbocharger. Mercedes-Benz currently utilizes this type of system on virtually all of its heavy-duty diesel engines sold in Europe. An alternative approach would be to route the blow-by gases into the exhaust system upstream of the catalyzed diesel particulate filter which would be expected to effectively trap and oxidize the engine oil and diesel PM. This approach may require the use of low sulfur engine oil to ensure that oil carried in the blow-by gases does not compromise the performance of the sulfur-sensitive emission control equipment.

e. The Complete System

We expect that the technologies described above would be integrated into a complete emission control system as described in the final RIA. The engine-out emissions will be balanced with the exhaust emission control package in such a way that the result is the most beneficial from a cost, fuel economy and emissions standpoint. The engine-out exhaust characteristics will also have a role in assisting the exhaust emission control devices used. The $NO_X$

[130] "The Impact of Sulfur in Diesel Fuel on Catalyst Emission Control Technology," report by the Manufacturers of Emission Controls Association, March 15, 1999, pp. 9 & 11.

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

[132] Letter from Marty Barris, Donaldson Corporation, to Byron Bunker US EPA, March 2000. Air Docket A–99–06.

adsorber, for instance, will require periods of oxygen-depleted exhaust flow in order to accomplish $NO_X$ regeneration and to allow for sulfur control using desulfation events. This may be most efficiently done by reducing the air-fuel ratio that the engine is operating under during the regeneration to reduce the oxygen content of the exhaust, or alternatively by partitioning the exhaust flow such that only a small portion of the exhaust flow is used for $NO_X$ regeneration, thereby reducing the amount of oxygen needing to be depleted through fuel addition. Further, it is envisioned that the PM device will be integrated into the exhaust system upstream of the $NO_X$ reduction device. This placement would allow the PM trap to take advantage of the engine-out $NO_X$ as an oxidant for the particulate, while removing the particulate so that the $NO_X$ exhaust emission control device will not have to deal with large PM deposits which may cause a deterioration in performance. Further it allows the $NO_X$ adsorber to make use of the upstream PM filter as a pre-catalyst to oxidize some NO to $NO_2$ and to partially oxidize the reductant (diesel fuel or exhaust hydrocarbons) to a more desirable reductant form such as CO before entering the $NO_X$ adsorber. Of course, there is also the possibility of integrating the PM and $NO_X$ exhaust emission control devices into a single unit to replace a muffler and save space (Toyota's DNPR system being an example of this approach).[133] The final component in any of these system configurations is likely to be some form of clean up catalyst which can provide control of HC slip during $NO_X$ regeneration as well as $H_2S$ slip during SOx regeneration. Particulate free exhaust may also allow for new options in EGR system design to optimize its efficiency.

We expect that the emission reduction efficiency of the exhaust emission control system will vary across the NTE zone as a function of exhaust temperature and space velocity.[134] Consequently, to maintain the NTE emission cap, the engine-out emissions would have to be calibrated with exhaust emission control system performance characteristics in mind. This would be accomplished by lowering engine-out emissions where the exhaust emission control system was less efficient, for example by retarding fuel injection timing or increasing the EGR rate. Conversely, where the exhaust emission control system is very efficient at reducing emissions, the engine-out emissions could be tuned for higher emissions and better fuel economy. These trade-offs between engine-out emissions and exhaust emission control system performance characteristics are similar to those of gasoline engines with three-way catalysts in today's light-duty vehicles and can be overcome through similar system based engineering solutions. Managing and optimizing these trade-offs will be crucial to effective implementation of exhaust emission control devices on diesel applications.

2. Feasibility of Stringent Standards for Heavy-Duty Gasoline

Gasoline emission control technology has evolved rapidly in recent years. Emission standards applicable to 1990 model year vehicles required roughly 90 percent reductions in exhaust NMHC and CO emissions and a 75 percent reduction in $NO_X$ emissions compared to uncontrolled emissions. Today, some vehicles' emissions are well below those necessary to meet the current federal heavy-duty gasoline standards, the 2004 heavy-duty gasoline standards, and the California Low-Emission Vehicle standards for medium-duty vehicles. The continuing emissions reductions have been brought about by ongoing improvements in engine air-fuel management hardware and software plus improvements in exhaust system and catalyst designs.

We believe that the types of changes being seen on current vehicles have not yet reached their technological limits and continuing improvement will allow them to meet today's standards. The RIA describes a range of specific emission control techniques that we believe could be used. There is no need to invent new technologies, although there will be a need to apply existing technology more effectively and more broadly. The focus of the effort will be in the application and optimization of these existing technologies.

In our light-duty Tier 2 rule, we have required that gasoline sulfur levels be reduced to a 30 ppm average, with an 80 ppm maximum. This sulfur level reduction is the primary enabler for the Tier 2 standards. Similarly, we believe that the gasoline sulfur reduction, along with refinements in existing gasoline emission control technology, will be sufficient to allow heavy-duty gasoline vehicles and engines to meet the emission standards sought by today's rule.

However, we recognize that the emission standards are stringent, and considerable effort will have to be undertaken. For example, we expect that every engine will have to be recalibrated to improve upon its cold start emission performance. Manufacturers will have to migrate their light-duty calibration approaches to their heavy-duty offerings to provide cold start performance in line with what they will have to achieve to meet the Tier 2 standards.

We also project that today's new heavy-duty gasoline standards would require the application of advanced engine and catalyst systems similar to those projected for their light-duty counterparts. Historically, manufacturers have introduced technology on light-duty gasoline applications and then applied those technologies to their heavy-duty gasoline applications. Today's standards will allow manufacturers to take this same approach. In other words, we expect that manufacturers will meet today's new standards through the application of technology developed to meet light-duty Tier 2 standards for 2004.

Improved calibration and systems management will be critical in optimizing the performance of the engine with the advanced catalyst system. Precise air/fuel control must be tailored for emissions performance and must be optimized for all types of driving. Calibration refinements may also be needed for EGR system optimization and to reduce cold start emissions through methods such as spark timing retard. We also project that electronic control modules with expanded capabilities will be needed on some vehicles and engines.

We also expect increased use of other technologies in conjunction with those described above. We expect some increased use of air injection to improve upon cold start emissions. We may also see air-gap manifolds, exhaust pipes, and catalytic converter shells as a means of improving upon catalyst light-off times thereby reducing cold start emissions. Other, non-catalyst related improvements to gasoline emission control technology include higher speed computer processors which enable more sophisticated engine control algorithms and improved fuel injectors providing better fuel atomization thereby improving fuel combustion.

Catalyst system durability is, and will always be, a serious concern. Historically, catalysts have deteriorated when exposed to very high temperatures. This has long been a concern especially for heavy-duty work

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

[134] The term, "space velocity," is a measure of the volume of exhaust gas that flows through a device.

vehicles. However, catalyst manufacturers continue to make strides in the area of thermal stability and we expect that improvements in thermal stability will continue for the next generation of catalysts.

We believe that, by optimizing all of these technologies, manufacturers will be able to achieve today's standards. Advanced catalyst systems have already shown potential to reduce emissions to close to these levels. Some current California vehicles are certified to levels below 0.20 g/mi $NO_X$. California tested an advanced catalyst system on a vehicle loaded to a test weight comparable to a heavy-duty vehicle test weight and achieved $NO_X$ and NMOG levels of 0.1 g/mi and 0.16 g/mi, respectively. The California vehicle with the advanced catalyst had not been optimized as a system to take full advantage of the catalyst's capabilities.

The compliance flexibility provisions can also be an important tool for manufacturers in implementing a new standard. The program allows manufacturers to transition to the more stringent standards by introducing emissions controls over a longer period of time, as opposed to a single model year. Manufacturers plan their product introductions well in advance. With the compliance flexibilities, manufacturers can better manage their product lines so that the new standards don't interrupt their product introduction plans. Also, the program allows manufacturers to focus on higher sales volume vehicles first and use credits for low sales volume vehicles.

3. Feasibility of the New Evaporative Emission Standards

The new evaporative emission standards appear to be feasible now. Many designs have been certified that already meet these standards. A review of 1998 model year certification data indicates that five of eight evaporative system families in the 8,500 to 14,000 pound range comply with the new 1.4 g/test standard, while all evaporative system families in the over 14,000 pound range comply with the new 1.9 g/test standard.

The new evaporative emission standards should not require the development of new materials but may, in some cases, require new application of existing materials. Low permeability materials and low loss connections and seals are already used to varying degrees on current vehicles, but that practice may become more widespread. Today's new standards would likely ensure their consistent use and discourage manufacturers from switching to cheaper materials or designs to take advantage of the large safety margins they have had under current standards.

There are two approaches to reducing evaporative emissions for a given fuel. One is to minimize the potential for permeation and leakage by reducing the number of hoses, fittings and connections. The second is to use less permeable hoses and lower loss fittings and connections. Manufacturers are already employing both approaches.

Most manufacturers are moving to "returnless" fuel injection systems. Through more precise fuel pumping and metering, these systems eliminate the return line in the fuel injection system. The return line carries unneeded fuel from the fuel injectors back to the fuel tank. Because the fuel injectors are in such close contact with the hot engine, the fuel returned from the injectors to the fuel tank has been heated. This returned fuel is a significant source of fuel tank heat and vapor generation. The elimination of the return line also reduces the total length of hose on the vehicle though which vapors can permeate, and it reduces the number of fittings and connections through which fuel can leak.

Low permeability hoses and seals, and low loss fittings are available and are already used on many vehicles. Fluoropolymer materials can be added as liners to hose and component materials to yield large reductions in permeability over such conventional materials as monowall nylon. In addition, fluoropolymer materials can greatly reduce the adverse impact of alcohols in gasoline on permeability of evaporative components, hoses and seals.

*F. Need for Low Sulfur Diesel Fuel*

The following discussion will build upon the brief sulfur sensitivity points made earlier in this section by providing a more in-depth discussion of sulfur's effect on the diesel exhaust emission control technologies. In order to evaluate the effect of sulfur on diesel exhaust control technologies, we used three key factors to categorize the impact of sulfur in fuel on emission control function. These factors were efficiency, reliability, and fuel economy. Taken together these three factors lead us to believe that diesel fuel sulfur levels of 15 ppm will be required in order to make feasible the heavy-duty vehicle emission standards. Brief summaries of these factors are provided below. A more in-depth review is given in the following subsections and in the final RIA.

The efficiency of emission control technologies to reduce harmful pollutants is directly affected by sulfur in diesel fuel. Initial and long term conversion efficiencies for $NO_X$, NMHC, CO and diesel PM emissions are significantly reduced by catalyst poisoning and catalyst inhibition due to sulfur. $NO_X$ conversion efficiencies with the $NO_X$ adsorber technology in particular are dramatically reduced in a very short time due to sulfur poisoning of the $NO_X$ storage bed. In addition, total PM control efficiency is negatively impacted by the formation of sulfate PM. As explained in detail in the following sections, all of the advanced $NO_X$ and PM technologies described here have the potential to make significant amounts of sulfate PM under operating conditions typical of heavy-duty vehicles. We believe that the formation of sulfate PM will be in excess of the total PM standard, unless diesel fuel sulfur levels are at or below 15 ppm. Based on the strong negative impact of sulfur on emission control efficiencies for all of the technologies evaluated, we believe that 15 ppm represents an upper threshold of acceptable diesel fuel sulfur levels.

Reliability refers to the expectation that emission control technologies must continue to function as required under all operating conditions for the life of the vehicle. As discussed in the following sections, sulfur in diesel fuel can prevent proper operation of both $NO_X$ and PM control technologies. This can lead to permanent loss in emission control effectiveness and even catastrophic failure of the systems. Sulfur in diesel fuel impacts reliability by decreasing catalyst efficiency (poisoning of the catalyst), increasing diesel particulate filter loading, and negatively impacting system regeneration functions. Among the most serious reliability concerns with sulfur levels greater than 15 ppm are those associated with failure to properly regenerate. In the case of the $NO_X$ adsorber, failure to regenerate will lead to rapid loss of $NO_X$ emission control as a result of sulfur poisoning of the $NO_X$ adsorber bed. In the case of the diesel particulate filter, sulfur in the fuel reduces the reliability of the regeneration function. If regeneration does not occur, catastrophic failure of the filter could occur. It is only by the availability of low sulfur diesel fuels that these technologies become feasible. The analysis given in the following section makes clear that diesel fuel sulfur levels will need to be under 15 ppm in order to ensure robust operation of the technologies under the variety of operating conditions anticipated to be experienced in the field.

Fuel economy impacts due to sulfur in diesel fuel affect both $NO_X$ and PM control technologies. The $NO_X$ adsorber sulfur regeneration cycle (desulfation cycle) can consume significant amounts of fuel unless fuel sulfur levels are very low. The larger the amount of sulfur in diesel fuel, the greater the adverse effect on fuel economy. As sulfur levels increase above 15 ppm, the adverse effect on fuel economy becomes more significant, increasing above one percent and doubling with each doubling of fuel sulfur level. Likewise, PM trap regeneration is inhibited by sulfur in diesel fuel. This leads to increased PM loading in the diesel particulate filter and increased work to pump exhaust across this restriction. With low sulfur diesel fuel, diesel particulate filter regeneration can be optimized to give a lower (on average) exhaust backpressure and thus better fuel economy. Thus, for both $NO_X$ and PM technologies the lower the fuel sulfur level the lower the operating costs of the vehicle.

1. Catalyzed Diesel Particulate Filters and the Need for Low Sulfur Fuel

Diesel particulate filters (PM traps) function to control diesel PM through mechanical filtration of PM from the diesel exhaust stream and then oxidation of the stored PM (trap regeneration). Through oxidation in the catalyzed diesel particulate filter the stored carbonaceous PM is converted to $CO_2$ and released into the atmosphere. Failure to oxidize the stored PM leads to accumulation in the trap, eventually causing the trap to become so full that it severely restricts exhaust flow through the device, leading to trap or vehicle failure.

As discussed earlier in this section, uncatalyzed diesel particulate filters require exhaust temperatures in excess of 650° C in order for the collected PM to be oxidized by the oxygen available in diesel exhaust. That temperature threshold for oxidation of PM by exhaust oxygen can be decreased to 450° C through the use of base metal catalytic technologies. For a broad range of operating conditions typical of in use operation, diesel exhaust is significantly cooler than 400° C. If oxidation of the trapped PM could be assured to occur at exhaust temperatures lower than 300° C, then diesel particulate filters would be expected to be robust for most applications and operating regimes. Oxidation of PM (regeneration of the trap) at such low exhaust temperatures can occur by using oxidants which are more readily reduced than oxygen. One such oxidant is $NO_2$.

$NO_2$ can be produced in diesel exhaust through the oxidation of the nitrogen monoxide (NO), created in the engine combustion process, across a catalyst. The resulting $NO_2$-rich exhaust is highly oxidizing in nature and can oxidize trapped diesel PM at temperatures as cool as 250°C.[135] Some platinum group metals are known to be good catalysts to promote the oxidation of NO to $NO_2$. Therefore in order to ensure passive regeneration of the diesel particulate filters, significant amounts of platinum group metals (primarily platinum) are being used in the wash-coat formulations of advanced diesel particulate filters. The use of platinum to promote the oxidation of NO to $NO_2$ introduces several system vulnerabilities affecting both the durability and the effectiveness of the catalyzed diesel particulate filter when sulfur is present in diesel exhaust. The two primary mechanisms by which sulfur in diesel fuel limits the robustness and effectiveness of diesel particulate filters are inhibition of trap regeneration, through inhibition of the oxidation of NO to $NO_2$, and a dramatic loss in total PM control effectiveness due to the formation of sulfate PM. Unfortunately, these two mechanisms trade-off against one another in the design of diesel particulate filters. Changes to improve the reliability of regeneration by increasing catalyst loadings lead to increased sulfate emissions and, thus, loss of PM control effectiveness. Conversely, changes to improve PM control by reducing the use of platinum group metals and, therefore, limiting ‘‘sulfate make’’ leads to less reliable regeneration. We believe the only means of achieving good PM emission control and reliable operation is to reduce sulfur in diesel fuel, as shown in the following subsections.

a. Inhibition of Trap Regeneration Due to Sulfur

The passively regenerating diesel particulate filter technologies rely on the generation of a very strong oxidant, $NO_2$, to ensure that the carbon captured by the PM trap's filtering media is oxidized under the exhaust temperature range of normal operating conditions. This prevents plugging and failure of the PM trap. $NO_2$ is produced through the oxidation of NO in the exhaust across a platinum catalyst. This oxidation is inhibited by sulfur poisoning of the catalyst surface.[136] This inhibition limits the total amount of $NO_2$ available for oxidation of the trapped diesel PM, thereby raising the minimum exhaust temperature required to ensure trap regeneration. Without sufficient $NO_2$, the amount of PM trapped in the diesel particulate filter will continue to increase and can lead to excessive exhaust back pressure, low engine power, and even catastrophic failure of the diesel particulate filter itself.

The failure mechanisms experienced by diesel particulate filters due to low $NO_2$ availability vary significantly in severity and long term consequences. In the most fundamental sense, the failure is defined as an inability to oxidize the stored particulate at a rate fast enough to prevent net particulate accumulation over time. The excessive accumulation of PM over time blocks the passages through the filtering media, making it more restrictive to exhaust flow. In order to continue to force the exhaust through the now more restrictive filter, the exhaust pressure upstream of the filter must increase. This increase in exhaust pressure is commonly referred to as increasing ‘‘exhaust backpressure’’ on the engine.

The increase in exhaust backpressure represents increased work being done by the engine to force the exhaust gas through the increasingly restrictive particulate filter. Unless the filter is frequently cleansed of the trapped PM, this increased work can lead to reductions in engine performance and increases in fuel consumption. This loss in performance may be noted by the vehicle operator in terms of poor acceleration and generally poor driveability of the vehicle. In some cases, engine performance can be so restricted that the engine stalls, stranding the vehicle. This progressive deterioration of engine performance as more and more PM is accumulated in the filter media is often referred to as ‘‘trap plugging.’’ Trap plugging also has the potential to cause engine damage. If the exhaust backpressure gets high enough to open the exhaust valves prematurely, the exhaust valves can then strike the piston causing catastrophic engine failure. Whether trap plugging occurs, and the speed at which it occurs, will be a function of many variables in addition to the fuel sulfur level; these variables include the vehicle application, its duty cycle, and ambient conditions. However, if the fuel sulfur level is sufficiently high to prevent trap regeneration in any real world conditions experienced, trap plugging can occur. This is not to imply that any time a vehicle is refueled once with high sulfur fuel trap plugging will occur. Rather, it is important to know that the use of fuel with sulfur levels higher than 15 ppm significantly

[135] Hawker, P. *et al.*, Experience with a New Particualte Trap Technology in Europe, SAE 970182.

[136] Hawker, P. *et al*, Experience with a New Particulate Trap Technology in Europe, SAE 970182.

increases the chances of particulate filter failure.

Catastrophic failure of the filter can occur when excessive amounts of PM are trapped in the filter due to a lack of $NO_2$ for oxidation. This failure occurs when excessive amounts of trapped PM begin to oxidize at high temperatures (combustion-like temperatures of over 1000° C) leading to a ''run-away'' combustion of the PM. This can cause temperatures in the filter media to increase in excess of that which can be tolerated by the particulate filter itself. For the cordierite material commonly used as the trapping media for diesel particulate filters, the high thermal stresses caused by the high temperatures can cause the material to crack or melt. This can allow significant amounts of the diesel particulate to pass through the filter without being captured during the remainder of the vehicle's life. That is, the trap is destroyed and PM emission control is lost. Further the high temperatures generated during this event can destroy the downstream catalyst components, such as the $NO_X$ adsorber, rendering them ineffective as well.

Full field test evaluations and retrofit applications of these catalytic trap technologies are occurring in parts of Europe where low sulfur diesel fuel is already available.[137] The experience gained in these field tests helps to clarify the need for low sulfur diesel fuel. In Sweden and some European city centers 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. Given the large number of vehicles participating in these test programs, the diversity of the vehicle applications which included intercity trains, airport buses, mail trucks, city buses and garbage trucks, and the extended time periods of operation (some vehicles have been operating with traps for more than 5 years and in excess of 300,000 miles[138]), there is a strong indication of the robustness of this technology on 10 ppm low sulfur diesel fuel. 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 cap low sulfur fuel have also been positive, matching the durability at 10 ppm, although sulfate PM emissions are much higher. However, field tests on 50 ppm fuel in Finland, where colder winter conditions are sometimes encountered (similar to many parts of the United States), showed a significant number of failures (~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.[139] 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 Arctic Circle.[140] 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.[141] 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.[142] The failure of some fraction of the traps to regenerate when operated on fuel with sulfur caps of 50 ppm and 200 ppm is believed to be primarily due to inhibition of the NO to $NO_2$ conversion as described here. Similarly the increasing frequency of failure with higher fuel sulfur levels is believed to be due to the further suppression of $NO_2$ formation when higher sulfur level diesel fuel is used.

As shown above, sulfur in diesel fuel inhibits NO oxidation leading to increased exhaust backpressure, reduced fuel economy, compromised reliability, and potentially engine damage. Therefore, we believe that, in order to ensure reliable and economical operation over a wide range of expected operating conditions, diesel fuel sulfur levels should be at or below 15 ppm. With these low sulfur levels we believe, as demonstrated by experience in Europe, that catalyzed diesel particulate filters will prove to be both durable and effective at controlling diesel particulate emissions. We did receive comments from the refining industry suggesting that PM filters could work on fuel sulfur levels as high as 50 ppm. The commenters pointed to some specific test programs where fuel with an approximate average sulfur level of 30 ppm was used as evidence of the robustness of the technology on higher sulfur fuels. While we do not deny that it is possible to operate some vehicles in limited applications over defined driving cycles on fuel as high as 30 ppm, we do not believe that this limited data should be the basis for a national program. The reality that some vehicles do fail on 50 ppm cap fuel, as demonstrated by the Finish fleet results mentioned above, shows that durability is not assured with the use of higher sulfur diesel fuel. We believe that the evidence, as a whole, shows that oxidation of NO to $NO_2$ will be poisoned due to these higher fuel sulfur levels with a resulting significant possibility of PM trap failures that is too great a concern for us to feel confident about a fuel sulfur level higher than 15 ppm.

b. Loss of PM Control Effectiveness

In addition to inhibiting the oxidation of NO to $NO_2$, the sulfur dioxide ($SO_2$) in the exhaust stream is itself oxidized to sulfur trioxide ($SO_3$) at very high conversion efficiencies by the precious metals in the catalyzed particulate filters. The $SO_3$ serves as a precursor to the formation of hydrated sulfuric acid ($H_2SO_4+H_2O$), or sulfate PM, as the exhaust leaves the vehicle tailpipe. Virtually all of the $SO_3$ is converted to sulfate under dilute exhaust conditions in the atmosphere as well in the dilution tunnel used in heavy-duty engine testing. Since virtually all sulfur present in diesel fuel is converted to $SO_2$, the precursor to $SO_3$, as part of the combustion process, the total sulfate PM is directly proportional to the amount of sulfur present in diesel fuel. Therefore, even though diesel particulate filters are very effective at trapping the carbon and the SOF portions of the total PM, the overall PM reduction efficiency of catalyzed diesel particulate filters drops off rapidly with increasing sulfur levels due to the formation of sulfate PM downstream of the trap.

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[137] Through tax incentives 50 ppm cap sulfur fuel is widely available in the United Kingdom and 10 ppm sulfur is available in Sweden and in certain European city centers.

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

[139] Letter from Dr. Barry Cooper, Johnson Matthey, to don Kopinski, US EPA, Air Docket A–99–06.

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

[141] The average temperature in Helsinki, Finland, for the month of January is 21° F. The average temperature in Stockholm, Sweden, for the month of Juanuary is 21° F. The average temperature at the University of Michigan in Ann Arbor, Michigan, for the month of January is 24° F. The temperatures 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).

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

$SO_2$ oxidation is promoted across a catalyst in a manner very similar to the oxidation of NO, except it is converted at higher rates, with peak conversion rates in excess of 50 percent. The $SO_2$ oxidation rate for a platinum based oxidation catalyst typical of the type which might be used in conjunction with, or as a washcoat on, a catalyzed diesel particulate filter can vary significantly with exhaust temperature. At the low temperatures typical of some urban driving and the heavy-duty federal test procedure (HD–FTP), the oxidation rate is relatively low, perhaps no higher than ten percent. However at the higher temperatures that might be more typical of highway driving conditions and the Supplemental Emission Test (also called the EURO III or 13 mode test), the oxidation rate may increase to 50 percent or more. These high levels of sulfate make across the catalyst are in contrast to the very low $SO_2$ oxidation rate typical of diesel exhaust (typically less than 2 percent). This variation in expected diesel exhaust temperatures means that there will be a corresponding range of sulfate production expected across a catalyzed diesel particulate filter.

The US Department of Energy in cooperation with industry conducted a study entitled DECSE to provide insight into the relationship between advanced emission control technologies and diesel fuel sulfur levels. Interim report number four of this program gives the total particulate matter emissions from a heavy-duty diesel engine operated with a diesel particulate filter on several different fuel sulfur levels. A straight line fit through this data is presented in Table III.F–1 below showing the expected total direct PM emissions from a heavy-duty diesel engine on the supplemental emission test cycle.[143] The data can be used to estimate the PM emissions from heavy-duty diesel engines operated on fuels with average fuel sulfur levels in this range.

TABLE III.F–1.—ESTIMATED PM EMISSIONS FROM A HEAVY-DUTY DIESEL ENGINE AT THE INDICATED FUEL SULFUR LEVELS

| Fuel sulfur [ppmm] | Supplemental emission test performance | |
|---|---|---|
| | Tailpipe PM[b] [g/bhp-hr] | PM increase relative to 3 to 3 ppm sulfur |
| 3 | 0.003 | |
| 7[a] | 0.006 | 100% |
| 15[a] | 0.009 | 200% |
| 30 | 0.017 | 470% |
| 150 | 0.071 | 2300% |

[a] The PM emissions at these sulfur levels are based on a straight-line fit to the DECSE data; PM emissions at other sulfur levels are actual DECSE data. (Diesel Emission Control Sulfur Effects (DECSE) Program—Phase II Interim Data Report No. 4, Diesel Particulate Filters-Final Report, January 2000. Table C1.) Although DECSE tested diesel particulate filters at these fuel sulfur levels, they do not conclude that the technology is feasible at all levels, but they do note that testing at 150 ppm is a moot point as the emission levels exceed the engine's baseline emission level.

[b] b Total exhaust PM (soot, SOF, sulfate).

Table III.F–1 makes it clear that there are significant PM emission reductions possible with the application of catalyzed diesel particulate filters and low sulfur diesel fuel. At the observed sulfate PM conversion rates, the DECSE program results show that the 0.01 g/bhp-hr total PM standard is feasible for diesel particulate filter equipped engines operated on fuel with a sulfur level at or below 15 ppm. The results also show that diesel particulate filter control effectiveness is rapidly degraded at higher diesel fuel sulfur levels due to the high sulfate PM make observed with this technology. It is clear that PM reduction efficiencies are limited by sulfur in diesel fuel and that, in order to realize the PM emissions benefits sought in this rule, diesel fuel sulfur levels must be at or below 15 ppm. The data further indicates that were the fuel sulfur level set at a 30 ppm average, as some commenters suggested, the PM emissions from the controlled vehicles would be nearly three times the emissions from a vehicle operating on fuel with a 7 ppm average.

c. Increased Maintenance Cost for Diesel Particulate Filters Due to Sulfur

In addition to the direct performance and durability concerns caused by sulfur in diesel fuel, it is also known that sulfur can lead to increased maintenance costs, shortened maintenance intervals, and poorer fuel economy for particulate filters. Diesel particulate filters are highly effective at capturing the inorganic ash produced from metallic additives in engine oil. This ash is accumulated in the filter and is not removed through oxidation, unlike the trapped carbonaceous PM. Periodically the ash must be removed by mechanical cleaning of the filter with compressed air or water. This maintenance step is anticipated to occur on intervals of well over one hundred thousand miles. However, sulfur in diesel fuel increases this ash accumulation rate through the formation of metallic sulfates in the filter, which increases both the size and mass of the trapped ash. By increasing the ash accumulation rate, the sulfur shortens the time interval between the required maintenance of the filter and negatively impacts fuel economy.

2. Diesel $NO_X$ Catalysts and the Need for Low Sulfur Fuel

All of the $NO_X$ exhaust emission control technologies discussed previously in Section III are expected to utilize platinum to oxidize NO to $NO_2$ to improve the $NO_X$ reduction efficiency of the catalysts at low temperatures or as in the case of the $NO_X$ adsorber, as an essential part of the process of $NO_X$ storage. This reliance on $NO_2$ as an integral part of the reduction process means that the $NO_X$ exhaust emission control technologies, like the PM exhaust emission control technologies, will have problems with sulfur in diesel fuel. In addition, $NO_X$ adsorbers have the added problem that the adsorption function itself is poisoned by the presence of sulfur. The resulting need to remove the stored sulfur (desulfate) leads to a need for extended high temperature operation which can deteriorate the $NO_X$ adsorber. These limitations due to sulfur in the fuel affect the overall performance and feasibility of the technologies.

a. Sulfur Poisoning (Sulfate Storage) on $NO_X$ Adsorbers

The $NO_X$ adsorber technology relies on the ability of the catalyst to store $NO_X$ as a nitrate ($MNO_3$) on the surface of the catalyst, or adsorber (storage) bed, during lean operation. Because of the similarities in chemical properties of $SO_X$ and $NO_X$, the $SO_2$ present in the exhaust is also stored by the catalyst surface as a sulfate ($MSO_4$). The sulfate compound that is formed is significantly more stable than the nitrate compound and is not released and reduced during the $NO_X$ release and reduction step ($NO_X$ regeneration step). Since the $NO_X$ adsorber is essentially 100 percent effective at capturing $SO_2$ in the adsorber bed, the sulfur build up on the adsorber bed occurs rapidly. As a result, sulfate compounds quickly occupy all of the $NO_X$ storage sites on the catalyst

[143] Note that direct emisisons are those pollutants emitted directly from the engine or from the tailpipe depending on the context in which the term is used, and indirect emissions are those pollutants formed in the atmosphere through chemical reactions between direct emissions and other atmospheric constituents.

thereby rendering the catalyst ineffective for $NO_X$ storage and subsequent $NO_X$ reduction (poisoning the catalyst).

The stored sulfur compounds can be removed by exposing the catalyst to hot (over 650°C) and rich (air-fuel ratio below the stoichiometric ratio of 14.5 to 1) conditions for a brief period.[144] Under these conditions, the stored sulfate is released and reduced in the catalyst.[145] While research to date on this procedure has been very favorable with regards to sulfur removal from the catalyst, it has revealed a related vulnerability of the $NO_X$ adsorber catalyst. Under the high temperatures used for desulfation, the metals that make up the storage bed can change in physical structure. This leads to lower precious metal dispersion, or ''metal sintering,'' (a less even distribution of the catalyst sites) reducing the effectiveness of the catalyst.[146] This degradation of catalyst efficiency due to high temperatures is often referred to as thermal degradation. Thermal degradation is known to be a cumulative effect. That is, with each excursion to high temperature operation, some additional degradation of the catalyst occurs.

One of the best ways to limit thermal degradation is by limiting the accumulated number of desulfation events over the life of the vehicle. Since the period of time between desulfation events is expected to be determined by the amount of sulfur accumulated on the catalyst (the higher the sulfur accumulation rate, the shorter the period between desulfation events) the desulfation frequency is expected to be proportional to the fuel sulfur level. In other words for each doubling in the average fuel sulfur level, the frequency and accumulated number of desulfation events are expected to double. We believe, therefore, that the diesel fuel sulfur level must be set as low as possible in order to limit the frequency and duration of desulfation events. Without control of fuel sulfur levels below 15 ppm, we can no longer conclude with any confidence that sulfur poisoning can be controlled without unrecoverable thermal degradation. Some commenters have suggested that the $NO_X$ adsorber technology could meet the $NO_X$ standard using diesel fuel with a 30 ppm average sulfur level. This would imply that the $NO_X$ adsorber could tolerate as much as a four fold increase in desulfation frequency (when compared to an expected seven to 10 ppm average) without any increase in thermal degradation. This conclusion is inconsistent with our understanding of the technology that, with each desulfation event, some thermal degradation occurs. Therefore, we believe that diesel fuel sulfur levels must be at or below 15 ppm in order to limit the number and frequency of desulfation events. Limiting the number and frequency of desulfation events will limit thermal degradation and, thus, enable the $NO_X$ adsorber technology to meet the $NO_X$ standard.

Sulfur in diesel fuel for $NO_X$ adsorber equipped engines will also have an adverse effect on fuel economy. The desulfation event requires controlled operation under hot and net fuel rich exhaust conditions. These conditions, which are not part of a normal diesel engine operating cycle, can be created through the addition of excess fuel to the exhaust. This addition of excess fuel causes an increase in fuel consumption. We have developed a spreadsheet model that estimates the frequency of desulfation cycles from published data and then estimates the fuel economy impact from this event.[147] Table III–F.2 shows the estimated fuel economy impact for desulfation of a $NO_X$ adsorber at different fuel sulfur levels assuming a desired 90 percent $NO_X$ conversion efficiency. The estimates in the table are based on assumed average fuel sulfur levels associated with different sulfur level caps. Note that, although we can estimate the fuel consumption penalty of operation on diesel fuel sulfur levels higher than 15 ppm, this analysis does not consider the higher degree of thermal degradation due to the more frequent desulfation events which are required for operation on these higher sulfur levels.

TABLE III.F–2.—ESTIMATED FUEL ECONOMY IMPACT FROM DESULFATION OF A 90% EFFICIENT $NO_X$ ADSORBER

| Fuel sulfur cap (ppm) | Average fuel sulfur (ppm) | Fuel economy penalty (in percent) |
|---|---|---|
| 500 | 350 | 27 |
| 50 | 30 | 2 |
| 25 | 15 | 1 |
| 15 | 7 | <1 |
| 5 | 2 | <<<1 |

The table highlights that the fuel economy penalty associated with sulfur in diesel fuel is noticeable even at average sulfur levels as low as 15 ppm and increases rapidly with higher sulfur levels. It also shows that the use of a $NO_X$ adsorber with a 15 ppm sulfur cap fuel would be expected to result in a fuel economy impact due to the need for desulfation of the catalyst of less than one percent, absent other changes in engine design. However, as discussed in Section G below, we anticipate that other engine modifications could be made to offset this fuel economy impact. For example, a $NO_X$ control device in the exhaust system could allow use of fuel saving engine strategies, such as advanced fuel injection timing, that could be used to offset the increased fuel consumption associated with the $NO_X$ adsorber. The result is that low sulfur fuel enables the $NO_X$ adsorber which, in turn, enables fuel saving engine modifications. The total emission control system fuel economy impact, which we estimate to be zero under a 15 ppm cap program, is discussed below in Section III.G.

Future improvements in the $NO_X$ adsorber technology are expected and needed if the technology is to provide the environmental benefits we have projected today. Some of these improvements are likely to include improvements in the means and ease of removing stored sulfur from the catalyst bed. However because the stored sulfate species are inherently more stable than the stored nitrate compounds (from stored $NO_X$ emissions), we expect that a separate release and reduction cycle (desulfation cycle) will always be needed in order to remove the stored sulfur. Therefore, we believe that fuel with a sulfur level at or below 15 ppm sulfur will be necessary in order to control thermal degradation of the $NO_X$ adsorber catalyst and to limit the fuel economy impact of sulfur in diesel fuel.

b. Sulfate Particulate Production and Sulfur Impacts on Effectiveness of $NO_X$ Control Technologies

The $NO_X$ adsorber technology relies on a platinum based oxidation function

[144] Dou, Danan and Bailey, Owen, ''Investigation of $NO_X$ Adsorber Catalyst Deactivation,'' SAE 982594.

[145] Guyon M. et al, ''Impact of Sulfur on $NO_X$ Trap Catalyst Activity—Study of the Regeneration Conditions'', SAE 982607.

[146] though it was favroable to decompose sulfate at 800°C, performance of the NSR ($NO_X$ Storage Reduction catalyst, *i.e.* $NO_X$ Adsorber) catalyst decreased due to sintering of precious metal.—Asanuma, T. *et al,* ''Influence of Sulfur Concentration in Gasoline on $NO_X$ Storage—Reduction Catalyst'', SAE 1999–01–3501.

[147] Memo from Byron Bunker, to docket A–99–06, ''Estimating Fuel Economy Impacts of $NO_X$ Adsorber De-Sulfurization.''

in order to ensure high $NO_X$ control efficiencies. As discussed more fully in section III.F.1, platinum based oxidation catalysts form sulfate PM from sulfur in the exhaust gases significantly increasing PM emissions when sulfur is present in the exhaust stream. The $NO_X$ adsorber technology relies on the oxidation function to convert NO to $NO_2$ over the catalyst bed. For the $NO_X$ adsorber this is a fundamental step prior to the storage of $NO_2$ in the catalyst bed as a nitrate. Without this oxidation function the catalyst will only trap that small portion of $NO_X$ emissions from a diesel engine which is $NO_2$. This would reduce the $NO_X$ adsorber effectiveness for $NO_X$ reduction from in excess of 90 percent to something well below 20 percent. The $NO_X$ adsorber relies on platinum to provide this oxidation function due to the need for high NO oxidation rates under the relatively cool exhaust temperatures typical of diesel engines. Because of this fundamental need for a catalytic oxidation function, the $NO_X$ adsorber inherently forms sulfate PM when sulfur is present in diesel fuel, since sulfur in fuel invariably leads to sulfur in the exhaust stream.

The Compact-SCR technology, like the $NO_X$ adsorber technology, uses an oxidation catalyst to promote the oxidation of NO to $NO_2$ at the low temperatures typical of much of diesel engine operation. As discussed above, there are substantial questions regarding the ability of SCR systems to be implemented successfully to meet the requirements finalized today. By converting a portion of the $NO_X$ emissions to $NO_2$ upstream of the ammonia SCR reduction catalyst, the overall $NO_X$ reductions are improved significantly at low temperatures. Without this oxidation function, low temperature SCR $NO_X$ effectiveness is dramatically reduced making compliance with the $NO_X$ standard impossible. As discussed previously in Section III, platinum group metals are known to be good catalysts to promote NO oxidation, even at low temperatures.[148] Therefore, future Compact-SCR systems would need to rely on a platinum oxidation catalyst in order to provide the required $NO_X$ emission control. This use of an oxidation catalyst in order to enable good $NO_X$ control means that Compact SCR systems will produce significant amounts of sulfate PM when operated on anything but the lowest fuel sulfur levels due to the oxidation of $SO_2$ to sulfate PM promoted by the oxidation catalyst.

Without the oxidation catalyst promoted conversion of NO to $NO_2$, neither of these $NO_X$ control technologies can meet the $NO_X$ standard set here. Therefore each of these technologies will require low sulfur diesel fuel to control the sulfate PM emissions inherent in the use of oxidation catalysts. The $NO_X$ adsorber technology may be able to limit its impact on sulfate PM emissions by releasing stored sulfur as $SO_2$ under rich operating conditions. The Compact-SCR technology, on the other hand, has no means to limit sulfate emissions other than through lower catalytic function or lowering sulfur in diesel fuel. The degree to which the $NO_X$ emission control technologies increase the production of sulfate PM through oxidation of $SO_2$ to $SO_3$ varies somewhat from technology to technology, but it is expected to be similar in magnitude and environmental impact to that for the PM control technologies discussed previously in section III.F.1, since both the $NO_X$ and the PM control catalysts rely on precious metals to achieve the required NO to $NO_2$ oxidation reaction.

Thus, we believe that diesel fuel sulfur levels will need to be at or below 15 ppm in order to apply any of these $NO_X$ control technologies. Without this low sulfur fuel, the $NO_X$ control technologies are expected to create PM emissions well in excess of the PM standard regardless of the engine-out PM levels. Again, as noted with the PM control technologies, test results to date on catalysts with high oxidation potential indicate that were the fuel sulfur level set with a 30 ppm average, as some commenters suggested, the PM emissions from the controlled vehicles would increase nearly three fold over the level expected from fuel with a 7 ppm average, the average fuel sulfur level we would expect from a 15 ppm cap fuel (see Table III.F.1).

3. What About Sulfur in Engine Lubricating Oils?

Current engine lubricating oils have sulfur contents which can range from 2,500 ppm to as high as 8,000 ppm by weight. Since engine oil is consumed by heavy-duty diesel engines in normal operation, it is important that we account for the contribution of oil derived sulfur in our analysis of the need for low sulfur diesel fuel. One way to give a straightforward comparison of this effect is to express the sulfur consumed by the engine as an equivalent fuel sulfur level. This approach requires that we assume specific fuel and oil consumption rates for the engine. Using this approach, estimates ranging from two to seven ppm diesel fuel sulfur equivalence have been made for the sulfur contribution from engine oil.[149] [150] If values at the upper end of this range accurately reflect the contribution of sulfur from engine oil to the exhaust this would be a concern as it would represent 50 percent of the total sulfur in the exhaust under a 15 ppm diesel fuel sulfur cap (with an average sulfur level assumed to be approximately seven ppm). However, we believe that this simplified analysis, while valuable in demonstrating the need to investigate this issue further, overstates the likely sulfur contribution from engine oil by a significant amount due to its inclusion of engine oil lost through the open crankcase system in the estimate of oil consumption to the exhaust.

Current heavy-duty diesel engines operate with open crankcase ventilation systems which ''consume'' oil by carrying oil from the engine crankcase into the environment. This consumed oil is correctly included in the total oil consumption estimates, but should not be included in estimates of oil entering the exhaust system for this analysis, since as currently applied this oil is not introduced into the exhaust. At present we estimate that the majority of lube oil consumed by an engine meeting the 0.1 g/bhp-hr PM standard is lost through crankcase ventilation, rather than through the exhaust. Based on assumed engine oil to PM conversion rates and historic soluble organic fraction breakdowns we have estimated the contribution of sulfur from engine oil to be less than two ppm fuel equivalency. With our action to close the crankcase, coupled with the use of closed crankcase ventilation systems that separate in excess of 90 percent of the oil from the blow-by gases, we believe that this very low contribution of lube oil to sulfur in the exhaust can be maintained. For a further discussion of our estimates of the sulfur contribution from engine oil refer to the final RIA in the docket.

*G. Fuel Economy Impact of High Efficiency Control Technologies*

The high efficiency emission control technologies expected to be applied in order to meet the $NO_X$ and PM standards involve wholly new system components integrated into engine designs and calibrations, and as such

[148] Platinum group metals include platinum, palladium, rhodium, and other precious metals.

[149] Whitacre, Shawn. ''Catalyst Compatible'' Diesel Engine Oils, DECSE Phase II, Presentation at DOE/NREL Workshop ''Exploring Low Emission Diesel Engine Oils.'' January 31, 2000.

may be expected to change the fuel consumption characteristics of the overall engine design. After reviewing the likely technology options available to the engine manufacturers, we believe that the integration of the engine and exhaust emission control systems into a single synergistic emission control system will lead to heavy-duty vehicles which can meet demanding emission control targets without increasing fuel consumption beyond today's levels.

1. Diesel Particulate Filters and Fuel Economy

Diesel particulate filters are anticipated to provide a step-wise decrease in diesel particulate (PM) emissions by trapping and oxidizing the diesel PM. The trapping of the very fine diesel PM is accomplished by forcing the exhaust through a porous filtering media with extremely small openings and long path lengths.[151] This approach results in filtering efficiencies for diesel PM greater than 90 percent but requires additional pumping work to force the exhaust through these small openings. The additional pumping work is anticipated to increase fuel consumption by approximately one percent.[152] However, we believe this fuel economy impact can be regained through optimization of the engine—PM trap—$NO_X$ adsorber system, as discussed below.

2. $NO_X$ Control Technologies and Fuel Economy

$NO_X$ adsorbers are expected to be the primary $NO_X$ control technology introduced in order to provide the reduction in $NO_X$ emissions envisioned in this rulemaking. $NO_X$ adsorbers work by storing $NO_X$ emissions under fuel lean operating conditions (normal diesel engine operating conditions) and then by releasing and reducing the stored $NO_X$ emissions over a brief period of fuel rich engine operation. This brief periodic $NO_X$ release and reduction step is directly analogous to the catalytic reduction of $NO_X$ over a gasoline three-way catalyst. In order for this catalyst function to occur the engine exhaust constituents and conditions must be similar to normal gasoline exhaust constituents. That is, the exhaust must be fuel rich (devoid of excess oxygen) and hot (over 250°C). Although it is anticipated that diesel engines can be made to operate in this way, it is assumed that fuel economy while operating under these conditions will be worse than normal. We have estimated that the fuel economy impact of the $NO_X$ release and reduction cycle would, all other things being equal, increase fuel consumption by approximately one percent. Again, we believe this fuel economy impact can be regained through optimization of the engine—PM trap—$NO_X$ adsorber system, as discussed below.

In addition to the $NO_X$ release and regeneration event, another step in $NO_X$ adsorber operation may affect fuel economy. As discussed earlier, $NO_X$ adsorbers are poisoned by sulfur in the fuel even at the low sulfur levels mandated here. As discussed in the RIA, we anticipate that the sulfur poisoning of the $NO_X$ adsorber can be reversed through a periodic "desulfation" event. The desulfation of the $NO_X$ adsorber is accomplished in a similar manner to the $NO_X$ release and regeneration cycle described above. However it is anticipated that the desulfation event will require extended operation of the diesel engine at rich conditions.[153] This rich operation will, like the $NO_X$ regeneration event, require an increase in the fuel consumption rate and will cause an associated decrease in fuel economy. With a 15 ppm fuel sulfur cap, we are projecting that fuel consumption for desulfation would increase by one percent or less, which we believe can be regained through optimization of the engine-PM trap-$NO_X$ adsorber system as discussed below.

While $NO_X$ adsorbers require non-power producing consumption of diesel fuel in order to function properly and, therefore, have an impact on fuel economy, they are not unique among $NO_X$ control technologies in this way. In fact $NO_X$ adsorbers are likely to have a very favorable $NO_X$ to fuel economy trade-off when compared to other $NO_X$ control technologies like cooled EGR and injection timing retard that have historically been used to control $NO_X$ emissions. Today, most diesel engines rely on injection timing control (retarding injection timing) in order to meet the 4.0 g/bhp-hr $NO_X$ emission standard. For 2004 model year compliance, we expect that engine manufacturers will use a combination of cooled EGR and injection timing control to meet the 2.0 g/bhp-hr $NO_X$ standard. Because of the more favorable fuel economy trade-off for $NO_X$ control with EGR when compared to timing control, we have forecast that less reliance on timing control will be needed in 2004. Therefore, fuel economy will not be changed even at this lower $NO_X$ level.

$NO_X$ adsorbers have a significantly more favorable $NO_X$ to fuel economy trade-off when compared to cooled EGR or timing retard alone, or even when compared to cooled EGR and timing retard together.[154] Current $NO_X$ adsorber data show greater than 90 percent reduction in $NO_X$ emissions over the SET, while only increasing fuel consumption by a very reasonable two percent. Further the data show that, for significant portions of the engine's typical operating range, $NO_X$ control in excess of 98 percent is possible even with engine-out emissions as high as 5 g/bhp-hr.[155] Therefore, we expect manufacturers to take full advantage of the $NO_X$ control capabilities of the $NO_X$ adsorber and project that they will decrease reliance on technologies with a less favorable emissions to fuel economy trade-off, especially injection timing retard, when operating at conditions where the $NO_X$ adsorber performance is significantly greater than 90 percent. We would therefore predict that the fuel economy impact currently associated with $NO_X$ control from timing retard would be decreased by at least three percent. In other words, through the application of advanced $NO_X$ emission control technologies, which are enabled by the use of low sulfur diesel fuel, we expect the $NO_X$ trade-off with fuel economy to continue to improve significantly when compared to today's technologies. This will result in both much lower $NO_X$ emissions, and potentially overall improvements in fuel economy. Improvements could easily offset the fuel consumption of the $NO_X$ adsorber itself and, in addition, the one percent fuel economy loss projected to result from the application of PM filters. Consequently, we are projecting no fuel economy penalty to result from this rule.

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

We anticipate that, in order to meet the stringent $NO_X$ and PM emission standards set today, the engine manufacturers will integrate engine-based emission control technologies and

[150] This estimate assumes that a heavy-duty diesel engine consumes 1 quart of engine oil in 2,000 miles of operation, consumes fuel at a rate of 1 gallon per 6 miles of operation and that engine oil sulfur levels range from 2,000 to 8,000 ppm.

[151] Typically, the filtering media is a porous ceramic monolith or a metallic fiber mesh.

[152] Engine, Fuel, and Emissions Engineering, Incorporated, "Economic Analysis of Diesel Aftertreatment System Changes Made Possible by Reduction of Diesel Fuel Sulfur Content," December 14, 1999, Air Docket A–99–06.

[154] Zelenka, P. *et al,* Cooled EGR—A Key Technology for Future Efficient HD Diesels, SAE 980190, Society of Automotive Engineers 1998. Figure 2 from this paper gives a graphical representation of how new technologies (including exhaust emission control technologies) can shift the trade-off between $NO_X$ emissions and fuel economy.

[155] "2007 Diesel Emission Test Program, Initial Test Report," December 11, 2000, Air Docket A–99–06, Item IV–A–29.

post-combustion emission control technologies into a single systems-based approach that will fundamentally shift historic trade-offs between emissions control and fuel economy. As outlined in the preceding two sections, individual components in this system will introduce new constraints and opportunities for improvements in fuel efficient control of emissions. Having considered the many opportunities to fundamentally improve these relationships, we believe 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 our analysis of economic impacts in Section V, no penalty or benefit for changes to fuel economy are considered.

### *H. Review of the Status of Heavy-Duty Diesel $NO_X$ Emission Control Technology*

In the NPRM, we provided a detailed technical evaluation of test data and other information that concluded that the proposed program would be technologically feasible for all heavy-duty engines. During the public comment period, we received many comments as well as additional information about the likely status and capability of emission control technology development in the 2007 time frame. To this information we have added our own updated evaluation of test data as well as technical information developed by ourselves and others.

Based on this information, and as discussed in Sections III.E and III.F above, we now have an even higher degree of confidence that manufacturers will be able to meet the new heavy-duty standards. Manufacturers of heavy-duty gasoline engines will apply essentially the same technology that is being developed for light-duty trucks under the Tier 2 program and should not have major problems doing so, especially given the significant available lead time. Regarding diesels, although the technological challenges are somewhat greater than for gasoline engines, we believe that manufacturers will achieve the engine standards adopted today for 2007 and later years, in conjunction with the low sulfur diesel fuel we are also requiring.

As we discussed earlier, there are two primary technologies that diesel engine manufacturers expect to use to meet the standards adopted in today's rule, and they are at different stages of commercial development. Catalyzed diesel PM trap technologies are in widespread fleet testing today, we have shown that there are no serious impediments to the widespread application of this technology to heavy-duty diesel engines that can meet our new standards by 2007, if not earlier. Diesel $NO_X$ adsorber technology, the emission control technology we believe will be used for heavy-duty diesel engines to meet the very low $NO_X$ emission standards adopted today, is less developed relative to PM control technology. Still, as we discussed earlier, we have identified a clear technological pathway to compliance with the $NO_X$ standards using $NO_X$ adsorber technology. While we do not anticipate major obstacles in commercializing these systems by 2007, it is important that the various parties in the industry continue to make good progress in their development of $NO_X$ adsorber technology for heavy-duty diesel engines.

As a mechanism for monitoring and evaluating this technological progress, we believe it will be important to publicly reassess the status of heavy-duty diesel $NO_X$ adsorber systems on an ongoing basis. To accomplish this, we will conduct regular biennial reviews of the status of heavy-duty $NO_X$ adsorber technology. For each review, we will collect and analyze information from engine manufacturers, $NO_X$ adsorber manufacturers, our own testing, and other sources. At the end of each review cycle, we will release (and post on the Web) a report discussing the status of the technology and any implications for the heavy-duty engine emission control program. We will release the first report by December 31, 2002 and subsequent reports at the end of each second year through December 31, 2008. This biennial process is similar to that used by the State of California to monitor and evaluate their emission control programs.

## IV. Our Program for Controlling Highway Diesel Sulfur

With today's action, we are requiring substantial reductions in highway diesel fuel sulfur levels nationwide, because sulfur significantly inhibits the ability of the diesel emission control devices to function which are necessary to meet the emission standards finalized today. With the highway diesel fuel sulfur standard we are finalizing today, we have concluded that there will be technology available to achieve the reductions required by the stringent emission standards we are implementing for model year 2007 and later heavy-duty engines.

In developing the provisions of the fuel program being adopted today, we identified several goals that we want the program to achieve. First, we must ensure that there will be an adequate supply of highway diesel fuel for all vehicles. Second, we must ensure that low sulfur diesel fuel will be readily available nationwide for the 2007 and later model year heavy-duty vehicles that need it. Finally, we want to ensure a smooth transition to low sulfur fuel.

In the NPRM, we proposed that refiners be required to start producing all of their highway diesel fuel at the 15 ppm sulfur level beginning in 2006. We also requested comment on a range of options for transitioning to the low sulfur diesel fuel over time. With regard to the programmatic goals noted above, the proposed approach, which would have required all highway diesel fuel to meet the 15 ppm sulfur standard in 2006, guaranteed availability of the low sulfur diesel fuel throughout the nation. However, many commenters stated concerns that the proposed program would not ensure adequate overall supplies of highway diesel fuel, especially if some refiners chose not to continue producing highway diesel fuel to avoid the changes needed to meet the low sulfur levels.

The final diesel fuel program we are adopting today includes flexibilities for the refining industry as a whole, as well as additional flexibilities for refiners experiencing hardship circumstances. First, the program gives refiners a temporary compliance option for low sulfur diesel fuel beginning in mid-2006. The final program also includes additional flexibilities for refineries located in certain western states (the Geographic Phase-In Area (GPA) [156]), provisions for qualifying small refiners, and a general hardship provision for which any refiner may apply under certain conditions. These flexibilities ensure that the vast majority of refiners nationwide can fully comply at the earliest possible date while avoiding an excessive burden on a subset of refiners. The following section details each of the requirements of the highway diesel fuel program for refiners and importers, summarizes the analyses we have performed on the impacts of the temporary compliance option being adopted today, and describes additional information we have received that supports the changes made to the proposed program. Section VII provides additional information about the

[156] As defined in the Tier 2 final rulemaking (see 65 FR 6698, February 10, 2000), the GPA encompasses the states of Alaska, Colorado, Idaho, Montana, New Mexico, North Dakota, Utah and Wyoming. Note that minor changes to this area are currently under consideration. Any such changes subsequent to today's rule are intended to be carried over into today's rule as well.

compliance and enforcement provisions that will accompany these requirements.

We believe the highway diesel fuel program we are adopting today meets all of the programmatic goals noted above. We believe that the final program will ensure that the overall supply of highway diesel fuel will be sufficient for all vehicles. To the extent there may have been supply concerns with a complete fuel turnover to low sulfur diesel in 2006 as some commenters have suggested, the flexibilities for refiners contained in the final program will serve as a ''safety valve'' by allowing up to 25 percent of the highway diesel fuel to remain at the current 500 ppm sulfur standard and providing additional time, if needed, for some refiners to fully convert over to low sulfur fuel. The combination of flexibilities provided to refiners in today's final rule should eliminate any concerns about the potential for supply shortfalls of highway diesel fuel. The final diesel fuel program is carefully structured so that we are confident there will be widespread availability of low sulfur fuel across the nation for 2007 and later model heavy-duty vehicles. In this way, the important health benefits of this program to people throughout the country can be achieved expeditiously, at a reasonable cost, while minimizing the burden on the affected industries.

This section also summarizes our technical feasibility analysis of the low sulfur highway diesel fuel program, and the impact of the program on other fuel properties and specialty fuels. Finally, the following section describes how state programs will be affected by today's action including a provision that allows the State of Alaska the option of developing an alternative transition plan for implementing low sulfur fuel.

### *A. Highway Diesel Sulfur Standards for Refiners and Importers*

The requirements of the highway diesel fuel sulfur control program will become effective in time to be available with the introduction of the first heavy-duty engines meeting the model year 2007 and later engine standards we are adopting today. The following paragraphs describe the requirements, standards, and deadlines that apply to refiners and importers of highway diesel fuel and the options available to all refiners.

#### 1. *Standards and Deadlines That Refiners and Importers Must Meet*

As described earlier in Section III.H. above, the new standards being adopted today for heavy-duty engines will begin with the 2007 model year. With today's action, we are adopting specific dates when fuel intended to be marketed as low sulfur diesel fuel must be produced at the refinery, distributed at the terminal level, and marketed at the retail level. Refiners and importers are required to produce highway diesel fuel meeting the 15 ppm sulfur standard beginning June 1, 2006.[157] At the terminal level, highway diesel fuel sold as low sulfur fuel is required to meet the 15 ppm sulfur standard beginning July 15, 2006. For retail stations and wholesale purchaser-consumers, highway diesel fuel sold as low sulfur fuel must meet the 15 ppm sulfur standard by September 1, 2006.

In the NPRM, we proposed a set of compliance dates slightly earlier than the dates contained in today's final rule. Under the proposal, refiners, terminals and retailers would have had to begin producing low sulfur diesel fuel by April 1, 2006, May 1, 2006 and June 1, 2006, respectively. Several commenters pointed out that the April introduction date for refiners occurred at the same time refiners would be changing over from winter to summer gasoline to comply with Reid Vapor Pressure (RVP) requirements. They recommended that the introduction of low sulfur diesel fuel be delayed for a couple of months to provide refiners and the distribution system the opportunity to focus on the two conversions separately and ensure that each occurs as designed. Commenters also suggested that we extend the time period between the refinery and downstream deadlines to better allow for the time it may take the distribution system to make a complete transition to the 15 ppm sulfur level.

In response to these concerns, today's action provides a few additional months for introduction of the low sulfur diesel fuel compared to the NPRM and provides an additional month between the refinery and retail compliance dates, to provide a smoother transition through the distribution system. We believe the additional time provides appropriate relief for the refiners, while still assuring that low sulfur diesel fuel will be available at the retail level no later than September 1, 2006. This schedule will allow manufacturers to introduce 2007 and later model year diesel engines and vehicles as early as September 1, 2006. While a slight delay from the dates of the proposal, the Agency does not believe this delay will place any undue burden on the engine manufacturers. Historically, new heavy-duty vehicle models were introduced on or around January 1 (of the same calendar year as the model year). Only recently, manufacturers have begun introducing some model lines earlier, particularly light heavy-duty vehicles.

In the NPRM, we proposed that all highway diesel fuel be required to comply with the 15 ppm sulfur standard starting in 2006. Today's program includes a combination of flexibilities available to refiners to ensure a smooth transition to low sulfur highway diesel fuel. 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 option, up to 20 percent of highway diesel fuel may continue to be produced at the existing 500 ppm sulfur maximum standard, though it must be segregated from 15 ppm fuel in the distribution system, and may only be used in pre-2007 model year heavy-duty vehicles. We are providing additional hardship provisions for small refiners to minimize their economic burden in complying with the 15 ppm sulfur standard and giving 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 effectively address the concerns over highway diesel fuel supply.

It should be noted that the requirements of the fuel program described below apply to refiners and importers only.[158] We are not adopting any retailer availability requirements

[157] Highway diesel fuel (referred to as motor vehicle diesel fuel in the regulatory language to be consistent with language in existing laws and regulations) includes any diesel fuel or any distillate product that is used, intended for use, or made available for use as a fuel in highway diesel vehicles or engines that are subject to the standards finalized today. However, kerosene or other distillates such as JP–8 are only considered to be highway diesel fuel and thus subject to our program at the point in the production or distribution system that they are either designated as such, or otherwise used, intended for use, or made available for use in highway diesel vehicles. Thus, if refiners do not designate these other distillates as highway diesel fuel, they are not subject to the 15 ppm sulfur standard.

[158] As described above, distributors and retailers marketing low sulfur diesel fuel have deadlines for compliance with the sulfur standards, as well as other requirements such as pump labeling. Section VII of today's action provides further details on the downstream requirements for distributors and retailers.

with these provisions. In other words, we are not requiring that diesel retailers sell the 15 ppm fuel. Rather, retailers may sell 15 ppm sulfur diesel fuel, 500 ppm sulfur diesel fuel, or both. We believe the program being adopted today for refiners and importers will ensure that adequate supplies of low sulfur diesel fuel are available throughout the nation. The voluntary compliance and hardship provisions have been designed with a required level of production that we believe will ensure that 15 ppm fuel is distributed widely through pipelines and at terminals throughout the country without the need for a retailer availability requirement. Our analysis supporting the design of these provisions can be found in Chapter IV of the RIA for today's action.

2. *Temporary Compliance Option for Refiners and Importers*

We believe there are several advantages to allowing some flexibility in the early years of the program such that not all of the highway diesel fuel pool must be converted to low sulfur diesel fuel at one time. First, some commenters expressed concerns over adequate supplies of highway diesel fuel if the entire pool converted to low sulfur diesel fuel in 2006, because they believe some refiners might produce less total highway diesel fuel volume or choose to leave the highway diesel fuel market altogether. Allowing the temporary compliance option lowers this concern because a portion of the highway diesel pool can remain at the current 500 ppm sulfur standard, if necessary, providing additional time for the market to adjust. This portion of the highway diesel pool that refiners choose to delay will likely be the portion that is more costly for them to desulfurize and, thus, most likely to raise concerns with respect to shortfalls. Second, a temporary compliance option can benefit refiners by reducing the fuel production costs in the early years of the program, because refiners are able to spread out their capital investments. The option also benefits refiners by spreading out the industry-wide demand for engineering and construction resources over several years, and also by allowing more time between the gasoline sulfur and diesel sulfur compliance dates. Third, refiners that are able to delay investment could attain lower costs for such equipment as technology improvements are realized during that time and as refiners see how well the desulfurization technologies achieve the 15 ppm sulfur standard.

The primary emissions benefits of low sulfur highway diesel fuel are the emissions reductions that will occur over time as new vehicles designed to meet the emission standards adopted today are introduced into the vehicle fleet. Consequently, in the NPRM we requested comment on several options that would allow refiners and importers to phase in the production of low sulfur highway diesel fuel. With today's action, we are adopting a temporary compliance option for refiners and importers that will allow them to produce less than 100 percent of their highway diesel fuel at the 15 ppm sulfur level. Refiners and importers may choose to participate in the compliance option on a refinery-by-refinery basis. A refiner must demonstrate compliance with the compliance option on an annual basis. Refiners with special financial hardships have additional flexibility provisions, which are described further in Section IV.C.

We believe today's temporary compliance option in combination with the hardship provisions discussed in Section IV.C. has the potential to provide flexibility to more than half of all U.S. refineries by allowing up to 25 percent[159] of the highway diesel fuel volume in the country to continue to be produced at the current sulfur level of 500 ppm. We estimate that refiners will be able to save as much as $1.7 billion over the duration of the optional compliance program compared to the proposed requirement that all highway diesel fuel comply with 15 ppm sulfur in 2006. Much, but not all, of this potential savings will be offset by increased costs in the distribution system. We project that in total a small overall savings should result from refiners taking advantage of the temporary compliance option.

Under the temporary compliance option finalized today, a refinery may produce up to 20 percent of its total highway diesel fuel at the existing highway diesel fuel sulfur standard of 500 ppm, determined on an annual basis. The remaining 80 percent of the highway diesel fuel produced at that refinery during the year must meet a sulfur standard of 15 ppm.[160] As part of this temporary compliance option, a PADD-based averaging, banking, and trading (ABT) program will be available. Figure IV–1 presents the five PADDs into which the United States is divided.[161] For example, a refinery could produce more than 80 percent of its highway diesel fuel as low sulfur diesel fuel and generate credits based on the volume of highway diesel fuel produced at 15 ppm that exceeded the 80 percent requirement. Within that same PADD (within the limits noted below for California, Alaska, Hawaii, and any state with an EPA-approved waiver from the federal program), these credits may be averaged with another refinery owned by that refiner, banked for use in future years, or sold to another refinery.

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[159] Up to 5 percent of which is small refiner production.

[160] We are aware that today there are refiners that produce one grade of diesel fuel for both highway and off-highway purposes, where dye is added by parties downstream if it is to be sold as off-highway diesel fuel. To the extent possible, we do not want to interfere with this practice. Consequently, for purposes of determining compliance with these optional requirements, a refiner producing all 15 ppm fuel may include the entire volume it produces in the calculation. Furthermore, a refiner producing all 500 ppm fuel must count any diesel fuel produced with a sulfur content of 500 ppm or less unless it has been dyed by the refiner to be used as nonroad diesel fuel. A refiner would only include kerosene in its volume calculation if the kerosene is less than 500 ppm sulfur content and the kerosene is blended at the refinery into non-dyed fuel with a sulfur content of less than 500 ppm.

[161] The Department of Energy divides the United States into five Petroleum Administrative Districts for Defense, or PADDs. The states encompassed by each of the five PADDs are defined in the Code of Federal Regulations at Title 40, § 80.41.

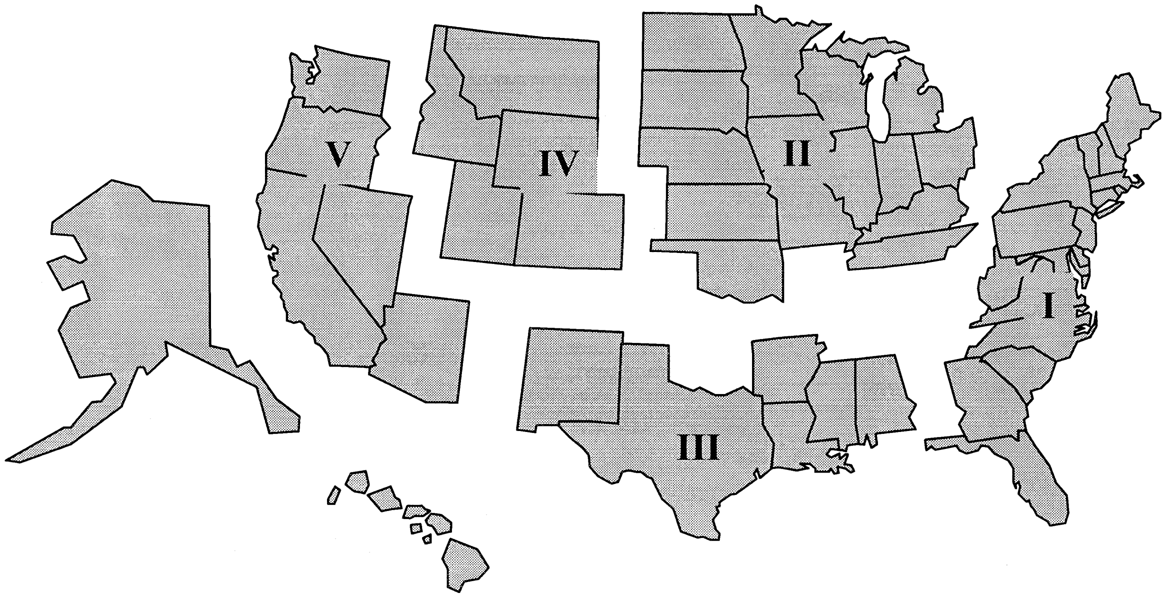


**Figure IV-1. Petroleum Administrative Districts for Defense (PADDs)**

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Also, a refinery may produce less than 80 percent of its highway diesel fuel at the 15 ppm sulfur level, as long as it obtains enough credits from another refinery within the PADD to offset the volume of 500 ppm sulfur fuel produced that exceeded the 20 percent of highway diesel fuel allowed to be produced at the 500 ppm sulfur level. As noted above, any credit trading will be limited to those refineries within the same PADD (within the limits noted below for California, Alaska, Hawaii, and any state with an EPA-approved waiver from the federal program). This restriction is necessary to limit the possibility that any area of the country is dominated by refineries complying via purchases of credits and, thus, producing a small volume of low sulfur diesel fuel, which could lead to concerns that the low sulfur diesel fuel would not be sufficiently available throughout the country.

Based on an extensive analysis which incorporates the hardship provisions and GPA refiner provisions discussed in Section IV.B. and C., we have chosen a level of 80 percent to have confidence that there will be widespread availability of 15 ppm fuel throughout the United States. Given the requirements of today's program, we believe that all pipelines are likely to carry the 15 ppm fuel. Pipelines that may be able to carry only one grade of highway diesel fuel are likely to carry 15 ppm as the majority diesel fuel in the market.[162] Those that are able to carry more than one grade of highway diesel fuel will facilitate the distribution of the remaining 500 ppm fuel. In addition, to ensure widespread availability of low sulfur diesel fuel throughout the nation, we have found it necessary to set the 15 ppm production threshold high enough so that there is a sufficient geographic scattering of refineries producing low sulfur diesel fuel around the country. At a lower threshold, there could be isolated regions of the country where 15 ppm fuel would not be available in sufficient quantities.

We have analyzed the refinery/pipeline distribution system in the United States in the context of the small refiner hardship and other provisions of the rule and believe a 80 percent temporary compliance option level for 15 ppm is necessary to achieve widespread availability and avoid shortages in specific areas. At levels below an 80 percent level, we would have concerns over whether 15 ppm sulfur diesel fuel would be the primary highway diesel fuel distributed through pipelines and whether the low sulfur diesel fuel would be available to all areas of the country in sufficient quantities. The reader is directed to Chapter IV of the RIA for today's action for our complete analysis supporting the development of the temporary compliance option.

While we have set the minimum requirement under the compliance option at 80 percent, we believe most refineries will focus on production of one grade or the other. We expect that certain refineries will find it more economically advantageous to install the necessary equipment to produce all of their highway diesel fuel at the 15 ppm sulfur level and generate credits. Conversely, other refineries may find it advantageous to continue producing all of their highway diesel fuel at the 500 ppm sulfur fuel through the period of the compliance option, by obtaining credits to demonstrate compliance. This will provide additional time for those refiners that have not converted to low sulfur fuel. This will allow refiners to spread out their capital investments and provide more time to arrange for engineering and construction resources. In addition, the refiners that are able to delay investment could attain lower costs for such equipment as technology improvements are realized during that time and as refiners see how well the range of desulfurization technologies works to achieve the 15 ppm sulfur standard.

Foreign refiners may choose to participate in the temporary compliance option. For purposes of determining compliance with the low sulfur diesel requirements, foreign refiners must demonstrate compliance based on the amount of highway diesel fuel they import into the United States. Therefore, a given foreign refiner must demonstrate that at least 80 percent of the highway diesel fuel it imported into each PADD

[162] Today, many pipelines carry only one grade of distillate (*e.g.*, only 500 ppm sulfur high diesel fuel) rather than both 500 ppm sulfur highway fuel and off-highway fuel which has even higher levels of sulfur (*e.g.*, on the order of 3,000 ppm).

meets a 15 ppm sulfur level, or show that it has enough credits from other refiners in the PADD into which it imported the fuel to cover the volume of fuel below the 80 percent requirement. Foreign refineries may also generate credits if they exceed the 80 percent requirement in a given PADD, and may sell those credits within the same PADD. A foreign refiner may also choose to not participate in the temporary compliance option and, as described below, let the fuel importer be the party which demonstrates compliance.

Importers of highway diesel fuel (i.e., companies that import fuel but are not solely refiners) may also participate in the temporary compliance option. Importers must demonstrate that at least 80 percent of the highway diesel fuel imported into each PADD (within the limits noted below for California, Alaska, Hawaii, and any state with an EPA-approved waiver from the federal program) meets a 15 ppm sulfur level, or show that they have enough credits from other refiners in the PADD into which the fuel is imported to cover the volume of fuel below the 80 percent requirement. Importers may also generate credits if they exceed the 80 percent requirement in a given PADD. Importers that import highway diesel fuel from foreign refiners that are participating in the temporary compliance option must exclude the volume of fuel purchased from those refiners in their compliance calculations or credit generation calculations.

Because we expect most refineries to choose to produce fuel either all at the 15 ppm sulfur level or all at the 500 ppm sulfur level, credits will be generated by some refiners and desired by others. Thus, the ABT program will play an important part in achieving overall compliance. The details of the ABT program are described below.

a. Generating Credits

Beginning on June 1, 2006 and continuing through December 31, 2009, refineries and importers may generate credits based on the volume of low sulfur diesel fuel produced above the required percentage (i.e., 80 percent). One credit will be generated for every gallon of highway diesel fuel produced at 15 ppm sulfur that exceeds the 80 percent requirement. Credits will be calculated on a calendar-year basis. For example, if a refinery produces 10 million gallons of highway diesel fuel in 2007, it must produce 80 percent of its highway diesel volume (8 million gallons) as low sulfur during 2007. If the refinery actually produces 100 percent of its highway diesel fuel as low sulfur during 2007, it can generate credits based on the volume of the ''extra'' 20 percent of low sulfur fuel it produced above the required minimal percentage—that is, two million gallons of credits. Because the requirements for low sulfur fuel begin in the middle of 2006, a refinery will generate credits in 2006 based on the volume of low sulfur fuel produced beginning June 1, 2006 that exceeds 80 percent of the highway diesel fuel produced at its facility between June 1, 2006 and December 31, 2006. Once credits are generated by a refinery, they may be used by the refinery for averaging purposes with other refineries owned by the same refiner, traded to another refinery, or banked for use in future calendar year averaging or trading. Credits may only be used in the PADD in which they are generated, with the further limitations on credit generation and use in PADD V noted below for California, Alaska, and Hawaii.

Refineries may no longer generate credits after December 31, 2009. Beginning January 1, 2010, every refinery must either comply with the low sulfur diesel fuel requirements by (1) producing 100 percent of its highway diesel fuel at the 15 ppm sulfur level or (2) by using credits through May 31, 2010 to demonstrate compliance with the 100 percent requirement, provided that banked credits are available to the refinery (described in more detail below). Starting June 1, 2010, all refineries must produce 100 percent of their highway diesel fuel as low sulfur fuel (without the use of credits).

Finally, early credits, or credits from low sulfur fuel produced at a refinery prior to June 1, 2006, may be generated, but only under limited circumstances. Unlike in the Tier 2 program, where significant emission benefits accrued with the early introduction of low sulfur gasoline, very little emission benefit (only a small reduction in sulfate PM emissions from the in-use fleet) will result from the early introduction of 15 ppm diesel fuel. Consequently, the main purpose in allowing early credits under the diesel program is to smooth program implementation beginning June 1, 2006, by allowing a pool of credits to be available upon program startup. By allowing the generation of early credits, both purchasers and sellers of credits can have confidence in the legitimacy of the credits traded, which, in turn, allows for the purchaser to have increased confidence in their ability to rely on the ABT program for compliance. Consequently, beginning June 1, 2005 we will allow refineries to generate credits for any volume of highway diesel fuel produced which meets the 15 ppm cap. Any refiner that chooses to do so may bank these credits for later use during the compliance option years, or may trade them to other refineries within the same PADD for use during the compliance option years. The one restriction placed on the generation of these credits is that refiners will have to demonstrate that the 15 ppm fuel produced early is segregated in the distribution system and not commingled with current 500 ppm sulfur fuel. Only that volume that the refiner verifies was actually sold as 15 ppm fuel at retail or into centrally-fueled fleets will be eligible for early credits.

Providing refiners with an incentive to produce diesel fuel complying with the 15 ppm cap earlier than required will not only instill confidence in the ABT program under the temporary compliance option, but will also provide both refiners and the distribution system the opportunity to gain valuable experience prior to the start of the program with producing and distributing fuel meeting the 15 ppm cap. We believe that allowing early credit generation for one year prior to the start of the program will provide the opportunity for the generation of sufficient early credits to provide refiners with the program implementation flexibility they will need. If we allowed early credits to be generated in this manner for a longer time period, we are concerned that the significant amounts of early credits that could be generated could compromise availability of 15 ppm fuel at the startup of the program. Use of these credits after June 1, 2006 could affect the availability of low sulfur highway diesel fuel across the country when the 2007 model year heavy-duty engines are introduced in the market, because the amount of 500 ppm fuel could significantly exceed the 20 percent threshold allowed under our temporary compliance option.

The only situation in which we will allow for the generation of credits prior to June 1, 2005 is if a refiner demonstrates that the fuel will be used in vehicles certified to meet the 2007 particulate matter standard being adopted today for heavy-duty engines (0.01 g/bhp-hr) or in vehicles with retrofit technologies that achieve emission levels equivalent to the 2007 $NO_X$ or PM standard verified as part of a retrofit program administered by EPA or a state. (Refer to section I.C.7 for more discussion on retrofit programs.) Under this situation, we will have confidence that emission benefits are in fact accruing early, along with the fuel sulfur credits. The early credit provision of this fuel program will complement the provisions that encourage the introduction of cleaner vehicles earlier than the 2007 model year, as discussed in Section III.D.

b. Using Credits

If a refinery does not meet the 80 percent minimum requirement for low sulfur highway diesel fuel with actual production at that refinery, the refinery will be able to use credits to demonstrate compliance with the 80 percent requirement. The use of credits is limited to credits generated by refineries within the same PADD (within the limits noted below for California, Alaska, Hawaii, and any state with an EPA-approved waiver from the federal program). Under the temporary compliance option, for every gallon of 500 ppm sulfur fuel produced by a refinery that exceeds the maximum allowed limit of 20 percent, the refinery must obtain one credit from another refinery within the same PADD or use banked credits (that were generated within the same PADD).

Although credits will not officially exist until the end of the calendar year (based on the generating refinery's actual low sulfur fuel production for that calendar year), refineries may contract with each other for credit sales prior to the end of the year, based on anticipated production. The actual trading of credits will not take place until the end of the year. All credit transfer transactions will have to be concluded by the last day of February after the close of the annual compliance period and each refinery must submit documentation (as described in Section VII.E.) demonstrating compliance with the appropriate volume of low sulfur highway diesel fuel. For example, a refinery that wishes to purchase credits from another refinery to comply with the 2007 required percentage of low sulfur fuel can do so based on the generating refinery's projections of low sulfur fuel production. By the end of February 2008, both the credit-purchasing refinery and the credit-selling refinery must reconcile the validity of the credits, and demonstrate compliance with the 80 percent requirement. As noted earlier, at the beginning of the program, the initial compliance period will begin on June 1, 2006 and end on December 31, 2006. For this initial period, refineries must submit documentation, by February 28, 2007, demonstrating compliance with the appropriate levels of low sulfur highway diesel fuel for the period between June 1, 2006 and December 31, 2006.

Because there could be situations where a refinery planning to use credits to comply with the minimum percentage of fuel required comes up short at the end of the year, we are adopting provisions that allow a limited amount of carryover, or ''credit deficits.'' A refinery that does not meet the required percentage of low sulfur fuel production in a given year will be allowed to carry forward a credit deficit for one year, as long as the deficit does not exceed five percent of its annual highway diesel fuel production. However, the refinery will have to make up the credit deficit and come into compliance with the required low sulfur production percentage in the next calendar year, or the refinery will be in violation of the program requirements. This provision is intended to give some relief to refineries faced with an unexpected shutdown or that otherwise are unable to obtain sufficient credits to meet the required percentage of low sulfur fuel production.

With regard to credit trading, any person can act as a broker in facilitating credit transactions, whether or not such person is a refiner and/or importer, so long as the title to the credits are transferred directly from the refinery generating the credits to the refinery purchasing the credits. Whether credits are transferred directly from the generating refinery to the purchasing refinery, or through a broker, the refinery purchasing the credits should have sufficient information to fully assess the likelihood that credits are valid. Any credits that are traded to another refinery may, in turn, be traded to another refinery; however, the credits cannot be traded more than twice. We believe this provision is necessary because repeated transfers of credits would significantly reduce our ability to verify the validity of credits.

c. How Long Will Credits Last?

The goal of the ABT provisions is to provide additional flexibility to refiners in the early years of the low sulfur diesel fuel program. After the first few years of the program, there will be a significantly greater proportion of after-treatment-equipped vehicles in the fleet. It will be important to ensure a full transition to the new low sulfur fuel to prevent misfueling of those vehicles and preserve the environmental benefits of the program. Therefore, the ability of refineries to generate credits will end on December 31, 2009. Refineries will be allowed to use any available banked credits, including early credits, for fuel produced through May 31, 2010. Any remaining credits not used for the compliance period until May 31, 2010 will expire. Beginning June 1, 2010, all refineries must produce 100 percent of their highway diesel fuel at the 15 ppm sulfur level without the use of credits, and the ABT program will end.

d. Additional Limitations on Credit Trading for Some States

At this time we are adopting a low sulfur highway diesel fuel program that will apply throughout the United States, with trading of credits limited to those refineries located within the same PADD. Although we are adopting a diesel fuel program that currently will apply nationwide, it is possible that the State of California, or some other state, may adopt in the future a different highway diesel fuel program than that adopted today.[163] To assure that adequate supplies of low sulfur diesel fuel will be available throughout all regions of the country, we are adopting provisions that do not allow refineries located in states with a state-approved 15 ppm highway diesel sulfur program to participate in the credit program. In other words, credit trading is limited only to those refineries complying with the federal program. For example, without such provisions, if California were to adopt its own state program requiring the production of 15 ppm diesel fuel, we are concerned that it might be possible for California refineries to generate enough credits such that areas outside of California in PADD V are dominated by the production of 500 ppm sulfur diesel fuel, with little or no 15 ppm fuel available. This would be problematic for the model year 2007 and later heavy-duty engines designed to be operated on low sulfur fuel. The reader is directed to Chapter IV of the RIA for today's action for our complete analysis supporting the development of the temporary compliance option.

As discussed in Section IV.F. of this preamble, the State of Alaska, which is a part of PADD V, will have the opportunity to develop, and submit to us for approval, an alternative transition plan for implementing the low sulfur highway diesel fuel program. Such a plan will allow Alaska to develop a transition program tailored to its isolated market. If, for some reason, Alaska does not submit an alternative plan, or we do not approve the plan submitted by Alaska, then the federal program described in today's action will apply. In the event we do not approve an alternative plan for Alaska, based on our analysis of the likely response of refineries in Alaska to the temporary compliance option and because its fuel distribution system is essentially isolated from the rest of PADD V, we are

[163] See Section IV.F. for a discussion of preemption of state diesel sulfur requirements.

concerned that all of the fuel offered for sale in Alaska could be 500 ppm sulfur fuel if refineries in Alaska were allowed to purchase credits from other PADD V refineries. For this reason, under today's program, refineries in Alaska will be allowed to generate credits as described earlier. However, they may only sell credits to, or purchase credits from, other refineries in or importers of fuel to Alaska. We believe this will provide assurance that low sulfur highway diesel fuel will be sufficiently available in Alaska and will also reduce the chance that credits from Alaska will result in significantly less low sulfur diesel fuel in PADD V areas outside of Alaska. Again, these default provisions of the national program will only be effective in the event that we do not approve an alternate transition plan for Alaska.

Hawaii is in a similar situation to Alaska with regard to fuel distribution. Hawaii, which is part of PADD V, is an isolated market and we have similar concerns with regard to whether low sulfur diesel fuel would be available in Hawaii if the two refineries currently operating were able to purchase credits from other PADD V refineries and produce all 500 ppm sulfur fuel. For this reason, under today's program, the refineries in Hawaii will be allowed to generate credits as described earlier. However, they may only sell credits to, or purchase credits from, other refineries in or importers of fuel to Hawaii. We believe this will ensure that low sulfur highway diesel fuel will be available in Hawaii.

3. What Information Must Refiners/Importers Submit to Us?

To ensure a smooth transition to the program and to evaluate compliance once the program has begun, we are requiring refiners and importers to submit a variety of information to us. Section VII.E of this document and the regulatory language for today's action provide detailed description of the information that must be submitted and the dates when such submittals are due.[164]

First, refiners and importers that currently or in 2006 expect to produce or supply highway diesel fuel are required to register with us by December 31, 2001. This will inform us on the universe of refiners that we expect to participate in the highway diesel market once the program begins.

Second, to help facilitate the market for credit trading under the temporary compliance option, any refiner or importer planning to produce or import highway diesel in 2006, is required to submit to us an annual pre-compliance report. Refiners and importers are required to submit these annual pre-compliance reports from 2003 through 2005. These reports must contain estimates of the volumes of 15 ppm sulfur fuel and 500 ppm sulfur fuel that will be produced at each refinery, and, for those refineries planning to participate in the trading program, a projection of how many credits will be generated or must be used by each refinery. These pre-compliance reports must also contain information outlining each refinery's timeline for compliance and provide information regarding engineering plans (e.g., design and construction), the status of obtaining any necessary permits, and capital commitments for making the necessary modifications to produce low sulfur highway diesel fuel. Based on the information submitted by refiners and importers, we plan to issue an annual report that summarizes, in a way that protects the confidentiality of individual refiners and importers, the information contained in the pre-compliance reports. Our annual report will provide information, summarized and aggregated on a PADD basis, describing the volumes of 15 ppm and 500 ppm highway diesel planned to be produced, and estimates of the number of credits that refineries expect to generate or use. We believe this information will be important to refiners as they make plans for complying with the temporary compliance option. For example, this information will be useful in giving refiners a better indication of the potential market for credits and availability of credits in their PADD. To prevent the release of confidential information, our annual report will not contain any information on individual refinery compliance plans.

Third, refiners and importers are required to submit annual compliance reports that demonstrate compliance with the requirements of this final rule. The first annual compliance report is due by the end of February 2007 (for the period of June 1, 2006 through December 31, 2006) and is required annually through February 2011. The reports must show, on a refinery basis, the volumes of 15 ppm and 500 ppm sulfur highway diesel fuel produced at each refinery during the compliance period, the number of credits used (or generated) at each refinery to demonstrate compliance with the 80 percent requirement for low sulfur diesel fuel, and the sources of the credits used. The information submitted in the annual compliance reports must be segregated by PADD.

4. Impacts of the Highway Diesel Fuel Program

Based on analyses we have performed, as described in more detail below, we believe the temporary compliance provisions contained in today's final rule will assure adequate supplies of highway diesel fuel, will provide flexibility for refiners, and should result in lower costs for both refiners and consumers. In addition, we believe the temporary compliance provisions as adopted today will ensure sufficient availability of low sulfur highway diesel fuel to new vehicle owners who need it without the need for a retailer availability requirement, and should not lead to significant levels of misfueling and the associated loss of emission benefits. We have analyzed each of these issues in developing the final fuel program. A summary of our analyses and the conclusions we have drawn are discussed below. A detailed description of these analyses are contained in the RIA for today's action. In addition, a complete list of the comments related to a possible phase-in program and our response to those comments is included in the Response to Comments document for this final rule.

a. Ensures Adequate Supplies of Highway Diesel Fuel

We received several comments on the NPRM fuel program that suggested there would be a shortfall in the amount of highway diesel supply if all of the highway diesel fuel were required to meet a 15 ppm sulfur limit beginning in 2006. As described later in Section V.C., in response to these comments we analyzed the capability of the entire diesel fuel refining industry in the U.S. to adjust to the low sulfur fuel requirements. Based on this analysis, we believe that supplies of highway diesel fuel will be sufficient even if all highway diesel fuel were required to comply with the 15 ppm standard in 2006. The temporary compliance option included in today's rule is intended as a "safety valve" that, along with the hardship provisions discussed in Section IV.C.,will further help to ensure adequate supplies of highway diesel fuel beginning in 2006.

In performing the analysis of diesel fuel supply, we examined all diesel fuel refiners (including those that currently make only off-highway diesel fuel but not highway diesel fuel) to assess the likelihood of their investing in the production of 15 ppm highway diesel

[164] As described in Sections IV.B., IV.C. and VII.E., small refiners and GPA refiners have special supplementary reporting requirements relating to the optional program they are participating in.

fuel. Using a refinery cost model, we made projections of the likely response by refineries to today's low sulfur requirements by estimating the cost for each refinery to produce low sulfur diesel fuel. The results of our analysis show that the overall supply of highway diesel fuel will continue to be adequate to meet market demands as refiners are required to start producing low sulfur highway diesel fuel. Most refineries that currently produce highway diesel fuel will produce about the same volume of low sulfur diesel fuel once the program takes effect. However, several refineries could economically expand their current highway diesel fuel production by shifting some of their off-highway production today, and a few others currently producing only off-highway diesel fuel could economically shift to some highway diesel production. Consequently, our analysis indicates that there is ample capability in the refining industry to continue to economically supply sufficient quantities of highway diesel fuel when today's program goes into effect. For a fuller discussion of this analysis, see Section V of this preamble and Chapter IV of the RIA.

If any potential for highway diesel fuel shortfalls exists by requiring all fuel to meet 15 ppm sulfur in 2006, as CRA's analysis suggests, we believe that allowing some continued supply of 500 ppm, as we are doing under the temporary compliance option and hardship provisions contained in today's action, addresses this concern. Since the final rule allows some transition period before the entire highway diesel pool is required to meet the 15 ppm sulfur standard, some refiners will not need to change their current operations and will be able to continue producing 500 ppm fuel during these years. Those refiners that delay production of low sulfur diesel fuel until the later years of the program will tend to be the refiners with the highest cost to comply and, thus, refiners that would otherwise have the greatest tendency not to invest and thereby impact supply. Refiners that begin producing low sulfur diesel fuel in the later years of the program will also be able to take advantage of ongoing improvements in desulfurization technology. Together, these factors will help avoid or reduce any potential losses in highway diesel fuel production when the program requires full compliance with low sulfur diesel fuel.

b. Ensures Widespread Availability of Low Sulfur Diesel Fuel

A major concern we noted in the NPRM regarding a fuel phase-in program was ensuring the widespread availability of low sulfur diesel fuel. Without an assurance of widespread availability, there would be concerns whether the 2007 and later model year heavy-duty vehicles that were designed to operate on low sulfur fuel would be able to purchase it in all parts of the country. If such vehicles were fueled with 500 ppm diesel fuel, the emission control systems could be irreversibly damaged and any benefit of the new emission standards could be eliminated (see Section III.F. above). Therefore, in setting the requirements for the temporary compliance option, we have analyzed the likelihood that fuel will be widely available so that 2007 and later model year heavy-duty vehicles will be able to find low sulfur fuel in all local markets across the country. To achieve this goal, we believe there need to be assurances that refineries producing 15 ppm fuel are sufficiently scattered throughout each of the PADDs and that most pipelines will carry 15 ppm fuel (either as the only highway diesel fuel or in addition to 500 ppm highway fuel).

In determining what fraction of highway diesel fuel would need to be low sulfur under the temporary compliance option provision, taking into account the potential impact of the hardship provisions, we used a refinery cost model to estimate the costs of producing 15 ppm fuel for all refineries. We then assumed that the refineries with the lowest costs would convert to 15 ppm fuel and assumed the other refineries would purchase credits and continue producing 500 ppm fuel through the compliance option period. We then overlaid the information on which refineries were estimated to be producing 15 ppm fuel with the highway diesel fuel distribution system in the United States. We examined different levels for the temporary compliance option beginning as low as 20 percent and ranging as high as 90 percent. The results of the analysis show that at temporary compliance option levels for 15 ppm below 80 percent, there are local regions of the country where we believe there would likely be shortages of low sulfur diesel fuel. The areas where we believe there would be shortages are either (1) served by pipelines that we believe would not carry 15 ppm fuel, because the refineries serving those pipelines are projected to produce primarily 500 ppm; or (2) dominated by refineries we believe would continue producing 500 ppm fuel under the temporary compliance option and are not currently capable of receiving significant supplies of a second grade of diesel fuel through other reasonable means. At the 80 percent level, we believe that all pipelines will carry low sulfur diesel fuel, since there are a sufficient number of refineries scattered across the country producing low sulfur diesel fuel and at sufficient volumes for pipelines to choose to carry it. We also believe that the program ensures that low sulfur diesel fuel will be sufficiently available to retail outlets at a reasonable cost either at a local terminal or by trucking the fuel a limited distance.

As noted earlier, we are not adopting any retailer availability requirements with today's fuel program. Given the amount of low sulfur diesel fuel required under today's temporary compliance option, we believe the distribution system will make low sulfur diesel fuel widely available without any requirements on retail outlets to supply low sulfur diesel fuel.

c. Provides Lower Costs to Refineries

One benefit of the temporary compliance option being adopted today is that a significant number of refiners will have the ability to delay the date when they convert their highway diesel fuel production to 15 ppm, allowing the refining industry to stretch out its engineering and construction resources. Given the flexibilities being adopted today, we believe that many large refineries, and other refineries for which diesel desulfurization is least expensive, will make the commitment to convert their entire highway diesel pool to 15 ppm sulfur in 2006 and sell credits to other refineries that will continue to produce all of their fuel at the 500 ppm sulfur level. Using a refinery cost model to estimate how refineries will respond to the temporary compliance option requirements, we believe that more than half of the refineries will delay capital investment by buying credits and continue producing 500 ppm sulfur diesel fuel under the temporary compliance option and small refiner hardship provisions. We estimate that refiners will be able to save as much as $1.7 billion over the transition period compared to a requirement that all highway diesel fuel comply with 15 ppm sulfur in 2006. As noted earlier, much of this potential savings will be offset by increased costs in the distribution system. Nevertheless, we project that in total, an overall savings of approximately $0.65 billion could result.

d. Misfueling Concerns Should Be Minimized

By allowing a 500 ppm and 15 ppm sulfur highway diesel fuels to be in the market at the same time, there is the possibility that model year 2007 and later heavy-duty vehicles will be misfueled with 500 ppm sulfur fuel, either accidentally or intentionally. As discussed above, if such vehicles are fueled with 500 ppm diesel fuel, the emission control systems could be irreversibly damaged and any benefit of the new emission standards could be eliminated. To minimize the possibility of misfueling, we are adopting labeling requirements that apply to both retail stations and vehicle manufacturers. Under these provisions, labels will be applied at the diesel fuel pumps at retail stations and at the fuel tank inlet on the vehicle. The labels must indicate that only 15 ppm sulfur highway diesel fuel may be used in 2007 and later model year heavy-duty vehicles. The labeling requirements for fuel pumps and vehicles are described in detail in Sections VII.C. and VI.G., respectively.

Given the program being adopted today, we believe that intentional misfueling will not be a serious problem. The main incentive vehicle owners may have for using 500 ppm sulfur fuel would likely be cost savings. In general, producing 500 ppm sulfur should be cheaper than producing 15 ppm fuel. However, given the requirements adopted today, we believe there should not be a large cost differential between the 15 ppm sulfur fuel and the 500 ppm sulfur fuel at retail outlets. Under the credit trading program, to produce 500 ppm fuel, most refiners will have to purchase credits from other refiners producing 15 ppm fuel, increasing the cost of the 500 ppm fuel, while decreasing the cost of the 15 ppm fuel. At the refinery gate, the cost of both fuels should be approximately the same. In addition, given the amount of 15 ppm fuel required under the temporary compliance option, 15 ppm fuel will be distributed through essentially the entire pipeline system. The distribution of 500 ppm fuel, on the other hand, will be more limited, due to its much lower volume. We expect that the 500 ppm fuel will be distributed by truck in the areas nearby refineries producing this fuel and through a few major pipelines to a limited number of major fuel consuming areas. Overall, the better economies of scale of transporting 15 ppm fuel should compensate for any additional handling cost due to the need to more carefully avoid contamination with higher sulfur fuels. For these reasons, we expect the price to consumers of 500 ppm sulfur fuel to be generally close to that of 15 ppm sulfur fuel and, therefore, there should not be a significant economic incentive to misfuel with 500 ppm sulfur fuel. Finally, because vehicle owners will likely void the manufacturer's warranty if they misfuel with 500 ppm sulfur fuel, they will have an additional incentive not to misfuel. Owners of heavy-duty vehicles make significant investments in these vehicles and will not want to take the chance of voiding their warranty for a relatively small savings in fuel cost.

In addition to our concern about intentional misfueling, we also have some concerns about accidental misfueling during the optional compliance program years. This concern is lessened to some extent because of the limited amount of 500 ppm sulfur fuel that will be available, the short duration of the optional compliance program, the knowledgeable owners and operators of trucks and most importantly, the labels that will be required on both the vehicle and the fuel pumps. Thus, we do not expect either type of misfueling to be a significant problem.

e. Summary

In summary, today's program has been structured to ensure a smooth transition to low sulfur highway diesel fuel. We believe this will allow the refining industry the ability to spread out capital investments and provide more time for the market to transition to the low sulfur diesel fuel. This, in turn, will help to mitigate any potential for concerns about highway diesel fuel supply shortfalls. We also believe the provisions included in the program will continue to provide assurance that adequate supplies of low sulfur highway diesel fuel will be available throughout the nation for the 2007 and later model year heavy-duty vehicles that will require the fuel to comply with the emission standards. Moreover, because the flexibilities included in the program should reduce the economic impact on refiners, we will also expect there to be a reduction in the costs to highway diesel fuel users.

### *B. What Provisions Apply in the Geographic Phase-in Area?*

#### 1. What Is the Geographic Phase-in Area and How Was it Established?

In the low sulfur gasoline rule, we established the GPA provision which provides temporarily less stringent standards for gasoline sold in certain parts of the West and Alaska (40 CFR 80.215). A map of the area is shown in Figure IV–2, below.[165] As described in the preamble to the low sulfur gasoline final rule, we used two criteria to develop and evaluate the GPA approach: (1) Relative environmental need and (2) the ability of U.S. refiners and the distribution system to provide compliant gasoline.

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[165] Alaska, Colorado, Idaho, Montana, New Mexico, North Dakota, Utah, and Wyoming. Note that minor changes to this area are currently under consideration. Any such changes subsequent to today's rule are intended to be carried over into today's rule as well.

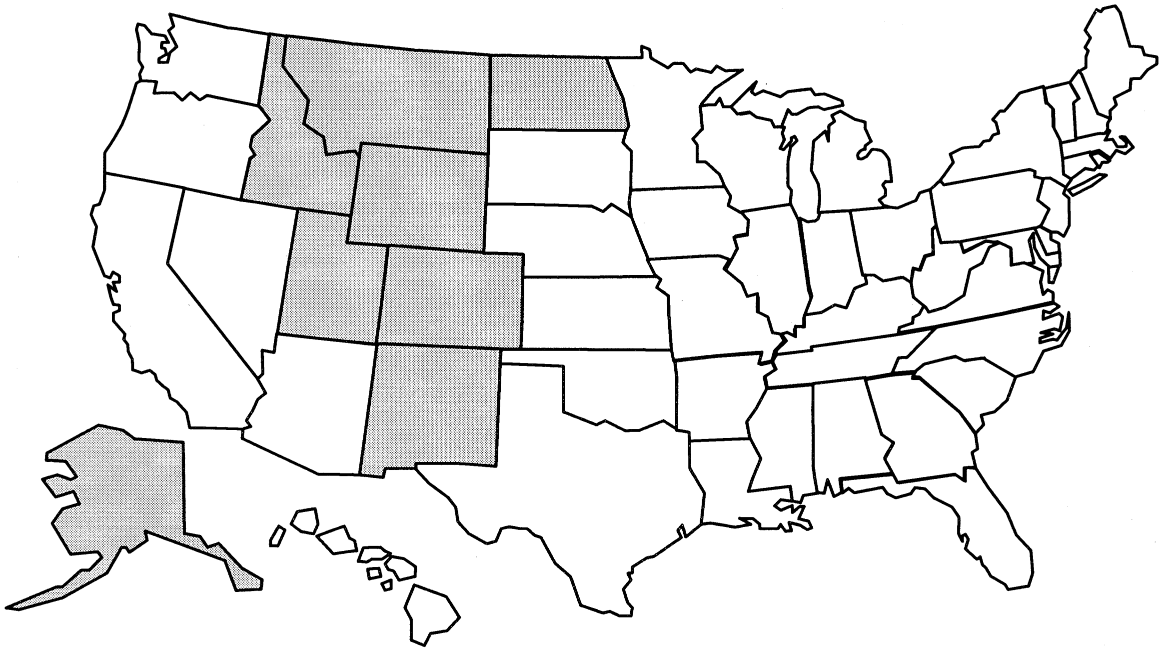

**Figure IV-2. Geographic Phase-in Area**

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In part, we defined the GPA based on the relative difficulty of producing or obtaining complying low sulfur gasoline (see preamble to the low sulfur gasoline rule at 65 FR 6698, February 10, 2000). The refining industry in the GPA is dominated by small capacity, geographically-isolated refineries located within that area. As a general rule, refineries in this area will (because of their crude oil capacity, corporate size, and location) have the most difficult time of all refineries nationwide in competing for the engineering and construction resources needed to modify their refineries to comply with the low sulfur gasoline standards.

Furthermore, an assessment of gasoline production and use data and information on the products pipeline system shows that states and counties in the GPA are solely or predominantly dependent on gasoline produced by these refineries and have limited or no access to gasoline from other parts of the country. Specifically, Department of Energy data for 1998 indicate that over 80 percent of the gasoline sold in this area is produced by the relatively small refineries located within the region. Much of this gasoline is produced by small volume refineries that are not owned by small businesses, and are therefore not afforded the flexibility of the small refiner provisions described in Section IV.C. Providing low sulfur gasoline to these states and counties is expected to be more difficult and costly in the near term.

The temporary gasoline provisions for the GPA apply for three years, 2004 through 2006. Since the low sulfur gasoline standards for the rest of the country require compliance in January 2006 with a 30 ppm refinery average standard and an 80 ppm gallon cap, the geographic phase-in provides an additional year for refiners to reach those standards. This extra year and the somewhat less stringent standards during the gasoline phase-in will provide the refining industry the opportunity for a more orderly transition to the 30/80 ppm gasoline sulfur standards by January 2007.

The gasoline GPA provision covers all gasoline produced (or imported) for use in the GPA[166], whether refined within the area or distributed within the area via pipeline, barge, truck, or rail. Foreign refiners are involved in this program through importers, which are the regulated entities.

2. *Highway Diesel Provisions for GPA Refiners*

In response to our proposal, we received many comments from the refining industry and others regarding the timing of our proposed highway diesel fuel sulfur program. Commenters argued that the proposed schedule for diesel sulfur compliance, beginning in mid-2006, would be a problem since it directly coincides with the December 2006 gasoline sulfur compliance date for the GPA. Some said that the timing of the diesel program could effectively negate the benefit to refiners of the GPA program since desulfurization investments would need to take place during essentially the same time period. This could thus increase the difficulty of refiners in this region to raise capital and to engage engineering and construction resources. Some also said that an extension of the GPA gasoline program would allow more rational planning without unduly reducing the air quality benefits of the program.

We agree with many of the commenters in this regard—refineries supplying the GPA tend to be disproportionately challenged compared to other refiners with respect to capital formation, the availability of engineering and construction resources, and the isolated nature of many of the markets. Moreover, the introduction of low sulfur highway diesel fuel in June 2006 indeed overlaps with the conclusion of the interim low sulfur gasoline standards for GPA refiners.

In consideration of these comments, we believe that it is appropriate to grant additional flexibility to refiners that supply gasoline to the GPA while also meeting the low sulfur diesel standards. Additional flexibility for GPA refiners will allow them to spread out their capital investments for producing low sulfur gasoline and highway diesel fuel. In light of the above, we are modifying

[166] As stated in the Tier 2/Gasoline Sulfur final rule (See § 80.215(a)(2)), we plan to expand the GPA to include counties and tribal lands in states adjacent to the eight core GPA states.

the GPA gasoline program while still achieving significant environmental benefits. We expect this provision will have little long-term impact on the environmental benefits of the Tier 2/Gasoline Sulfur program, while providing for considerable near-term implementation flexibility and improved feasibility of the highway diesel fuel program.

Refiners that produce both gasoline and highway diesel fuel and are subject to the GPA gasoline sulfur program may choose to stagger their desulfurization investments for the two fuels. Refiners that comply with the low sulfur diesel fuel standard by June 1, 2006 for all of their highway diesel fuel production may receive a two-year extension of their interim GPA gasoline standards for 2006, that is through December 31, 2008. In addition to allowing refiners the opportunity to spread out their desulfurization investments, we believe this provision will encourage the production of 15 ppm diesel fuel by some refiners producing fuel for the GPA, which will further help to ensure the new fuel is widely available for new vehicles throughout the area. Although the GPA gasoline program applies to both refiners and importers, the extension of the GPA gasoline program under today's program applies only to refiners. This reflects the fact that only refiners have to make capital investments to comply with the diesel sulfur standard.

To receive the two-year extension of the GPA standards, a U.S. refinery must by June 1, 2006 produce 100 percent of its highway diesel fuel at 15 ppm sulfur (including refineries that supply only a fraction of their gasoline production to the GPA). In addition, the refinery must maintain a production volume of 15 ppm highway diesel fuel that is at least 85 percent of the baseline highway diesel volume that was produced at that refinery on average during calendar years 1998 and 1999. We believe that it is very important that the extension of a GPA refinery's interim gasoline sulfur standard be linked to a substantial environmental benefit from the production of 15 ppm diesel fuel in 2006. We have established a minimum volume requirement to prevent the extension of the GPA gasoline program from applying in situations where a refinery changes its refinery product slate to produce very little highway diesel fuel—even though this production is at 15 ppm sulfur. We believe the 85 percent level is sufficient to reflect a substantial investment in desulfurization technology. At the same time the 85 percent level should allow for any reasonable variation in production of highway diesel fuel that would be expected to occur in typical situations between now and 2006, particularly given the continued growth of the highway diesel market.

Similarly, a foreign refinery that meets the same conditions as a domestic GPA refiner may also sell gasoline into the GPA that meets a less stringent sulfur standard during 2007 and 2008.[167] That is, a foreign refinery that by June 1, 2006 sells 100 percent of the highway diesel fuel it imports into the U.S. as 15 ppm fuel (and that maintains the 85 percent of baseline volume requirement) may sell somewhat higher-sulfur gasoline into the GPA in 2007 and 2008. The actual gasoline sulfur standard during this period, as with domestic refiners, would be based on the foreign refinery's gasoline sulfur baseline.

If a situation arises where a GPA refinery did not produce highway diesel fuel in 1998 or 1999 but later begins to produce 15 ppm diesel fuel, use of the GPA gasoline phase-in extension will require case-by-case EPA approval. In its application for such approval, a refinery must show us that the loss of emission reductions will not be significant and must propose an appropriate minimum production volume. In evaluating such a proposed minimum volume, we may consider, among other factors, the typical ratio between highway diesel and gasoline production for other refineries in the industry. Again, the reason for the two-year extension of the gasoline interim program is to allow the GPA refinery to spread out its capital investments while increasing the quantity of 15 ppm fuel being produced. We expect that GPA refineries using this option will make a substantive capital investment in diesel desulfurization and have thus set this minimum 15 ppm diesel production volume limit.

Since refiners participating in this program are required to produce 100 percent of their highway diesel at 15 ppm, those that choose this option cannot participate in the highway diesel temporary compliance option, and, therefore, are not permitted to generate credits on the low sulfur diesel fuel that they produce. If, after June 1, 2006, a foreign refinery is not producing 100 percent of its highway diesel fuel imported into the U.S. at 15 ppm sulfur in the required volume, it forfeits the two-year extension or any remaining portion of the extension of its interim gasoline program.

3. *How Do Refiners Apply for an Extension of the GPA Gasoline Program?*

Any refinery that seeks an extension of its GPA gasoline standards must apply to us as a part of its registration, due by December 31, 2001. In this application, the refinery must indicate its intention to produce 100 percent of its highway diesel fuel at 15 ppm (and at a volume at least 85 percent of the highway diesel fuel volume it produced on average during calendar years 1998 and 1999) by June 1, 2006.

4. *Required Reporting for GPA Refiners*

As described in Section VII.E below, refiners that plan to use the extension of the GPA gasoline standard must report their plans and progress several times over the course of the program. In addition to their initial registration and application discussed above, a refinery must submit pre-compliance reports in 2003, 2004, and 2005, describing its progress toward the capacity to produce 100 percent of its highway diesel fuel at 15 ppm sulfur (at a volume at least 85 percent of its baseline volume). Then, by July 1, 2006, such a refinery must confirm to us that by June 1, 2006 it was producing 100 percent of its highway diesel fuel at 15 ppm, at the appropriate volume.[168] After the diesel sulfur program is underway in 2006, the refinery must provide us with annual compliance reports by the end of February of 2007, 2008, and 2009 (i.e., until after the end of the extended interim gasoline sulfur program for GPA refiners on December 31, 2008).

*C. Hardship Provisions for Qualifying Refiners*

This section describes various provisions for certain qualifying refiners, both domestic and foreign, that may face hardship circumstances.

1. *Hardship Provisions for Qualifying Small Refiners*

In developing our diesel sulfur program, we evaluated the need and the ability of refiners to meet the 15 ppm standard as expeditiously as possible. This analysis is described in detail in Chapter IV of the RIA. As a part of this analysis, we found that while the majority of refiners would be able to meet the needed air quality goals in the

[167] Prior to 2007, foreign refiners can participate in the GPA program through importers. Under today's provisions for 2007 and 2008, importers are not eligible and foreign refiners can participate directly as refiners.

[168] If the refiner was not producing 15 ppm fuel for all its highway diesel production at that refinery by June 1, 2006, the July 1, 2006 letter must confirm that the refiner is forfeiting the "automatic" two-year extension of that refinery's interim gasoline program.

2006 time frame, there would be some refiners that would face particularly challenging circumstances which would cause them to have more difficulty, in comparison to the industry as a whole, in meeting the standards.

We believe it is feasible and necessary for the vast majority of the program to be implemented reasonably quickly to achieve the air quality benefits as soon as possible. To do otherwise would be to base the time frame of the entire program on the lowest common denominator. Thus, we have provided special flexibility provisions for a subset of refiners that qualify as ''small refiners,'' which represent about five percent of the overall highway diesel volume. As described in more detail below, and in the Regulatory Impact Analysis (Chapter VIII of the RIA), we concluded that refineries owned by small businesses face unique hardship circumstances, compared to larger companies.

a. Qualifying Small Refiners

The primary reason for special small refiner provisions is that small businesses generally lack the resources available to large companies which enable the large companies (including those large companies that own small volume refineries) to raise capital for investing in desulfurization equipment. The small businesses are also likely to have more difficulty in securing loans, competing for engineering resources, and completing construction of the needed desulfurization equipment in time to meet the standards adopted today which begin in 2006. In addition, the implementation of the low sulfur diesel program will occur in the same general time frame as the implementation of the low sulfur gasoline program, since most of those small refiners that are covered by the interim standards under the Tier 2/Gasoline Sulfur program (40 CFR Part 80, Subpart H) are also covered by today's diesel fuel sulfur program.

The emissions benefits of the low sulfur diesel program are needed as soon as possible—to allow the implementation of new emission reduction requirements on heavy-duty engines and vehicles and, thus, to reduce ozone, particulate matter, and other harmful air pollutants. Since our analysis showed that small businesses in particular face hardship circumstances, we are adopting temporary provisions that will provide refineries owned by small businesses additional time to meet the ultimate 15 ppm sulfur cap or balance investments of this program with those related to the Tier 2/Gasoline Sulfur program. This approach allows us to achieve the earliest implementation date for advanced technology diesel vehicles (i.e., the 2007 model year) and the needed emission reductions they will bring.

We believe that the temporary flexibilities described below are an effective way to begin the broad implementation of the standards as expeditiously as is feasible and thereby achieve significant air quality benefits in an expeditious manner. This section describes the special provisions we are offering small businesses to mitigate the impacts of our program on them and generally explains the analysis we undertook of those impacts. Please refer to the Response to Comments document for a detailed discussion of comments we received on these provisions, and to the RIA for a more detailed discussion of our analysis of small refiner circumstances.

As explained in the discussion of our compliance with the Regulatory Flexibility Act in Section X.B. and in the Regulatory Flexibility Analysis in Chapter VIII of the RIA, we considered the impacts of our proposed regulations on small businesses. We have historically, as a matter of practice, considered the potential impacts of our regulations on small businesses. We believe that the temporary flexibilities we are adopting for small refiners contributed to our development of a framework to achieve significant environmental benefits from lower sulfur diesel in the most expeditious manner that is reasonably practicable.

A large part of the analysis of small business impacts conducted for this rulemaking was performed in conjunction with a Small Business Advocacy Review (SBAR) Panel we convened, pursuant to the Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA). In the SBREFA amendments, Congress stated that ''uniform Federal regulatory requirements have in numerous instances imposed unnecessary and disproportionately burdensome demands including legal, accounting, and consulting costs upon small businesses . . . with limited resources[,]'' and directed agencies to consider the impacts of certain actions on small entities. The final report of the Panel is available in the docket. Through the SBREFA process, the Panel provided information and recommendations regarding:

- The significant economic impact of the proposed rule on small entities;
- Any significant alternatives to the proposed rule which would ensure that the objectives of the proposal were accomplished while minimizing the economic impact of the proposed rule on small entities;
- The projected reporting, recordkeeping, and other compliance requirements of the proposed rule; and,
- Other relevant federal rules that may duplicate, overlap, or conflict with the proposed rule.

In addition to our participation in the SBREFA process, we conducted our own outreach, fact-finding, and analysis of the potential impacts of our regulations on small businesses. Some of the small refiners with whom we and the Panel met indicated their belief that their businesses may close due to the substantial costs, capital and other impacts of meeting the 15 ppm diesel fuel standard without either additional time or flexibility with respect to gasoline sulfur compliance. Based on these discussions and analyses, the Panel and we agree that small refiners would likely experience a significant and disproportionate financial hardship in reaching the objectives of our diesel fuel sulfur program. However, the Panel also noted that the burden imposed upon the small refiners by our sulfur requirements varied from refiner to refiner and could not be alleviated with a single provision. We agree with the Panel and are offering qualifying small refiners three options to choose from in moving toward compliance with the low sulfur diesel fuel requirements.

For today's action, we have structured a selection of temporary flexibilities for qualifying small refiners, both domestic and foreign, based on the factors described below. Generally, we structured these provisions to address small refiner hardship while expeditiously achieving air quality benefits and ensuring that the low sulfur diesel fuel coincides with the introduction of 2007 model year diesel vehicles.

First, the compliance deadlines in the program, combined with flexibility for small refiners, will quickly achieve the air quality benefits of the program, while helping to ensure that small refiners will have adequate time to raise capital for new or revamped equipment. Most small refiners have limited additional sources of income beyond refinery earnings for financing the equipment necessary to produce low sulfur diesel. Because these small refiners typically do not have the financial backing that larger and generally more integrated companies have, they can benefit from additional time to secure capital financing from their lenders.

Second, we believe that allowing time for refinery sulfur-reduction technologies to be proven out by larger refiners before small refiners have to put them in place will reduce the risks incurred by small refiners that utilize these technologies to meet the standards. The added time will likely allow for lower costs of these improvements in desulfurization technology (e.g., better catalyst technology or lower-pressure hydrotreater technology). Because of the poorer economies of scale and the higher relative capital and operating costs faced by small refiners, more time for technology development and commercialization will limit the economic consequences for small refiners. Small refiners are disadvantaged by the economies of scale that exist for the larger refining companies-capital costs and per-barrel fixed operating costs are generally higher for small refiners.

Third, providing small refiners more time to comply will increase the availability of engineering and construction resources. Since most large and small refiners must install additional processing equipment to meet the sulfur requirements, there will be a tremendous amount of competition for technology services, engineering manpower, and construction management and labor. Our analysis shows that there are limits to the price elasticity of these resources. In addition, vendors will be more likely to contract their services with the major companies first, as their projects will offer larger profits for the vendors.

Finally, because the gasoline and diesel sulfur requirements will occur in approximately the same time frame, small refiners that produce both fuels will have a greater difficulty than most other refiners in securing the necessary financing. Hence, any effort that increases small refiners' ability to stagger investments for low sulfur gasoline and diesel will facilitate compliance with the two programs.

Providing these options to assist small refiners experiencing hardship circumstances enables us to go forward with the 15 ppm sulfur standard beginning in 2006. Without this flexibility, the benefits of the 15 ppm standard would possibly not be achieved as quickly. By providing temporary relief to those refiners that need additional time, we are able to adopt a program that expeditiously reduces diesel sulfur levels in feasible manner for the industry as a whole. In addition, we believe the volume of diesel that will be affected by this hardship provision is marginal. We estimate that small refiners contribute approximately five percent of all domestic diesel fuel production.

b. How Do We Define Small Refiners?

The following definition of small refiner is based closely on our small refiner definition in the Tier 2/Gasoline Sulfur rule. We define a refiner that meets both of the following criteria as a "small refiner" for purposes of this rule:

- No more than 1,500 employees corporate-wide, based on the average number of employees for all pay periods from January 1, 1999 to January 1, 2000.
- A corporate crude oil capacity less than or equal to 155,000 barrels per calendar day (bpcd) for 1999.

In determining the total number of employees and crude oil capacity, a refiner must include the number of employees and crude oil capacity of any subsidiary companies, any parent company and subsidiaries of the parent company, and any joint venture partners. We define a subsidiary of a company to mean any subsidiary in which the company has a 50 percent or greater ownership interest. This definition of small refiner is the same definition used under the recently promulgated Tier 2/Gasoline Sulfur program (40 CFR 80.225), except that we have included additional regulatory language to clarify our interpretation of the term "subsidiary" and we have updated the time period used to determine the employee number and crude oil capacity criteria to reflect data for the most recent calendar years. This approach is consistent with the Small Business Administration's regulations, which specify that, where the number of employees is used as a size standard, the size determination is to be based on the average number of employees for all pay periods during the preceding 12 months (13 CFR 121.106).

The gasoline sulfur standards and the diesel sulfur standards will impact small refiners in approximately the same time frame. For this reason, we will consider any refiner that we approve as meeting the small refiner definition under the gasoline sulfur program (40 CFR 80.235) to be a small refiner under the highway diesel sulfur rule as well without further demonstration.

In addition, a company that after January 1, 2000 either acquires or reactivates a refinery that was shutdown or non-operational between January 1, 1999 and January 1, 2000 may also apply for small refiner status. Such an application needs to be submitted to us no later than June 1, 2003. In this case, we will judge eligibility under the employment and crude oil capacity criteria based on the most recent 12 consecutive months unless data provided by the refiner indicates that another period of time is more appropriate. Companies with refineries built after January 1, 2000 are not eligible for the small refiner hardship provisions.

If a refiner with approved small refiner status later exceeds the 1,500 employee threshold or the corporate crude oil capacity of 155,000 bpcd without merger or acquisition, it may keep its small refiner status. This is to avoid stifling normal company growth and is subject to our finding that the company did not apply for and receive the small refiner status in bad faith. On the other hand, if a refiner with approved small refiner status later exceeds the small refiner criteria through merger or acquisition, its refineries must forfeit their small refiner status and begin complying with the national standards by January 1 of the next calendar year. For example, if a small refiner with two refineries purchases a third refinery in 2007 and that purchase causes the refiner to exceed the employee or corporate crude oil capacity thresholds for small refiner status, then that refiner must forgo its small refiner status and begin complying with the national standards by January 1, 2008 at all its refineries.

c. What Options Are Available for Small Refiners?

All refiners producing highway diesel fuel are able to take advantage of the temporary compliance option discussed in Section IV.A. Diesel producers that also market gasoline in the GPA may receive additional flexibility under today's rule (Section IV.B.). As an alternative, refiners that seek and are granted small refiner status may choose from the following three options under the diesel sulfur program. These three options have evolved from concepts on which we requested and received comment in the proposal. In most cases, we believe that small refiners will find these options preferable to either the broader diesel fuel temporary compliance option or the GPA provision discussed above.

*500 ppm Option.* A small refiner may continue to produce and sell diesel fuel meeting the current 500 ppm sulfur standard for four additional years, until May 31, 2010, provided that it reasonably ensures the existence of sufficient volumes of 15 ppm fuel in the marketing area(s) that it serves.

*Small Refiner Credit Option.* A small refiner that chooses to produce 15 ppm fuel prior to June 1, 2010 may generate and sell credits under the broader temporary compliance option. Since a small refiner has no requirement to produce 15 ppm fuel under this option, any fuel it produces at or below 15 ppm sulfur will qualify for generating credits.

*Diesel/Gasoline Compliance Date Option.* For small refiners that are also subject to the Tier 2/Gasoline sulfur program (40 CFR Part 80, Subpart H), the refiner may choose to extend by three years the duration of its applicable interim gasoline standards, provided that it also produces all its highway diesel fuel at 15 ppm sulfur beginning June 1, 2006.

All refiners producing diesel fuel are required to provide us with basic data on their progress toward compliance in 2003–2005 under the pre-compliance reporting requirements described above in Section IV.A. As a part of their pre-compliance reports, small refiners must provide a limited amount of additional information specific to the option they choose. We discuss each option, and the special pre-compliance reporting requirements for each option, in the next paragraphs and in Section VII.E below.

i. 500 ppm Option

The 500 ppm option is available for any refiner that qualifies as a small refiner. Under this option, small refiners may continue selling highway diesel fuel with sulfur levels meeting the current 500 ppm standard for four additional years, provided that they supply information showing that sufficient alternate sources of 15 ppm diesel fuel in their market area will exist for fueling new heavy-duty highway vehicles. Under this option, small refiners may supply current 500 ppm highway diesel fuel to any markets for use only in vehicles with older (pre-2007) technology until May 31, 2010. In other words, small refiners that choose this option may delay production of highway diesel fuel meeting the 15 ppm standard for four years.

This 500 ppm option for small refiners is similar to the option provided to all refiners under the temporary compliance option described in Section IV.A above in that it allows a refiner to continue producing and selling the current 500 ppm fuel for a period of time. However, this option differs from the broader compliance option in that small refiners may produce and sell 100 percent of their highway fuel at 500 ppm without needing to buy credits. In contrast, under the broader temporary compliance option, refiners must buy credits to produce any volume of 500 ppm fuel over 20 percent of their total highway diesel production.

At the retail level, retailers will not be subject to any availability requirements and thus may sell 500 ppm fuel, 15 ppm highway fuel, or both (as is the case under the broader diesel temporary compliance option described in Section IV.A). All parties in the diesel fuel distribution system will have to maintain the segregation of 15 ppm fuel and 500 ppm fuel and only 15 ppm fuel may be sold for use in model year 2007 and later heavy-duty diesel vehicles.

As a part of their pre-compliance reporting due June 1, 2003 (see Section IV.A. above), any small refiners taking advantage of this 500 ppm option must show that sufficient sources of 15 ppm fuel will likely exist in the area served by the small refiner in the absence of production of 15 ppm fuel by that refiner.[169] A small refiner could approach this showing in different ways. For example, depending on the circumstances, the refiner might point to the presence of other refiners in the area that are expected to produce 15 ppm fuel, or to the refiner's proximity to a major pipeline that will be carrying 15 ppm fuel. Similarly, the refiner might show that its market share in the area's highway diesel market will be too small to significantly affect the volume of 15 ppm fuel regardless of the small refiner's actions.

Another approach could be to indicate practical steps that the refiner itself is prepared to take to help ensure that 15 ppm diesel fuel will be available. One commenter suggested a plan to add a separate tank and expand its fuel loading rack for handling 15 ppm diesel fuel that would be supplied by a different refiner—thus making low sulfur fuel available, at least at the wholesale level, at its refinery gate even though it produced no 15 ppm fuel.

Because of the wide distribution of 15 ppm fuel that we believe will occur under the industry-wide optional compliance program discussed in Section IV.A. above, we expect that few if any small refiners wishing to use the 500 ppm option will find it difficult to make the showing that 15 ppm fuel will exist in the area. If we do not take action on this showing within four months of receiving a refiner's 2003 pre-compliance report (i.e., by October 1, 2003 at the latest), the refiner's showing will be considered approved.

[169] If circumstances arise that cause the availability of 15 ppm fuel in the refiner's market area to decline, the refiner must provide a supplemental showing in its pre-compliance reports due in June 1, 2004 and/or June 1, 2005. As with the 2003 report, we will either approve or disapprove these additional showings within four months or, if we take no action, the showing will be deemed approved.

Finally, we are providing this option so that small refiners may use the temporary flexibility provided by the 500 ppm option as a pathway toward compliance with the 15 ppm standard and not as an opportunity for those refiners to greatly expand their production of fuel meeting the 500 ppm sulfur standard. To help ensure that any significant expansion of refining capacity that a small refiner undertakes in the future will be accompanied by an expansion of desulfurization capacity, we are limiting the volume of 500 ppm sulfur fuel that a small refiner may produce under this option to a baseline level. Specifically, small refiners selecting this 500 ppm option must limit the volume they produce of highway diesel fuel meeting the 500 ppm sulfur standard to the lesser of the following values: (1) 105 percent of the average highway diesel volume it produced from crude oil in calendar years 1998 and 1999 or (2) the average highway diesel volume it produced from crude oil in calendar years 2004 and 2005. Any volume of 500 ppm highway diesel fuel (averaged over the previous 12 consecutive months) that exceeds this limitation after 2006 must comply with the diesel sulfur standards that apply to other refiners under the broader program (i.e., the standards described in Section IV.A. above, including the 80% requirement of the temporary compliance option).

ii. Small Refiner Credit Option

We believe that the relative difficulty for small refiners to comply with today's program warrants compliance flexibility for these refiners. At the same time, we want to encourage all refiners to produce low sulfur diesel fuel as early and in as many geographic areas as possible. As an incentive for small refiners to invest in desulfurization capacity, those that choose to produce 15 ppm fuel earlier than required under the 500 ppm option may generate credits for each gallon of diesel fuel produced that meets the 15 ppm standard. This includes the ability to generate credits prior to the start of the program on June 1, 2006 under the provisions described in Section IV.A.1.a. They could then sell these credits to other refiners for use in the broader optional diesel fuel compliance program described above in Section IV.A, helping to offset some low sulfur diesel fuel production costs.

Under this option, credits may be generated based on the volume of any diesel fuel that meets the 15 ppm standard. Refiners may then sell their remaining highway diesel fuel under the 500 ppm option above.

Pre-compliance reporting for small refiners choosing this Small Refiner Credit option is identical to that for the 500 ppm option (that is, if the small refiner is also producing 500 ppm highway diesel fuel), with the additional requirement that the refiner also report on any credits it expects to generate and sell. If the quantity of 15 ppm fuel that the refiner is preparing to produce is significant, this factor may be useful in making the necessary showing that 15 ppm fuel will be available in the refiner's market area.

iii. Diesel/Gasoline Compliance Date Option

The Tier 2/Gasoline Sulfur program included a special provision that applies for refiners that qualify as small refiners (40 CFR Part 80, Subpart H). Under that program, each small refiner is assigned an interim gasoline sulfur standard for each of its refineries. This interim standard for each refinery is established based on the baseline sulfur level of that refinery. The standards are designed to require each small refiner to either make a partial reduction in their gasoline sulfur levels or, if they already produce low sulfur fuel, to maintain their current levels. The interim program lasts for four years, 2004 through 2007, and the refiner can apply for an extension of up to three years. After the interim program expires, small refiners must produce the same low sulfur gasoline as other refiners.

Today's diesel sulfur program takes effect in the same time frame as the small refiner interim program for low sulfur gasoline. To avoid the need for simultaneous investments in both gasoline and diesel fuel desulfurization, several small refiners subject to both programs raised the concept of allowing those investments to be staggered in time. Because of the relative difficulty small refiners will face in financing desulfurization projects, especially for both diesel and gasoline desulfurization in the same time frame, we agree that this concept has merit and have adopted it for this rule. Under this concept, small refiners may extend the duration of their gasoline sulfur interim standards and, thus, potentially postpone some or all of their gasoline desulfurization investments while they work to achieve the low sulfur diesel standard ''on time'' in 2006. To the extent that small refiners choose this Diesel/Gasoline Compliance Date option, this provision will benefit the overall diesel program by increasing the availability of 15 ppm diesel fuel in the small refiners' market areas.

Specifically, this option provides that a small refiner can receive a three-year extension of a refinery's interim gasoline standard, until January 1, 2011, if it meets two criteria: (1) It produces both gasoline and diesel fuel at a refinery and chooses to comply with the 15 ppm diesel fuel sulfur standard by June 1, 2006 for all its highway diesel production at that same refinery, and (2) it produces a minimum volume of 15 ppm fuel at that refinery that is at least 85 percent of the average volume of highway diesel fuel that it produced at that refinery during calendar years 1998 and 1999. We believe that it is very important that the extension of a small refiner's interim low sulfur gasoline standard be linked to a substantial environmental benefit from the production of low sulfur diesel fuel in 2006. We have established a minimum volume requirement to prevent the Diesel/Gasoline Compliance Date option from applying in situations where a refiner changes its refinery product slate to produce very little highway diesel fuel—even though this production is at a 15 ppm sulfur level—and yet receives an extension of its interim gasoline sulfur standard.[170] We believe the 85 percent level is sufficient to reflect a substantial investment in desulfurization technology. At the same time the 85 percent level should allow for any reasonable variation in production of highway diesel fuel that would be expected to occur in typical situations between now and 2006, particularly given the continued growth of the highway diesel market. Again, the three-year extension of the gasoline interim program is to allow small refiners to stretch out their capital investments while increasing the quantity of 15 ppm fuel being produced. We expect that small refiners using this option will make a substantive capital investment in diesel desulfurization and have thus set this minimum 15 ppm diesel volume limit.

We believe that the additional three-year extension of the interim gasoline sulfur standards provided today is warranted without any further action by small refiners, provided that they assume the financial burden of full low sulfur diesel compliance in 2006 (i.e., instead of choosing the flexibility of the broader temporary compliance program). The diesel and gasoline desulfurization investments for those refiners can thus be staggered in time. We believe a three-year extension is appropriate due to the substantial investment in highway diesel fuel that these small refiners will be undertaking.

By July 1, 2006, small refiners that plan to use the Diesel/Gasoline Compliance Date option for one or more refineries must send a letter to us confirming that by June 1, 2006 they were producing 100 percent of their highway diesel fuel in compliance with the 15 ppm sulfur standard at their refinery(ies). These refiners must make similar confirmations each year through 2011 in their annual compliance reports (due by the end of February of each year)—until after the end of the extended interim low sulfur gasoline program for small refiners on December 31, 2010.

If a given small refiner was not producing 15 ppm fuel for all its highway diesel production at that refinery by June 1, 2006, the July 1, 2006 letter must confirm that the refiner is forfeiting the ''automatic'' three-year extension of that refinery's interim gasoline program (although the refiner may still apply for a case-by-case extension through the Tier 2/Gasoline Sulfur program under 40 CFR 80.260). In this case, we will consider a request that the refiner be allowed to use either the 500 ppm option or the Small Refiner Credit option, or both, provided that information addressing the conditions of these options as described above are included in the July 1, 2006 letter. If the refiner does not request the use of the 500 ppm option or the Small Refiner Credit option, the letter must confirm that the refiner is complying with the diesel sulfur requirements applicable to refiners that are not small refiners.

The Tier 2/Gasoline Sulfur program includes a general hardship provision for which refiners may apply. (Today's program also includes a similar provision). Depending on the nature of its hardship, a small refiner that applies for this general hardship provision under the gasoline program may be granted a ''tailor-made'' interim gasoline sulfur program different from the ''default'' program established in the rule. If such a small refiner were then to be covered by today's diesel fuel requirements and chose this Diesel/Gasoline Compliance Date option, we will allow it an extension of its special interim program for gasoline (as established under the general hardship provision) for three years beyond the scheduled end date (although no later than December 31, 2010) so long as it

[170] If a situation arises where a small refiner did not produce highway diesel fuel in 1998 or 1999 but later begins to produce 15 ppm diesel fuel, use of the Diesel/Gasoline Compliance Date option will require case-by-case EPA approval. In its application for such approval, a refiner must show us that the net loss of emission reductions will not be significant and must propose an appropriate minimum production volume. In evaluating such a proposed minimum volume, we may consider, among other factors, the typical ratio between highway diesel and gasoline production for small-to-medium sized refineries in the industry.

met the 15 ppm diesel fuel standard and production volume requirements in 2006.

As with the other two options, refiners expecting to use the Diesel/Gasoline Compliance Date option and thus to produce their highway diesel fuel exclusively at 15 ppm fuel will have to report certain information beginning in 2003. As a part of their pre-compliance reporting due June 1, 2003 (see Section IV.A. above), any small refiners taking advantage of this option must provide information showing that diesel desulfurization plans are on track. The information supplied under this requirement must include, but will not be limited to, the following: (1) Status of applying for and receiving any necessary air pollution control permits, (2) financing that is in place or being sought, and (3) the status of engineering or construction contracts. As a part of the pre-compliance reporting due in 2004 and 2005, the refiner must provide more complete information as it becomes available to update its earlier report (e.g., the status of beginning or completing construction of desulfurization equipment).

iv. Relationship of the Options to Each Other

By definition, since a small refiner must produce 100 percent of its highway diesel as 15 ppm under the Diesel/Gasoline Compliance Date option, that option is not compatible with either the 500 ppm option or the Small Refiner Credit option. Thus a refiner choosing the Diesel/Gasoline Compliance Date option may not choose either of the other two options. However, the 500 ppm option and the Small Refiner Credit option are compatible with each other, and so a refiner may choose either or both of these options.

d. How Do Small Refiners Apply for Small Refiner Status?

Refiners that are not small refiners under the gasoline sulfur program but that are seeking small refiner status under the diesel sulfur program must apply to us as a part of their registration for the general diesel sulfur program, due no later than December 31, 2001. The application must include the following information: [171]

- The name and address of each location at which any employee of the company, including any parent companies or subsidiaries,[172] worked during the 12 months preceding January 1, 2000;
- The average number of employees at each location, based on the number of employees for each of the company's pay periods for the 12 months preceding January 1, 2000;
- The type of business activities carried out at each location; and
- The total crude oil refining capacity of its corporation. We define total capacity as the sum of all individual refinery capacities for multiple-refinery companies, including any and all subsidiaries, as reported to the Energy Information Administration (EIA) for 1999, or in the case of a foreign refiner, a comparable reputable source, such as professional publication or trade journal.[173] Refiners do not need to include crude oil capacity used in 1999 through a lease agreement with another refiner in which it has no ownership interest.

The crude oil capacity information reported to the EIA or comparable reputable source is presumed to be correct. However, in cases where a company disputes this information, we will allow 60 days after the company submits its application for small refiner status for that company to petition us with detailed data it believes shows that the EIA or other source's data was in error. We will consider this data in making a final determination about the refiner's crude oil capacity.

We will consider any refiner that was granted small refiner status under the Tier 2/Gasoline Sulfur program to also qualify as a small refiner under today's program, provided that it also produced highway diesel fuel in 1999. Such a refiner only needs to indicate as a part of its registration for this program that it is covered by the gasoline sulfur small refiner program and that it expects to be eligible for any small refiner optioins available in today's diesel program.

2. *Farmer Cooperative Refiners Will Benefit From the Flexible Provisions Available to Other Refiners*

Some refineries in the U.S. are owned by farmer cooperatives. In the NPRM, we asked for comment on whether it would be appropriate to extend hardship relief to farmer cooperatives, similar to the flexibility options for small refiners. Representatives of farmer cooperative refiners have commented to us that as refiners they face unique challenges under a diesel fuel sulfur program. As described in more detail below and in the Response to Comments document, we have carefully considered the situation of farmer cooperative refiners. We have concluded that while there are clearly differences in how farmer cooperative refiners are organized and are financed compared to other refiners, we are not able to make a determination that farmer cooperative refiners, as a class, face unique economic hardship. As discussed further below, we believe that the combination of flexibilities built into today's diesel program will be valuable to farmer cooperative refiners. To the extent any of the farmer cooperative refiners face economic hardship in complying with the diesel sulfur program, this determination can best be made on a case-by-case basis for each farmer cooperative refiner, as discussed further below.

As is the case for all refiners, we believe that farmer cooperative refiners will be able to benefit significantly from the several flexibility provisions discussed elsewhere in Section IV of this preamble. As we mentioned above, the farmer cooperative refiner with the smallest refinery appears to meet the criteria for status as a ''small refiner,'' and thus will likely be eligible for the special provisions discussed earlier (Section IV.C.1. above). The second smallest refinery owned by a farmer cooperative is located and markets all or most of its gasoline within the geographic GPA and, as such, is eligible for GPA low sulfur gasoline extension described in Section IV.B. above (if it meets the production and volume requirements for 15 ppm fuel). Alternatively, this refinery could participate in the temporary compliance option for diesel fuel described in Section IV.A. above.

The two other farmer cooperative refiners (as well as any other refiner) may participate in the temporary compliance option for diesel fuel and the averaging, banking, and trading provisions described above (Section IV.A.), potentially allowing them to postpone diesel desulfurization investments. If needed, any of the farmer cooperative refiners may also apply for case-by-case hardship relief (Section IV.C.3. below). Through such a case-by-case review, we will be in a better position to make a determination of whether a particular farmer cooperative refiner faced an economic hardship situation, as we would then have available to us specific financial information about each cooperative owner. If we determine that a cooperative refiner faced an economic

[171] See the Section VII.E below and regulatory language associated with this rule for detailed requirements for registration and application for small refiner status.

[172] ''Subsidiary'' here covers entities of which the parent company has 50 percent or greater ownership.

[173] We will evaluate each foreign refiner's documentation of crude oil capacity on an individual basis.

hardship situation, we could then tailor any temporary hardship provisions to best suit the needs of that refiner. Given this combination of options and ''safety valves'' built into the diesel sulfur program, and the factors discussed below, we do not believe it is necessary to provide special provisions specifically for farmer cooperative refiners as a class.

Farmer cooperatives that own refineries, like all farmer cooperatives, are organized as a means for individual farmers (or local cooperatives owned by individual farmers) to collectively gain benefits in important aspects of their farming businesses—in this case, the production and distribution of the fuel needed for their operation. It should also be noted that the diesel fuel produced by farmer cooperative refiners is sold not only to farmers, but also to the wholesale petroleum market, for sale at service stations, truck stops, or fleets. Individual farmers and others become members of local cooperatives that provide a range of products and services to their members. These local cooperatives in turn often form the membership of larger, regional cooperatives, including those that own three of the four farmer cooperative refineries in the U.S.

Refiners that are also cooperative businesses are significantly different from other refiners in several respects. The key aspect is that several avenues for accessing capital used by many other refiners (in this case, the capital needed to carry out diesel fuel desulfurization projects in their refineries) are not available to, or are not practical for, cooperative refiners. In particular, farmer cooperatives, unlike publicly-held corporations, are generally not permitted to raise equity capital in the securities markets (that is, by selling stock). At the same time, the equity financing provided by the membership, usually a modest amount assessed from each member as a condition of membership, provides a return for the members only to the extent that the members purchase the products or services of the cooperative. Conventional investors that do not regularly patronize the cooperative have little incentive to provide investment from the outside, since their investment will not appreciate in value.

For farmer cooperatives, money for capital projects is generally raised internally as equity from members and as loans from banks or other financial institutions. In this sense, farmer cooperative refiners are similar to privately-held refining companies, which are also unable to raise capital by selling public stock. In the case of farmer cooperatives, equity capital is raised either by assessment of the members or, more often, by retaining a portion of the cooperative's earnings that would otherwise be distributed to the members (on the basis of how much business they have done with the cooperative). The amount of equity available to the cooperative, as well as the earning prospects of the cooperative, usually determine whether financial institutions will lend additional capital, how much money will be lent, and what terms the cooperative will have to agree to. For example, when a cooperative's equity is low and/or the farm economy is stressed (and thus the prospects for strong earnings performance by the cooperative are diminished) cooperatives can have difficulty competing among other potential borrowers for loans for large capital projects.

While the unique structural and financial characteristics of farmer cooperative refiners can present special challenges to these refiners, their status as cooperatives can also provide advantages not shared by other refiners. The same federal and state laws and regulations that place limitations on the financial avenues available to cooperatives also tend to include special provisions only available to cooperatives. These include special treatment for cooperatives under securities laws, antitrust laws, contractual marketing laws, and restrictive corporate entity laws, some or all of which may come into play in efforts to capitalize refinery desulfurization projects.

Also, the relatively large regionally-based cooperatives that own refineries have a variety of other business interests as well. This broader business base, which involves not only the refining and distribution of fuels but also a variety of other agricultural supply, processing, and related operations, may often provide an advantage to these larger cooperative refiners as compared to competing refiners that have little or no business beyond refining and fuel marketing. Finally, the three larger farmer cooperative refiners have developed several economic relationships among one another—including joint refinery ownership, a joint refinery operating agreement, and a joint fuel distribution and marketing organization—that together create greater options for financing than are available to many other refiners.

Based on the compliance option provisions in this action we do not believe that farmer cooperative refiners as a class face a disproportionate economic burden in complying with the diesel sulfur program. However, certain cooperative refiners may face additional economic obstacles, therefore the potential need exists for some financial assistance to farmer cooperative refiners from U.S. government programs. During interagency review, concerns were discussed relating to the uniqueness of the structure of farmer cooperative refineries and the key issue of accessing capital was identified. The U.S. Department of Agriculture (USDA) has indicated an interest and willingness to review its existing authorities for the potential mechanisms to provide financial assistance to refiner cooperatives who do invest in desulfurization programs. Congress and USDA have long recognized the unique circumstances of farmers and rural communities by establishing programs to provide assistance. This assistance would be primarily in the form of guaranteed loans, which could provide a significant source of funding for cooperative refiners to make capital investment in desulfurization. However, USDA's loan program is subject to limitations, including a $25 million annual cap on individual loans, so the cooperative refiners may have to acquire additional financing. EPA understands that USDA supports efforts, where appropriate, to provide assistance to farmer-owned cooperatives from other sources.

In conclusion, after reviewing this information, we have not been able to clearly distinguish a unique economic burden that today's program will place on farmer cooperative refiners, as a class, apart from other refiners, especially other refiners of similar size and/or those that are privately-held companies. However, as described above, several of the flexible provisions we have incorporated into the overall diesel sulfur program will be valuable to farmer cooperative refiners.

3. *General Hardship Provisions*

a. Temporary Waivers from Low Sulfur Diesel Requirements in Extreme Unforseen Circumstances

In this final rule, we are adopting a provision which, at our discretion, will permit domestic or foreign refiners to seek a temporary waiver from the highway diesel sulfur standards under certain rare circumstances. This waiver provision is similar to provisions in the reformulated gasoline (RFG) and low sulfur gasoline regulations. It is intended to provide refiners short-term relief in unanticipated circumstances—such as a refinery fire or a natural disaster—that cannot be reasonably foreseen now or in the near future.

Under this provision, a refiner may seek permission to distribute highway diesel fuel that does not meet the applicable low sulfur standards for a brief time period. An approved waiver of this type could, for example, allow a refiner that has reached its maximum allowable production volume of 500 ppm sulfur fuel under the temporary compliance option to temporarily and modestly exceed that volume, so long as the other conditions described below were met. Such a request will be based on the refiner's inability to produce complying highway diesel fuel because of extreme and unusual circumstances outside the refiner's control that could not have been avoided through the exercise of due diligence. The request will also need to show that other avenues for mitigating the problem, such as purchase of credits toward compliance under the temporary compliance option, had been pursued and yet were insufficient.

As with other types of relief established in this rule, this type of temporary waiver will have to be designed to prevent fuel exceeding the 15 ppm standard from being used in 2007 and later vehicles. As with the small refiner hardship provisions described above, any such waiver must show that other sources of 15 ppm fuel exist in the refiner's market area to help reduce the risk that owners of 2007 and later diesel vehicles will have difficulty finding the 15 ppm fuel they need during the period of the waiver.

The conditions for obtaining a low sulfur diesel waiver are similar to those in the RFG and low sulfur gasoline regulations. These conditions are necessary and appropriate to ensure that any waivers that are granted are limited in scope, and that refiners do not gain economic benefits from a waiver. Therefore, refiners seeking a waiver must show that the waiver is in the public interest, that the refiner was not able to avoid the nonconformity, that it will make up the air quality detriment associated with the waiver, that it will make up any economic benefit from the waiver, and that it will meet the applicable diesel sulfur standards as expeditiously as possible.

b. Temporary Waivers Based on Extreme Hardship Circumstances

In addition to the provision for short-term relief in extreme unforseen circumstances, we are adopting a provision for relief based on extreme hardship circumstances. In developing our diesel sulfur program, we considered whether any refiners would face particular difficulty in complying with the standards in the lead time provided. As described earlier in this section, we concluded that refineries owned by small businesses will experience more difficulty in complying with the standards on time because they have less ability to raise the capital necessary for refinery investments, face proportionately higher costs because of poorer economies of scale, and are less able to successfully compete for limited engineering and construction resources. However, it is possible that other refiners that are not small refiners will also face particular difficulty in complying with the sulfur standards on time. Therefore, we are including in this final rule a provision which allows us, at our discretion, to grant temporary waivers from the diesel sulfur standards based on a showing of extreme hardship circumstances.

The extreme hardship provision allows any domestic or foreign refiner to request a waiver from the sulfur standards based on a showing of unusual circumstances that result in extreme hardship and significantly affect a refiner's ability to comply with the low sulfur diesel standards by June 1, 2006. An approved extreme hardship waiver may provide refiners with provisions similar to those for small refiners, or as with the waiver for extreme unforseen circumstances, may provide a greater allowance for producing 500 ppm (for sale only for use in pre-2007 vehicles) during the period the temporary compliance option is in effect. As with other relief provisions established in this rule, any waiver under this provision must be designed to prevent fuel exceeding the 15 ppm standard from being used in 2007 and later vehicles.

By providing short-term relief to those refiners that need additional time because they face hardship circumstances, we can adopt an overall program that reduces diesel fuel sulfur beginning in 2006 for the majority of the industry. However, we do not intend for this waiver provision to encourage refiners to delay planning and investments they would otherwise make. We do not expect to grant temporary waivers that apply to more than approximately one percent of the national highway diesel fuel pool in any given year.

The regulatory language for today's action includes a complete list of the information that must be included in a refiner's application for an extreme hardship waiver. If a refiner fails to provide all the information, as specified in the regulations, as part of its hardship application, we can deem the application void. The following are some examples of the types of information that must be contained in an application:

—The crude oil refining capacity and diesel fuel sulfur level at each of the refiner's refineries.

—Details on how the refiner plans to modify its current operation to achieve future diesel fuel sulfur levels.

—The anticipated timing for the overall project the refiner is proposing and key milestones to ultimately produce 100 percent of highway diesel fuel at the 15 ppm sulfur standard.

—The refiner's capital requirements for the proposed project

—Plans for financing the project and financial statements

—List of the areas where the refiner's diesel fuel will be sold.

We will consider several factors in our evaluation of the hardship waiver applications. Such factors will include whether a refinery's configuration is unique or atypical; the proportion of diesel fuel production relative to other refinery products; whether the refiner, its parent company, and its subsidiaries are faced with severe economic limitations (for example, a demonstrated inability to raise necessary capital or an unfavorable bond rating); steps the refiner has taken to attempt to comply with the standards, including efforts to obtain credits towards compliance. In addition, we will consider the total crude oil capacity of the refinery and its parent or subsidiary corporations, if any, in assessing the degree of hardship and the refiner's role in the diesel market. Finally, we will consider where the diesel fuel will be sold in evaluating the environmental impacts of granting a waiver.

This extreme hardship provision is intended to address unusual circumstances that should be apparent now or will emerge in the near future. Thus, refiners seeking additional time under this provision must apply for relief by June 1, 2002. Applicants for a hardship waiver must also submit a plan demonstrating how they will achieve the standards as quickly as possible. In submitting the plan, applicants must include a timetable for obtaining the necessary capital, contracting for engineering and construction resources, obtaining any necessary permits, and beginning and completing construction.

We will review and act on applications and, if a waiver is granted, will specify a time period, not to extend beyond May 31, 2010, for the waiver.

*D. Technological Feasibility of the Low Sulfur Diesel Fuel Program*

This section summarizes our assessment of the feasibility of refining and distributing diesel fuel with a sulfur content of no more than 15 ppm. Based on this evaluation, we believe it is technologically feasible for refiners to meet the 15 ppm sulfur standard in the lead time provided. We are summarizing our analysis here and we refer the reader to the RIA for more details.

1. *What Technology Will Refiners Use?*

Conventional diesel desulfurization technologies have been available and in use for many years. Conventional hydrotreating technology involves combining hydrogen with the distillate (material falling into the boiling range of diesel fuel) at moderate pressures and temperatures and flowing the mixture through a fixed bed of catalyst.

We project that all refiners will be technically capable of meeting the 15 ppm sulfur cap with extensions of the same conventional hydrotreating which they are using to meet the current highway diesel fuel standard of 500 ppm sulfur. This extension will likely mean adding a second stage of conventional hydrotreating. Converting an existing one-stage hydrotreater into a two-stage hydrotreater will involve adding an additional reactor as well as other, more minor units to support the new desulfurization unit. These units could include hydrogen plants, sulfur recovery plants, amine plants and sour water scrubbing facilities. All of these units are already operating in refineries, but may have to be expanded or enlarged. We also project that all refiners will utilize recently developed, high activity catalysts, which increase the amount of sulfur that can be removed relative to the catalysts which were available when the current desulfurization units were designed and built.

While still utilizing this conventional hydrotreating technology, we expect that some refiners (roughly 20 percent of current production volume) will decide to invest in a completely new two-stage hydrotreater rather than revamp their current unit. This could occur because the current hydrotreater is too old or designed to operate at too low a pressure, or because the refiner desires to expand production of highway diesel fuel.

The sufficiency of conventional hydrotreating to meet a 15 ppm sulfur cap with current diesel fuel blendstocks is based primarily on information provided by several refining technology vendors.[174] The vendors all projected that two-stage hydrotreating would be sufficient to meet a 15 ppm sulfur cap. However, their projections of hydrogen consumption and requisite reactor volume varied widely. Our projections for hydrogen consumption and reactor volume are near the lower end of the range and are essentially the same projections as were made in support of the proposed rule.

Many refiners commented that we had underestimated the cost of meeting the 15 ppm sulfur cap. They argued that higher pressure, thick walled reactors of greater volume would be needed and that hydrogen consumption would be much higher than we projected. With one exception, neither the refiners, nor the technology vendors provided any underlying catalyst performance data with which we could use to arbitrate between the varying projections. One vendor did submit catalyst performance data from a commercial unit processing a diesel fuel like that produced in the U.S. Such commercial data is very limited, as refiners are generally not currently producing diesel fuel at sulfur levels below 10 ppm with this technology from diesel fuel feedstocks typical of U.S. refiners. Some refiners are currently producing diesel fuel at sulfur levels below either 10 or 50 ppm. However, their diesel fuel blendstocks differ substantially in quality from those available in the U.S., so their experience cannot be extrapolated easily to producing sub-15 ppm sulfur diesel fuel in the U.S.

Based on our review of the limited catalyst performance data in the published literature and the one set of confidential data submitted, we believe that the projections of the more optimistic vendors are the most accurate for the 2006 timeframe. For example, the confidential commercial data indicated that five ppm sulfur levels could be achieved with two-stage hydrotreating a moderate hydrogen pressures despite the presence of a significant amount of light cycle oil (LCO). The key factor was the inclusion of a hydrogenation catalyst in the second stage, which saturated many of the poly-nuclear, aromatic rings in the diesel fuel, allowing the removal of sulfur from the most sterically hindered compounds. In addition, refiners that are able to defer production of 15 ppm diesel fuel through the purchase of credits will have the added benefit of being able to observe the operation of those hydrotreating units starting up in 2006. This should allow these refiners to be able to select from the best technologies which are employed in the first phase of the program.

In addition, alternative technologies are presently being developed which could produce additional savings for refiners that are able to delay production of 15 ppm fuel until 2010. Phillips 66 Company, for example, just announced that they are developing a version of their S-Zorb technology for diesel fuel desulfurization. This technology has been selected by at least one major refiner (Marathon-Ashland) to meet the Tier 2/low sulfur gasoline requirements. In conjunction with a DOE research program, Phillips is designing and constructing a commercially sized S-Zorb diesel fuel unit at their Borger refinery. This unit is currently scheduled for start-up in 2004. We believe that this technology could reduce the cost of meeting the 15 ppm cap by roughly 25 percent.

2. Have These Technologies Been Commercially Demonstrated?

As mentioned above, conventional diesel desulfurization technologies have been available and in use for many years. U.S. refiners have roughly seven years of experience with this technology in producing highway diesel fuel with less than 500 ppm sulfur. Refiners in California also have the same length of experience with meeting the California 500 ppm cap on sulfur and an additional aromatics standard.[175] To meet both sulfur and aromatics standards, refineries in California are producing highway and nonroad diesel fuel with an average sulfur level of 150 ppm.

Some refiners in Europe are producing a very low-sulfur, low aromatics diesel fuel for use in the cities in Sweden (Class I Swedish Diesel) using two-stage hydrotreating. This ‘‘Swedish city diesel’’ is averaging under 10 ppm sulfur and under 10 volume percent aromatics. While clearly demonstrating the feasibility of consistently producing diesel fuel with less than 10 ppm sulfur from selected feedstocks, there are a few differences between the Swedish fuel and typical U.S. diesel fuel. First, the tight aromatics specification applicable to Swedish City diesel fuel usually requires the use of ring-opening or dearomatization catalysts in the second stage of the two-stage hydrotreating unit. Second, Swedish Class I diesel fuel also must meet a tight density specification. Third, it is not clear

[174] Technology vendors were invited to submit projections of technology and cost to two studies of the cost of diesel fuel desulfurization by Mathpro, Inc. One study was performed for EMA, and the other for the National Petroleum Council.

[175] California allows refiners to use an engine test to certify an alternative fuel mixture which meets or exceeds the $NO_X$ reducing performance of a 10 volume percent maximum aromatics and a 500 ppm maximum sulfur diesel fuel.

whether any refiner is producing a large fraction of their distillate production to this specification. Thus, the European experience demonstrates the efficacy of the two-stage process and its ability to produce very low sulfur diesel fuel. However, doing so without saturating most of the aromatics present and with heavier feedstock has only been demonstrated in pilot plants and not commercially. Even this pilot plant data has not been available for us to evaluate directly, due to vendors' competitiveness concerns.

Europe has adopted a 50 ppm cap sulfur standard for all diesel fuel which takes effect in 2005. Some countries, including England, have implemented tax incentives for refiners to produce this fuel sooner. The majority of diesel fuel in England already meets the 50 ppm specification. Refiners have reported no troubles with this technology. This diesel fuel is being produced in one-stage hydrotreaters. However, as mentioned above, European diesel fuel contains less heavier compounds than diesel fuel in the U.S., so the use of one-stage conventional hydrotreating to meet very low sulfur levels is applicable, but not sufficient to demonstrate feasibility in the U.S. Germany has also established a tax incentive, but for diesel fuel containing 10 ppm or less sulfur. One European technology vendor indicated that they have already licensed two desulfurization units to German refiners planning to produce diesel fuel to obtain this tax credit. Europe also is considering a 10 ppm sulfur cap to take effect later in the decade. However, no refiner is currently producing number two diesel fuel to this specification.

Phillips Petroleum is currently in the process of designing and constructing a commercial sized S-Zorb unit to produce sub-15 ppm diesel fuel at their Borger, Texas refinery. This plant is scheduled to begin commercial operation in 2004. This may not be in time to give refiners sufficient confidence in this novel process to rely on it to meet the 2006 deadline. However, this process, with its attendant hydrogen, cost, and global emission savings should be available for those refiners that are able to defer investment under the temporary compliance option and hardship provisions of today's rule. While we are confident that this and other technology will be available to meet the requirements of today's rule, EPA will work with the Department of Energy, refiners and technology providers to continue to monitor and analyze the progress in further developing and implementing this new diesel desulfurization technology. This will allow us to improve our understanding of how this new technology can be employed to enhance the implementation of this program.

3. Feasibility of Distributing Low Sulfur Highway Diesel Fuel

We believe that with relatively minor changes and associated costs, the existing distribution system will be capable of adequately managing sulfur contamination during the transportation of 15 ppm highway diesel fuel from the refinery through to the end-user. Further, we believe that the existing system is capable of handling two grades of highway diesel fuel (500 ppm and 15 ppm sulfur cap) in a limited fashion during the transition period of the sulfur program at acceptable cost with the addition of storage tanks at a fraction of distributor facilities.

The following minor changes in distribution practices will be needed as a result of today's rule during the transition years of the fuel program when various hardship and optional compliance provisions are in effect and thereafter:

—To adequately separate shipments of highway diesel fuel from shipments of higher sulfur products, pipeline operators will need to increase the amount of highway diesel fuel that they downgrade to a lower value product.

—Instead of cutting the mixture of jet fuel and highway diesel fuel that results during pipeline shipments of these products into the highway diesel pool, pipeline operators will need to segregate this mixture and sell it into the nonroad diesel pool. This change will necessitate the addition at some terminals of small tanks to handle the mixture of jet fuel and highway diesel fuel.

—Terminal operators will need to perform additional quality control testing to ensure compliance with the 15 ppm sulfur cap.

We also recognize that tank truck operators will need to more carefully and consistently observe current industry practices to limit contamination during the transport of 15 ppm sulfur highway diesel fuel. However, because these practices already exist and need only to be better enforced by distributors, we continue to believe that this can be accomplished at insignificant cost. We believe that there will not be a significant increase in the volume of highway diesel fuel discovered to exceed the sulfur standard downstream of the refinery as a result of today's rule. Distributors will quickly optimize the distribution system using the means described above to avoid creating additional volumes of out of specification product.

To accommodate two grades of highway diesel fuel during the transition period, additional storage tanks will need to be added at some refineries, terminals, bulk plants, and truck stops. There are significant costs associated with the addition of tanks which are fully accounted for during the transition period (see Section V). Commenters on the NPRM stated that in addition to the substantial economic burden that adding additional storage tanks would represent for some distributors, limitations in available space and permitting restrictions could preclude some distributors from installing additional tanks. This transition is also an added concern for those users of specialty fuels (i.e., military fuels, etc.) who currently compete for the limited storage tanks because these fuels must be segregated. We believe that the burden of adding new storage tanks to the system is made manageable by the fact that not all distributors will need to handle 500 ppm as well as 15 ppm sulfur highway diesel fuel during this time period. Marketplace forces will determine which facilities assume the additional burden of handling both grades of highway diesel fuel. Those facilities for which the addition of a storage tank would represent an unacceptable burden would opt not to serve the 500 ppm sulfur highway diesel market during the transition years.

We received several comments on the proposed rule that substantial uncertainties exist regarding the ability of the distribution system to adapt to the added hardship of limiting sulfur contamination of highway diesel fuel meeting a 15 ppm sulfur cap. These commenters noted that under today's rule other products in the distribution system would have a sulfur content of over 300 times the 15 ppm highway diesel fuel sulfur cap, and that unavoidable mixing of small quantities of these high sulfur products into highway diesel fuel could easily cause the 15 ppm sulfur cap to be exceeded. To illustrate the magnitude of the challenge, these commenters noted that currently the maximum sulfur content of any product that shares the distribution system with highway diesel fuel is no more than 10 times the current 500 ppm sulfur cap for highway diesel fuel.[176] Some commenters stated that the only way to adequately limit sulfur contamination in the distribution

[176] Nonroad diesel fuel has a sulfur cap of 5,000 ppm versus a 500 ppm for current highway diesel fuel.

of diesel fuel with a 15 ppm sulfur cap may be to create a completely segregated system (at an unacceptably high cost). These commenters stated that unavoidable contamination could cause many batches of highway diesel fuel to be noncompliant with the 15 ppm cap resulting in shortages and high costs. Some commenters stated that additional evaluation is needed to determine the capability of the distribution system to limit contamination to the very low levels necessitated by today's rule.

While we acknowledge that today's rule will pose a substantial new challenge to the distribution system, we believe that the additional measures outlined in this section will substantially address issues associated with adequately limiting sulfur contamination during the distribution of 15 ppm sulfur highway diesel fuel.[177] Its true that not all of the potential minute sources of sulfur contamination in the distribution sources have been identified and that the cumulative magnitude from these sources is uncertain. However, we believe that the contamination from such sources, while made more significant by the implementation of the 15 ppm sulfur cap, is not of a sufficient magnitude to jeopardize the feasibility of distributing low sulfur highway diesel fuel. We will work with the Department of Energy, refiners and others involved in diesel fuel distribution to analyze, compile data, and conduct additional research, where appropriate, to not only more fully understand all sources of contamination and deliverability in the distribution of diesel fuel below the 15ppm cap, but also their impact on the deliverability of other fuels, including specialty military fuels. This information will be used, in conjunction with information being developed on the operation of emission control devices (which are affected by exposure to sulfur), to monitor progress on the successful implementation of this final rule which depends on an integrated vehicle/fuel systems approach. Please refer to Section V.D. on the costs of today's rule to the distribution system, and to the Regulatory Impact Analysis and Response to Comments documents for additional discussion regarding the feasibility of distributing highway diesel fuel with a 15 ppm sulfur cap.

[177] See the Response to Comments document for this rule.

### *E. What Are the Potential Impacts of the Low Sulfur Diesel Program on Lubricity and Other Fuel Properties?*

#### 1. What Is Lubricity and Why Might It Be a Concern?

Engine manufacturers depend on diesel fuel lubricity properties to lubricate and protect moving parts within fuel pumps and injection systems for reliable performance. Unit injector systems and in-line pumps, commonly used in heavy-duty engines, are actuated by cams lubricated with crankcase oil, and have minimal sensitivity to fuel lubricity. However, rotary and distributor type pumps, commonly used in light and medium-duty diesel engines, are completely fuel lubricated, resulting in high sensitivity to fuel lubricity.

In the United States, there is no government or industry standard for diesel fuel lubricity. Thus, specifications for lubricity are determined by the market. Since the beginning of the 500 ppm sulfur highway diesel program in 1993, fuel system producers, engine and vehicle manufacturers, and the military have been working with the American Society for Testing and Materials (ASTM) to develop protocols and standards for diesel fuel lubricity in its D–975 specifications for diesel fuel. Although the ASTM has not yet adopted specific protocols and standards, we understand that refiners have been treating diesel fuel with lubricity additives on a batch to batch basis, when poor lubricity fuel is expected. In addition, the military has found that traditional corrosion inhibitor additives that it uses in its fuels have been highly effective in reducing fuel system component wear. Some commenters expressed concern about the impacts of a 15 ppm standard on fuel lubricity.

Experience has shown that it is very rare for a naturally high-sulfur fuel to have poor lubricity, although, most studies show relatively poor overall correlation between sulfur content and lubricity. Considerable research remains to be performed for a better understanding of the fuel components most responsible for lubricity. Consequently, we are uncertain about the potential impacts of the 15 ppm sulfur standard on fuel lubricity. There is evidence that the typical process used to remove sulfur from diesel fuel—hydrotreating—can impact lubricity depending on the severity of the treatment process and characteristics of the crude. Because refiners will likely rely on hydrotreating to achieve the proposed sulfur limit, there may be reductions in the concentration of those components of diesel fuel which contribute to adequate lubricity. As a result, the lubricity of some batches of fuel may be reduced compared to today's levels, resulting in an increased need for the use of lubricity additives in highway diesel fuel. In response to the proposal, all comments submitted regarding lubricity either stated or implied that the proposed sulfur standard of 15 ppm would likely cause the refined fuel to have lubricity characteristics that would be inadequate to protect fuel injection equipment, and that mitigation measures such as lubricity additives would be necessary. However, the commenters suggested varied approaches for addressing lubricity. For example, some suggested that we need to establish a lubricity requirement by regulation, but others suggested that the current voluntary (market) system would be adequate. The Department of Defense recommended that we encourage the industry (ASTM) to adopt lubricity protocols and standards before the implementation date of the low sulfur fuel established by today's action. Other suggested approaches included incorporation of biodiesel as a solution to the lubricity issue, and the need to further examine the issues.

Blending small amounts of lubricity-enhancing additives increases the lubricity of poor-lubricity fuels to acceptable levels. These additives are available in today's market, are effective, and are in widespread use around the world. For example, in the U.S., we understand that refiners are treating diesel fuel with lubricity additives on a batch to batch basis, when poor lubricity fuel is expected. Other examples include Sweden, Canada, and the U.S. military. Since 1991, the use of lubricity additives in Sweden's 10 ppm sulfur Class I fuel and 50 ppm sulfur Class II fuel has resulted in acceptable equipment durability.[178] Since 1997, Canada has required that its 500 ppm sulfur diesel fuel not meeting a minimum lubricity be treated with lubricity additives. The U.S. military has found that the traditional corrosion inhibitor additives that it uses in its fuels have been highly effective in reducing fuel system component wear.

#### 2. Today's Action on Lubricity: A Voluntary Approach

We have decided to not establish a lubricity standard in today's action, but have included a 0.2 cents per gallon cost in our calculations for the economic

[178] See letter from MTC to Michael P. Walsh, dated October 16, 2000. In public docket, document IV–G–42.

impact to account for the potential increased use of lubricity additives (see section V.D.2). We believe the best approach is to allow the industry and the market to address the lubricity issue in the most economical manner, while avoiding an additional regulatory scheme. A voluntary approach should provide adequate customer protection from engine failures due to low lubricity, while providing the maximum flexibility for the industry. This approach will be a continuation of current industry practices for diesel fuel produced to meet the current federal and California 500 ppm sulfur diesel fuel specifications, and benefits from the considerable experience gained since 1993. It will also include any new specifications and test procedures that we expect will be adopted by the American Society for Testing and Materials (ASTM) regarding lubricity of highway diesel fuel quality.

We do not believe that an EPA regulation for lubricity is appropriate for several reasons. First, the expertise and mechanism for a lubricity standard already exist in the industry. According to the comments, the industry has been working on a lubricity specification for ASTM D–975, and low cost remedies for poor lubricity have already been proven and are already being used around the world. Although some commenters expressed concerns that the ASTM process might move too slowly to establish a lubricity specification by 2006, we fully expect the refining industry, engine manufacturers and end users to work together to resolve any issues as part of their normal process in dealing with customer and supplier fuel quality issues. Today's action will increase the urgency of those working to establish an ASTM D–975 lubricity specification, and we believe they will do so in time for the production and distribution of the low sulfur highway diesel fuel. We will do our part to encourage the ASTM process be brought to a successful conclusion.

Second, we have no firm basis to justify a lubricity specification in today's action. One such basis might be adequate demonstration that a lubricity level below or above a certain specification would either cause emissions to increase, or hinder the operation of emission control equipment. However, we have no evidence that lubricity impacts emissions, or emission control equipment. This issue is primarily a concern about equipment performance. Equipment performance is more appropriately addressed by the industry rather than government regulation by this Agency.

Third, even if we had a statutory basis to justify a lubricity standard, we are concerned that establishing an EPA lubricity regulation would provoke the same disagreements that the industry is now engaged in its efforts to establish an ASTM D–975 specification. We are in no better position to judge those issues than the industry experts who are already involved. Further, once a specification is put into the regulations and the industry subsequently determines that the specification should be changed, based on new information or circumstances, the burden would be on us to amend the mandated specification by rulemaking. This is a significant burden to put on the Agency for an engine performance issue that can and should be resolved by the industry without government intervention.

Subsequent to the close of the comment period another issue related to lubricity concerns was raised to the Agency. These concerns related to potential incompatibilities in old vehicles of the new engine oils the industry hopes to develop for use in the new 2007 and later model year vehicles. Much of the ash in today's motor oil results from the need to control acidification of the engine oil (maintain total base number, or TBN control), which is in large part a function of the sulfur content of the fuel and the sulfuric acid that it forms. Without the ability to control acidification of the engine oil, engine wear increases significantly. The ash in the oil, however, will tend to shorten the maintenance intervals for particulate filters to remove built up ash on new 2007 and later model year vehicles. At the same time, engines operated on low sulfur fuel have much less need for TBN control and the high ash levels that result. Consequently, manufacturers are investigating with the lubricant industry the potential of lower ash oils for use in engines operated on low sulfur diesel fuel and equipped with particulate traps. If the new oil developed is not ''backwards compatible'' to sufficiently control acidification and wear in the pre-existing fleet of vehicles on the road that may still be operated on high sulfur diesel fuel for the first few years of the program, then two grades of motor oil would have to be on the market simultaneously. This has caused some stakeholders to raise vehicle performance and durability concerns that might result from using the new oil in the old vehicles—namely ''mis-oiling.''

Since the engine and lubricant industries still have a number of years to develop these new oil formulations, it is still premature to determine whether or not the new oils will be backwards compatible and whether mis-oiling would raise any serious concerns. While this would not appear to be an air quality concern and as such something the Agency generally leaves up to the industry to resolve, we will nevertheless offer to work with the industry and industry associations on this issue over the coming years.'' EPA anticipates that engine manufacturers would likely provide engine labels to distinguish low ash oil from high ash oil because misoiling could result in engine damage.

3. What Are Today's Actions on Fuel Properties Other Than Sulfur?

We are not taking action today on any fuel properties other than sulfur. We have examined the impact of fuel properties other than sulfur, such as aromatics, on the materials used in engines and fuel supply systems. We do not believe there will be impacts on materials from such other fuel properties.

While there were some problems with leaks from fuel pump O-ring seals made of a certain material (Nitrile) after the introduction of 500 ppm sulfur diesel fuel in the United States in 1993, these issues have since been addressed by equipment manufacturers who switched to materials that are compatible with low aromatic fuels. The leakage from the Nitrile seals was determined to be due to low aromatics levels in some 500 ppm sulfur fuel, not the low sulfur levels. In the process of lowering the sulfur content of some fuel, some of the aromatics had also been removed. Normally, the aromatics in the fuel penetrate the Nitrile material and cause it to swell, thereby providing a seal with the throttle shaft. When low-aromatics fuel is used after conventional fuel has been used, the aromatics already in the swelled O-ring will leach out into the low-aromatics fuel. Subsequently, the Nitrile O-ring will shrink and pull away, thus causing leaks, or the stress on the O-ring during the leaching process will cause it to crack and leak. Not all 500 ppm sulfur fuels caused this problem, because the amount and type of aromatics varied. Fuel pumps using a different material (Viton) for the seals did not experience leakage. We believe that no additional problems will occur with a change of fuel from 500 to 15 ppm sulfur.

*F. How Are State Programs Affected by the Low Sulfur Diesel Program?*

1. State Preemption

Section 211(c)(4)(A) of the CAA prohibits states (and political subdivisions of states) from prescribing or attempting to enforce controls or prohibitions respecting any fuel characteristic or component if EPA has prescribed a control or prohibition applicable to such fuel characteristic or component under section 211(c)(1). This preemption applies to all states except California, as explained in section 211(c)(4)(B). For states other than California, the Act provides two mechanisms for avoiding preemption. First, section 211(c)(4)(A)(ii) creates an exception to preemption for state prohibitions or controls that are identical [179] to the prohibition or control adopted by EPA. Second, states may seek EPA approval of SIP revisions containing fuel control measures, as described in section 211(c)(4)(C). We may approve such SIP revisions, and thereby ''waive'' preemption, only if it finds the state control or prohibition ''is necessary to achieve the national primary or secondary ambient air quality standard which the plan implements.''

When we adopted the current highway diesel fuel sulfur standard of 500 ppm pursuant to our authority under section 211(c)(1) of the CAA in 1990, States were preempted from also doing so under the provisions of section 211(c)(4)(A). The 15 ppm highway diesel fuel sulfur standard promulgated today modifies the existing standard and, as a result, do not initiate any new preemption of state authority. Today's action continues the explicit preemption under section 211(c)(4)(A) of state actions to prescribe or enforce highway diesel fuel sulfur controls. States other than California with highway diesel fuel sulfur control programs not already approved into their SIPs are preempted under Section 211(c)(4)(A) and will therefore need to obtain a waiver from us under the provisions described in section 211(c)(4)(C) for all state fuel sulfur control measures, unless the state control or prohibition is identical to ours.

Aside from the explicit preemption in Section 211(c)(4)(A), a court could also consider whether a state sulfur control is implicitly preempted under the Supremacy Clause of the U.S. Constitution. Courts have determined that a state law is preempted by federal law where the state requirement actually conflicts with federal law by preventing compliance with both federal and state requirements, or by standing as an obstacle to accomplishment of Congressional objectives. A court could thus consider whether a given state sulfur control is preempted, notwithstanding waiver of preemption under 211(c)(4)(C), if it places such significant cost and investment burdens on refiners that refiners cannot meet both state and federal requirements in time, or if the state control would otherwise meet the criteria for conflict preemption.

2. What Provisions Apply in Alaska?

There are important nationwide environmental and public health benefits that will be achieved with cleaner diesel engines and fuel, particularly from reduced particulate emissions, nitrogen oxides, and air toxics (as further discussed in section II). Therefore, it is also important to implement this program in Alaska. Any 2007 and later model year diesel vehicles in Alaska, or driven to Alaska, must be fueled with low sulfur highway diesel, or risk potential damage to the aftertreatment technologies or even the engines themselves. Although the engine standards established today are not based upon different technology and cost implications for Alaska as compared to the rest of the country, the low sulfur fuel program has different implications.

Unlike the rest of the nation, Alaska is currently exempt from the 500 ppm sulfur standard for highway diesel fuel and dye requirements. Since the beginning of the 500 ppm highway diesel fuel program, we have granted Alaska exemptions from meeting the sulfur standard and dye requirements, because of its unique geographical, meteorological, air quality, and economic factors. (These unique factors are discussed generally in this section, and in more detail in the RIA.) Because of these unique factors, we are establishing in today's action an alternative option for implementing the low sulfur fuel program in Alaska.

We are providing the State of Alaska an opportunity to develop an alternative low sulfur transition plan. We intend to facilitate the development of this plan by working in close cooperation with the state and key stakeholders. This plan must ensure that sufficient supplies of low sulfur diesel fuel are available in Alaska to meet the demand of any new 2007 and later model year diesel vehicles. Given that Alaska's demand for highway diesel fuel is very low and only a small number of new diesel vehicles are introduced in Alaska each year, it may be possible to develop an alternative implementation plan for Alaska in the early years of the program that provides low sulfur diesel only in sufficient quantities to meet the demand from the small number of new diesel vehicles. This would give Alaska refiners more flexibility during the transition period because they would not have to desulfurize the entire highway diesel volume. Our goal in offering this additional flexibility is to transition Alaska into the low sulfur fuel program in a manner that minimizes costs, while still ensuring that the new vehicles receive the low sulfur fuel they need. We expect that the transition plan will begin to be implemented at the same time as the national program, but the state will have an opportunity to determine what volumes of low sulfur fuel must be supplied, and in what timeframes, in different areas of the state.

At a minimum, this transition plan must: (1) Ensure an adequate supply (either through production or imports) of 15 ppm fuel to meet the demand of any 2007 or later model year vehicles, (2) ensure sufficient retail availability of low sulfur fuel for new vehicles in Alaska, (3) address the growth of supply and availability over time as more new vehicles enter the fleet, (4) include measures to ensure segregation of the 15 ppm fuel and avoid contamination and misfueling, and (5) ensure enforceability. We anticipate that, to develop a workable transition plan, the state will likely work in close cooperation with refiners and other key stakeholders, including retailers, distributors, truckers, engine manufacturers, environmental groups, and other interested groups. For example, the state will likely rely on input from the trucking industry in determining the expected low sulfur fuel volume needed in Alaska, based on the anticipated number of new vehicles, and how this volume is expected to grow during the first few years of the program. Similarly, the state will likely rely on the Alaska refiners' input regarding plans for supplying (either through production or imports) low sulfur fuel to meet the expected demand. Further, the state will likely rely on input and cooperation from retailers and distributors to determine at which locations the low sulfur fuel should be made available. Retailers offering low sulfur fuel will have to take measures to prevent misfueling, such as pump labeling, which must include

[179] In evaluating whether a state fuel prohibition or control is ''identical'' to a prohibition or control adopted by us, we might consider but is not limited to the following factors in comparing the measures: (1) The level of an emission reduction or pollution control standard for any particular batch of diesel fuel; (2) the use of ''per gallon'' or ''averaged'' amounts in setting that level; (3) the lead time allowed to the affected industry for compliance; (4) the test method(s) and sampling requirements used in determining compliance; and (5) reporting and recordkeeping requirements.

provisions that are at least as stringent as those required of retailers nationally by the regulations and as described in section VII. Similarly, all parties in the distribution system must ensure the low sulfur fuel remains segregated and must take measures to prevent sulfur contamination, in a manner that is at least as stringent as that required nationally by the regulations and as described in section VII.

If the state anticipates that the primary demand for low sulfur fuel will be along the highway system (e.g., to address truck traffic from the lower-48 states) in the early years of the program, then the initial stages of the transition plan could be focused in these areas. We believe it would be appropriate for the state to consider an extended transition schedule for implementing the low sulfur program in rural Alaska, as part of the state's overall plan, based on when they anticipate the introduction of a significant number of 2007 and later model year vehicles in the remote areas.

Under this approach, the state will be given the opportunity to develop such a transition plan, as an alternative to the national program, and submit it to us for approval. We intend to help facilitate the development of the plan, by working closely with the state and the relevant stakeholders so they will have an opportunity to address our concerns in their submittal. It is our intent that any flexibility that is available to small refiners nationwide (as described in Section IV) will also be available to small refiners in Alaska under an approved alternative transition plan. To ensure that refineries and other affected parties will have certainty regarding their regulatory requirements with adequate lead time, Alaska must submit this plan by April 1, 2002 (approximately one year after the effective date of today's rule). If Alaska submits such a plan to us within one year, and if it provides a reasonable alternative as described above, we will conduct a rulemaking with notice for public comment and then publish a final rule promulgating the new regulatory scheme for Alaska. Our intent is to issue such a final rule within one year of Alaska's submittal of the plan. However, if the state chooses not to submit an alternative plan, or if the plan it submits does not provide a reasonable alternative for Alaska as described above, then refiners and other regulated parties in Alaska will be subject to the national program, including the implementation schedule established in today's action, without further regulatory action.

a. Today's Action Regarding the 500 ppm Standard in Alaska

We are extending the existing temporary exemption from the current diesel fuel sulfur standard of 500 ppm for the areas of Alaska served by the Federal Aid Highway System (FAHS) to the effective date for the new standard (*i.e.,* June 1, 2006 at the refinery level; July 15, 2006 at the terminal level; and September 1, 2006 at all downstream locations). While Alaska submitted a petition for a permanent exemption from the 500 ppm standard for these areas, we are not taking further action on that petition. Our goal is to take action on that petition in a way that minimizes costs through Alaska's transition to the new low sulfur program. The cost of compliance could be reduced if Alaska refiners were given the flexibility to meet the low sulfur standard in one step, rather than two steps (*i.e.,* once for the current 500 ppm sulfur standard in 2004 when the temporary exemption expires, and again for the new 15 ppm standard in 2006).

As already discussed, we are allowing Alaska to develop an alternative transition plan for implementing the low sulfur diesel fuel program. During such a transition period, it is possible that both low sulfur diesel fuel (for 2007 and later model year vehicles) and higher sulfur (for older vehicles) highway fuels might be available in Alaska. To avoid the two-step sulfur program described above during an alternative transition period, we will consider additional extensions to the temporary exemption of the 500 ppm standard beyond 2006 (*e.g.,* for that portion of the highway diesel pool that is available for the pre-2007 vehicles) during Alaska's transition period. We will make a decision on any additional temporary extensions, if appropriate, in the context of the separate rulemaking taking action on the alternative transition plan submitted by Alaska.

As in previous actions to grant Alaska sulfur exemptions, we will not base any vehicle or engine recall on emissions exceedences caused by the use of high-sulfur (>500 ppm) fuel in Alaska during the period of the temporary sulfur exemption. Our in-use testing goals are to establish whether representative engines, when properly maintained and used, will meet emission standards for their useful lives. These goals are consistent with the requirements for recall outlined in Section 207(c)(1) of the CAA. Further, manufacturers may have a reasonable basis for denying emission related warranties where damage or failures are caused by the use of high sulfur fuel in Alaska.

The Engine Manufacturers Association commented that the level of protection provided to engine manufacturers under the current exemption for Alaska and the proposal, as described above, falls short of what is reasonable and necessary. It asserted that the use of high sulfur diesel fuel by an engine should raise a ''rebuttable presumption'' that the fuel has caused the engine failure, and that EPA should have the burden of rebutting that presumption. It also asserted that the emissions warranty is a regulatory requirement under Section 207, that only EPA has the authority to exclude claims based on the use of high sulfur diesel fuel. We understand and concur with the manufacturers' concerns about in-use testing of engines operated in an area exempt from fuel sulfur requirements. Consequently, we affirm that, for recall purposes, we will not seek to conduct or cause the in-use testing of engines we know have been exposed to high sulfur fuels. We will likely screen any engines used in our testing program to see if they have been operated in the exempt area. We believe we can readily obtain sufficient samples of engines without testing engines from exempt areas. Also, in any recall that we order, manufacturers have the option of requesting a public hearing. The use of engines that have seen high sulfur fuel will increase the likelihood of a recall hearing. We expect manufacturers to scrutinize any test engines for sulfur usage that were used to justify an ordered recall. In reviewing the warranty concerns of the Engine Manufacturers Association, we have determined that our position regarding warranties, as previously stated and described above, is consistent with section 207(a) and (b) of the CAA and does not require any new or amended regulatory language to implement.

Today's action also grants Alaska's request for a permanent exemption from the dye requirement of 40 CFR 80.29 and 40 CFR 80.446 for the entire state. The costs of complying with the low sulfur (both the current 500 ppm sulfur and new 15 ppm sulfur) diesel fuel requirements could be reduced significantly if Alaska were not required to dye the non-highway fuel. Dye contamination of other fuels, particularly jet fuel, is a serious potential problem. This is a serious issue in Alaska since the same transport and storage tanks used for jet fuel (which is more than half of Alaska's distillate market) are generally also used for other diesel products, including off-highway diesel products which are required to be dyed under the current national program. This issue is discussed further in the RIA (Chapter VIII).

b. Why Are We Treating Alaska Uniquely?

Section 211(i)(4) of the Clean Air Act (CAA) provides that the states of Alaska and Hawaii may seek an exemption from the diesel fuel sulfur standard (500 ppm as specified in section 211(i)) in the same manner as provided in section 325 of the CAA. The requested exemption could be granted if EPA determines that compliance with such requirement is not feasible or is unreasonable due to unique geographical, meteorological, or economic factors of the territory, or other local factors as EPA considers significant.

On February 12, 1993, Alaska submitted a petition under section 325 of the CAA to exempt highway vehicle diesel fuel in Alaska from paragraphs (1) and (2) of section 211(i) of the CAA, except for the minimum cetane index requirement.[180] The petition requested that we temporarily exempt highway vehicle diesel fuel in communities served by the FAHS from meeting the sulfur content (500 ppm) specified in section 211(i) of the CAA and the dye requirement for non-highway diesel fuel of 40 CFR 80.29, until October 1, 1996. The petition also requested a permanent exemption from those requirements for areas of Alaska not reachable by the FAHS'the remote areas. On March 22, 1994, (59 FR 13610), we granted the petition based on geographical, meteorological, air quality, and economic factors unique to Alaska.

On December 12, 1995, Alaska submitted a petition for a permanent exemption for all areas of the state served by the FAHS, that is, those areas covered only by the temporary exemption. On August 19, 1996, we extended the temporary exemption until October 1, 1998 (61 FR 42812), to give us time to consider comments to that petition that were subsequently submitted by stakeholders. On April 28, 1998 (63 FR 23241) we proposed to grant the petition for permanent exemption. Substantial public comments and substantive new information were submitted in response to the proposal. To give us time to consider those comments and new information, we extended the temporary exemption for another nine months until July 1, 1999 (September 16, 1998, 63 FR 49459). During this time period, we started work on a nationwide rule to consider more stringent diesel fuel requirements, particularly for the sulfur content (today's action). To coordinate the decision on Alaska's request for a permanent exemption with the new nationwide rule on diesel fuel quality, we extended the temporary exemption until January 1, 2004 (June 25, 1999, 64 FR 34126).

As discussed in the previous section, in today's action we are extending the temporary exemption from the 500 ppm diesel fuel sulfur standard to the effective date for the new nationwide 15 ppm diesel fuel sulfur standard in 2006. While it is important to implement in Alaska the cleaner diesel engines and fuel of today's action, our goal is to take action on the petition in a way that minimizes costs through Alaska's transition to the new low sulfur program. The cost of compliance could be reduced if Alaska refiners were given the flexibility to meet the low sulfur standard in one step (i.e., going straight from uncontrolled levels to the 15 ppm sulfur standard), rather than in two steps. We considered the prior public comments we received as a result of our previous notices and actions regarding exemptions from the 500 ppm sulfur standard for highway diesel fuel in Alaska (see RIA).

Unlike in the rest of the country, diesel fuel consumption for highway use in Alaska represents only five percent of the State's total distillate fuel consumption. Aviation and marine applications, power generation and heating consume most of the distillate, while Alaska's highway diesel vehicle fleet is relatively small, particularly outside the FAHS. The state estimates that there are less than 9000 diesel vehicles in the entire state, with less than 600 of these vehicles in all of rural Alaska. The state also indicates that new model vehicles are introduced into the Alaska market at a slower rate than elsewhere, thus Alaska does not need to transition its highway fuel to low sulfur as quickly as the rest of the nation.

Most of the fuel consumed in Alaska is produced by refineries located in Alaska. This is primarily because of the more severe cloud point specification needed for the extremely low temperatures experienced in much of Alaska during the winter and the high cost to import fuel that is produced elsewhere. There are four commercial refineries in Alaska. Only one of these refineries currently has any desulfurization capacity, which is relatively small. Consequently, because these refineries will have to reduce sulfur from uncontrolled levels to meet the new 15 ppm standard established by today's action, these refineries could incur substantially higher costs than those in the rest of the nation. Given the very small highway diesel demand, however, it is doubtful that more than one or two Alaska refineries will choose to produce low sulfur highway fuel, and these refiners could even decide to import it from refineries outside of Alaska.

Further, Alaska's fuel distribution system faces many unique challenges. Unlike the rest of the country, because of its current exemption from the 500 ppm sulfur standard and dye requirements, Alaska does not currently segregate highway diesel fuel from that used for off-road, marine, heating oil, and other distillate uses. Therefore, the distribution system costs for segregating a low sulfur grade of diesel for highway uses will be significant. The existing fuel storage facilities limit the number of fuel types that can be stored. In addition to significant obstacles to expanding tankage in Alaska, the cost of constructing separate storage facilities, and providing separate tanks for transporting low sulfur diesel fuel (e.g., by barge or truck), could be significant. Most of Alaska's communities rely on barge deliveries, and ice formation on the navigable waters during the winter months restricts fuel delivery to these areas. Construction costs are 30 percent higher in Alaska than in the lower-48 states, due to higher costs for freight deliveries, materials, electrical, mechanical, and labor. There is also a shorter period of time during which construction can occur, because of seasonal extremes in temperature and the amount of daily sunlight.

The severe impacts to Alaska's fuel distribution system of implementing a low sulfur requirement for highway diesel fuel would likely occur whether we require the current 500 ppm standard or the new 15 ppm standard. The impacts to Alaska's refineries and fuel importers are greater at 15 ppm than at 500 ppm. It is likely that the refiners and fuel importers would have a significant incremental impact if we required Alaska to implement the 500 ppm diesel fuel sulfur standard in 2004 when the current exemption expires, and the 15 ppm diesel fuel sulfur standard in 2006 when the new national requirement becomes effective, rather than only once for the 15 ppm diesel fuel sulfur standard in 2006.

[180] Copies of information regarding Alaska's petition for exemption, subsequent requests by Alaska, public comments received, and actions by EPA area available in public docket A–96–26.

3. What Provisions Apply in American Samoa, Guam, and the Commonwealth of Northern Mariana Islands?

a. Today's Action Regarding the Highway Diesel Fuel Standard in the Territories

As we proposed, today's action excludes American Samoa, Guam and the Commonwealth of Northern Mariana Islands from the new diesel fuel sulfur requirement of 15 ppm and the 2007 heavy-duty diesel vehicle and engine emissions standards, and other requirements associated with those emission standards. The territories will continue to have access to 2006 heavy-duty diesel vehicle and engine technologies, at least as long as manufacturers choose to market those technologies. We will not, however, allow the emissions control technology in the territories to backslide from those available in 2006. If, in the future, manufacturers choose to market only heavy-duty diesel vehicles and engines with 2007 and later emission control technologies, we believe the market will determine when and if the territories will make the investment needed to obtain and distribute the low sulfur diesel fuel necessary to support these technologies.

This exclusion from emission standards does not apply to the new heavy-duty gasoline engine and vehicle emission standards, because low sulfur gasoline that complies with our regulations will be available, and so concerns about damage to engines and emissions control systems will not exist. This exclusion from emission standards also does not apply to light-duty diesel vehicles and trucks because gasoline vehicles and trucks meeting the emission standards and capable of fulfilling the same functions will be available. We believe that the market will determine when and if having access to new light-duty diesel technologies in the territories, in place of or in addition to gasoline technologies, is important enough to obtain and distribute the low sulfur diesel fuel needed to support those technologies.

As we also proposed, we are requiring all heavy-duty diesel motor vehicles and engines for these territories to be certified and labeled to the applicable requirements (either to the 2006 model year standards and associated requirements under the exclusion, or to the standards and associated requirements applicable for the model year of production under the nationwide requirements) and warranted, as otherwise required under the Clean Air Act and EPA regulations. Special recall and warranty considerations due to the use of excluded high sulfur fuel are the same as those for Alaska during its exemption and transition periods (see the discussion in previous section). To protect against this exclusion being used to circumvent the emission requirements applicable to the rest of the United States (*i.e.,* continental United States, Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands) after 2006 by routing exempted (pre-2007 technology) vehicles and engines through one of these territories, we are restricting the importation of vehicles and engines from these territories into the rest of the United States. After the 2006 model year, diesel vehicles and engines certified under this exclusion to meet the 2006 model year emission standards for sale in American Samoa, Guam and the Commonwealth of the Northern Mariana Islands will not be permitted entry into the rest of the United States.

b. Why Are We Treating These Territories Uniquely?

Unlike the rest of the nation (except Alaska), these territories are currently exempt from the 500 ppm sulfur standard for highway diesel fuel. Section 325 of the CAA provides that upon request of Guam, American Samoa, the Virgin Islands, or the Commonwealth of the Northern Mariana Islands, we may exempt any person or source, or class of persons or sources, in that territory from any requirement of the CAA, with some specific exceptions. The requested exemption could be granted if we determine that compliance with such requirement is not feasible or is unreasonable due to unique geographical, meteorological, or economic factors of the territory, or other local factors as we consider significant.

Prior to the effective date of the current highway diesel sulfur standard of 500 ppm, the territories of American Samoa, Guam and the Commonwealth of Northern Mariana Islands petitioned us for an exemption under section 325 of the CAA from the sulfur requirement under section 211(i) of the CAA and associated regulations at 40 CFR 80.29. The petitions were based on geographical, meteorological, air quality, and economic factors unique to those territories. We subsequently granted the petitions.[181]

These U.S. territories are islands with limited transportation networks. Combined, these three territories have only approximately 1300 registered diesel vehicles. Diesel fuel consumption in these vehicles represents just a tiny fraction of the total diesel fuel volume consumed on these islands; the bulk of diesel fuel is burned in marine, nonroad, and stationary applications. Consequently highway diesel vehicles are believed to have a negligible impact on the air quality in these territories, which, with minor exceptions, is very good.

All three of these territories lack internal petroleum supplies and refining capabilities and rely on long distance imports. Given their remote location from Hawaii and the U.S. mainland, most petroleum products are imported from East rim nations, particularly Singapore. Although Australia, the Philippines, and certain other Asian countries have or will soon require low sulfur diesel fuel, their sulfur limit is 500 ppm, not the new 15 ppm sulfur limit established by today's action for the United States. Compliance with low sulfur (15 ppm) requirements for highway fuel would require construction of separate storage and handling facilities for small quantities of a unique grade of diesel fuel for highway purposes, or use of low sulfur (15 ppm) diesel fuel for all purposes to avoid segregation. Either of these alternatives would require importation of the low sulfur fuel from Hawaii or the U.S. mainland, and would significantly add to the already high cost of diesel fuel in these territories, which rely heavily on United States support for their economies.

*G. Refinery Air Permitting*

Prior to making diesel desulfurization changes, some refineries may be required to obtain a preconstruction permit, under the New Source Review (NSR) program, from the applicable state/local air pollution control agency.[182] We believe that today's program provides sufficient lead time for refiners to obtain any necessary NSR permits well in advance of the compliance date. Further, refiners will be able to stagger their construction of desulfurization projects, since many

[181] See 57 FR 32010, July 20, 1992 for American Samoa; 57 FR 32010, July 30, 1992 for Guam; and 59 FR 26129, May 19, 1994 for CNMI.

[182] Hydrotreating diesel fuel involves the use of process heaters, which have the potential to emit pollutants associated with combustion, such as $NO_X$, PM, CO and $SO^2$. In addition, reconfiguring refinery processes to add desulfurization equipment could increase fugitive VOC emissions. The emissions increases associated with diesel desulfurization will vary widely from refinery to refinery, depending on many source-specific factors, such as crude oil supply, refinery configuration, type of desulfurization technology, amount of diesel fuel produced, and type of fuel used to fire the process heaters.

refineries could take advantage of the temporary compliance option for low sulfur diesel fuel from 2006–2009, as described in Section IV.A. Although some refiners commented that obtaining air permits would be a factor in their ability to comply in the 2006 time frame, state/local agencies commented that they will make the issuance of permits a top priority, because they strongly support achieving the environmental objectives of the low sulfur highway diesel program. State/local agencies further commented that they are committed to working with all affected parties to expedite the processing and issuance of any necessary permits.

For the Tier 2/gasoline sulfur control program promulgated in December 1999, refiners had expressed concerns that permit delays might impede their ability to meet compliance dates. Although we believed that the Tier 2 program provided sufficient lead time for refiners to obtain permits, we committed to undertake several actions to minimize the possibility of any delays for refineries obtaining major NSR permits for gasoline desulfurization projects. These actions include providing federal guidance on emission control technologies[183] and the appropriate use of motor vehicle emission reductions (resulting from the use of low sulfur gasoline), where available, as emission offsets, as well as forming EPA permit teams to assist states in quickly resolving issues, where needed. These three items are discussed in more detail in the Tier 2 final rule (see 65 FR 6773, Feb. 10, 2000).

Given that today's diesel sulfur program provides more than five years of lead time, as well as an additional transitional period, we believe refiners will have ample time to obtain any necessary preconstruction permits. Nevertheless, we believe it is reasonable to continue our efforts under the Tier 2 program, as described above, to help states in facilitating the issuance of permits under the highway diesel sulfur program. For example, the guidance on BACT and LAER control technology that is currently under development for the gasoline sulfur program should have application for diesel desulfurization projects as well. We will plan to reevaluate this guidance to the extent that it may need to be revised or updated for application to highway diesel desulfurization projects. Similarly, we believe the concept of EPA permit teams for gasoline sulfur projects could readily be extended to permits related to diesel projects as well. These teams will track the overall progress of permit issuance and will be available to assist state/local permitting authorities, refineries and the public upon request to resolve site-specific permitting questions. Further, in Tier 2, we announced our plan to issue guidance to help states determine whether and to what extent they may wish to use vehicle emissions reductions as offsets for refineries implementing gasoline desulfurization projects. We are currently in the process of evaluating public comments received on the draft guidance relating to the use of Tier 2 reductions as refinery offsets. Whatever resolution we determine is appropriate for this guidance in the Tier 2 context, we plan to apply a similar approach for diesel desulfurization projects as well. Finally, to facilitate the processing of permits, we encourage refineries to begin discussions with permitting agencies and to submit permit applications as early as possible.

[183] Best Available Control Technology (BACT) and Lowest Achievable Emission Rate (LAER) technology.

## V. Economic Impact

This Section discusses the projected economic impact and cost effectiveness of the emission standards and low-sulfur fuel requirement. Full details of our cost and cost effectiveness analyses can be found in the RIA.

### *A. Cost for Diesel Vehicles to Meet Emissions Standards*

#### 1. Summary of New System and Operating Costs

The technologies described in Section III represent significant technological advancements for controlling emissions, but also make clear that much effort remains to develop and optimize these new technologies for maximum emission-control effectiveness with minimum negative impacts on engine performance, durability, and fuel consumption. On the other hand, it has become clear that manufacturers have a great potential to advance beyond the current state of understanding by identifying aspects of the key technologies that contribute most to hardware or operational costs or other drawbacks and pursuing improvements, simplifications, or alternatives to limit those burdens. To reflect this investment in long-term cost savings potential, the cost analysis includes an estimated $385 million in R&D outlays for heavy-duty engine designs and $220 million in R&D for catalysts systems giving a total R&D outlay for improved emission control of more than $600 million. The cost and technical feasibility analyses accordingly reflect substantial improvements on the current state of technology due to these future developments.

Estimated costs are broken into additional hardware costs and life-cycle operating costs. The incremental hardware costs for new engines are comprised of variable costs (for hardware and assembly time) and fixed costs (for R&D, retooling, and certification). Total operating costs include the estimated incremental cost for low-sulfur diesel fuel, any expected increases in maintenance cost or fuel consumption costs along with any decreases in operating cost expected due to low-sulfur fuel. Cost estimates based on these projected technology packages represent an expected incremental cost of engines in the 2007 model year. Costs in subsequent years will be reduced by several factors, as described below. Separate projected costs were derived for engines used in three service classes of heavy-duty diesel engines. All costs are presented in 1999 dollars.

The costs of these new technologies for meeting the 2007 model year standards are itemized in the RIA and summarized in Table V.A–1. For light heavy-duty vehicles, the cost of an engine is estimated to increase by $1,990 in the early years of the program reducing to $1,170 in later years and operating costs over a full life-cycle to increase by approximately $500 in the near term. For medium heavy-duty vehicles the cost of a new engine is estimated to increase by $2,560 initially decreasing to $1,410 in later years with life-cycle operating costs increasing by approximately $900 in the near term. Similarly, for heavy heavy-duty engines, the vehicle cost in the first year is expected to increase by $3,230 decreasing to $1,870 in later years. Estimated additional life-cycle operating costs for heavy heavy-duty engines in the near term are approximately $3,800. The higher incremental increase in operating costs for the heavy heavy-duty vehicles is due to the larger number of miles driven over their lifetime (714,000 miles on average) and their correspondingly high lifetime fuel usage. Emission reductions are also proportional to VMT and so are significantly higher for heavy heavy-duty vehicles.

We also believe there are factors that will cause cost impacts to decrease over time, making it appropriate to distinguish between near-term and long term costs. Research in the costs of manufacturing has consistently shown that as manufacturers gain experience in production, they are able to apply innovations to simplify machining and assembly operations, use lower cost materials, and reduce the number or complexity of component parts.[184] Our analysis, as described in more detail in the RIA, incorporates the effects of this learning curve by projecting that the variable costs of producing the low-emitting engines decreases by 20 percent starting with the third year of production (2009 model year) and by reducing variable costs again by 20 percent starting with the fifth year of production. Additionally, since fixed costs are assumed to be recovered over a five-year period, these costs are not included in the analysis after the first five model years. Finally, manufacturers are expected to apply ongoing research to make emission controls more effective and to have lower operating cost over time. However, because of the uncertainty involved in forecasting the results of this research, we have conservatively not accounted for it in this analysis. Table V.A–1 lists the projected costs for each category of vehicle in the near-and long-term. For the purposes of this analysis, ''near-term'' costs are those calculated for the 2007 model year and ''long term'' costs are those calculated for 2012 and later model years.

TABLE V.A–1.—PROJECTED INCREMENTAL SYSTEM COST AND LIFE CYCLE OPERATING COST FOR HEAVY-DUTY DIESEL VEHICLES

[net present values in the year of sale, 1999 dollars]

| Vehicle class | Model year | Hardware cost | Life-cycle operating cost [a b] |
|---|---|---|---|
| Light | near term | 1,990 | 509 |
| Heavy-duty | long term | 1,170 | 537 |
| Medium | near term | 2,560 | 943 |
| Heavy-duty | long term | 1,410 | 996 |
| Heavy | near term | 3,230 | 3,785 |
| Heavy-duty | long term | 1,870 | 3,979 |

[a] Incremental life-cycle operating costs include the incremental costs to refine and distribute low sulfur diesel fuel, the service cost of closed crankcase filtration systems, the maintenance cost for PM filters and the lower maintenance costs realized through the use of low sulfur diesel fuel (see discussion in Section V.C).

[b] These costs are for new vehicles only and do not reflect any costs or savings for the existing fleet.

2. New System Costs for $NO_X$ and PM Emission Control

Several new technologies are projected for complying with the 2007 model year emission standards. We are projecting that $NO_X$ adsorbers and catalyzed diesel particulate filters will be the most likely technologies applied by the industry in order to meet the emissions standards. The fact that manufacturers will have several years before implementation of the new standards ensures that the technologies used to comply with the standards will develop significantly before reaching production. This ongoing development could lead to reduced costs in three ways. First, we expect research will lead to enhanced effectiveness for individual technologies, allowing manufacturers to use simpler packages of emission control technologies than we would predict given the current state of development. Similarly, we anticipate that the continuing effort to improve the emission control technologies will include innovations that allow lower-cost production. Finally, we believe that manufacturers will focus research efforts on any drawbacks, such as fuel economy impacts or maintenance costs, in an effort to minimize or overcome any potential negative effects.

We anticipate that in order to meet the standards, industry will introduce a combination of primary technology upgrades for the 2007 model year. Achieving very low $NO_X$ emissions will require continued development of $NO_X$ emission control technologies and improvements in engine management to take advantage of the exhaust emission control system capabilities. The manufacturers are expected to take a systems approach to the problem of optimizing the engine and exhaust emission control system to realize the best overall performance possible. Since most research to date with exhaust emission control technologies has focused on retrofit programs, there remains room for significant improvements by taking such a systems approach. The $NO_X$ adsorber technology in particular is expected to benefit from re-optimization of the engine management system to better match the $NO_X$ adsorbers performance characteristics. The majority of the $600 million dollars we have estimated for research is expected to be spent on developing this synergy between the engine and $NO_X$ exhaust emission control systems. PM control technologies are expected to be less sensitive to engine operating conditions as they have already shown good robustness in retrofit applications with low-sulfur diesel fuel.

The $NO_X$ adsorber system that we are anticipating will be applied in 2007 consists of a catalyst which combines traditional gasoline three-way conversion technology with a newly developed $NO_X$ storage function, a reductant metering system and a means to control exhaust air fuel (A/F) ratio. The $NO_X$ adsorber catalyst itself is a relatively new device, but is benefitting in its development from over 20 years of gasoline three-way catalyst development. In order for it to function properly, a systems approach that includes a reductant metering system and control of exhaust A/F ratio is also necessary. Many of the new air handling and electronic system technologies developed in order to meet the 2004 heavy-duty engine standards can be applied to accomplish the $NO_X$ adsorber control functions as well. Some additional hardware for exhaust $NO_X$ or $O_2$ sensing, for exhaust partitioning and for fuel metering will likely be required. The RIA also calculates an increase in warranty costs for this additional hardware. In total the new $NO_X$ control technologies required in order to meet the 2007 emission standards are estimated to increase light heavy-duty engine costs by $1,000, medium heavy-duty engine costs by $1,310 and heavy heavy-duty engine costs by $1,650 in the year 2007. In the year 2012 and

[184] See Chapter V of the final Tier 2 Regulatory Impact Analysis, contained in Air Docket A–97–10.

beyond the incremental costs are expected to decrease to $590 for a light heavy-duty engine, $690 for a medium heavy-duty engine and to $930 for a heavy heavy-duty engine.

Catalyzed diesel particulate filters are experiencing widespread retrofit use in much of Europe as low-sulfur diesel fuel becomes readily available. These technologies are proving to be robust in their non-optimized retrofit applications requiring no modification to engine or vehicle control functions. We therefore anticipate that catalyzed diesel particulate filters can be integrated with new diesel engines with only a minimal amount of engine development. We do not anticipate that additional hardware beyond the diesel particulate filter itself and an exhaust pressure sensor for OBD will be required in order to meet the PM standard. However, in order to ensure trap durability under all possible operating conditions, some engine manufacturers may choose to provide backup regeneration technologies for their PM filter based systems. As detailed further in the RIA and the RTC documents, we do not anticipate that these redundant systems will add to variable costs. We estimate in 2007 that diesel particulate filter systems will add $730 to the cost of a light heavy-duty vehicle, $950 to the cost of a medium heavy-duty vehicle and $1,190 to the cost of a heavy heavy-duty vehicle. By 2012 these costs are expected to decrease to $425, $530, and $690 respectively. These cost estimates are comparable to estimates made by the Manufacturers of Emission Controls Association for these technologies.[185]

The hydrocarbon (HC) exhaust standards set in this rulemaking will be challenging for both diesel and gasoline engine technologies. For diesel engines utilizing the $NO_X$ adsorber based technology solution to control $NO_X$ emissions, HC control due to imprecise $NO_X$ regeneration control may be difficult. One way to ensure HC compliance will be to apply a separate diesel oxidation catalyst which can control HC emissions to the limits set here. These diesel oxidation catalysts are expected to add an additional cost to the system of $206 for light heavy-duty vehicles, $261 for medium heavy-duty vehicles, and $338 for heavy heavy-duty vehicles.

We have eliminated the exemption that allowed turbo-charged heavy-duty diesel engines to vent crankcase gases directly to the environment, so called open crankcase systems, and have projected that manufacturers will rely on engineered closed crankcase ventilation systems which filter oil from the blow-by gases. We estimate that the initial cost of these systems in 2007 will be $37, $42, and $49 for light, medium and heavy heavy-duty diesel engines respectively. Additionally we expect a portion of the oil filtration system to be a service replacement oil filter which will be replaced on a 30,000 mile service interval with a service cost of $10, $12, and $15 for light, medium, and heavy heavy-duty diesel engines respectively. These cost are summarized with the other cost for emission controls in Table V.A–1 and are included in the aggregate cost reported in Section V.D.

3. Operating Costs Associated With $NO_X$ and PM Control

The RIA assumes that a variety of new technologies will be introduced to enable heavy-duty vehicles to meet the new emissions standards. Primary among these are advanced emission control technologies and low-sulfur diesel fuel. The many benefits of low-sulfur diesel fuel are described in Section III, and the incremental cost for low-sulfur fuel is described in Section V.C. The new emission control technologies are themselves not expected to introduce additional operating costs in the form of increased fuel consumption. Operating costs are estimated in the RIA over the life of the vehicle and are expressed as a net present value (NPV) in 1999 dollars for comparison purposes.

Total operating cost estimates include both the expected increases in maintenance and fuel costs (both the incremental cost for low-sulfur fuel and any fuel consumption penalty) due to the emission control systems application and the predicted decreases in maintenance cost due to the use of low-sulfur fuel. Our analysis projects some increase in operating costs due to the incremental cost of low-sulfur diesel fuel but no net increase in fuel consumption with the application of the new emission control technologies (see discussion in Section III.G). The net increase in operating costs are summarized in Table V.A–1. While we are using these incremental operating cost estimates for our cost effectiveness calculations, it is almost certain that the manufacturers will improve existing technologies or introduce new technologies in order to offset at least some of the increased operating costs.

We estimate that the low-sulfur diesel fuel required in order to enable these technologies will have an incremental cost of approximately $0.045/gallon in the near term increasing to $0.050/gallon in the long term as discussed in Section V.C. The low-sulfur diesel fuel may also provide additional benefits by reducing the engine maintenance costs associated with corrosion due to sulfur in the current diesel fuel. These benefits, which are discussed further in Section V.C.5 and in the RIA, include extended oil change intervals due to the slower acidification rate of the engine oil with low-sulfur diesel fuel. Service intervals for the EGR system are also expected to increase due to lower-sulfur induced corrosion than will occur with today's higher-sulfur fuel. This lengthening of service intervals provides a significant savings to the end user. As described in more detail in the RIA we anticipate that low-sulfur diesel fuel will provide additional cost savings to the consumer of $153 for light heavy-duty vehicles, $249 for medium heavy-duty vehicles and $610 dollars for heavy heavy-duty vehicles.

The operating costs for replacement filters in the closed crankcase filtration systems expressed as a net present value in the year of sale are estimated to be $31 for light heavy-duty vehicles, $59 for medium heavy-duty vehicles and $218 for heavy heavy-duty vehicles for vehicles sold in 2007.

PM filter based technologies capture all forms of particulate in the exhaust including inorganic solid particles which can come from the engine oil or wear products of the engine. These inorganic particles (often call ash) must be periodically cleaned from the particulate filter. We have estimated the additional maintenance cost to clean the PM filter expressed as a net present value in the year of sale of $55 for light heavy-duty vehicles, $56 for medium heavy-duty vehicles and $208 dollars for heavy heavy-duty vehicles, as detailed in the RIA.

Factoring the cost savings due to low sulfur diesel fuel into the additional cost for low-sulfur diesel fuel and the service cost of the closed crankcase ventilation system and the PM filter system yields an increase in vehicle operating costs expressed as a net present value in the year of sale of $509 for a light heavy-duty vehicle, $943 for a medium heavy-duty vehicle and $3,785 for a heavy heavy-duty vehicle. These life cycle operating costs are also summarized in Table V.A–1. The net increase in operating cost can also be expressed as an average annual operating cost for each class of heavy-duty vehicle by dividing the total undiscounted operating costs by the average vehicle life assumed to be 9 years for light heavy-duty vehicles, and

[185] Letter from Bruce Bertelsen, Manufacturers of Emission Controls Association (MECA) to William Charmley, US EPA, December 17, 1998. The letter documents a MECA member survey of expected diesel particulate filter costs. Air Docket A–98–32 Item II–D–09.

11 years for medium and heavy heavy-duty engines. Expressed as an approximate annual per vehicle cost, the additional operating cost is estimated as $80 for a light heavy-duty vehicle, $130 for a medium heavy-duty vehicle, and $510 for a heavy heavy-duty vehicle.

*B. Cost for Gasoline Vehicles to Meet the New Emissions Standards*

1. Summary of New System Costs

To perform a cost analysis for the final gasoline standards, we first determined a package of likely technologies that manufacturers could use to meet the standards and then determined the costs of those technologies. In making our estimates, we have relied on our own technology assessment which included publicly available information such as that developed by California, confidential information supplied by individual manufacturers, and the results of our own in-house testing.

In general, we expect that heavy-duty gasoline vehicles would (like Tier 2 light duty vehicles) be able to meet these standards through refinements of current emissions control components and systems rather than through the widespread use of new technology. More specifically, we anticipate a combination of technology upgrades such as the following:

- Improvements to the catalyst system design, structure, and formulation, plus an increase in average catalyst size and loading.
- Air and fuel system modifications including changes such as improved oxygen sensors, and calibration changes including improved precision fuel control and individual cylinder fuel control.
- Exhaust system modifications, possibly including air gapped components, insulation, leak free exhaust systems, and thin wall exhaust pipes.
- Increased use of fully electronic exhaust gas recirculation (EGR).
- Increased use of secondary air injection.
- Use of ignition spark retard on engine start-up to improve upon cold start emission control.
- Use of low permeability materials and minor improvements to designs, such as the use of low-loss connectors, in evaporative emission control systems.

We expect that the technologies needed to meet the heavy-duty gasoline standards will be very similar to those required to meet the Tier 2 standards for vehicles over 8,500 pounds GVWR. Few heavy-duty gasoline vehicles currently rely on technologies such as close coupled catalysts and secondary air injection, but we expect they would to meet the new standards.

For each group we developed estimates of both variable costs (for hardware and assembly time) and fixed costs (for R&D, retooling, and certification). Cost estimates based on the current projected costs for our estimated technology packages represent an expected incremental cost of vehicles in the near-term. For the longer term, we have identified factors that would cause cost impacts to decrease over time. First, since fixed costs are assumed to be recovered over a five-year period, these costs disappear from the analysis after the fifth model year of production. Second, the analysis incorporates the expectation that manufacturers and suppliers would apply ongoing research and manufacturing innovation to making emission controls more effective and less costly over time. Research in the costs of manufacturing has consistently shown that as manufacturers gain experience in production and use, they are able to apply innovations to simplify machining and assembly operations, use lower cost materials, and reduce the number or complexity of component parts.[186] These reductions in production costs are typically associated with every doubling of production volume. Our analysis incorporates the effects of this ''learning curve'' by projecting that a portion of the variable costs of producing the new vehicles decreases by 20 percent starting with the third year of production. We applied the learning curve reduction only once since, with existing technologies, there would be less opportunity for lowering production costs than would be the case with the adoption of new technology. We did not apply the learning curve reduction to precious metal costs, nor did we apply it for the evaporative standards.

We have prepared our cost estimates for meeting the new heavy-duty gasoline standards using a baseline of current technologies for heavy-duty gasoline vehicles and engines. Finally, we have incorporated what we believe to be a conservatively high level of R&D spending at $2,500,000 per engine family where no California counterpart exists. We have included this large R&D effort because calibration and system optimization is likely to be a critical part of the effort to meet the standards. However, we believe that the R&D costs may be generous because the projection probably underestimates the carryover of knowledge from the development required to meet the light-duty Tier 2 and CARB LEV–II standards.

Table V.B–1 provides our estimates of the per vehicle cost for heavy-duty gasoline vehicles and engines. The near-term cost estimates in Table V.B–1 are for the first years that vehicles meeting the standards are sold, prior to cost reductions due to lower productions costs and the retirement of fixed costs. The long-term projections take these cost reductions into account.

TABLE V.B–1.—PROJECTED INCREMENTAL SYSTEM COST AND LIFE CYCLE OPERATING COST FOR HEAVY-DUTY GASOLINE VEHICLES

[Net Present Values in the year of sale, 1999 dollars]

| Vehicle class | Model year | Incremental system cost | Life-cycle operating cost |
|---|---|---|---|
| Heavy-Duty | near term | $198 | $0 |
| Gasoline | long term | 167 | 0 |

[186] See Chapter V of the final Tier 2 Regulatory Impact Analysis, contained in Air Docket A–97–10.

2. Operating Costs Associated With Meeting the Heavy-Duty Gasoline Standard

Low sulfur gasoline is a fundamental enabling technology which will allow heavy-duty gasoline vehicles to meet the very low emission standards being finalized today. The low sulfur gasoline required under the Tier 2 proposal will enable advanced exhaust emission control for heavy-duty vehicles as well. Today's final rule puts no additional requirements on gasoline sulfur levels and as such should not increase gasoline fuel costs. Additionally, the new technologies being employed in order to meet the new standards are not expected to increase fuel consumption for heavy-duty gasoline vehicles. In fact, there may be some small improvement in fuel economy from the application of improved fuel and air control systems on these engines. Therefore, in the absence of changes to gasoline specifications and with no decrease in fuel economy, we do not expect any increase in vehicle operating costs.

*C. Cost of Fuel Change*

We estimate that the overall net cost associated with producing and distributing 15 ppm diesel fuel, when those costs are allocated to all gallons of highway diesel fuel, will be approximately 5.0 cents per gallon in the long term, or an annual cost of roughly $2.2 billion per year once the program is fully effective starting June 1, 2010. During the initial years under temporary compliance option, the overall net cost is projected to be 4.5 cents per gallon, or an annual cost of roughly $1.7 billion per year.

This cost consists of a number of components associated with refining and distributing the new fuel. The majority of the cost is related to refining. From 2006–2010, refining costs are estimated to be approximately 3.3 cents per gallon of highway diesel fuel (4.1 cents per gallon for that portion produced to the 15 ppm standard), increasing to 4.3 cents per gallon once the program is fully in place. In annual terms, the 2006–2010 refining costs are expected to be about $1.4 billion per year, increasing to about $1.8 billion in 2011. These figures include the cost of producing slightly more volume of diesel fuel because: (1) Desulfurization decreases the energy density of the fuel and (2) slightly more highway diesel fuel is expected to be downgraded to nonroad diesel fuel in the distribution system.

A small cost of 0.2 cents per gallon is associated with an anticipated increase in the use of additives to maintain fuel lubricity. Also, distribution costs are projected to increase by 1.0 cents per gallon during the initial years under the temporary compliance option, including the cost of distributing slightly greater volumes of fuel. Together, these two cost components only amount to about $0.5 billion per year beginning in 2006. These costs drop to only about $0.3 billion in 2011.

As discussed in Sections V.A. and V.C.5, operation with 15 ppm sulfur diesel fuel is expected to reduce average vehicle maintenance costs by approximately 1 cent on a per gallon basis. Beginning in 2011, this reduction in maintenance costs will total roughly $400 million per year. All of these cost estimates are discussed in more detail below and in the RIA.

1. Refinery Costs

As explained in Section IV, EPA believes that refiners will meet the 15 ppm sulfur standard through an extension of the same hydrotreating technology which is used today to meet the current 500 ppm sulfur standard. Meeting the new standard will generally require refiners to install additional hydrotreating equipment. Most refiners are expected to add another hydrotreating reactor and other related equipment to their existing desulfurization unit. However, we project that some refiners, roughly 20 percent, will conclude that it is not economical to add onto their existing unit and will instead build an entirely new hydrotreater.

Consistent with our analysis for the NPRM, we estimate that a refinery's diesel fuel will have to average 7 ppm in order to consistently meet the 15 ppm standard. For the NPRM, we estimated the cost of producing highway diesel fuel with a 7 ppm average sulfur level for the average U.S. refinery. We received a number of comments on the NPRM which indicated that the cost for various refiners would differ dramatically, as would the cost of treating the various blendstocks which comprise highway diesel fuel. In response, we extended our refining cost model to be specific to each refinery in the U.S., based on a refinery's production volume and estimated composition of its highway diesel fuel. Using this model, we estimated each refinery's cost of producing 7 ppm sulfur highway diesel fuel and then aggregated these results to estimate a national average cost.

This analysis considers the fact that some diesel fuel blendstocks are more difficult to desulfurize than others. As indicated in some comments on the NPRM, this could lead refiners to shift their blendstocks between highway diesel fuel and other distillate products in order to minimize costs. For example, our analysis found that the incremental cost of desulfurizing current highway diesel fuel can be more expensive for some refiners than the cost to other refiners of desulfurizing nonroad diesel fuel to meet the 15 ppm standard, despite the fact that the current sulfur level of nonroad diesel fuel is roughly 2500–3000 ppm.

We evaluated costs under two scenarios: (1) all current producers of highway diesel fuel continued to do so, and (2) some refiners increase production of highway diesel fuel and some refiners facing higher desulfurization costs leave the highway diesel fuel market. Our cost projections presented below are based on the first scenario. This is conservative, because in this scenario, some refineries currently produce relatively low volumes of highway diesel fuel and would face relatively high costs per gallon to desulfurize this same volume of fuel.

We project that the average refining cost to meet the 15 ppm cap standard will be 4.3 cents per gallon, including capital costs amortized at 7 percent per year before taxes, once the standard is fully in place in June, 2010. Refining costs will be lower, 4.1 cents per gallon of 15 ppm fuel (or 3.3 cents per gallon of all highway diesel fuel), during optional compliance provisions (2006–2010), because we expect that those refiners facing the lowest cost of meeting the standard in each PADD will invest to produce the new fuel. We project that refiners will invest $3.8 billion in new equipment in order for about 80 percent of highway diesel fuel to meet the 15 ppm standard in 2006. An additional $1.4 billion will be invested for the rest of the highway diesel fuel market to meet the new standard in 2010, for a total capital cost of $5.2 billion. The average refinery is projected to spend about $43 million in capital costs, and $7 million per year in operating costs.

Table V.C–1 shows the range of average costs per refinery by PADD. Despite the varying size of refineries and differences in their available distillate blendstocks, the variations in the average cost between PADDs in either 2006 or 2010 are small, with the exception of PADD 4. PADD 4 average costs are 30–40 percent higher than the costs in the other PADDs.

TABLE V.C–1.—AVERAGE REFINING COSTS BY PADD (CENTS PER GALLON OF 15 PPM FUEL)

| | 2006 | 2010 |
|---|---|---|
| PADD 1 | 4.4 | 4.7 |
| PADD 2 | 4.3 | 4.5 |
| PADD 3 | 3.8 | 3.9 |
| PADD 4 | 5.1 | 5.3 |
| PADD 5 | 4.2 | 4.5 |
| U.S. Average | 4.1 | 4.3 |

A number of other estimates of the cost of the 15 ppm sulfur standard were submitted as part of the comments. Mathpro used a notional refinery model to estimate the national average costs of the proposed standard for EMA. Charles River Associates (CRA), along with Baker and O'Brien, used the Prism refinery model to estimate the cost for each refinery in the U.S. for API. Finally, EnSys used the Oak Ridge National Laboratory PADD 3 refinery model to estimate costs for DOE. Table V.C–2 summarizes these estimates after adjusting the projected costs to represent a 7 percent rate of return on investment before taxes (except for the CRA cost, which could not be adjusted).

TABLE V.C–2.—COMPARISON OF NATIONAL AVERAGE REFINING COST ESTIMATES

[7 percent rate of return on investment before taxes]

| | Average cost (cents per gallon of 15 ppm fuel) | Capital cost ($ billion) |
|---|---|---|
| EPA (Full program) | 4.4 | 5.3 |
| Methpro for EMA* | 4.2–6.1 | 3.4–6.1 |
| CRA for API (10% after tax rate of return) | 6.2 | — |
| EnSys for DOE (conservative technology)* † | 5.1–6.0 | 3.9–6.5 |
| EnSys for DOE (optimistic technology)* † | 4.2–4.4 | 2.7–4.5 |

* Lower end of range assumes 100 percent revamped equipment; upper end assumes all new equipment.

† Costs are only for the Gulf Coast refining region, which have slightly lower per-gallon costs than the entire U.S., and about half the capital costs.

The costs estimated by Mathpro are the most similar to those estimated by EPA. This is primarily because the desulfurization technology projected to be used were similar in the two studies.

CRA projected the use of similar technology, but estimated that 40 percent of refiners would build new desulfurization units, versus our estimate of 20 percent. CRA also assumed that technology vendors are inherently optimistic in their projections and increased their projected costs by roughly 20 percent. CRA also projected that nonroad diesel fuel sulfur levels would be capped at 500 ppm. How this affected the projected cost of producing 15 ppm fuel is not clear. CRA assumed that this 500 ppm fuel would be produced by blending 8 ppm sulfur highway diesel fuel and 3000 ppm heating oil. Much of this production was assumed to occur due to mixing in the distribution system. An unknown amount of 500 ppm fuel was produced at refineries. Desulfurization costs are not linear, as shown by CRA's own study. Thus, any blending of 15 ppm sulfur highway diesel fuel with non-desulfurized heating oil at refineries was much more costly than simply hydrotreating nonroad diesel fuel to 500 ppm. It also required refiners to hydrotreat the most difficult blendstocks at a much higher cost. Because of these significant differences in both methodology and assumptions, it is not surprising that CRA's costs would be higher than those estimated by Mathpro or ourselves.

EnSys's cost estimates require some explanation due to the number of scenarios they analyzed. EnSys did not estimate how many refiners would build new desulfurization units and how many would modify their current hydrotreaters, but simply presented costs if refiners took one approach or the other. Thus, the lower limits of the ranges shown in Table V.C–2 assume refiners modify their current hydrotreaters, while the upper limits assume that refiners would build new units. EnSys also projected costs for two separate sets of technologies. One set was considered conservative and relied on technologies that are already in commercial use. The other was considered to be optimistic and was similar to that projected to be used by EPA, Mathpro and CRA. EnSys' costs using the conservative technology are higher than our estimates. This is due to the fact that this technology involves greater capital investment and greater consumption of hydrogen. These greater costs are due to the fact that this technology is not just designed to reduce sulfur, but to reduce aromatic content, increase cetane levels and perform some cracking. EnSys' costs using the optimistic technology are much more similar to those of EPA and Mathpro, considering that EnSys' range of costs reflects both revamped and new desulfurization units and that EPA's costs are dominated (80 percent) by revamped units.

Some of the variation in the costs projected by the various studies involves uncertainty in exactly what degree of hydrotreating will be necessary to meet the 15 ppm sulfur standard day in and day out with a variety of distillate feedstocks. As discussed in Section IV above, there is currently no commercial experience in the U.S. and only a limited amount of information in the public literature on the costs associated with reducing the sulfur level in diesel fuel to very low levels on an ongoing operational basis. Thus, any cost projections involve a significant amount of uncertainty.

2. Highway Diesel Fuel Supply

While API and many refiners did not question the feasibility of the 15 ppm standard, they did indicate that the cost would be higher than that projected by EPA. API believes that those refiners facing higher than average costs may decide to leave the highway diesel fuel market. They argue this is especially a possibility if they are faced with a sulfur standard below a 30 ppm average (or 50 ppm cap), which they believe will require very large investments for high pressure hydrotreating to maintain current highway diesel production volumes. API also believes that many refiners may reduce their production of highway diesel fuel, by switching the feedstocks (i.e., LCO) which are most difficult to desulfurize to other markets, thus avoiding the higher investments associated with high pressure hydrotreating. If some refiners reduce highway diesel fuel production, that could present an opportunity for other refiners, who choose to make the investment, of higher prices for the new 15 ppm sulfur product.

This view is embodied by a study by Charles River Associates (CRA) and Baker and O'Brien which was commissioned by API. CRA polled refiners concerning their plans under a 15 ppm sulfur cap. Using the results of this survey, as well as other information, CRA projected refiners' costs of meeting the 15 ppm standard, as well as their likely production volumes. CRA concluded that U.S. refiners would likely reduce their highway diesel fuel production by an average of 12 percent, creating significant shortages and price spikes.

CRA's conclusions appear to have been strongly affected by their assumptions, as well as the refiner survey they conducted. For example, CRA assumed that the new sulfur standard would cause 10 percent more highway diesel fuel to be ''lost'' in the distribution system compared to today (i.e., downgraded to off-highway diesel fuel). We believe based on the analysis outlined in the RIA that 2.2 percent is a more accurate estimate, resulting in 9 percent more 15 ppm fuel being available than CRA estimated. This difference alone accounts for 75 percent of the potential national supply shortfall projected by CRA.

CRA also concluded, with little explanation, that 20 refineries producing highway diesel fuel today would not produce highway diesel fuel under the 15 ppm standard and that many more would reduce production. Given the lack of information provided in the study, it was not possible to evaluate CRA's criteria in selecting these 20 refineries, nor was it possible to determine how much of the shortfall was attributable to this conclusion. While CRA evaluated whether refiners currently producing highway diesel fuel would be likely to leave the market, they did not assess whether any refineries currently not producing highway diesel fuel might enter the market. EPA did conduct such an assessment. We found 2 refineries that produce essentially no highway diesel fuel today which could meet the new standard for less than 5 cents per gallon. Production from these refineries would increase highway diesel fuel production by 9 percent. We also found based on our assessment that 4 other refineries could produce highway diesel fuel from their off-highway diesel fuel blendstocks for less than 5 cents per gallon. Production from these 6 refineries would increase highway diesel fuel production by 7 percent. Together with a more reasonable estimate of downgrades in the distribution system, this would more than compensate for any potential lost production, even as estimated by CRA.

CRA also implicitly assumed that the material it projected could be removed from the highway diesel market could be sold at a reasonable price. However, CRA did not analyze the impact of this additional supply on the prices which could be obtained in these markets, or even if these alternative markets could physically absorb all of this material. Much of this material is not diesel fuel, but poor quality blendstock. It is not clear that such material could be blended into non-highway diesel fuel and CRA did not analyze this likely problem. Our analyses, supported by a study by Muse, Stancil and Co., indicate that any substantial quantities of highway diesel fuel diverted to other markets will depress prices in those markets substantially.[187] Hydrotreating diesel fuel to meet the 15 ppm standard avoids these depressed prices, reducing the net cost of meeting the new standard. Since CRA only considered the cost to desulfurize highway diesel fuel, and ignored the added cost of dumping this fuel into markets with depressed prices, CRA's conclusions must be considered to be seriously flawed in this regard.

Furthermore, CRA ignored the fact that roughly 15 percent of today's highway diesel fuel is consumed in engines and furnaces not requiring this fuel. Any shortage of highway diesel fuel would lead many of these non-essential users to switch to nonroad diesel fuel or heating oil. Only limitations in the fuel distribution system would cause these users to continue to burn highway diesel fuel.

These problems with CRA's analysis, plus the lack of detail available concerning the specifics of the study, lead us to reject the study's conclusions that there will be significant supply shortfalls under a 15 ppm sulfur standard.

Finally, if any potential for highway diesel fuel shortfalls exists by requiring all fuel to meet 15 ppm sulfur in 2006, as CRA's analysis suggests, we believe that allowing some continued supply of 500 ppm, as we are doing under the temporary compliance option and hardship provisions contained in today's action, addresses this concern. Since the final rule allows some transition period before the entire highway diesel pool is required to meet the 15 ppm sulfur standard, some refiners will not need to change their current operations and will be able to continue producing 500 ppm fuel during these years. Those refiners that delay production of low sulfur diesel fuel until the later years of the program will tend to be the refiners with the highest cost to comply and, thus, refiners that would otherwise have the greatest tendency not to invest and thereby impact supply. Refiners that begin producing low sulfur diesel fuel in the later years of the program will also be able to take advantage of ongoing improvements in desulfurization technology. Together, these factors will help avoid or reduce any potential losses in highway diesel fuel production when the program requires full compliance with low sulfur diesel fuel.

As mentioned above, EPA agrees that some refiners will face higher desulfurization costs than others. This is generally the case with any fuel quality regulation, since the crude oils processed by, as well as the configurations and product slates of individual refineries vary dramatically. As mentioned above and summarized in the RIA, we used our refining cost model to assess the likelihood that refiners would leave the highway diesel fuel market or reduce their production of highway diesel fuel. We also assessed the likelihood of other refiners entering this market. We found that a number of refiners appear to be in a position to expand their highway diesel fuel production capacity very economically relative to other refiners facing higher desulfurization costs. We also found that up to 2 refineries not now producing highway diesel fuel could easily enter the highway diesel fuel market at very competitive costs.

Some refiners may have an alternative market for their diesel fuel. In the extreme, a refiner would likely prefer to only shift his light cycle oil to other distillate products, like nonroad diesel fuel and No. 2 heating oil, retaining his other blendstocks in the higher value highway diesel fuel market. However, in many cases, a refiner cannot shift light cycle oil directly to a distillate product, because the resulting non-highway fuel would no longer meet applicable specifications, such as sulfur or cetane. In most cases, we expect that the refiner must shift highway diesel fuel to alternative markets in order to be able to obtain a reasonable price.

As mentioned above, Muse, Stancil, & Co. analyzed the ability of refiners to

[187] ''Alternate Markets for Highway Diesel Fuel Components,'' Muse, Stancil & Co., for Southwest Research Institute, for U.S. EPA, September, 2000.

divert highway diesel fuel or its blendstocks to other distillate markets. Muse, Stancil found that this ability varied significantly by PADD. In PADDs II and IV, it would be difficult for refiners to move any appreciable quantity of highway diesel fuel to other markets. For example, compared to the value of highway diesel fuel today, the achievable value for the diverted material would decrease by 14 to 20 cents per gallon if refiners tried to move more than 5 percent of their highway diesel fuel to other markets. The loss in value was highest in these two PADDs, because growth in nonroad diesel fuel consumption is small or negative, the ability to reduce the consumption of highway diesel fuel by users other than highway vehicles was limited, and exports are only available through the Gulf or West Coasts with a large transportation cost of getting the material there.

In PADDs III and V, the loss of value was lower, at 4.5–5 cents per gallon and was the lowest in PADD I, 2 cents per gallon. This was primarily because of the ability to export high sulfur diesel fuel overseas. Generally, these losses in value apply if diesel fuel was being diverted to other distillate markets. If light cycle oil was being diverted, the value would drop an additional 3–3.5 cents per gallon.

At lower levels of diversion (e.g., 5 percent or less), the loss in value was much less, ranging from 1.6–5 cents per gallon across the five PADDs. However, the primary reason for this was the reduced use of highway diesel fuel by users other than highway vehicles, who do not require this fuel. Muse believed that such conversions were limited, but real and could represent roughly a third of the current use of highway diesel fuel in other than highway vehicles. If this occurs, then demand for highway diesel fuel drops at the same time. Thus, in this case, the total refining costs associated with the new sulfur standard will decline because the total amount of fuel; needing to be desulfurized will decrease.

The only area where refiners could easily divert substantial amounts of highway diesel fuel is PADD I. PADD I refiners currently produce a relatively low amount of highway diesel fuel and substantial amounts of high sulfur diesel fuel/heating oil are imported. Thus, refiners in PADD I facing relatively high costs of meeting the 15 ppm standard could shift some or all of their highway diesel fuel to other markets, reducing imports and not substantially affecting prices in this market.

In the end, refiners will make their decisions regarding investment based on their projections of demand of 15 and 500 ppm diesel fuel, the prices of these fuels and the prices available in alternative markets. At this time, we do not project that the specifics involved in this case (technology, cost, alternative markets) are significantly different from those which have existed in the past. The last time EPA regulated diesel fuel, the refining industry actually overbuilt desulfurization capacity for the current 500 ppm standard, as evidenced by the significant use in the nonroad market of diesel fuel produced to the current highway diesel sulfur standard of 500 ppm and the relatively low price of highway diesel fuel relative to nonroad diesel fuel. Some of this overproduction may have been due to limitations in the distribution system to distribute both highway and nonroad grades of diesel fuel. However, the refinery system as a whole was able to supply both highway diesel vehicles, plus the use of highway diesel fuel by other users. This was accomplished despite the fact that a number of small refiners did decide to switch from the highway diesel fuel market to the nonroad diesel fuel market, presumably for economic reasons.

3. Cost of Lubricity Additives

As discussed in Section IV, the refinery processes needed to achieve the sulfur standard have some potential to degrade the natural lubricity characteristics of the fuel. Consequently, an increase in the use of lubricity additives for diesel fuel may be anticipated over the amounts used today. As described in more detail in the Regulatory Impact Analysis in the Public Docket, we include in our fuel cost estimate an average cost of 0.2 cents per gallon for lubricity additives over the entire pool of low sulfur highway diesel fuel (the same cost estimate as used in the proposal). This estimate is comparable to an estimate made by Mathpro in a study sponsored by the Engine Manufacturers Association, and is consistent with the cost estimate submitted by Cummins in its comments.

Prior to the proposal, we contacted various producers of lubricity additives to get their estimates of what costs might be incurred for this increase in the use of lubricity additives. The cost estimates varied from 0.1 to 0.5 cents per gallon. The cost is likely to be a strong function of not only the additive type, but also the assumed treatment rate and the volume of fuel that needs to be treated, both of which will be, to some extent, a function of the sulfur cap. We requested comment on our cost estimate, including whether there may be unique costs for the military to maintain the lubricity of their distillate fuels. We requested that comments addressing this issue include a detailed discussion of the volumes of fuel affected, current lubricity additive use, and the additional measures that might be needed (and associated costs) to maintain the appropriate level of fuel lubricity. In response to the proposal, we received few comments on the cost of lubricity additives, and none on the volumes of fuel affected, current lubricity additive use, or additional measures that might be needed to maintain the appropriate level of lubricity. In considering the comments, we have found no basis in today's action to use a different average cost estimate to treat low sulfur diesel for lubricity than that which was used in the proposal (0.2 cents per gallon). See more discussion in the Response to Comments Document in the Public Docket.

4. Distribution Costs

We estimate that as a result of today's rule, distribution costs will increase by 0.5 cents per gallon of highway diesel fuel supplied when the sulfur requirements are fully implemented beginning in the year 2010. During the initial years (2006 through May 31, 2010) we estimate that the increase in distribution costs will be 0.4 cents per gallon of highway diesel fuel supplied, with an additional 0.7 cents per gallon equivalent related to capital costs for additional storage tanks to handle two grades of highway diesel fuel.[188]

In the proposal, we estimated that distribution costs would increase by 0.2 cents per gallon if the proposed requirement that the entire highway diesel fuel pool meet a 15 ppm sulfur cap beginning in 2006 be adopted. This cost was comprised of roughly 0.1 cents per gallon due to an increase in pipeline interface and testing costs, and 0.1 cents per gallon for distributing the additional volume of highway diesel fuel needed due to an anticipated decrease in fuel energy density as a side effect of reducing the sulfur content to the proposed 15 ppm cap. The case evaluated in the NPRM is most similar to that for the fully implemented sulfur program in this final rule.

We took advantage of additional information contained in the comments to the NPRM in formulating a more comprehensive estimate of the

[188] This cost is expressed in terms of the total volume of highway diesel fuel supplied, including the fuel which meets the 15 ppm sulfur cap and that which meets the 500 ppm sulfur cap.

distribution costs under today's rule. In some cases this involved adjusting an estimate for a parameter that factored into our calculation of costs in the NPRM. One important example is that we increased our estimate of the additional volume of highway diesel shipped by pipeline that would need to be downgraded to a lower-value product. This product downgrade is necessitated by mixing that takes place between products that abut each other while in the pipeline. The mixture is referred to as interface when it can be blended into another product and transmix when it must be returned to the refinery for reprocessing. In other cases, our reevaluation of distribution costs included the consideration of parameters that did not factor into the estimation of distribution costs in the proposed rule. For example, commenters to the NPRM brought to our attention that there would be additional costs associated with needed changes in the handling practices for interface volumes which result from shipments of jet fuel and highway diesel fuel that abut each other in the pipeline.

There are a number of common factors in the estimation of distribution costs during the initial period and after the sulfur requirements are fully implemented, such as the increase in interface volumes for pipeline shipments of highway diesel fuel. However, there are other factors that are unique to the estimation of costs during the initial years as well. For example, with two grades of highway diesel fuel in the distribution system at the same time there are costs associated with the need for additional storage tanks at some petroleum terminals and refineries. Our estimation of distribution costs under these two periods is discussed separately in the following sections. Where there is a commonality, the issue is discussed under the section on distribution costs for the fully implemented program.

a. Distribution Costs Under the Fully Implemented Program

Based on the considerations discussed below, we estimate that the increase in distribution costs under the fully implemented sulfur program will be 0.5 cents per gallon of highway diesel fuel supplied.

The cost of distributing the additional volume of highway diesel fuel needed to compensate for the lower energy density of highway diesel fuel that meets a 15 ppm sulfur cap is estimated at 0.17 cents per gallon of highway diesel fuel supplied. As in the NPRM, the cost of producing this additional volume was included in the calculation of refinery costs (see Section V.C.1.). In the NPRM, we estimated that the cost of distributing highway diesel fuel was equal to the difference in price at the refinery rack and the retail price. For today's final rule, we based our estimate of distribution cost on a PADD by PADD evaluation of the difference in the price of highway diesel fuel at the refiner rack versus the retail price. The price differential for each PADD was weighted by the additional volume of fuel we anticipate will need to be produced in each PADD to arrive at an estimate of distributing the additional volume needed for the nation as a whole. We believe this approach provides a more accurate estimate of costs.

Based on additional information provided in the comments on the changes in pipeline interface practices that would result from today's rule, we adjusted our estimate of the increased volume of highway diesel fuel that would be downgraded to a lower-value product from 1.5 percent to 2.2 percent of highway diesel fuel supplied (see the RIA to this rule). As in the NPRM, the cost of producing this additional volume was included in the calculation of refinery costs (see Section V.C.1.). The cost of downgrading the increased volume of highway diesel fuel to a lower-value product is based on the difference in the cost of 15 ppm sulfur diesel fuel and the product to which the interface is downgraded. Under the fully imlemented program, this downgrade would be made into the nonroad diesel pool. The cost of this increased volume of downgrade is estimated at approximately 0.14 cents per gallon of highway diesel supplied.

We identified that there would also be an increase in the economic impact for the existing volume of interface currently associated with pipeline shipments of highway diesel fuel. This is because the cost of downgrading the existing interface volume would be determined by the difference between the cost of 15 ppm sulfur fuel and nonroad diesel fuel rather than the difference in cost between current 500 ppm diesel fuel and nonroad diesel fuel as it is today. We estimate that the increase in the cost of downgrading the existing highway diesel interface would be 0.09 cents per gallon of highway diesel fuel supplied.

We anticipate that there may be minor costs in addition to those discussed above associated with optimizing the distribution system to adequately limit sulfur contamination. These costs could result from various minor changes to distribution practices and or hardware discovered to be needed by industry while preparing to comply with today's rule. While it is not possible to specifically identify the nature of these changes, they could include the occasional replacement of a leaking valve or improvements in communication practices to facilitate batch changes in the pipeline system. There may also be some cost associated with the process that we anticipate the distribution industry will undertake to evaluate its readiness to comply with the requirements in today's rule. Such costs might result from testing to determine the level of contamination introduced through the use of various distribution hardware or practices. It is not possible to specifically identify the costs that might be associated with this optimization process. However, given the limited nature of the changes that might be needed and that the need for such changes would not be widespread, we believe that the associated costs would not pose a substantial burden. We estimate that the miscellaneous costs associated with optimizing the distribution system to limit sulfur contamination would be 0.025 cents per gallon of highway diesel fuel supplied (on average) during the period from when the sulfur program is fully implemented (2010) through the year 2020. These costs were amortized at a rate of 7% over the period of 2006 through 2020. The per gallon cost is somewhat higher during the initial years.

Commenters to the proposed rule stated that it is current practice for all of the interface generated when highway diesel fuel abuts jet fuel in the pipeline to be cut into highway diesel fuel. They pointed out that this practice would no longer be possible when all highway diesel fuel is required to meet a 15 ppm sulfur cap because of the relatively high sulfur content of jet fuel (as high as 3000 ppm).[189] They stated that the mixture of highway diesel fuel meeting a 15 ppm sulfur cap and jet fuel would need to be returned from the terminal to the refinery for reprocessing, at high cost (*i.e.* would need to be treated as transmix). While we agree that handling procedures for this mixture will need to change, we believe that it will not be necessary to treat it as transmix. We believe that there will be opportunity for the mixture to be sold from the terminal into the nonroad diesel pool. This will increase the cost associated with downgrading this mixture.

[189] During the initial years of the sulfur program, the current practice used to handle the interface between shipments of jet fuel and highway diesel fuel can be used for that portion of the highway diesel fuel that continues to meet a 500 ppm sulfur cap.

Expressed in terms of the volume of highway diesel fuel supplied, we estimate this cost at 0.07 cents per gallon. Additional storage tanks will be needed to handle the mixture at those terminals that currently do not handle nonroad diesel fuel. The cost of these tanks has been fully accounted for in the calculation of costs during the initial years of the program.

The additional quality control testing at the terminal level needed to ensure compliance with the 15 ppm sulfur cap would be the same during the initial years as after the requirements are fully implemented. We estimate that the cost of this additional testing would be as we projected in the proposal, 0.002 cent per gallon of highway diesel supplied (see the RIA to this rule).

We believe that there will not be a significant increase in the volume of highway diesel fuel discovered to exceed the sulfur standard downstream of the refinery as a result of today's rule. We believe this will be the case both during the initial years and after the sulfur requirements are fully implemented. We anticipate that distributors will quickly optimize their practices to avoid sulfur contamination. We also anticipate that distributors will gain some experience in reducing sulfur contamination in the distribution system through complying with the recently finalized Tier 2 low sulfur gasoline requirements (65 FR 6698, February 10, 2000). While outside the scope of this final rule, it is worth pointing out that potential difficulties in distributing 15 ppm diesel fuel would be lessened if the sulfur content of nonroad diesel fuel is reduced by a future rulemaking (as discussed in Section 8). We anticipate that the batches of highway diesel fuel that are discovered to exceed the 15 ppm sulfur cap will be coped with as follows:

—When possible, by blending highway diesel fuel that is below the 15 ppm cap with the out-of-specification batch to bring the resulting mixture into compliance. This practice will be more difficult than it is currently because the amount of fuel needed to blend the out-of-specification batch into compliance may increase. However, we expect it to continue to be the method of choice for handling out-of-specification highway diesel whenever possible.
—By downgrading the batch either to nonroad diesel fuel or to 500 ppm highway diesel during the initial years.
—By reprocessing the batch to meet the 15 ppm cap, but only in those infrequent instances where the previous options do not exist.

We do not believe that the cost of handling out-of specification highway diesel batches will increase significantly as a result of today's action.

Tank truck, tank wagon, and barge operators may need to more carefully and consistently observe current industry practices to limit contamination in some situations. However, these situations are more the exception than the rule and are of a limited nature. Consequently, we believe that this can be accomplished at an insignificant cost. Additional considerations exist for distributors during the initial years as discussed in the following section.

Please refer to the Response to Comments Document for an evaluation of the comments received on the increase in fuel distribution costs associated with today's rule, and to the RIA for a detailed discussion of the way in which we derived the our cost estimates.

b. Distribution Costs During the Initial Years

The factors that cause distribution costs to differ during the initial years include:

—Having a lesser volume of 15 ppm diesel fuel in the system reduces the costs associated with distributing 15 ppm fuel.
—Having an additional grade of highway diesel fuel in the system (500 ppm) creates additional pipeline interface volumes, and additional product downgrade costs.
—The need for additional equipment to handle an additional grade leads to additional costs that must be accounted for during the initial years.
—Having 500 ppm highway diesel fuel in the system allows some opportunity for the pipeline interface volumes associated with the shipment of 15 ppm fuel and jet fuel to be downgraded to 500 ppm diesel fuel rather than nonroad diesel fuel. This will reduce the cost associated with downgrading the subject interface volumes.

In calculating the distribution costs for the initial years of the program, we estimated that 60 percent of the 15 ppm highway diesel fuel shipped by pipeline will be carried in pipelines that choose not to carry 500 ppm diesel fuel. We estimated that the remaining 40 percent of 15 ppm highway diesel fuel shipped by pipeline would be carried in pipelines that carry 500 ppm as well as nonroad diesel fuel. For the sake of simplicity and to allow a comparison with distribution costs when the program is fully implemented, the distribution costs during the initial years as discussed below are expressed in terms of the total volume of highway diesel fuel supplied. This includes 500 ppm as well as 15 ppm highway diesel fuel.

For the reasons outlined above, the following costs, which are also present under the fully implemented sulfur program, were adjusted to reflect the unique conditions during the initial years. During the initial years, the cost of distributing the additional volume of highway diesel fuel needed to compensate for lower energy density of 15 ppm sulfur fuel is estimated at 0.14 cents per gallon of highway diesel fuel supplied. The cost of the increased volume of highway diesel fuel that must be downgraded to a lower-value product is estimated at 0.1 cents per gallon of highway diesel supplied. We estimate that during the initial years of the program the increase in the cost of downgrading the existing highway diesel interface would be 0.08 cents per gallon of highway diesel fuel supplied. During the initial years, the cost of downgrading the interface between pipeline shipments of jet fuel and highway diesel fuel is estimated to increase by 0.03 cents per gallon of highway diesel fuel supplied. The cost of the additional tanks required at terminals to handle this interface is estimated at 0.009 cents per gallon of highway diesel fuel supplied. This tank cost was amortized over the period of the four-year transition period. We estimate that the miscellaneous costs associated with optimizing the distribution system to limit sulfur contamination would be 0.027 cents per gallon of highway diesel fuel supplied (on average) during the initial period (2006—2010).

As noted in the previous section, the additional quality control testing at the terminal level needed to ensure compliance with the 15 ppm sulfur cap would be the same during the initial years and after the requirements are fully implemented. We estimate that the cost of this additional testing would be as we projected in the proposal, 0.002 cent per gallon of highway diesel supplied.

The cost during the initial years of downgrading the additional interface volumes associated with having two grades of highway diesel fuel in part of the pipeline system is estimated at 0.004 cents per gallon of highway diesel full supplied

The most substantial costs associated with the provisions during the initial years of the program are due to the need to handle an additional grade of highway diesel fuel in the distribution system. Under the final program, the production of 500 ppm sulfur fuel will be much less than that of 15 ppm fuel. At the same time, most of the diesel vehicle fleet can burn 500 ppm fuel during the initial period. Because of its greater volume and the need to distribute it everywhere in the country, we expect that essentially all pipelines and terminals will handle 15 ppm fuel. In contrast, distribution of 500 ppm fuel will concentrate on those areas nearest the refineries producing that fuel, plus a few major pipelines serving major refining areas.

Regarding distribution to the final user, we expect that nearly all truck stops in areas where 500 ppm fuel is available will invest in piping and tankage to handle a second fuel. Because of the significant expense involved in adding a second tank, in these areas, we expect service stations will only carry one fuel or the other, as market demands dictate. Likewise, we expect that centrally fueled fleets and card locks will only handle 15 ppm fuel. Under this scenario, sales of 500 ppm fuel are limited to only those vehicles which refuel at truck stops and service stations. This is somewhat conservative since some centrally fueled fleets may have the flexibility to inexpensively handle two fuels. Likewise, some card locks in a given area may be able to carry 15 ppm fuel and others 500 ppm fuel and still serve their clients at little extra cost. Still, given the above assumptions, we project that the 500 ppm fuel will have to be distributed to areas representing about 50 percent of the national diesel fuel demand. Also, as the fleet turns over to 2007 and later vehicles during the initial years, the amount of 500 ppm fuel produced will gradually decrease from just over 20 percent in 2007 to about 16 percent in 2010.

The tankage cost at refineries, terminals, pipelines and bulk plants handling both fuels is estimated to be $0.81 billion. The cost for truck stops to handle two fuels is roughly $0.24 billion, for a total cost of $1.05 billion. Amortized over all of the highway diesel fuel supplied during the initial four-years (15 ppm and 500 ppm) at 7 percent per annum, the cost per gallon is 0.7 cents.

5. Benefits of Low-Sulfur Diesel Fuel for the Existing Diesel Fleet

We estimate that the low-sulfur diesel fuel will provide additional benefits to the existing heavy-duty vehicle fleet as soon as the fuel is introduced. We believe these benefits will offer significant cost savings to the vehicle owner without the need for purchasing any new technologies. The RIA has catalogued a variety of benefits from the low-sulfur diesel fuel. These benefits are summarized in Table V.C–3.

TABLE V.C–3.—COMPONENTS POTENTIALLY AFFECTED BY LOWER SULFUR LEVELS IN DIESEL FUEL

| Affected components | Effect of lower sulfur | Potential impact on engine system |
|---|---|---|
| Piston Rings | Reduce corrosion wear | Extended engine life and less frequent rebuilds. |
| Cylinder Liners | Reduce corrosion wear | Extended engine life and less frequent rebuilds. |
| Oil Quality | Reduce deposits and less need for alkaline additives. | Reduce wear on piston ring and cylinder liner and less frequent oil changes. |
| Exhaust System (tailpipe) | Reduces corrosion wear | Less frequent part replacement. |
| EGR | Reduces corrosion wear | Less frequent part replacement. |

The actual value of these benefits over the life of the vehicle will depend upon the length of time that the vehicle operates on low-sulfur diesel fuel and the degree to which vehicle operators change engine maintenance patterns to take advantage of these benefits. For a vehicle near the end of its life in 2007 the benefits will be quite small. However for vehicles produced in the years immediately preceding the introduction of low-sulfur fuel the savings will be substantial. The RIA estimates that a heavy heavy-duty vehicle introduced into the fleet in 2006 will realize savings of $610 over its life. This savings could alternatively be expressed in terms of fuel costs as approximately 1 cent per gallon as discussed in the RIA. These savings will occur without additional new cost to the vehicle owner beyond the incremental cost of the low-sulfur diesel fuel, although these savings will require changes to existing maintenance schedules. Such changes seem likely given the magnitude of the savings and the nature of the regulated industry.

*D. Aggregate Costs*

Using current data for the size and characteristics of the heavy-duty vehicle fleet and making projections for the future, the diesel per-engine, gasoline per-vehicle, and per-gallon fuel costs described above can be used to estimate the total cost to the nation for the emission standards in any year. Figure V.D–1 portrays the results of these projections.[190] All capital costs have been amortized.

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[190] Figure V.E–1 is based on the amortized engine, vehicle and fuel costs as described in the RIA. Actual capital investments, particularly important for fuels, would occur prior to and during the initial years of the program.

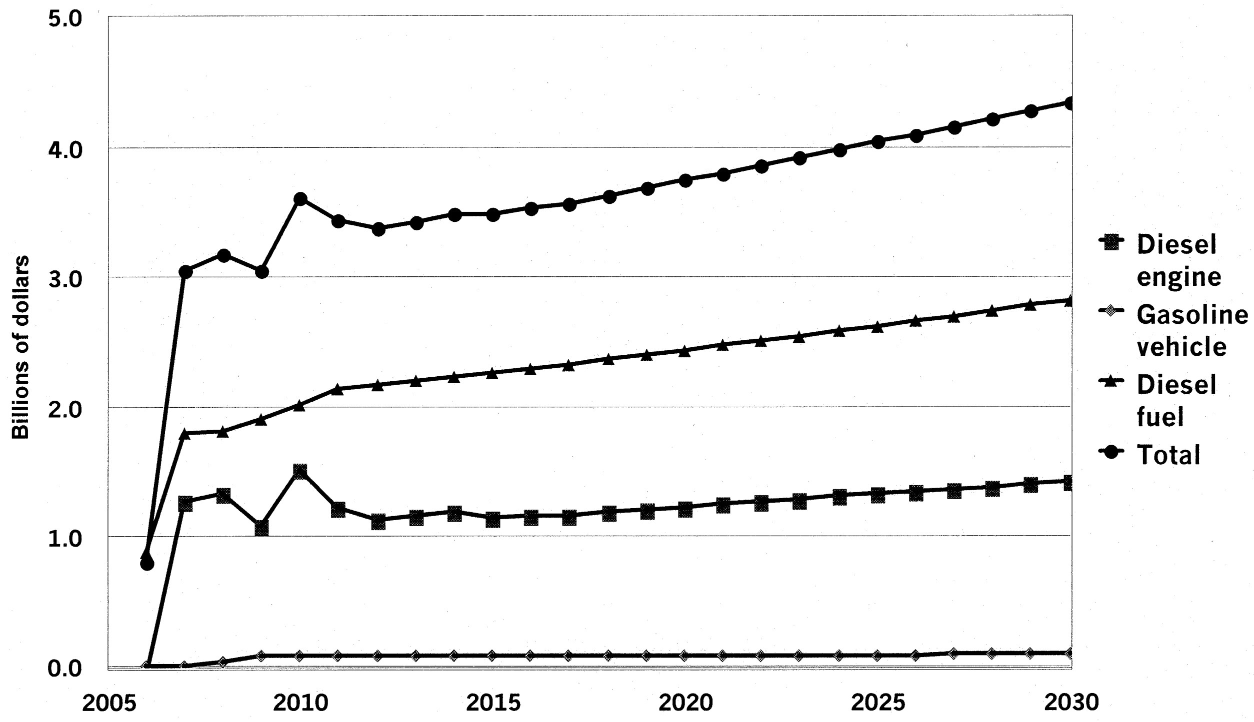


**Figure V.D-1 Total Annualized Costs**

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