State of California
AIR RESOURCES BOARD

Staff Report: Initial Statement of Reasons
for Proposed Rulemaking

PUBLIC HEARING TO CONSIDER AMENDMENTS TO REGULATIONS REGARDING CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY ENGINES AND VEHICLES, TO SPECIFY MANDATORY STANDARDS FOR 1998 AND SUBSEQUENT HEAVY-DUTY ENGINES AND OPTIONAL STANDARDS FOR 1995 AND SUBSEQUENT HEAVY-DUTY ENGINES.

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I. INTRODUCTION

Despite significant control of emissions from motor vehicles, progress towards attainment of ambient air quality standards has been slowed by substantial increases in vehicle population and the number of vehicle miles traveled (VMT). California has the worst air quality in the nation. Of the seven cities with the worst ozone problems in the United States, six are located in California. Residents who live in the Los Angeles area are exposed to unhealthy levels of ozone about half the days each year. Approximately 40 percent of the air quality problem is attributable to motor vehicles that are driven on the state's roads and highways. Heavy-duty vehicles (HDVs), including trucks and urban buses, account for only about 3 percent of the current on-road vehicles registered in California. However, HDVs contribute significantly to California's air quality problem because of their high per-mile emissions of certain pollutants, relative to light-duty vehicles, and because they account for about 8 percent of the vehicle miles traveled on the state's roads and highways, disproportionate to their numbers.

Increasing concern over air pollution problems has prompted government agencies at the state, federal, and local levels to promulgate extensive programs to further reduce motor vehicle emissions. Among other accomplishments, the Air Resources Board (ARB or the "Board") adopted, in 1990, new more stringent low-emission standards for light-duty and medium-duty vehicles, including passenger cars, that would require significant reductions in emissions from these classes of vehicles. These regulations will provide improvements in air quality by reducing ozone-forming hydrocarbons (HC) and oxides of nitrogen (NOx), as well as other emissions.

In addition, emission inventory estimates for California show that HDVs are becoming an increasing portion of the emissions problem. By the year 2010, the projected HDV contribution to on-road vehicle emissions will be 20 percent of the HC and carbon monoxide (CO) emissions, 55 percent of the NOx, and 85 percent of the exhaust particulate matter (PM) emitted from all on-road vehicles. Heavy-duty diesel vehicles that operate in urban areas, such as transit buses, are of particular concern because of the high public exposure to the exhaust pollutants. Furthermore, the ARB staff is currently reviewing diesel exhaust for possible identification as a toxic air contaminant.

Recognizing the need to further reduce emissions from HDVs, the Board, in June, 1993, adopted new emission standards and test procedures for urban transit buses. That action was in response to Health and Safety Code (H&SC) Section 43806 which mandated that the regulations are to be effective by January 1, 1996, and that they are to reflect the best emission control technologies available at that time. The ensuing regulation set the California PM emission standards for urban transit buses to be as stringent as the corresponding federal standards (0.07 gram/brake horsepower-hour, or g/bhp-hr, in 1994 and 0.05 g/bhp-hr in 1996) and to take effect at the same time. It also set the state NOx emission standard for urban bus engines to be identical to the 1998 federal standard for all heavy-duty engines (HDEs) (4.0 g/bhp-hr), although two years ahead of the federal requirement. Moving ahead of federal standards in this way, or even simply aligning with them, is an integral part of the California motor vehicle emissions program and keeps with the spirit of the federal waiver which allows that program.

However, the Board's 1993 action only dealt with the urban bus subset of heavy-duty vehicles, leaving the regulations for HDEs other than urban bus engines (referred to herein as heavy-duty truck or HDT engines) untouched. This means that, without additional action, the 1998 California standards for HDT engines would be less stringent than the corresponding federal standard. The primary purpose of this regulatory proposal is to address the need to align the California NOx emission standard for 1998 and subsequent model year new heavy-duty engines, other than urban bus engines, with the federal standard. In addition, provision is made for aligning the California statutory useful life for HDE NOx emissions with the new, increased federal useful lifespan that goes into effect in 1998.

The State Implementation Plan (SIP), recently approved by the Board, contains provisions for the use of incentives to encourage the early introduction of low-emission heavy-duty vehicles in advance of regulatory mandates. Engines for such vehicles would have to be certified to an optional, reduced-emission standard before their sale in California would be allowed. An additional purpose for this proposal is to provide such optional certification standards so that engines can be adequately certified for use in these incentive programs. These optional standards will also provide means for vehicle operators to generate mobile source emission reduction credits as part of a credits program for HDTs. Guidelines for such credit programs will be presented to the Board in the near future for approval for inclusion in the existing document entitled "Mobile Source Emission Reduction Credits---Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits."

II. BACKGROUND

A wide variety of HDVs operate in California. For 1995 and subsequent model years, they can be categorized as light HDVs (14,001 lbs. gross vehicle weight rating (GVWR) up to but not including 19,500 lbs.), medium HDVs (19,500 lbs. to 33,000 lbs.) and heavy HDVs (over 33,000 lbs.). (For 1994 and earlier model years, light HDVs included HDVs with a GVWR of 8,501 to 19,500 lbs.) These ranges cover vehicles from delivery vans through line-haul trucks ("semi's") of 60,000 lbs. GVWR or more. In 1994 there were about 198,000 diesel-fueled HDTs, about 587,000 gasoline-fueled HDTs, and almost 6,000 HD urban transit buses registered in the state with many more out-of-state HDVs contributing to California's air quality problems. Mobile source inventory estimates for 1994 indicate that in-state plus out-of-state HDVs were responsible for emitting approximately 148 tons per day of total organic gases (TOG), 1,316 tons per day of CO, 717 tons per day of NOx, and 65 tons per day of exhaust PM.

It is difficult to describe the types of HDV operations conducted daily in the state due to the wide variety of vehicles and applications that exist. At the risk of over-simplifying, the smaller vehicles generally conduct operations within a small, localized area, usually delivery type operations, and many are centrally-fueled. The larger vehicles tend to be line-haul trucks which provide long-distance, over-the-road transport of freight within the state or even between states, obtaining fuel at points along the routes of travel. In contrast, urban transit buses are large vehicles which transport people in local operations and are usually centrally-fueled. Smaller HDVs tend to be gasoline-fueled while almost all heavy HDVs are diesel-fueled.

Heavy-duty vehicles that use diesel-cycle engines normally fueled by diesel fuel, inherently emit relatively low levels of HC and CO, but relatively high levels of NOx and PM, compared to gasoline vehicles. Diesel-cycle engines provide high efficiency over a wide range of loads and speeds while using a simple distillate fuel. Also, most of the diesel engines that have been developed for heavy-duty vehicles provide much greater durability than is associated with gasoline engines. Many diesel engines may be rebuilt several times before being replaced. As a result, diesel engines are used widely in line-haul trucks and buses that need to travel many miles over the life of the vehicle.

As a final background note, the California test procedures and standards for heavy-duty engines provide for a variation on the applicability of the diesel standards and the Otto-cycle standards. The diesel engine procedures, entitled "CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL-ENGINES AND VEHICLES", cover not only diesel-fueled, diesel-cycle engines, but also all natural gas-fueled and liquefied petroleum gas-fueled engines derived from diesel-cycle engines, regardless of whether they operate on a diesel cycle or an Otto cycle. Correspondingly, the Otto-cycle procedures and standards, entitled "CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES" apply to all Otto-cycle engines, *except* those natural gas-fueled and liquefied petroleum gas-fueled engines derived from diesel-cycle engines. The body of this report assumes this convention unless stated explicitly otherwise. The proposed regulations in the attachments to this report state this convention unless the meaning is otherwise clear from the context.

A. DEFINITIONS

Title 13 of the California Code of Regulations (CCR) defines heavy-duty vehicle as any vehicle with a gross vehicle weight rating (GVWR) over 6,000 pounds except for passenger cars. However, it also defines medium-duty vehicles as: 1) pre-1995 model year heavy-duty vehicles of 8,500 lbs. or less; 2) heavy-duty vehicles of 1992 or subsequent model year and of 14,000 lbs. or less GVWR and also certified to low-emission, ultra-low-emission or zero-emission vehicle standards; or 3) any heavy-duty vehicle of 1995 or subsequent model year of 14,000 lbs. GVWR or less. Accordingly, for purposes of this proposal, the term heavy-duty vehicle refers to any vehicle over 6,000 lbs. GVWR which also is not classified as a medium-duty vehicle, light-duty truck or passenger car.

The statutory useful life for HDEs is that period of time or mileage during which the engine's actual emissions of a specific pollutant are expected to remain at or below the level required by the certification standard. At present, the useful life for all pollutants from Otto-cycle heavy-duty engines and light heavy-duty diesel engines is 8 years or 110,000 miles. For medium heavy-duty diesel engines it is 8 years or 185,000 miles for all pollutants. Similarly, the useful life for all pollutants from heavy heavy-duty diesel engines is 8 years or 290,000 miles except for the useful life standard for PM emissions from urban transit buses which was recently changed in both California and federal regulations to a useful life of 10 years and 290,000 miles. In order to comply with the recently amended Clean Air Act, the U.S. EPA has changed the federal useful life requirement for NOx emissions from 1998 and later heavy-duty vehicles, from 8 years to 10 years, while retaining the current useful life mileage values. Accordingly, this proposal would align the California definitions with the Federal definitions.

B. EMISSION STANDARDS

The recent history of both California and federal NOx and PM standards for heavy-duty engines is presented in Tables 1a, and 1b:

Table 1a

California and Federal Heavy-Duty Truck and Urban Bus Engine NOx Emission Standards (g/bhp-hr)

	CA Truck	Fed. Truck	CA Bus	Fed. Bus
1990	6.0	6.0	6.0	6.0
1991	5.0	5.0	5.0	5.0
1996	5.0	5.0	4.0	5.0
1998	5.0	4.0	4.0	4.0

Table 1b

California and Federal Heavy-Duty Truck and Urban Bus Engine PM Emission Standards (g/bhp-hr)

	CA Truck	Fed. Truck	CA Bus	Fed. Bus
1990	0.6	0.6	0.6	0.6
1991	0.25	0.25	0.1	0.25
1993	0.25	0.25	0.1	0.1
1994	0.1	0.1	0.07	0.07
1996	0.1	0.1	0.05*	0.05*

* in-use standard of 0.07 g/bhp-hr

These tables show that California's HDE standards for NOx and PM have been maintained at levels at least as stringent as the corresponding federal standards. For example, as indicated in Table 1a, the Board adopted a 4.0 g/bhp-hr standard for urban bus engine NOx emissions in June 1993, to become effective in 1996, two years before the federal urban bus engine standard becomes effective at that level. But this same table also shows that, without adoption of a 4.0 g/bhp-hr standard to become effective in 1998, the California NOx standard for HDT engines will not keep pace with the reductions in the corresponding federal standard and, therefore, the California standard would be less stringent.

III. SUMMARY OF RECOMMENDED ACTION

The staff recommends that the Board amend Sections 1956.8, 1965, and 2112, Title 13, California Code of Regulations, and the incorporated "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles", "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles", and "California Motor Vehicle Emission Control Label Specifications" as amended. This proposal would require heavy-duty engines, used in applications other than urban transit buses, to meet a more stringent NOx exhaust emission standard (4.0 grams/bhp-hr) beginning with the 1998 model year (urban bus engines are excluded since a stricter standard for them has already been placed into regulation for initial implementation in 1996). The proposal would also extend the useful life requirement for NOx emissions from 8 years to 10 years, beginning with the 1998 model year. Also proposed are optional emission standards for 1995 and later model year heavy-duty vehicle engines, other than those for use in urban buses (excluded since optional standards for urban buses have already been implemented), which can be used for the purpose of early low-emission vehicle introduction programs and for generating emission reductions that could be applied towards a local air pollution control district's mobile source emission credit program. The major provisions of the staff proposal are discussed in further detail below.

A. APPLICABILITY

The federal Clean Air Act (CAA), as amended by Congress in 1990, contains several provisions related to heavy-duty engines and vehicles, including urban transit buses. These provisions, in part, required the U.S. EPA to develop new, more stringent emission standards for heavy-duty engines in general, with special attention to those used in urban transit buses. The U.S. EPA issued a final rule (Federal Register, Vol. 58, No. 55, p. 15781, March 24, 1993) which, in part, implements new standards for new urban bus engines in the nation. In addition, the California Legislature, in 1991, added Section 43806 to the H&SC which required the ARB to establish reduced emission standards for urban transit buses. The Board approved the proposed response to H&SC 43806 in June 1993, with increasingly stringent PM standards to become effective in 1994 and 1996 and a more stringent NOx standard to become effective in 1996. That action also sufficed to make the California urban bus engine standards at least as stringent as the established federal standards.

The referenced U.S. EPA rule established reduced standards for NOx emissions from all HDVs beginning in 1998. At that time, new federally-regulated HDEs must be certified to a 4.0 g/bhp-hr NOx standard, down from the 5.0 g/bhp-hr standard in effect since 1991. The current California NOx standard is 5.0 g/bhp-hr, and would remain California's effective standard for HDEs, other than those used in urban buses, in 1998 and later years if no action is taken to change it. Without the change, California would have a less stringent standard than that applied to the other 49 states, a situation that is contrary to the federal waiver for California, which requires California to have a motor vehicle program at least as stringent as the federal program in the aggregate. The regulations proposed herein would align the relevant California standard with the federal standard to maintain the stringency of the California vehicular program.

As defined in Title 13, California Code of Regulations, "heavy-duty" has the same meaning as defined in Section 39033 of the H&SC, which means vehicles greater than 6,000 pounds GVWR. As stated in the introduction to this report, the proposed action would not include all heavy-duty vehicles greater than 6,000 pounds GVWR. Very stringent emission standards have already been established for vehicles with GVW ratings from 6,001 to 14,000 pounds (medium-duty vehicles or MDVs), to be implemented starting with the 1995 model year. Therefore, by excluding from applicability those heavy-duty vehicles in the 6,000 to 14,000 pound GVWR range (that is, medium-duty vehicles), the proposed regulatory changes would not impede the effectiveness of regulations already in place and the expected emissions benefit would not be affected. The proposed changes to the mandatory standards in Title 13 will apply to all new heavy-duty vehicles, starting with the 1998 model year, and to all new engines for use in heavy-duty vehicles, starting with the 1998 model year. The proposed optional standards will be available for application to all new heavy-duty vehicles, and all new engines for use in heavy-duty vehicles, purchased on or after 30 days from the date of final approval of the applicable proposed regulations.

B. EMISSION STANDARDS

To align the California heavy-duty emission standards for 1998 and subsequent model year heavy-duty vehicles and engines with the standards of the U.S. EPA, staff is proposing, for the Board's consideration, a heavy-duty NOx standard of 4.0 g/bhp-hr, beginning with the 1998 model year. Staff is also proposing that the Board adopt optional lower heavy-duty truck engine NOx standards, beginning with the 1995 engine model year, which could be used in conjunction with early-introduction incentive programs or with a local air pollution control district's mobile source emission reduction credit program.

1. Proposed Mandatory Emission Standards and Useful Life Extension

Staff is proposing that the Board adopt, for new heavy-duty engines to be used in heavy-duty vehicles other than urban buses, a mandatory 4.0 g/bhp-hr NOx standard for the 1998 and later model years. Also, as discussed in EPA's "Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Particulate Emission Regulations for 1993 Model Year Buses, Particulate Emission Regulations for 1994 and Later Model Year Urban Buses, Test Procedures for Urban Buses, and Oxides of Nitrogen Emission Regulations for 1998 and Later Model Year Heavy-duty Engines" (the U.S. EPA's regulatory support document for the associated federal regulation), the federal Clean Air Act directed EPA to adopt an extended useful life requirement for any new standards that first become applicable after the enactment of the 1990 amendments to the federal Clean Air Act. The EPA, in setting the federal 4.0 g/bhp-hr NOx standard for HDVs, also set the useful life calendar age requirement of 10 years for NOx emissions from HDVs for the 1998 and later model years. In order to be consistent with federal regulations, this proposal also requests that the useful life requirement of 10 years be adopted for the proposed California HDT NOx standards, beginning with the 1998 model year.

Certain gasoline-fueled and alternative-fueled heavy-duty engines are already certified at levels that would meet the proposed standards. However, it is anticipated that production diesel-fueled engines would also be able to meet the proposed mandatory emission standards by 1998. Staff's analyses of the feasibility of the standards are discussed in further detail in the section entitled "Technological Feasibility" and the attached Technical Support Document. Table 2 presents the proposed mandatory standards as well as the standards for pollutants not changed by this proposal:

Table 2

Proposed Mandatory Heavy-Duty Engine Emission Standards (1998 and later) (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
diesel-cycle truck	1.3	1.2	15.5	4.0	0.10
Otto-cycle truck (over 14,000 lbs.)	1.9	1.7	37.1	4.0	NA

2. Proposed Optional Emission Standards

(1) Range of NOx Standards

Under the optional emission standards, beginning with the 1995 model year, staff is proposing to establish a range of diesel-cycle engine NOx standards from 0.5 g/bhp-hr to 3.5 g/bhp-hr, at 0.5 g/bhp-hr increments, for engines used in vehicles other than urban buses. This range of standards could be used to certify engines that emit substantially less NOx than the current mandatory 5.0 g/bhp-hr NOx standard. However, in 1998, this optional diesel-cycle engine NOx emission standards range would be tightened to 0.5 g/bhp-hr to 2.5 g/bhp-hr, at 0.5 g/bhp-hr increments, to follow the mandatory NOx standard which would be lowered to 4.0 g/bhp-hr NOx.

For heavy-duty Otto-cycle engines, the proposed optional standards starting in 1995 would range from 0.5 g/bhp-hr through 2.5 g/bhp-hr, at 0.5 g/bhp-hr increments. The lower maximum, compared to diesel engines, is necessary since gasoline-fueled Otto-cycle engines typically have lower NOx emission levels than diesel engines. In 1998, the optional Otto-cycle engine NOx emission standards range would be tightened to 0.5 g/bhp-hr through 1.5 g/bhp-hr, at 0.5 g/bhp-hr increments, to follow the mandatory NOx standard which would be lowered at that time.

The optional NOx standards are contained in Tables 3a and 3b. Note that only the NOx standards differ from the mandatory standards of Table 2.

Table 3a

Proposed Optional Heavy-Duty Engine Emission Standards, 1995 - 1997 (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
diesel-cycle truck	1.3	1.2	15.5	0.5 to 3.5*	0.10
Otto-cycle truck (over 14,000 lbs.)	1.9	1.7	37.1	0.5 to 2.5*	NA

* by 0.5 g/bhp-hr increments

Table 3b

Proposed Optional Heavy-Duty Engine Emission Standards, 1998 and later (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
diesel-cycle truck	1.3	1.2	15.5	0.5 to 2.5*	0.10
Otto-cycle truck (over 14,000 lbs.)	1.9	1.7	37.1	0.5 to 1.5*	NA

* by 0.5 g/bhp-hr increments

The adoption of the proposed optional emission standards would allow low-emitting heavy-duty engines to be certified to more stringent standards and purchased to participate in early introduction efforts or to create NOx emission credits that could be used in a mobile source emission credit program. (The Sacramento Metropolitan Air Quality Management District already has a control measure in place that requires some HDV fleet purchases to be cleaner than the current standards. These clean vehicles would utilize the optional reduced-emission standards.) For example, if an engine emits 2.0 g/bhp-hr NOx and meets the mandatory emission standards for the other pollutants, a manufacturer may apply for certification to meet either a 2.0, 2.5, 3.0, or 3.5 g/bhp-hr NOx standard for the 1995 through 1997 model years. Selection of one of these levels would be related to the manufacturer's confidence as to which standard could be maintained in-use for the engine's useful life. Starting in 1998, however, a manufacturer would be limited to optionally certifying a heavy-duty engine that emits 2.0 g/bhp-hr NOx to only a 2.0 or 2.5 g/bhp-hr NOx standard. This follows the change in the mandatory NOx standard (and thus the maximum optional standard) proposed to occur in 1998. As an example for emission reduction calculation purposes, a 1998 diesel engine certified to a 2.0 g/bhp-hr optional standard, would achieve a maximum reduction of 2.0 g/bhp-hr NOx (the difference between the proposed mandatory 4.0 g/bhp-hr NOx and optional 2.0 g/bhp-hr NOx standards.)

It is necessary to set the maximum optional emission standard significantly more stringent than the mandatory emission standards in order to assure that "low-emission" control technology is, indeed, utilized on any heavy-duty engines and vehicles claiming reduced emission status.

The reason for limiting the optional NOx standards to 0.5 g/bhp-hr increments is related to the variability in emissions from different engines within a certified engine family. For example, if an engine family is certified to an optional 2.0 g/bhp-hr NOx standard, one individual engine from that engine family may actually be emitting in-use at 2.0 g/bhp-hr NOx, another engine at 1.9 g/bhp-hr NOx and another at 2.1 g/bhp-hr NOx. All three engines under that engine family have been certified to a 2.0 g/bhp-hr NOx standard and emission reductions would be calculated accordingly. However, if other optional NOx standards were allowed too close in range to the optional 2.0 g/bhp-hr NOx standard, (i.e., increments less than 0.5 g/bhp-hr), then another engine family that could be certified to an optional 1.9 g/bhp-hr NOx standard, as an example, would have engines whose actual in-use emissions overlap with that engine family that is certified to the optional 2.0 g/bhp-hr NOx standard. This would make it virtually impossible to determine if the additional reductions calculated for the 1.9 g/bhp-hr NOx engine family were valid in-use. Also, alternative-fueled engine emissions variability has not been established to the degree that it has been for diesel engines so there is greater uncertainty associated with the emissions performance of such engines (an important consideration since most of the engines to be certified to the optional standards, at least initially, are expected to utilize alternative fuels.) Therefore, staff has proposed that the optional NOx standards be allowed with increments of no less than 0.5 g/bhp-hr. This will help to maintain an acceptable confidence level that an engine certified to an optional standard is actually meeting that standard in-use and that the emission reductions claimed are real. The Board has previously directed the staff to reexamine the possibility of implementing smaller increment sizes as experience with optional standard certification is gained. The staff remains committed to doing so once the necessary in-use data are available.

(2) Labeling Requirement

To help identify those engines that are certified to the proposed optional emission standards, it is proposed that manufacturers be required to include additional information on the emission control label for each engine. This information would identify the engine by the optional NOx emission standard it is certified to, and would state that it meets all other applicable California emission standards for that particular engine model year. It is also proposed that manufacturers be given the option to use a supplemental emission control label in the event that there is not enough space to add this information on to the present label, pursuant to currently referenced Society of Automotive Engineers (SAE) specifications (J1877, J1892) for letter sizing and spacing.

(3) Tamper-Resistance Requirement

Staff is also proposing that additional measures be taken to discourage tampering of heavy-duty engines that are intended to be certified under the proposed optional emission standards. Staff proposes that all 1995 and later model year heavy-duty engines, that manufacturers intend to certify to the optional emission standards, be subject to the tamper-resistant measures as required by 40 CFR 86.090-22. Thus, any adjustable parameter that could affect emission performance will be made adequately inaccessible and sealed. This requirement will help ensure the in-use validity of any emission reductions claimed for the use of engines certified to an optional standard.

(4) Mobile Source Credit Programs

Several air pollution control districts that are interested in emission credits programs have developed specific rules for the generation and use of mobile source emission reduction credits. Among the criteria followed in developing these rules are the principles that the reductions must be in excess of what is required by law, they must be real, and they must be quantified to an acceptable degree of certainty. Also, according to the U.S. EPA, the mechanism used to obtain mobile source emission reduction credits must be enforceable and legally binding, and have an established life span. These criteria necessitate a strong enforcement program, and in-use testing of heavy-duty vehicles and engines certified under the proposed optional emission standards is essential in order for credits to be valid over the useful life of the vehicle.

By adopting and implementing a mobile source emission reduction credit program, the air pollution control district would create an opportunity for businesses and industry to create and use mobile source emission reduction credits. This would provide flexibility to industry in meeting requirements for emission reductions needed to offset increases in emissions associated with economic growth, and to reduce emissions from certain mobile sources. The development of such programs may also encourage the advancement of technologies that increase the emission reductions possible from mobile sources, such as the advancement of electric-powered vehicles and fuel cell technology. The proposed optional emission standards, as part of this regulatory action, are supportive of these goals. Staff believes that the proposed mandatory and optional emission standards provide a balanced proposal that requires the further reduction of NOx emissions from heavy-duty vehicles while encouraging the use of more cleanly operating vehicles.

3. Regulatory Language

The proposed formal amendments to the existing regulations, which are needed to implement the new standards as described in this proposal, are presented in Attachments I through IV at the end of this report. In addition, three changes were made to correct typographical errors in the existing regulatory sections. The first involves clarification of the exceptions in paragraph (c)(1) of Section 1956.8, Title 13, California Code of Regulations, made necessary due to misplaced punctuation marks. The proper intent of the paragraph was verified through comparison with previous versions of the document.

The second typographical correction is made to include the proper NOx certification standard magnitude in Section 86.098-10 of the Code of Federal Regulations, as incorporated into Section 1956.8, Title 13, California Code of Regulations. The desired intent was verified by personnel of the U.S. EPA.

A final change was made to correct redundant paragraph numbering in California Motor Vehicle Emission Control Label Specifications, as incorporated in Section 1965, Title 13, California Code of Regulations.

IV. TECHNOLOGICAL FEASIBILITY

The attached technical support document (TSD) describes many of the technologies that can be used to achieve reduced NOx emissions from heavy-duty engines. The approaches that staff expects manufacturers to use in order to meet the proposed mandatory 4.0 g/bhp-hr NOx standard are essentially refinements of those proven techniques already in use on production engines. For example, for diesel engines, further injection timing retard, improved turbochargers, aftercoolers, combustion chambers and oil control, and aftertreatment such as oxidation catalysts (all currently-used technology), will probably be the primary means of achieving the reduction from 5.0 g/bhp-hr to 4.0 g/bhp-hr. For gasoline engines, many of which are already certified at levels well below the proposed mandatory standard, the staff expects only changes of degree in the current use of exhaust gas recirculation (EGR), oxidation catalysts and three-way catalysts. Therefore, the staff concurs with the U.S. EPA's conclusion that the mandatory 4.0 g/bhp-hr NOx standard is technologically feasible for heavy-duty engines, and will require no major breakthroughs on the part of engine manufacturers.

The more advanced emission control techniques described in the TSD, such as diesel engine EGR and alternative fuels, will probably be necessary only for those manufacturers wanting to certify engines to the optional low-emission standards. Several current production alternative fuel engines have already been tested at very low NOx levels and could be readily certified to at least some of the optional low-emission standards, should the manufacturers desire to do so.

V. ISSUES OF CONTROVERSY

The staff held a public workshop on January 13, 1994, in part to discuss the proposed regulations. That portion of the staff's presentation regarding emission standards was essentially identical to the material contained in this report. Most comments were supportive and few changes relating to the mandatory or optional standards were requested. The few requested changes are discussed below.

A. BACKGROUND

The proposed regulations give HD truck operators the alternatives of purchasing vehicles, beginning in 1998, meeting either a 4.0 g/bhp-hr mandatory NOx standard, or more stringent optional NOx standards of a range between 0.5 to 2.5 g/bhp-hr NOx for diesel engines and a range between 0.5 to 1.5 g/bhp-hr NOx for Otto-cycle engines, at 0.5 gram increments. Also, to help facilitate earlier introduction of reduced-emission heavy-duty vehicles and the earlier implementation of mobile source emission reduction credits programs, the proposed regulations provide for optional NOx standards in a range between 0.5 to 3.5 g/bhp-hr for diesel engines and a range between 0.5 to 2.5 g/bhp-hr NOx for Otto-cycle engines, both at 0.5 gram increments, for the 1995 through 1997 model years. The proposal also would extend the HD statutory useful life for NOx emissions from 8 years to 10 years, beginning in 1998.

B. INCREMENTS FOR THE OPTIONAL STANDARDS

The Engine Manufacturers Association (EMA) requested that the optional low-emission standards be modified to incorporate increments of 0.1 g/bhp-hr instead of the current 0.5 g/bhp-hr increments. EMA has made similar requests in the past with respect to the optional low-emission standards for urban transit buses and for retrofit kits. Staff's position remains that the 0.5 g/bhp-hr increments are the minimum necessary to provide assurance that the engine will be certified with a reasonable compliance margin to allow for test and production variations. EMA claims that a lot of real emission reductions will not be eligible for the reduced-emission standards if a manufacturer cannot quite reduce emissions to a particular optional standard and has to certify to the next higher standard instead. However, staff believes that it is equally as likely that this scenario will encourage the manufacturer to strive to reduce the emissions level to allow certification to the next lower standard. In addition, the 0.5 g/bhp-hr increment size has already been used in the optional standards approved for urban bus engine certification and is planned for the retrofit system optional certification standards.

Finally, during previous consideration of optional emission standards, the Board directed staff to reconsider the possibility of reducing increment size once practical experience has been gained with optional standard certification. After a sufficient number of heavy-duty engines have been certified to the optional standards, and sufficient in-use experience and emissions durability data are available, staff will re-evaluate the EMA's request. If, at that time, the emissions performance of such engines warrants a smaller increment size, staff will recommend the appropriate regulatory changes to the Board.

C. MAXIMUM OPTIONAL STANDARD

The EMA also requested that the maximum optional standard be set closer in value to the mandatory standard. The EMA has previously made this request related to the optional urban transit bus standards and discussions on standards for retrofits. The specific example previously used is the case of diesel engine standards for the period of 1995 through 1997. EMA had suggested that the maximum optional standard for this case be set to 25 percent below the mandatory ceiling standard of 5.0 grams/bhp-hr rather than 30 percent below as contained in this proposal. EMA's request would result in a maximum optional standard of 3.75 grams/bhp-hr as opposed to staff's proposed 3.5 grams/bhp-hr. The EMA claims that this higher maximum optional standard would make more engines eligible for mobile source credit programs, even to the point of enabling relatively clean diesel engines to be included.

The staff continues to believe that the maximum optional standard should remain set at 30 percent below the mandatory standard for this period to provide adequate assurance that real, significant and surplus emission reductions are taking place. The 30 percent criterion is used in the case of low-emission certification of new urban transit bus engines and staff believes it is reasonable to follow that example in this proposal. In the case of the retrofit optional standards, the typical mandatory ceiling standard is 6.0 grams/bhp-hr and 25 percent below represents the same 1.5 g/bhp-hr reduction for retrofits as 30 percent below the new engine ceiling of 5.0 g/bhp-hr. Staff believes that, for this range of emission levels, the numerical value of the difference between the mandatory ceiling standard and maximum optional standard is what is important to provide assurance of surplus emission reductions, as opposed to reductions resulting from minor engine retuning. The 30 percent and 25 percent designations are only convenient means of description.

Note that the maximum optional standards for Otto-cycle engines are lower than the corresponding standards for diesel engines. This is because existing gasoline-fueled engines already are capable of meeting emission levels significantly below the optional standards. Staff believes it is important to reserve giving low-emission status only for engines that have emissions significantly lower than those that are commonly available at present.

D. OTHER ISSUES

Finally, staff has endeavored to provide an emissions standards proposal that could be reasonably complied with using conventional fuel technology while still providing significant emission reductions and the opportunity for participation in early introduction programs and mobile source emission reduction credits programs.

VI. <u>REGULATORY</u> <u>ALTERNATIVES</u>

No alternative considered by the staff would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective or less burdensome to affected private persons than the proposed regulation. Additionally, staff have determined, as discussed below in the cost-effectiveness analysis, that this is not a major regulation within the meaning of Health and Safety Code Section 57005 which requires the consideration of less costly alternatives or combinations of alternatives.

VII. AIR QUALITY AND COST EFFECTIVENESS ANALYSIS

A. AIR QUALITY IMPACT

The U.S. EPA estimates that the mandatory 4.0 g/bhp-hr NOx standard implemented in 1998 would reduce nationwide heavy-duty vehicle NOx emissions by approximately 16 percent to 19 percent in the time frame of the years 2005 to 2010. It is expected that California HDV emissions would be reduced by a like proportion since the same per vehicle reduction from 5.0 g/bhp-hr to 4.0 grams/bhp-hr is being proposed.

The optional emission standards provide a means for certifying reduced-emission HDVs to standards below the mandatory levels so they could be used in early-introduction programs. Such programs would help to reduce overall fleet emission levels due to vehicle turnover more quickly than otherwise expected. This effect would provide a significant air quality benefit, although the magnitude is not readily estimable at present.

Optional standards could also provide increased flexibility to stationary sources in meeting regulations by allowing early introduction of low-emission heavy-duty vehicles and by allowing participation in an air pollution control district's mobile source emission reduction credit program. It is assumed that vehicles generating credits otherwise would have been replaced by vehicles meeting the new mandatory standard and that the vehicle emission reductions would be offset by the allowed increase in stationary source emissions. Given these premises, there would be no air quality benefits with the proposed optional standards, although an air pollution control district has the right to require that a percentage of the emission reductions be earmarked to improve air quality. With such a discount, use of the optional standards in a mobile source credit program would entail an improvement in air quality. At present, quantification of the improvement is not feasible based on lack of experience with such programs and the resulting lack of empirical data necessary to make the estimates.

B. COST EFFECTIVENESS

Since the mandatory portion of this proposal simply aligns California emission standards and useful life requirements with federal regulations, and since it is likely that only the federal engines would be available even if the mandatory California standard and useful life are not adopted, there would be no real incremental cost increase to adopting the federal standard as the California standard. For information purposes, however, the U.S. EPA estimates that the price for a typical Otto-cycle heavy-duty engine would increase by $16 and that of a typical diesel engine would increase by $78. These increases cover the incremental purchase cost of the 4.0 g/bhp-hr engines relative to the 5.0 g/bhp-hr engines previously available. Since it is expected that fuel economy will not be adversely affected, no increased operating costs are expected.

Combining these per engine costs with current emission inventory information (based on ARB's motor vehicle emissions inventory models) for the number of new HDTs to be purchased in California in 1998, the total cost to California businesses for that year is estimated to be less than \$1.3 million. The U.S. EPA also estimates that the cost-effectiveness for the emission reductions for a typical Otto-cycle engine is \$258/ton (\$0.13/pound) of NOx and for a typical diesel-cycle engine is \$207/ton (\$0.10/pound) of NOx, over the engine's useful life. These values are well below the cost-effectiveness values of \$5,000/ton to \$10,000/ton of NOx for other previously accepted control measures, such as those for stationary sources.

The cost effectiveness of the proposed optional emission standards is not at issue in this regulatory action given that these standards are optional, not mandated. It is assumed, however, that if costs are excessive, market forces will prevent the use of the optional standards, in which case the mandatory standard cost estimates, as discussed above, will be appropriate.

VIII. ENVIRONMENTAL IMPACTS

Implementation of the proposed mandatory and optional emission standards for heavy-duty trucks, as described in this staff report, would have a substantial positive impact on the environment by reducing emissions of NOx, thereby improving air quality. The anticipated emissions benefits of the regulations are set forth under "Air Quality and Cost Effectiveness Analysis."

The staff believes that the proposed regulations would not result in any significant adverse environmental impacts. Therefore, feasible mitigation measures and feasible alternatives to the proposed action which would reduce any significant adverse impact are not addressed.

IX. REFERENCES

1. EMFAC7F/BURDEN7F, California Air Resources Board.

2. California Health & Safety Code, Section 43806, added 1991.

3. Mobile Source Emission Reduction Credits-Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits, California Air Resources Board, issued February 1994.

4. Technical Feasibility of Reducing NOx and Particulate Emissions from Heavy-Duty Engines, draft final report, Acurex Environmental Corporation, July 27, 1992.

5. Notice of Public Workshop to Consider (1) Guidelines for New Heavy-duty Vehicles to Generate Mobile Source Emission Reduction Credits and (2) Credit Standards for Heavy-duty Engines, Mailout #93-55.

6. Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Particulate Emission Regulations for 1993 Model Year Buses, Particulate Emission Regulations for 1994 and Later Model Year Urban Buses, Test Procedures for Urban Buses, and Oxides of Nitrogen Emission Regulations for 1998 and Later Model Year Heavy-Duty Engines, Federal Register, Vol. 58 No. 55, Wednesday, March 24, 1993 p15781

7. Public Hearing to Consider Amendments to Regulations Regarding California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles, to Specify Standards for 1994 and Subsequent Urban Bus Engines, released April 23, 1993, Mailout #93-19.

ATTACHMENT I:
PROPOSED AMENDMENTS TO SECTIONS OF TITLE 13,
CALIFORNIA CODE OF REGULATIONS

PROPOSED REGULATION ORDER

Amend the following sections of Title 13, California Code of Regulations, to read as set forth on the following pages:

Section 1956.8	- Exhaust Emission Standards and Test Procedures - 1985 and Subsequent Model Heavy-Duty Engines and Vehicles
Section 1965	- Emission Control Labels - 1979 and Subsequent Model-Year Motor Vehicles
Section 2112	- Definitions

Note: The regulatory amendments proposed in this rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions.

SECTION 1956.8, TITLE 13, CCR

Amend Title 13, California Code of Regulations, section 1956.8 to read as follows:

1956.8. Exhaust Emission Standards and Test Procedures - 1985 and Subsequent Model Heavy-Duty Engines and Vehicles.

(a)(1) The exhaust emissions (A) from new 1985 and subsequent model heavy-duty diesel engines (except methanol-fueled engines) and heavy-duty natural-gas-fueled and liquefied-petroleum-gas-fueled engines derived from diesel-cycle engines, (B) from new 1991 and subsequent model heavy-duty methanol-fueled diesel transit bus engines, and (C) from all new 1993 and subsequent model heavy-duty methanol-fueled, diesel engines, except in all cases engines used in medium-duty vehicles, shall not exceed:

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Non-methane Hydrocarbons[A]	Carbon Monoxide	Oxides of Nitrogen	Particulates
1985-1986	1.3		15.5	5.1	---
1987[B]	1.3		15.5	5.1	---
1988-1989	1.3		15.5	6.0	0.60
1990	1.3	1.2	15.5	6.0	0.60
1991-1993[C]	1.3	1.2	15.5	5.0	0.10
1991-1993[D]	1.3	1.2	15.5	5.0	0.25 [E]
1994 ~~and subsequent~~ -1997	1.3	1.2	15.5	5.0	0.10 [E]
1994-1995[F]	1.3	1.2	15.5	5.0	0.07
1994-1995[G]	1.3	1.2	15.5	3.5 to 0.5	0.07
1995-1997 [J]	1.3	1.2	15.5	3.5 to 0.5	0.10

1996 and[F] subsequent	1.3	1.2	15.5	4.0 [I]	0.05 [H]
1996 and[G] subsequent	1.3	1.2	15.5	2.5 to 0.5	0.05 [H]
1998 and [K] subsequent	1.3	1.2	15.5	4.0	0.10
1998 and [J] subsequent	1.3	1.2	15.5	2.5 to 0.5	0.10

[A] The total or optional non-methane hydrocarbon standards apply to petroleum-fueled, natural-gas-fueled and liquefied-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

[B] As an option a manufacturer may elect to certify to the 1988 model-year emission standards one year early, for the 1987 model year.

[C] These standards apply to urban bus engines only.

[D] For engines other than urban bus engines. For methanol-fueled engines, these standards shall be applicable beginning with the 1993 model year.

[E] Emissions averaging may be used to meet this standard. Averaging is restricted to within each useful life subclass and is applicable only through the 1995 model year. Emissions from engines used in urban buses shall not be included in the averaging program. However, emissions from methanol-fueled, natural-gas-fueled and liquefied-petroleum-gas-fueled urban bus engines certified to a 0.10 grams per brake horsepower-hour standard for particulates for the 1991-1993 model years, and certified to a 0.07 grams per brake horsepower-hour standard for particulates for the 1994-1995 model years, may be included in the averaging program for petroleum-fueled engines other than urban bus engines.

[F] These mandatory standards apply to urban bus engines only.

[G] These optional standards apply to urban bus engines only. A manufacturer may elect to certify to an optional NOx standard by 0.5 grams per brake horsepower-hour increments.

[H] For in-use testing, a 0.07 gram per brake horsepower-hour standard for particulates shall apply.

[I] A manufacturer may apply to the Executive Officer for an exemption from the 4.0 gram per brake horsepower-hour standard for oxides of nitrogen for 1996 and 1997 model year urban bus engines for which the manufacturer can demonstrate a technological need for the exemption. The exemption or exemptions shall not exceed 10 percent of the average of the manufacturer's total urban bus engine sales in California for the three model years prior to the model year for which an exemption is requested. The manufacturer shall submit technical justification for each engine model and shall provide the number of urban bus engine sales in California for the engine model for which the exemption is requested (if any) and for all urban bus engine models for the three preceding model years, to the Executive Officer when the manufacturer applies for the exemption.

[J] These are optional standards and apply to all heavy-duty engines excluding urban bus engines. A manufacturer may elect to certify to an optional NOx standard between the values, inclusive, by 0.5 grams per brake horsepower-hour increments.

[K] These mandatory standards apply to all heavy-duty engines except urban bus engines.

(2) Formaldehyde exhaust emissions from new 1993 and subsequent model methanol-fueled diesel engines, shall not exceed:

Model Year	Formaldehyde (g/bhp-hr)
1993-1995	0.10
1996 and subsequent	0.05

(b) The test procedures for determining compliance with standards applicable to 1985 and subsequent heavy-duty diesel engines and vehicles are set forth in the "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles", adopted April 8, 1985, as last amended [________], which is incorporated herein by reference.

(c)(1) The exhaust emissions from (A) new 1987 and subsequent model heavy-duty otto-cycle engines, (except methanol-fueled engines, and except heavy-duty otto-cycle natural-gas-fueled and liquefied-petroleum-gas-fueled otto-cycle engines derived from diesel-cycle engines,) and (B) from new 1993 and subsequent model heavy-duty methanol-fueled otto-cycle engines, except in all cases engines used in medium-duty vehicles, shall not exceed.:

Exhaust Emission Standards
(grams per brake horsepower-hour)

Model Year	Total Hydrocarbons or OMHCE[A]	Optional Non-methane Hydrocarbons[A]	Carbon Monoxide[B]	Oxides of Nitrogen
1987[C]	1.1 [D] 1.9 [E]		14.4 [D] 37.1 [E]	10.6 10.6
1988-1989	1.1 [D] 1.9 [E]		14.4 [D] 37.1 [E]	6.0 6.0
1990	1.1 1.9 [E]	0.9 [D] 1.7 [E]	14.4 [D] 37.1 [E]	6.0 6.0
1991-1994	1.1 [D] 1.9 [E]	0.9 [D] 1.7 [E]	14.4 [D] 37.1 [E]	5.0 5.0
1995 ~~and subsequent~~ -1997	1.9 [E]	1.7 [E]	37.1 [E]	5.0
1995-1997	1.9 [E]	1.7 [E]	37.1	2.5 to 0.5 [E]
1998 and subsequent	1.9 [E]	1.7 [E]	37.1	4.0
1998 and subsequent	1.9 [E]	1.7 [E]	37.1	1.5 to 0.5 [E]

[A] The total or optional non-methane hydrocarbon standards apply to petroleum-fueled, natural-gas-fueled and liquefied-petroleum-gas-fueled engines. The Organic Material Hydrocarbon Equivalent, or OMHCE, standards apply to methanol-fueled engines.

[B] Carbon Monoxide emissions from engines utilizing exhaust aftertreatment technology shall also not exceed 0.5 percent of the exhaust gas flow at curb idle.

[C] Manufacturers with existing heavy-duty otto-cycle engines certified to the California 1986 steady-state emission standards and test procedures may as an option certify those engines, for the 1987 model year only, in accordance with the standards and test procedures for 1986 heavy-duty otto-cycle engines established in Section 1956.7.

[D] These standards are applicable to otto-cycle engines intended for use in all heavy-duty vehicles.

[E] Applicable to heavy-duty otto-cycle engines intended for use only in vehicles with a gross vehicle weight rating greater than 14,000 pounds. Also, as an option, a manufacturer may certify one or more 1988 through 1994 otto-cycle heavy-duty engine configurations intended for use in all heavy-duty vehicles to these emission standards, provided that the total model-year sales of such configuration(s) being certified to these emission standards represent no more than 5 percent of total model-year sales of all otto-cycle heavy-duty engines intended for use in vehicles with a Gross Vehicle Weight Rating of up to 14,000 pounds by the manufacturer.

[F] These are optional standards and apply to all heavy-duty engines intended for use only in vehicles with a gross vehicle weight greater than 14,000 pounds. A manufacturer may elect to certify to an optional standard between the values, inclusive, by 0.5 grams per brake horsepower-hour increments.

(2) Formaldehyde exhaust emissions from new 1993 and subsequent model methanol-fueled otto cycle engines shall not exceed:

Model Year	Formaldehyde (g/bhp-hr)
1993-1995	0.10
1996 and subsequent	0.05

(d) The test procedures for determining compliance with standards applicable to 1987 and subsequent model heavy-duty otto-cycle engines and vehicles are set forth in the "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles," adopted April 25, 1986, as last amended [_______], which is incorporated by reference herein.

(e) through (h) [No Change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43103, 43104, and 43806, Health and Safety Code, and Vehicle Code section 28114. Reference: Sections 39002, 39003, 43000, 43013, 43018, 43100, 43101, 43101.5, 43102, 43103, 43104, 43106, 43204, and 43806, Health and Safety Code.

SECTION 1965, TITLE 13, CCR

Amend section 1965, Title 13, California Code of Regulations, as follows:

1965. Emission Control Labels - 1979 and Subsequent Model-Year Motor Vehicles.

In addition to all other requirements, emission control labels required by California certification procedures shall conform to the "California Motor Vehicle Emission Control Label Specifications", adopted March 1, 1978, as last amended [_________], which is incorporated herein by reference.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43013, 43100, 43101, 43102, 43103, 43104, and 43107, Health and Safety Code.

SECTION 2112, TITLE 13, CCR

Amend title 13, California Code of Regulations, section 2112 to read as follows:

2112. Definitions.

(a) through (k) [No Change]

(l) "Useful life" means, for the purposes of this Article:

(1) For Class I motorcycles and motorcycle engines (50 to 169 cc or 3.1 to 10.4 cu. in.), a period of use of five years or 12,000 kilometers (7,456 miles), whichever first occurs.

(2) For Class II motorcycles and motorcycle engines (170 to 279 cc or 10.4 to 17.1 cu. in.), a period of use of five years or 18,000 kilometers (11,185 miles), whichever first occurs.

(3) For Class III motorcycles and motorcycle engines (280 cc and larger or 17.1 cu. in. and larger), a period of use of five years or 30,000 kilometers (18,641 miles), whichever first occurs.

(4) For 1982 through 1984 model-year diesel heavy-duty vehicles (except medium-duty vehicles), and 1982 through 1984 model-year motor vehicle engines used in such vehicles, a period of use of five years, 100,000 miles, or 3000 hours of operation, whichever first occurs.

(5) For 1982 through 1987 model-year gasoline heavy-duty vehicles (except medium-duty vehicles) certified using the steady-state emission standards and test procedures, and 1982 through 1987 model-year gasoline heavy-duty motor vehicle engines certified using the steady-state emission standards and test procedures, a period of use of five years or 50,000 miles, whichever first occurs.

(6) For 1987 and subsequent model-year gasoline heavy-duty vehicles (except medium-duty vehicles) certified to the transient emission standards and test procedures, and 1987 and subsequent model-year gasoline heavy-duty motor vehicle engines certified using the transient emission standards and test procedures, a period of use of eight years or 110,000 miles, whichever first occurs, except as noted in paragraph (12).

(7) For 1985 and subsequent model-year diesel heavy-duty vehicles (except medium-duty vehicles), and 1985 and subsequent model-year motor vehicle engines used in such vehicles, a period of use of eight years or 110,000 miles, whichever first occurs, for diesel light, heavy-duty vehicles; eight years or 185,000 miles, whichever first occurs, for diesel medium, heavy-duty vehicles; and eight years or 290,000 miles, whichever first occurs, for diesel heavy, heavy-duty vehicles, except as provided in paragraphs (11), (13), (14) and (15); or any alternative useful life period approved by the Executive Officer. (The classes of diesel light, medium, and heavy, heavy-duty vehicles are defined in 40 CFR section 86.085-2, as amended November 16, 1983.)

(8) For light-duty and medium-duty vehicles certified under the Optional 100,000 Mile Certification Procedure, and motor vehicle engines used in such vehicles, a period of use of ten years or 100,000 miles, whichever first occurs.

(9) For 1995 and subsequent model-year medium-duty vehicles, and motor vehicle engines used in such vehicles and 1992 and subsequent model-year medium-duty low-emission and ultra-low-emission vehicles, and motor vehicle engines used in such vehicles, a period of use of eleven years or 120,000 miles, whichever occurs first.

(10) For all other light-duty and medium-duty vehicles, and motor vehicle engines used in such vehicles, a period of use of five years or 50,000 miles, whichever first occurs. For those passenger cars, light-duty trucks and medium-duty vehicles certified pursuant to section 1960.1.5, Title 13, California Code of Regulations, the useful life shall be seven years or 75,000 miles, whichever first occurs; however, the manufacturer's reporting and recall responsibility beyond 5 years or 50,000 miles shall be limited, as provided in section 1960.1.5. For those passenger cars and light-duty trucks certified pursuant to Title 13, California Code of Regulations, section 1960.1(f) and section 1960.1(g), the useful life shall be ten years or 100,000 miles, whichever first occurs; however, for those vehicles certified under section 1960.1(f), the manufacturer's warranty failure and defects reporting and recall responsibility shall be subject to the conditions and standards specified in section 1960.1(f).

(11) For 1994 and subsequent model-year heavy heavy-duty diesel urban buses, and 1994 and subsequent model-year heavy heavy-duty diesel engines to be used in urban buses, for the particulate standard, a period of use of ten years or 290,000 miles, whichever first occurs; or any alternative useful life period approved by the Executive Officer.

<u>(12) For 1998 and subsequent model-year gasoline heavy-duty engines, for the NOx standard, a period of use of ten years or 110,000 miles, whichever first occurs; or any alternative useful life period approved by the Executive Officer.</u>

<u>(13) For 1998 and subsequent model-year light heavy-duty diesel engines, for the NOx standard, a period of use of ten years or 110,000 miles, whichever first occurs; or any alternative useful life period approved by the Executive Officer.</u>

<u>(14) For 1998 and subsequent model-year medium heavy-duty diesel engines, for the NOx standard, a period of use of ten years or 185,000 miles, whichever first occurs; or any alternative useful life period approved by the Executive Officer.</u>

<u>(15) For 1998 and subsequent model-year heavy heavy-duty diesel engines, for the NOx standard, a period of use of ten years or 290,000 miles, whichever first occurs; or any alternative useful life period approved by the Executive Officer.</u>

(m) [No Change]

(n) [No Change]

Appendix A to Article 2.1 [No Change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43104, and 43105, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43009.5, 43013, 43018, 43100, 43101, 43101.5, 43102, 43103, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code.

ATTACHMENT II:

PROPOSED AMENDMENTS TO THE CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL ENGINES AND VEHICLES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL-ENGINES AND VEHICLES

Adopted: April 8, 1985
Amended: July 29, 1986
Amended: January 22, 1990
Amended: May 15, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: October 23, 1992
Amended: October 22, 1993
Amended: March 24, 1994
[Amended: ___________]

NOTE: This document is printed in a style to indicate amendments to the existing California standards and test procedures. The amendments made in the present rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. Federal language for a specific section which is not to be included in these procedures is denoted by the word "DELETE". The symbols "*****" mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. For those portions of the federal provisions incorporated in this document with modifications, the modifications to the federal text are displayed in double underline and ~~strikeout~~. The symbols "#####" mean that the remainder of the text of these procedures for a specific section, which is not shown in this amendment document, has not been changed.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL-ENGINES AND VEHICLES

The following provisions of Subparts A, I, and N, Part 86, Title 40, Code of Federal Regulations, as adopted or amended by the U.S. Environmental Protection Agency on the date listed, and only to the extent they pertain to the testing and compliance of exhaust emissions from heavy-duty Diesel-engines and vehicles, are adopted and incorporated herein by this reference as the California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles, except as altered or replaced by the provisions set forth below.

The federal regulations contained in the Subparts identified above which pertain to oxides of nitrogen emission averaging shall not be applicable to these procedures. The federal regulations contained in the Subparts identified above which pertain to particulate emission averaging shall not be applicable to these procedures for 1996 and later model engines and vehicles. The smoke exhaust test procedures shall be applicable to California petroleum-fueled, liquefied-petroleum gas-fueled, and compressed-natural gas fueled heavy-duty Diesel engines and vehicles for 1988 and later model years.

Starting with the 1990 model year, these regulations shall be applicable to all heavy-duty Diesel natural-gas-fueled and liquefied-petroleum gas-fueled engines (and vehicles) including those engines derived from existing Diesel engines. For any engine which is not a distinctly Diesel engine nor derived from such, the Executive Officer shall determine whether the engine shall be subject to these regulations or alternatively to the heavy-duty Otto-cycle engine regulations, in consideration of the relative similarity of the engine's torque-speed characteristics and vehicle applications with those of Diesel and Otto-cycle engines.

The regulations concerning the certification of methanol-fueled diesel urban bus engines are not applicable in California until 1991 and subsequent model years. The regulations concerning the certification of all other methanol fueled diesel engines and vehicles are not applicable in California until 1993 and subsequent model years.

Regulations concerning the certification of incomplete medium-duty diesel low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel are applicable for the 1992 and subsequent model years.

Subpart A, General Provisions for Emission Regulations for 1977 and Later model Year New Light-Duty Vehicles, Light-Duty Trucks, and Heavy-Duty Engines, and for 1985 and later Model Year New Gasoline-Fuel and Methanol Fueled Heavy-Duty Vehicles.

<u>§ 86.098-2 Definitions. [April 6, 1994]</u>

~~The definitions of § 86.096-2 continue to apply to 1996 and later model year vehicles.~~ <u>The definitions listed in this section apply beginning with the 1998 model year.</u>

"Dispensed fuel temperature" DELETE

"Evaporative/refueling emission control system" DELETE

"Evaporative/refueling emission family" DELETE

"Integrated refueling emission control system" DELETE

"Non-integrated refueling emission control system" DELETE

"Refueling emissions" DELETE

"Refueling emission canister(s)" DELETE

"Resting losses" DELETE

Useful life means:

(1) DELETE

(2) DELETE

(3) DELETE

(4) For a diesel heavy-duty engine family:

(i) DELETE

(ii) For light heavy-duty diesel engines, for the oxides of nitrogen standard, a period of use of 10 years or 110,000 miles, whichever first occurs.

(iii) DELETE

(iv) For medium heavy-duty diesel engines, for the oxides of nitrogen standard, a period of use of 10 years or 185,000 miles, whichever first occurs.

(v) DELETE

(vi) For heavy heavy-duty diesel engines, for the oxides of nitrogen standard, a period of use of 10 years or 290,000 miles, whichever first occurs.

(vii) DELETE

######################################

§ 86.098-11 Emission standards for 1998 and later model year diesel heavy-duty engines and vehicles and optional standards for 1995 through 1997 model year diesel heavy-duty engines. [March 24, 1993]

(a) Exhaust emissions from new 1998 and later model year diesel heavy-duty engines shall not exceed the following:

(1) DELETE

(2) DELETE

(3) Oxides of Nitrogen. (i) 4.0 grams per brake horsepower-hour (1.49 grams per megajoule), as measured under transient operating conditions.

(ii) A manufacturer may elect to certify 1998 and later model year diesel engines, for use in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 pounds, other than urban transit buses, to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 2.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(4) DELETE

(b) DELETE

(c) DELETE

(d) DELETE

(e) (1) Exhaust emission standards for certain 1995 and later model year heavy-duty diesel engines may be optionally selected as follows:

(i) A manufacturer may elect to certify 1996 and later model year diesel engines for use in urban buses, to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 2.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(ii) A manufacturer may elect to certify 1995 through 1997 model year diesel engines for use in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 pounds except urban bus engines, and 1994 through 1995 model year urban bus engines, to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 3.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

# # # # # # # # # # # # #

ATTACHMENT III:
PROPOSED AMENDMENTS TO THE CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

Adopted: April 25, 1986
Amended: June 2, 1988
Amended: January 22, 1990
Amended: May 15, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: October 23, 1992
Amended: May 28, 1993
[Amended: __________]

NOTE: This document is printed in a style to indicate amendments to the existing California standards and test procedures. The amendments made in the present rulemaking are shown in underline to indicate additions to the text and ~~strikeout~~ to indicate deletions.

This document incorporates by reference various sections of the Code of Federal Regulations, some with modifications. Federal language for a specific section which is not to be included in these procedures is denoted by the word "DELETE". The symbols "*****" mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. For those portions of the federal provisions incorporated in this document with modifications, the modifications to the federal text are displayed in double underline and ~~strikeout~~. The symbols "#####" mean that the remainder of the text of these procedures for a specific section, which is not shown in this amendment document, has not been changed.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

The following provisions of Subparts A, L, N, and P, Part 86, Title 40, Code of Federal Regulations, as adopted or amended by the U.S. Environmental Protection Agency on the date listed, and only to the extent they pertain to the testing and compliance of exhaust emissions from heavy-duty Otto-cycle gasoline engines and vehicles, are adopted and incorporated herein by this reference as the California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles, except as altered or replaced by the provisions set forth below.

The federal regulations contained in the subparts identified above which pertain to evaporative emissions and oxides of nitrogen emission averaging shall not be applicable to these procedures. Regulations pertaining to evaporative emissions are contained in "California Evaporative Emission Standards and Test Procedures for 1978 and Subsequent Model Liquefied Petroleum Gas- or Gasoline- or Methanol-Fueled Motor Vehicles," as incorporated in Title 13, California Code of Regulations, Section 1976.

The federal regulations contained in the subparts identified above which pertain to nonconformance penalty shall be applicable for the 1988 model year. The Executive Officer shall not implement a nonconformance fee schedule until it is established that payment of nonconformance fees in California may substitute, on the basis of each heavy-duty engine or vehicle certified for sale in California, for payment of nonconformance fees to the federal government.

Starting with the 1990 model year, these regulations shall be applicable to all heavy-duty Otto-cycle natural-gas-fueled and liquefied-petroleum-gas-fueled engines (and vehicles) except those engines derived from existing Diesel engines. For any engine which is not a distinctly Otto-cycle engine nor derived from such, the Executive Officer shall determine whether the engine shall be subject to these regulations or alternatively to the heavy duty Diesel engine regulations, in consideration of the relative similarity of the engine's torque-speed characteristics and vehicle applications with those of Otto-cycle and Diesel engines.

The regulations concerning the certification of methanol-fueled vehicles and engines including dedicated methanol and fuel-flexible vehicles and engines are not applicable in California until the 1993 and subsequent model years.

Regulations concerning the certification of incomplete medium-duty Otto-cycle low-emission vehicles and engines and ultra-low-emission vehicles and engines operating on any fuel are applicable for the 1992 subsequent model years.

Subpart A, General Provisions for Emission Regulations for 1977 and Later Model Year New Light-Duty Vehicles, Light-Duty Trucks, and Heavy-Duty Engines, and for 1985 and Later Model Year Gasoline-Fueled and Methanol-Fueled Heavy-Duty Vehicles.

# # # # #

§ 86.098-2 Definitions. [April 6, 1994]

~~The definitions of § 86.096-2 continue to apply to 1996 and later model year vehicles.~~ The definitions listed in this section apply beginning with the 1998 model year.

"Dispensed fuel temperature" DELETE

"Evaporative/refueling emission control system" DELETE

"Evaporative/refueling emission family" DELETE

"Integrated refueling emission control system" DELETE

"Non-integrated refueling emission control system" DELETE

"Refueling emissions" DELETE

"Refueling emission canister(s)" DELETE

"Resting losses" DELETE

Useful life means:

(1) DELETE

(2) DELETE

(3) For an Otto-cycle heavy-duty engine family:

(i) DELETE

(ii) For the oxides of nitrogen standard, a period of use of 10 years or 110,000 miles, whichever first occurs.

(iii) DELETE

(4) DELETE

# # # # # #

§ 86.098-10 Emission Standards for 1998 and Later Model Year Otto-cycle Heavy-duty Engines and Vehicles and Optional Standards for 1995 Through 1997 Model Year Otto-cycle Heavy-duty Engines. [September 21, 1994].

~~Section 86.098-10 includes text that specifies requirements that differ from §86.096-10. Where a paragraph in §86.096-10 is identical and applicable to §86.098-10, this may be indicated by specifying the corresponding paragraph and the statement "[Reserved]. For guidance see §86.096-10."~~

(a)(1) Exhaust emissions from new 1998 and later model year Otto-cycle heavy-duty engines shall not exceed.

(i) DELETE

(ii) For Otto-cycle heavy-duty engines fueled with either gasoline or liquefied petroleum gas and intended for use only in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 pounds.

(A) DELETE

(B) DELETE

(C) Oxides of nitrogen (*1*) 4.0 grams per brake horsepower-hour (1.49 grams per megajoule), as measured under transient operating conditions.

(*2*) DELETE.

(*3*) DELETE.

(*4*) A manufacturer may elect to certify to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 1.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(iii) DELETE.

(iv) For methanol-fueled Otto-cycle heavy-duty engines intended for use only in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 lbs.

(A) DELETE

(B) DELETE

(C) Oxides of nitrogen. (*1*) 4.0 grams per brake horsepower-hour (1.49 grams per megajoule), as measured under transient operating conditions.

(*2*) DELETE; REPLACE WITH:

(*2*) A manufacturer may elect to certify to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 1.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(v) DELETE

(vi) For natural gas-fueled Otto-cycle engines intended for use only in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 pounds.

(A) DELETE

(B) DELETE

(C) Oxides of nitrogen. (*1*) ~~5.0~~ 4.0 grams per brake horsepower-hour (~~1.9~~ 1.49 grams per megajoule), as measured under transient operating conditions.

(*2*) DELETE.

(*3*)A manufacturer may elect to certify to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 1.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(2) The standards set forth in paragraph (a)(1) of this section refer to the exhaust emitted over the operating schedule set forth in paragraph (f)(1) of appendix I to this part, and measured and calculated in accordance with the procedures set forth in subpart N or P of this part.

(3) DELETE.

* * * * *

(c) DELETE

(d) DELETE

(e) A manufacturer may elect to certify 1995 through 1997 model year Otto-cycle engines, for use in vehicles with a Gross Vehicle Weight Rating of greater than 14,000 pounds, to an optional oxides of nitrogen standard between 0.5 grams per brake horsepower-hour and 2.5 grams per brake horsepower-hour, inclusive, at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

ATTACHMENT IV:
PROPOSED AMENDMENTS TO THE CALIFORNIA MOTOR VEHICLE EMISSION CONTROL LABEL SPECIFICATIONS

PROPOSED

State of California
AIR RESOURCES BOARD

CALIFORNIA MOTOR VEHICLE EMISSION CONTROL LABEL SPECIFICATIONS

Adopted: March 1, 1978
Amended: June 16, 1982
Amended: April 26, 1984
Amended: April 8, 1985
Amended: April 25, 1986
Amended: June 2, 1988
Amended: July 21, 1988
Amended: January 22, 1990
Amended: May 15, 1990
Amended: July 12, 1991
Amended: March 24, 1994
[Amended: ________]

NOTE: Amendments to the labeling specifications made in this rulemaking are shown in underline to indicate additions.

State of California
AIR RESOURCES BOARD

California Motor Vehicle Emission Control
Label Specifications

1. through 3. [No Change]

~~3~~4.Label Content and Location.

(a) The tune-up label shall contain the following information lettered in the English language in block letters and numerals which shall be of a color that contrasts with the background of the label:

i. through viii. [No Change]

ix. An unconditional statement of compliance with the appropriate model-year California regulations; for example, "This vehicle (or engine, as applicable) conforms to California regulations applicable to ______ model-year new ______ (for 1992 and subsequent model-years, specify TLEV, LEV, ULEV, or ZEV, as applicable)______(specify motorcycles, passenger cars, light-duty trucks, medium-duty vehicles, heavy-duty otto-cycle engines, or heavy-duty diesel engines, as applicable)." For federally certified vehicles certified for sale in California the statement must include the phrase "conforms to U.S. EPA regulations and is certified for sale in California." For Class III motorcycles for sale in California, the statement must include the phrase "is certified to______HC engine family exhaust emission standard in California." For incomplete light-duty truck and incomplete medium-duty vehicles the label shall contain the following statement in lieu of the above:

"This vehicle conforms to California regulations applicable to ______ model-year new______(for 1992 and subsequent model-years specify LEV or ULEV as applicable) vehicles when completed at a maximum curb weight of______pounds and a maximum frontal area of______square feet."

For 1994 and later model year heavy heavy-duty diesel engines to be used in urban buses that are certified to the optional emission standards, the label shall contain the following statement in lieu of the above:

"This engine conforms to California regulations applicable to _____ model-year new urban bus engines and is certified to a NOx emission standard of _____ g/bhp-hr (for optional emission standards specify between 0.5 and 3.5 at 0.5 g/bhp-hr increments for 1994 and 1995 model years and between 0.5 and 2.5 at 0.5 g/bhp-hr increments for 1996 and later model years)."

For 1995 and later model year heavy-duty engines, other than those for use in urban buses, that are certified to the optional emission standards, the label shall contain the following statement in lieu of the above:

"This engine conforms to California regulations applicable to ______ model-year new heavy-duty engines, other than those for use in urban buses, and is certified to a NOx emission standard of ______ g/bhp-hr (for optional emission standards specify between 0.5 and 3.5 at 0.5 g/bhp-hr increments for 1995 through 1997 model-year diesel engines, between 0.5 and 2.5 at 0.5 g/bhp-hr increments for 1998 and later model-year diesel engines, between 0.5 and 2.5 at 0.5 g/bhp-hr increments for 1995 through 1997 model-year Otto-cycle engines, and between 0.5 and 1.5 at 0.5 g/bhp-hr increments for 1998 and later model-year Otto-cycle engines)."

Manufacturers may elect to use a supplemental label in addition to the original label if there is not sufficient space to include all the required information. The supplemental label must conform to all specifications as the original label. In the case that a supplemental label is used, the original label shall be numbered "1 of 2" and the supplemental label shall be numbered "2 of 2."

x. through xiii. [No Change]

(b) through (d) [No Change]

4~~5~~., ~~5~~6.,~~6~~7.,~~7~~8.,~~9~~10.,~~10~~11. [No Change other than renumbering.]

ATTACHMENT V:
TECHNICAL SUPPORT DOCUMENT

State of California
AIR RESOURCES BOARD

Staff Report: Technical Support Document

PUBLIC HEARING TO CONSIDER AMENDMENTS TO REGULATIONS REGARDING CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY ENGINES AND VEHICLES, TO SPECIFY MANDATORY STANDARDS FOR 1998 AND SUBSEQUENT HEAVY-DUTY ENGINES AND OPTIONAL STANDARDS FOR 1995 AND SUBSEQUENT HEAVY-DUTY ENGINES.

Date of Release: **May 12, 1995**

I. INTRODUCTION

This technical support document provides the technical background supporting the technical feasibility conclusions and recommendations contained in the staff report.

In recent years, there has been significant advancement in controlling NOx and PM emissions from heavy-duty diesel engines. The staff has previously determined, and the Board agreed, that the proposed mandatory 4.0 g/bhp-hr NOx and 0.05 g/bhp-hr PM standards are feasible with diesel technology, as well as alternative fuel technology, for 1996 implementation in urban transit buses. In addition, several heavy-duty Otto-cycle engines have already been certified at emission levels well below the proposed mandatory standard. Therefore, the staff believes that the 4.0 g/bhp-hr NOx standard is achievable by all heavy-duty vehicles by the proposed 1998 implementation date. In addition, the U. S. EPA, as stated in its regulatory support document for "Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Particulate Emission Regulations for 1993 Model Year Buses, Particulate Emission Regulations for 1994 and Later Model Year Urban Buses, Test Procedures for Urban Buses, and Oxides of Nitrogen Emission Regulations for 1998 and Later Model Year Heavy-duty Engines", does not believe that there is sufficient justification to determine that a 1998 4.0 g/bhp-hr NOx standard is infeasible. The following sections describe the relatively simple technologies that can be used to meet the mandatory 4.0 g/bhp-hr NOx standard, as well as the more advanced technologies that could be used to meet the optional low-emission standards.

II. DIESEL TECHNOLOGY

Currently, there are heavy heavy-duty diesel engines that have been certified to NOx levels near 4.0 g/bhp-hr. For instance, Cummins has certified its diesel-fueled M11 engine for 1994 at 4.2 g/bhp-hr NOx and 0.06 g/bhp-hr PM, utilizing low-sulfur (0.05 percent by weight) fuel without aftertreatment. However, simultaneous NOx and PM control from other engine makes and models has not been so easily accomplished and aftertreatment may be necessary to control the engine-out PM emissions that are increased by in-cylinder NOx reduction procedures. Utilization of aftertreatment devices in conjunction with further improvements in fuel injection, turbocharging, aftercooling, the sulfur content of diesel fuel, and combustion chamber modifications can provide substantial NOx and PM emission reductions. The staff does not expect that exhaust gas recirculation (EGR) will be needed to comply with the proposed mandatory emission standard, but it will be useful in meeting the optional standards. Manufacturers have several emission control technology options to meet the proposed regulations. Staff has provided a short discussion of the various control technologies that could be utilized in meeting the proposed mandatory and optional emission standards.

Diesel engines operate by compression ignition which causes the fuel to spontaneously ignite when injected into air under high pressure and temperature at the end of the piston's compression stroke. This diffusion flame approach results in regions in the combustion chamber with high flame temperatures. NOx formation is strongly dependent on temperature; as combustion temperatures increase, NOx emissions also increase. Therefore, in-cylinder NOx control technologies focus on reducing the combustion temperatures and the amount of time at which these high temperatures exist in the cylinder.

Manufacturers of new engines utilize several approaches when designing their products for reduced emissions. Such strategies as modifications to the fuel system and the use of aftertreatment (for example, catalysts) are discussed in this section.

A. Fuel Injection

Control of NOx emissions through manipulation of combustion temperatures and duration generally entails a tradeoff with emissions of hydrocarbons and particulate matter. For example, reducing the combustion temperature reduces formation of NOx, but it also inhibits the complete oxidation of carbon particles.

Retarding injection timing is the simplest and lowest-cost method of controlling NOx emissions by starting combustion later in the engine cycle so that most of the combustion occurs during the downward expansion stroke of the piston. This expansion reduces the combustion gas temperatures, and thus NOx formation. However, as the injection timing is retarded, PM emissions and brake specific fuel consumption increase. One of the methods that diesel engine manufacturers are developing to help reduce these fuel economy and PM emission penalties is the use of higher pressure fuel injection systems.

Higher injection pressures result in better fuel atomization and, therefore, better air utilization, more complete combustion, and subsequently a reduction in PM emissions. In one study, for the range of injection timing settings tested, increasing injection pressure from 10,000 psi to 14,000 psi decreased fuel consumption about 5 percent to 6 percent with a negligible change in NOx emissions. This means that fuel consumption deterioration due to the use of retarded timing for NOx control can at least partially be compensated by use of a higher pressure injection system. In another case, increased injection pressure, from the value of about 10,000 to 12,000 psi typical of older engines to higher values of near 20,000 psi, had the beneficial effect of reducing the Bosch smoke number from about 2 to less than 1 (Bosch smoke number is a measure of exhaust PM content, and a value of 1.5 is considered to be the threshold of visibility). This would have a beneficial effect on the soot portion of PM emissions.

One diesel engine manufacturer has developed a hydraulically actuated, electronically controlled unit injector system that provides programmable injection characteristics and high injection pressure (maximum 22,000 psi) at all loads and speeds. Such a high pressure injection system could be added to a diesel engine operated with retarded injection timing, and could subsequently operate with NOx emissions down to 4.0 grams NOx or lower for turbocharged/aftercooled engines, possibly in combination with PM aftertreatment to meet a 0.05 gram PM standard. These values are equivalent to the 1996 California urban bus standards.

During the ignition delay period, fuel is being injected into the cylinder but combustion has not yet begun. If this period is relatively lengthy, a large amount of unburned fuel will be present in the combustion chamber when ignition finally occurs. This pre-mixed charge burns quite quickly causing combustion temperatures to rise very sharply, in turn producing large amounts of NOx. Several manufacturers have been developing injector systems that minimize the amount of fuel injected prior to ignition and then increases the injection rate after combustion has begun. Such a scheme, called "rate shaping", limits the amount of fuel present and thus the amount of NOx formed during the pre-mixed combustion phase. Results have been good and provide a major incentive for electronically-controlled engine and fuel injection system development as a means of achieving effective rate shaping.

B. Turbochargers and Aftercoolers

Many pre-1991 diesel engine designs needed better air/fuel management and lower intake air temperatures to meet increasingly stringent emission standards while still providing good fuel efficiency. To accomplish this, most manufacturers added or improved turbochargers and charge air cooling. Turbocharging has a major influence on the pumping losses of an engine and on the combustion efficiency through control of the air/fuel ratio. Charge air cooling cools the intake charge to reduce peak combustion temperatures which, in turn, reduces NOx formation. Further improvements in turbocharging, such as the development of variable geometry turbochargers (VGTs, which vary the internal turbine flow geometry with operating conditions to improve performance over a wide speed and flow range) and charge air cooling, in conjunction with other engine modifications, will be important in achieving better fuel economy and lower emissions.

C. Exhaust Gas Recirculation (EGR)

Exhaust gas recirculation is one of the most promising methods for reducing NOx emission levels. Spent combustion gases recirculated back into the intake system serve as a diluent to lower the oxygen concentration and also increase the heat capacity of the air/fuel charge. These effects reduce the peak combustion temperature and the rate of combustion, thus reducing NOx emissions. Two research organizations, Ricardo Engineering Consultants and Southwest Research Institute (SwRI), are studying the use of EGR and developing strategies for obtaining low NOx emissions while minimizing fuel economy losses and any increase in PM emissions. The exhaust gases recirculated at low loads are used at the highest available temperature to also help reduce ignition delay. At higher loads, cold EGR is used (cooled through the aftercooler) to further reduce combustion temperatures. The primary drawback to EGR is the potential for fouling of the turbocharger and aftercooler (if present) and other intake components with particulate matter and other contaminants present in the recirculated exhaust gases.

Navistar's experimental 7.3 liter heavy-duty diesel engine utilizes EGR and has reported preliminary results of 2.9 g/bhp-hr NOx at 0.10 g/bhp-hr PM (with no aftertreatment). This engine demonstrates the significant NOx reduction potential of EGR on diesel engines. In addition, with the very low PM levels in current diesel engines and with low-sulfur diesel fuel, EGR systems would not be expected to be subject to plugging. Therefore, EGR is more durable and feasible for heavy-duty diesel engines than in the past. The ARB staff believes that EGR could be used to reduce NOx emissions to well below 4.0 g/bhp-hr. Although PM emissions may increase slightly with EGR usage, particulate traps, catalytic traps, or oxidation catalysts could be used to control the excess PM emissions down to regulated levels.

D. Water Injection/Fumigation/Emulsions

Using principles similar to those of EGR, the inclusion of water in the combustion chamber also has the potential to reduce NOx emissions and is currently being investigated. The vaporization of water during the compression stroke reduces the cylinder temperature and pressure at that time and therefore reduces the amount of work the engine does to compress the gases. This helps to improve engine efficiency and fuel consumption. The heat capacity of the water vapor then reduces combustion temperatures, just like EGR gases do, and therefore NOx formation is reduced by up to 50 percent in some test cases. Research also indicates that such techniques can reduce PM, CO and HC emissions. Water can be injected directly into the cylinder at the time of fuel injection, it can be fumigated into the cylinder with the intake of the fresh air charge, or it can be mixed into the fuel with an emulsifying agent. Concerns about corrosion and freezing effects are currently being addressed.

E. Combustion Chamber Improvements

If the fuel-air mixing rates and the shape of the flame in the combustion chamber can be sufficiently controlled, they can be optimized over the range of engine operating conditions to control and minimize the formation of pollutants. This involves careful attention to combustion chamber geometry to optimize such air flow parameters as swirl (the organized rotation of the combustion chamber gases about the cylinder axis), squish (the gas motion occurring when a portion of the piston face and the cylinder head approach each other closely) and the resultant turbulence (which greatly enhances mixing of fuel and air). Manufacturers have made great strides in this area with, for example, improved piston bowl designs which enhance mixing of fuel and air.

Proper air flow in the combustion chamber is also important to allow proper fuel injection penetration. If injected too far, the fuel spray will wet the cylinder wall leading to increased unburned HC emissions and increased wear. If not injected far enough, inadequate mixing will lead to increased HC and PM emissions. This issue is closely related to proper injector design and swirl control.

F. Engine Oil Control

Since engine oil leakage past piston oil control rings has been a major contributor to diesel engine PM emissions in the past, manufacturers have made great strides in improving engine oil control. Improved machining tolerances, cylinder honing processes and piston ring pack design have contributed greatly to the reduction of the organic fraction of exhaust PM and therefore to the overall PM emission levels. While this does not address the carbon particle component of PM emissions, it does allow manufacturers to concentrate a little more on NOx emissions because of the NOx/PM tradeoff. Better oil control also has the added benefit of reducing oil consumption and the attendant operating costs.

G. Particulate Traps

The tradeoff between NOx and PM emissions can limit the extent to which some methods of in-cylinder NOx control can be utilized. If PM aftertreatment can be made effective, then more extensive use of combustion control for NOx reductions can be utilized with the aftertreatment serving to control the increased engine-out PM levels.

Regenerative particulate traps have been used to reduce PM emissions from urban buses and have demonstrated a high efficiency of close to 90 percent. Particulate traps are filters made from a variety of materials, including ceramic monoliths, ceramic fibers, and catalyzed wire mesh. In general, they are used to capture the exhaust particulate matter which must periodically be burned off to "regenerate" the trap and keep it from clogging. Heat must often be added to accomplish the regeneration process because the exhaust temperatures are not always high enough to complete this task. The Donaldson dual trap oxidizer uses an electric heater to accomplish regeneration, and was certified with the Detroit Diesel Corporation (DDC) 6V92-TA and the Cummins L-10 urban bus diesel engines for the 1992 and 1993 model years (MY) in California. Such engines were certified with PM levels as low as 0.05 g/bhp-hr. The U.S. EPA certified the DDC diesel-trap urban bus engine at a PM level of 0.02 g/bhp-hr using low-sulfur diesel fuel. However, in operation, these traps suffer from severe durability problems in the ceramic wall-flow filter related to the large temperature extremes of the regeneration process (since temperatures of at least 1500 deg. F are required to oxidize the carbon buildup). Due to this and other difficulties, this trap has not proven to be a successful device, at least for use in urban bus diesel engine exhaust emission control. Since engine manufacturers have been able to meet current PM standards using approaches other than regenerative traps, the Donaldson Company ceased development and production of its trap in late 1993.

A potential additional benefit to particulate traps is that they would provide a source of relatively contaminant-free exhaust gas for EGR purposes while avoiding the fouling of engine components.

H. Oxidation Catalytic Converters

An alternative to the catalytic trap is the simple oxidation catalytic converter. These devices, similar in function to those used on late-70's and early-80's passenger cars, do not filter the exhaust, as a trap does, but instead simply present a large, catalytic surface area to the exhaust flow to oxidize gaseous HC and CO emissions as well as the organic portion of exhaust PM. However, they have little effect on the carbonaceous particle portion of PM emissions. Diesel engine exhaust temperatures are lower than those of gasoline engines and diesel fuel is a much heavier hydrocarbon than gasoline. Therefore, diesel engine oxidation catalysts (as distinct from the catalytic trap previously described) must operate at lower temperatures and oxidize heavier hydrocarbons than gasoline engine catalysts. Also, catalysts are sensitive to the sulfur content of fuels. High sulfur content can lead to the formation of sulfates in the converter which leave the converter as additional PM. The use of the low-sulfur diesel fuel (0.05 weight percent sulfur) that has been required throughout California and nationwide since October 1993 is beneficial to catalyst performance.

Oxidation catalysts may typically provide a 15 to 50 percent reduction in total PM emissions, depending on the amount and make-up of the engine's uncontrolled PM levels, and at a lower cost than for particulate traps. Several engine manufacturers have certified diesel engines for the 1994 model year using oxidation catalysts. Additionally, some engine manufacturers are endeavoring to meet the 1996 urban bus PM standard of 0.05 g/bhp-hr using catalytic converters. Oxidation catalysts cost approximately $500 to $1,000 for new engine installation. Currently, one manufacturer has applied to the EPA to certify a combination oxidation catalyst and muffler system under the federal urban bus retrofit program and estimates the cost will be less than $2,000.

I. Lean-NOx Catalysts

Catalytic converter devices for NOx control from vehicular diesel engines are currently not available. Three-way catalysts, as commonly used on gasoline engines, require an engine air/fuel ratio near stoichiometric to control NOx through reduction reactions with hydrocarbons and CO also present in the exhaust stream. Diesel engines operate with excess air and it is difficult to maintain the necessary NOx reduction reactions in such an oxidizing environment. Some approaches to a so-called lean-NOx catalyst employ the separate addition of reduction agents such as urea or ammonia in a process known as Selective Catalytic Reduction (SCR). SCR is widely used for stationary source NOx control but is considered impractical for vehicular use due to the widely varying operating conditions of diesel engines, to the need to carry a supply of the reducing agent on the vehicle, and to the potential toxicity of the unreacted reducing agents. Spent SCR catalyst material can also contain toxic metal oxides which pose serious disposal problems.

A variation on the SCR approach employs the use of a zeolite (or similar) adsorbent/catalyst in the exhaust stream to collect hydrocarbons emitted during low-load, low-speed, low-NOx operation to be made available later during high-load, high-speed operation (that is, high NOx-emitting conditions) for catalytic NOx reduction. For extended periods of NOx control, additional hydrocarbons would be needed, perhaps made available through de-tuning the engine to increase engine-out HC emissions or by direct injection of raw fuel into the exhaust flow between the engine and the catalyst. Currently, Southwest Research Institute is conducting a demonstration project, under contract to ARB, to investigate the feasibility of this type of lean-NOx catalytic converter. Research conducted to date indicates an adverse fuel economy impact but this is expected to be minimized with continued development and operating experience. It is even possible that engine injection timing could be advanced over currently used settings, thus offsetting at least a portion of the catalyst fuel penalty and relying on the catalyst to control the increased engine-out NOx emissions.

Practical vehicular lean-NOx catalysts are not currently available but represent the type of advanced technology that could be used in the future to meet more stringent NOx standards. Whether they will be available to support manufacturers' efforts to meet near-term reductions in standards is uncertain.

J. Summary

Overall, manufacturers have several options to consider in meeting the proposed mandatory emission standards. Combinations of some levels of turbocharger and aftercooling improvements, increased timing retard, higher injection pressures, EGR, oxidation catalysts or traps and, more remotely, lean-NOx catalysts should allow heavy-duty diesel engines to meet the proposed standards.

III. GASOLINE TECHNOLOGY

Gasoline engines utilize spark ignition of a pre-mixed fuel/air mixture. The air/fuel ratio of such a mixture is much more uniform and controllable than the spatially varying ratios of the diffusion flame used in diesel engine combustion. This, in turn, allows better control of the combustion process for ease of emissions control.

Because of the use of such engines in passenger cars, and the emphasis placed on passenger car emissions control over the past several decades, engine manufacturers have many years of pollution control technology to rely on in meeting the proposed standards as applied to heavy-duty gasoline engines. Also, gasoline engines inherently emit negligible levels of PM (indeed, heavy-duty PM standards are not available for gasoline engines) so that the NOx/PM control tradeoff problem is non-existent. Since the exhaust is relatively clean of PM, the use of EGR for NOx control is readily achieved without the contamination that occurs when using this technology in diesel engines. The hydrocarbon standards can be readily met with oxidation catalysts so that the NOx/hydrocarbon control trade-off problem is not quite so severe as for diesel engines. Finally, the readily controlled mixture ratio allows the use of stoichiometric air/fuel ratios and three-way catalysts where necessary for NOx control.

The final support that the technology is available for controlling heavy-duty gasoline engines to the level required by the proposed mandatory standards is that it has already been done. As early as 1991, General Motors certified a 5.7 liter engine for use in vehicles over 14,000 pounds at a NOx level of 3.5 g/bhp-hr. Since this engine was certified without the use of three-way catalyst technology, it is reasonable to assume that even lower NOx levels could be achieved with that approach. It is also reasonable to assume that such control measures could be applied to other gasoline engines with similar levels of success.

Therefore, because of the relatively advanced state of development of gasoline engine emission control technology, and because NOx emission levels below the proposed standard have been demonstrated on production engines, staff concludes that NOx control of heavy-duty gasoline engines to the levels required by the proposed standard is feasible.

IV. ALTERNATIVE FUEL TECHNOLOGY

Alternative fuels have provided manufacturers with new options to meet exceedingly low emission levels. Although the staff does not expect that alternative fuel use will be necessary to meet the proposed mandatory NOx standard, the current state of the technology is such that only their use can achieve the lower levels of the optional low-emission standards. Compared to conventional diesel control efficiencies, alternative fuel technology can provide emission reductions in the range of 50 percent for NOx while maintaining low emission levels of other pollutants. Such technology has been applied to every-day use in urban buses with reasonable levels of success. However, urban buses also have the characteristics of central fueling and relatively small areas of operation. Many heavy-duty trucks, on the other hand, cover great distances and must refuel at facilities along their route of travel. Such facilities are not widely available in the case of alternative fuels. The following is a brief discussion of current promising alternative fuel technologies.

A. Methanol

Methanol (M100) has been demonstrated to be a clean-burning alternative fuel, primarily in urban buses. By far the most prevalent example is the methanol version of the DDC 6V92-TA urban bus engine. There are two different horsepower ratings for this compression-ignition engine, 253 hp and 277 hp, from which a purchaser may choose. Both the 253 hp and 277 hp engines are certified at an emissions level of 1.7 g/bhp-hr NOx and 0.03 g/bhp-hr PM. Both engines would easily meet the proposed optional emissions standards for the 1995 through 1997 model years, with the manufacturer choosing from the range of optional NOx standards of 3.5 g/bhp-hr or less, by 0.5 g/bhp-hr increments, depending on which standard the manufacturer would be willing to demonstrate compliance with for the full useful life. Starting with the 1998 model year, the manufacturer could certify both engines only to the proposed optional 2.5 NOx standard or less.

Compression-ignition methanol engines rely on higher compression ratios than diesel engines and utilize glow plugs to assist in starting and at low loads because of the lower auto-ignition properties of alcohol fuels. Methanol engines must also use special fuel systems to increase the volume of the fuel injected to make up for the lower energy density of methanol. However, this lower energy density, along with the high latent heat of vaporization of methanol, also provides lower combustion temperatures, which results in lower NOx emissions. Methanol fuel properties also cause the ignition delay to substantially lengthen. If the ignition delay becomes too long, the fuel will not burn completely, resulting in high HC and CO emissions. Therefore, methanol engines use oxidation catalysts to control excess HC and CO emissions, as well as aldehydes. Methanol engines are required to meet formaldehyde emission standards of 0.10 g/bhp-hr for 1993 to 1995 and 0.05 g/bhp-hr for 1996 and later.

Demonstration projects have also been conducted with methanol-fueled dump trucks and refuse trucks, and with semi tractors in limited local service. Engines manufactured by DDC, Cummins, Caterpillar, Navistar and Ford were used. These projects were primarily conducted in Southern California although one involved a refuse truck in the Lake Tahoe area. They showed that methanol could be used to fuel these vehicles in actual operation although fuel consumption and cost tended to be higher than for comparable conventional-fueled operation. However, few or no demonstration projects with HHD line-haul trucks have been attempted, probably due to the higher fuel costs and scarce refueling facilities. Experience from these programs and from urban bus operation has also raised concerns about reduced engine durability.

B. Compressed Natural Gas (CNG)

Natural gas is another alternative fuel that can provide significant emission reductions. There are currently several CNG engines being developed or in production for heavy-duty applications. The primary California-certified examples are the Cummins L-10-240G and the Detroit Diesel Series 50G urban bus engines. The L-10 has been certified at levels of 2.0 g/bhp-hr NOx and 0.02 g/bhp-hr PM. The Series 50G has been certified at 2.6 g/bhp-hr NOx and 0.06 g/bhp-hr PM. Obviously, these engines could comply with one of several of the proposed optional standards, if the respective manufacturers should choose to do so. The Cummins L-10 CNG urban bus engine is a spark-ignited, lean-burn engine and utilizes an oxidation catalyst to control HC, CO, and aldehyde emissions. Lean-burn engines operate with excess air to reduce NOx emissions. The excess air absorbs some of the heat of combustion to reduce peak cylinder temperatures and thus provide lower NOx emissions. The DDC Series 50G does not use an oxidation catalyst, which accounts for its higher PM levels.

Most of the development of natural gas engines has centered on CNG where the fuel is stored on-board in high pressure vessels between 3,000 and 3,600 psi. Because of the higher storage volumes and heavier fuel tanks needed for a gaseous fuel, 6 large tanks are required for a CNG urban bus to achieve the same mileage range as a typical diesel urban bus. These tanks add approximately 2,500 pounds to the total vehicle weight and cause some transit agencies increased difficulty in meeting maximum axle weight road requirements when carrying a full passenger load.

Tecogen and Hercules have also certified natural gas-fueled engines in the heavy-duty category. These engines are commonly used in school buses including California Energy Commission's (CEC) alternative fuel school bus program. They have NOx certification levels of 1.4 and 2.0 g/bhp-hr, respectively, sufficiently low to certify to one of the applicable optional standards, as well as the mandatory standard.

Several demonstration programs applying CNG engines to other heavy-duty applications have been conducted. For example, Von's Supermarkets operated a CNG tractor/trailer for the CEC for a demonstration period. The major problems found were the range limitation and scarcity of refuelling locations.

C. Liquefied Natural Gas (LNG)

Because of the tank weight and fuel volume issues associated with CNG, heavy-duty vehicle operators considering natural gas have expressed great interest in LNG. LNG must be stored at very low temperatures (-260°F), but provides increased range over CNG, while avoiding substantial increases in total vehicle weight. This is because LNG has a volumetric energy density closer to diesel fuel than CNG has. Although the storage systems differ, the emissions control technology for CNG and LNG engines, and the expected emissions benefits, remain about the same. However, LNG engine development has lagged behind that of CNG primarily because the fueling infrastructure for LNG is not yet in place. Because LNG must be kept at very low temperatures, specialized trucks must be used to transport the fuel, whereas CNG may be transported using the existing pipeline system.

Engines certified for use with CNG cannot automatically be used with LNG. LNG engines require special valves and heat exchangers which are not used with CNG engines. These LNG-unique parts are considered to be part of the emission control system and, as such, must be certified as part of the engine. Therefore, LNG engines must be certified separately from CNG engines, regardless of how similar the basic engines are to each other. Currently, the LNG version of the Cummins L-10-240G engine is the only heavy-duty LNG engine certified in California.

Houston Metropolitan Transit Authority is conducting a demonstration program of several urban buses retrofitted to use LNG fuel. Also, the Los Angeles County Metropolitan Transit Authority (LACMTA) will be launching its own LNG urban bus demonstration project with the aid of the Southern California Gas Company in the near future. Demonstration projects for LNG fueled trucks have also been discussed, although fuel availability problems similar to those of CNG and methanol vehicles must still be addressed before LNG is widely used. Staff anticipates that once the infrastructure has been established, any LNG heavy-duty engine that manufacturers may certify in the future would meet the proposed optional emission standards with emission levels comparable to CNG heavy-duty engines.

D. Other Fuels

Besides methanol and natural gas, there are other fuels in which industry and vehicle operators have expressed interest. Ethanol, which is an alcohol fuel, can also be used as an engine fuel. Like methanol, ethanol has a lower energy density than diesel, and would require a larger volume of fuel to obtain the same power and range as diesel-fueled trucks. It is expected that ethanol-fueled vehicles would perform much in the same way as methanol-fueled vehicles, and may provide significant emission reductions compared to diesel vehicles. However, the cost of ethanol is substantially higher than most other alternative fuels, so it is questionable whether it would be widely used for heavy-duty vehicles.

Liquefied petroleum gas (LPG) is another alternative fuel that has been used mainly in retrofit applications, but is gaining interest with some transit agencies and smaller heavy-duty vehicle operators as a potential new engine technology. As LPG has a significantly lower hydrogen to carbon ratio than methanol or natural gas, the emissions from an LPG engine are not likely to be as low as those from methanol or natural gas engines. However, it is likely that an LPG heavy-duty engine may provide emission reductions over a comparable diesel engine. Currently, there is only one certified LPG heavy-duty engine (Ford's 7.0 liter spark ignition model), but LPG still provides manufacturers with another technology option to explore.

V. ELECTRIC AND FUEL CELL TECHNOLOGY

The emission standards and test procedures proposed in this regulatory action would apply to internal combustion engines. It should be noted, however, that technologies such as battery and fuel cell power are being developed for heavy-duty vehicles, although almost exclusively in the urban transit bus category. Although great strides have been made in the development of zero emission vehicles as passenger cars, the unique characteristics of heavy-duty truck applications do not lend themselves to the current level of electric vehicle technology. For example, one of the major techniques for obtaining acceptable range and performance from battery powered passenger cars is to reduce their weight to the minimum possible that is consistent with safety, durability and economics. However, most HDV applications are concerned with payload transportation which means that most of the weight is in the cargo, not in the vehicle, and there is little opportunity for significant and effective weight reduction. Plus, while smaller HD trucks, such as delivery vehicles, may have areas of operation small enough to be within the available vehicle range, larger ones typically cover distances many times the possible electric powered range.

The two most promising approaches to electric heavy-duty trucks consider the use of fuel cells or hybrid configurations. Again, urban buses are leading the way in these technologies. LACMTA and South Coast Air Quality Management District (SCAQMD) have a demonstration program for a small fuel cell-powered bus. CalStart has a program, managed by Santa Barbara County Air Pollution Control District, to develop hybrid buses (fueled by natural gas), in the form of 3 retrofitted school bus-type vehicles, one retrofitted 40-foot bus and one new ground-up 40-foot design. While hybrid vehicles are not true zero-emission vehicles, they do have the potential for greatly reduced emissions relative to their conventional-fueled counterparts.

In short, application of zero-emission technologies to heavy-duty trucks is currently of limited feasibility. The requirements of such vehicles extend beyond the practical limits provided by current technology and, other than for urban buses, little development work is presently being conducted.

VI. SUMMARY

To reiterate, not all of these technologies will be required on engines to meet the proposed mandatory NOx standard of 4.0 g/bhp-hr. The staff believes that the more basic diesel engine measures of retarded injection timing and oxidation catalysts will be sufficient for this level of emissions from diesel engines. Many Otto-cycle gasoline engines already have NOx emission levels well below the proposed mandatory standard, and the others are expected to meet the requirements without major engine redesign. The more advanced control strategies presented in this technical support document, including the alternative fuel approaches, will be needed only for engines intended to certify to the optional low-emission standards. Therefore the potentially more expensive and developing engine technologies will not be needed unless the engine manufacturer is attempting to meet market demand for engines significantly cleaner than those it is required to produce.