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 DIESEL-ENGINES AND VEHICLES, TO SPECIFY STANDARDS FOR 1994 AND SUBSEQUENT URBAN BUS 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 travelled (VMT). California continues to have the worst air quality and the most severe air pollution problem in the nation. In 1991, the state ambient ozone standard was exceeded on more than 200 days across California, and maximum levels were 0.32 parts per million, nearly four times the standard. Ambient carbon monoxide (CO) levels were also frequently exceeded at a maximum of nearly twice the applicable standard. Particulate matter (PM) emissions are of increasing concern because they impair visibility and are potentially carcinogenic. The state ambient standard for PM is currently exceeded in 13 of the 14 air basins.

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 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. The South Coast Air Quality Management District is continuing to update its twenty-year attainment plan with transportation control measures that include market incentives for accelerated introduction of low-emission technologies. Other local districts are also updating their plans to provide for the earliest achievement of the ambient air quality standards. Federally, new amendments to the Clean Air Act were adopted to require more stringent standards for new and in-use vehicles and for the fuels these vehicles use.

Emission inventory estimates for California show that heavy-duty vehicles (HDVs) are becoming an increasing portion of the emissions problem. By the year 2010, HDVs will account for only 8 percent of the total on-road VMT, yet the projected HDV contribution will be 20 percent of the HC and CO emissions, 55 percent of the NOx, and 85 percent of the 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, diesel exhaust is currently being reviewed by the ARB as a possible toxic air contaminant.

Recognizing the need to further reduce emissions from HDVs, the California Legislature passed Senate Bill 135 (SB 135; Stats. 1991, ch. 496) in 1991 which requires the Board to adopt new emission standards and test procedures for transit buses. SB 135 mandates that the regulations are to be effective by January 1, 1996, and that they are to reflect the best emission control technology available at that time. In adopting the standards, the Board is to consider the projected costs and availability of alternative fuels compared with other air pollution control measures.

This regulatory package addresses the specific mandates of SB 135 by proposing more stringent exhaust emission standards for new heavy-duty engines and new replacement heavy-duty engines used in transit buses. This proposal would also provide for optional emission standards to allow the opportunity to generate emission credits as part of a mobile source credits program for buses, which is outlined in a separate 1993 ARB staff report entitled "Mobile Source Emission Reduction Credits---Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits."

II. BACKGROUND

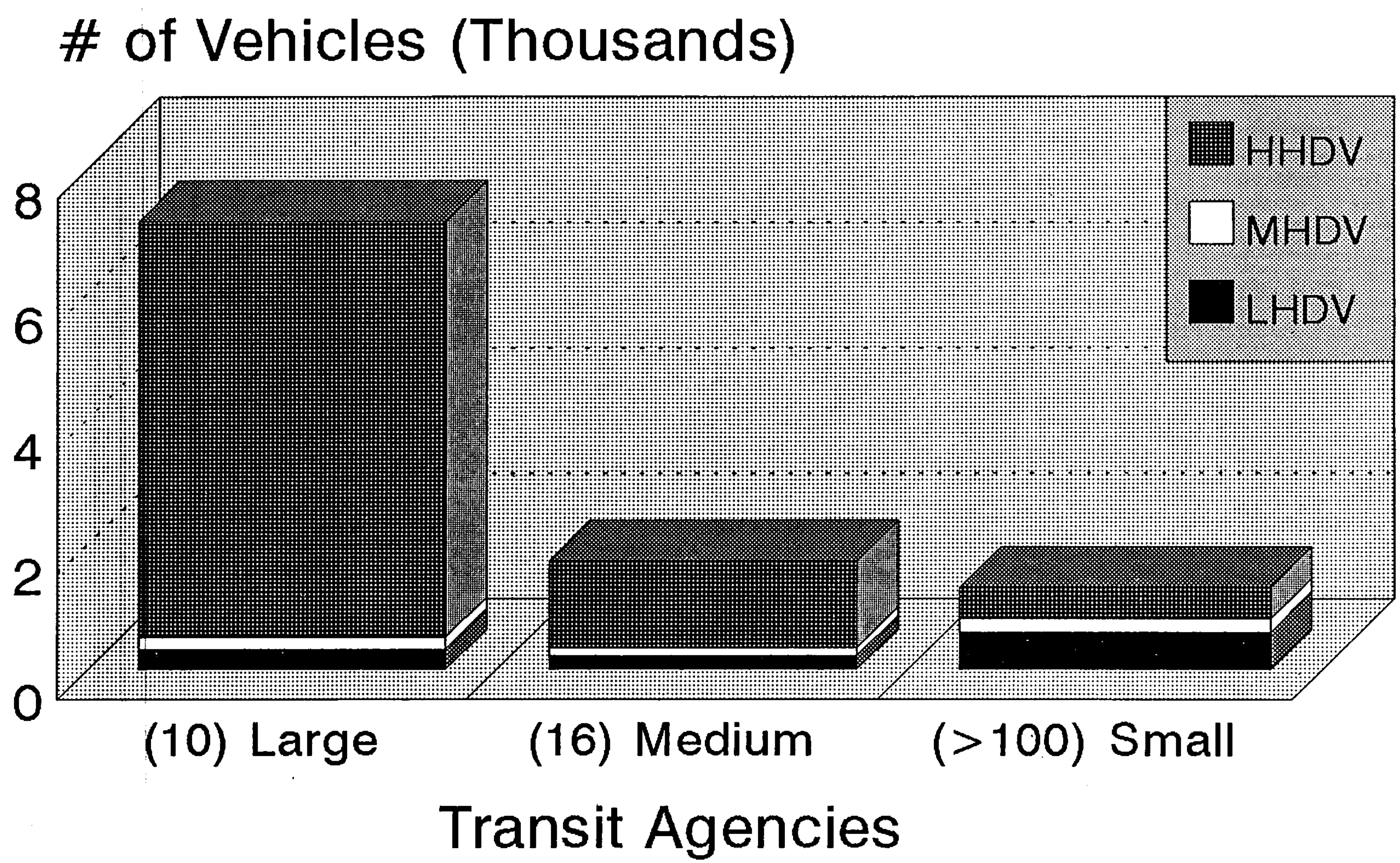
In general, transit buses are operated in urban areas with a typical route consisting of mostly stops and starts as passengers are routinely picked up and dropped off at their destinations. These buses are normally owned and operated by public transit agencies which receive federal, state, and local funds to help purchase new buses and to operate and maintain their transit bus fleets and facilities. It is estimated that there are 10 large-sized transit agencies in California that operate more than 200 buses in their fleet, 16 medium-sized transit agencies that operate between 50 and 200 buses, and over 100 small-sized transit agencies that operate fewer than 50 buses.

Transit buses vary in size and are generally from 16 to 60 feet in length. A standard size transit bus is normally 40 feet in length and has a carrying capacity of 70 passengers, including standing persons. As shown in Figure 1, the large and medium transit agencies operate buses that are normally of standard size and fall within the heavy heavy-duty vehicle class of greater than 33,000 pounds (>33,000 pounds) gross vehicle weight rating (GVWR) and, more specifically, the urban bus category. These transit agencies operate very few buses that are less than 33,000 pounds (<33,000 pounds) GVWR. On the other hand, small transit agencies operate a proportionately larger mix of different size buses, and they generally use buses in the light and medium heavy-duty vehicle classes (<33,000 pounds GVWR). These smaller transit buses are generally used in more rural areas, for demand response routes or special services.

There are approximately 8,000 urban buses on the road in California today. Mobile source inventory estimates, for 1993, indicate that urban buses are responsible for emitting approximately 3 tons per day of HC, 15 tons per day of CO, 20 tons per day of NOx, and 3 tons per day of PM. The smaller transit buses contribute only a minor portion of the overall statewide transit bus emissions, primarily because there are very few

FIGURE 1

CA Bus Distribution



Lrg TA = >200 buses, Med TA = 50-200 buses, Sm TA = < 50 buses   Year 1992 transit buses that are <33,000 pounds GVWR and many of them utilize gasoline-powered engines.

Urban buses and other heavy-duty vehicles that are normally powered 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 needing to be replaced. As a result, diesel engines are used heavily in line haul trucks and buses that need to travel many miles over the life of the vehicle.

A. DEFINITIONS

Current California regulations, by reference to the Code of Federal Regulations (CFR), Section 86.091-2, define an urban bus as a heavy-duty diesel-powered passenger-carrying vehicle with a load capacity of fifteen or more passengers and intended primarily for intra-city operation. Urban bus operation is characterized by short rides and frequent stops and normally equipped with 2 sets of doors and a farebox. Urban buses are also typically characterized by the absence of equipment and facilities for long distance travel, such as restrooms and large luggage compartments. The federal Environmental Protection Agency (EPA) is adopting a revised urban bus definition which would clarify that urban buses are normally powered by a heavy heavy-duty engine (generally for vehicles >33,000 pounds GVWR).

The useful life for urban bus engines is the same as the useful life for other heavy heavy-duty diesel engines which is 8 years or 290,000 miles. However, in order to comply with the recently revised Clean Air Act, EPA is adopting an extended useful life requirement, for the PM standard, for 1994 and later urban buses, from 8 years to 10 years while retaining the useful life mileage.

B. EMISSION STANDARDS

In 1985, the Board adopted a 0.10 g/bhp-hr PM standard for urban buses which became effective with the 1991 model year. The federal urban bus engine standards are the same except that the 1990 federal Clean Air Act amendments delayed the 0.10 g/bhp-hr PM requirement until 1993. However, EPA has adopted a 0.07 g/bhp-hr PM standard for urban bus engines for the 1994 and 1995 model years, and a 0.05 g/bhp-hr PM standard for 1996 and later model years with an in-use standard of 0.07 g/bhp-hr PM. The in-use PM standard was adopted to address manufacturer concerns over the uncertain durability of particulate traps and other aftertreatment devices which are expected to be utilized to meet the more stringent PM standards. The emission standards for California and federal urban buses are shown in Table 1. Note that manufacturers have the option to certify to either the total hydrocarbon (THC) or the non-methane hydrocarbon (NMHC) standards shown, except for methanol engines which must certify to the THC standard.

Table 1

California and Federal Urban Bus Emission Standards (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
Current California	1.3	1.2	15.5	5.0	0.10
Current Federal (1992)	1.3	1.2	15.5	5.0	0.25
1993 Federal PM standard					0.10
1994 Federal PM standard					0.07*
1996 Federal PM standard					0.05*

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

The adoption of a 0.10 PM standard required California urban buses to either use particulate traps or alternative fuels in order to be certified for the 1991 model year. Because urban buses comprise only a small portion of the heavy-duty engine market, manufacturers were able to concentrate their efforts on reducing PM levels on just a few engine families. In fact, most urban buses (85 percent) utilize engines from the Detroit Diesel Corporation (DDC) and the remainder from the Cummins Engine Company. Currently, there are two diesel particulate trap engines, two methanol-fueled engines, and one compressed natural gas-fueled (CNG) engine that have been certified for urban bus applications. Recently, DDC's Series 50 diesel engine was certified at 4.6 g/bhp-hr NOx and 0.08 g/bhp-hr PM without any exhaust aftertreatment devices. The certification levels are shown in Table 2. It is also anticipated that a DDC ethanol-fueled urban bus engine will be certified for 1993. Note that the emissions from the alternative-fueled engines are very low in NOx and that all five engines meet or nearly meet the federal 0.05 g/bhp-hr PM standard adopted for 1996 and later urban buses.

Table 2

California Certified Urban Bus Engines (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
DDC Series 50 Diesel	0.10		0.9	4.6	0.08
DDC 6V-92TA Diesel-Trap	0.40		2.4	4.9	0.06
Cummins L-10 Diesel-Trap	0.30		2.9	5.0	0.05
DDC 6V-92TA M-100 (253 & 277 hp)	0.19		2.1	1.7	0.03
Cummins L-10 CNG		0.6	0.4	2.0	0.02

III. SUMMARY OF RECOMMENDED ACTION

The staff recommends that the Board amend Section 1956.8, 1965, and 2112, Title 13, California Code of Regulations (CCR), and the incorporated "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles", and "California

Motor Vehicle Emission Control Label Specifications." This proposal would require heavy-duty engines used in transit buses to meet more stringent exhaust emission standards beginning with the 1994 model year. Also proposed are optional emission standards that can be used for the purpose of 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

SB 135 established a new California Health and Safety Code (CH&SC) Section 43806 which requires the Board to adopt emission standards and test procedures applicable to new engines used in public transit buses, and to make the regulations effective on or before January 1, 1996. SB 135 also added to the California Vehicle Code (CVC) Section 28114 requiring that heavy-duty vehicles operated by a transit authority or transit district, or owned by a private entity providing transit service under contract with a transit district or transportation authority, and used to transport persons for compensation meet the emission standards adopted by the Board pursuant to the CH&SC 43806. As used in CVC Section 28114, "heavy-duty" has the same meaning as defined in Section 39033 of the CH&SC which means vehicles >6,000 pounds GVWR. Also, Section 28114 is to apply to all new heavy-duty vehicles purchased on or after January 1, 1996, and all new or replacement engines purchased on or after January 1, 1996, for use in heavy-duty vehicles.

SB 135 specifies that replacement engines, in addition to new engines, for use in transit buses meet the emission standards adopted by the Board. It is proposed that any new replacement engine that is purchased, starting with the 1994 model year, and used to replace an existing transit bus engine would need to meet the emission standards proposed in this regulatory action.

As stated, SB 135 would include all heavy-duty vehicles >6,000 pounds GVWR operated by transit agencies. However, staff is proposing to limit the applicability of the transit bus regulations to urban buses as defined by EPA.

Staff proposes to adopt the new urban bus definition specified in the CFR Section 86.094-2: a passenger-carrying vehicle powered by a heavy heavy-duty diesel engine, or of a type normally powered by a heavy heavy-duty diesel engine, with a load capacity of fifteen or more passengers and intended primarily for intra-city operation. Very stringent low emission standards have already been established for vehicles with GVW ratings from 6,001 to 14,000 pounds to be implemented starting with the 1995 model year. Also, those few transit buses that fall in the medium heavy-duty vehicle class of 14,001 to 33,000 pounds GVWR, utilize a variety of different model engines which have not had the extensive development that has been devoted to urban buses. Exclusion of these smaller buses from this regulatory action will help assure model availability since this market is more widely arrayed, and it will provide small transit agencies with more flexibility since they tend to operate a larger proportion of small transit buses. Furthermore, larger urban buses constitute approximately 93 percent of the total transit bus fleet in California and 98 percent of the total NOx emissions from transit buses. Therefore, by limiting the applicability to urban buses that normally use heavy heavy-duty engines, the overall effectiveness of the regulations or the expected emissions benefit would not be significantly reduced.

B. EMISSION STANDARDS

Because of the high levels of NOx and PM that are emitted from buses, staff is proposing to adopt the federal 0.07 g/bhp-hr and 0.05 g/bhp-hr PM standards for engines to be used in 1994 and 1995 model year urban buses and 1996 and later model year urban buses, respectively. A more stringent NOx standard of 4.0 g/bhp-hr is proposed, beginning with the 1996 model year. Staff is also proposing to adopt optional standards beginning with the 1994 urban bus engine model year which could be used in conjunction with a local air pollution control district's mobile source emission credit program. Both new and replacement urban bus engines would need to meet the proposed mandatory emission standards. Tables 3 and 4 show the proposed mandatory and optional emission standards for urban bus engines.

1. Proposed Mandatory Emission Standards

Staff is proposing that the Board adopt, for engines to be used in urban buses, a 0.07 g/bhp-hr PM standard for the 1994 and 1995 model years and a 0.05 g/bhp-hr PM standard for 1996 and later model years. An in-use standard of 0.07 g/bhp-hr PM is also proposed in order to align California regulations with recently adopted federal regulations. As discussed in EPA's "Notice of Proposed Rulemaking for 1994 and Later Model Year Urban Buses", the federal Clean Air Act directed EPA to adopt an extended useful life requirement for any new requirements that first become applicable after the enactment of the 1990 amendments to the federal Clean Air Act. Since EPA only changed the PM standard for urban buses, an extended useful life requirement of 10 years/290,000 miles was subsequently adopted for only the 1994 and later model year urban bus PM standards. In order to be consistent with federal regulations, it is also proposed that an extended useful life requirement of 10 years/290,000 miles be adopted for the proposed California urban bus PM standards, beginning with the 1994 model year. Furthermore, staff is proposing a more stringent 4.0 g/bhp-hr NOx standard for 1996 and later model year urban bus engines. Alternative-fueled urban bus engines are already certified to levels that would meet the proposed standards. However, it is anticipated that diesel-fueled urban bus engines would also be able to meet the proposed mandatory emission standards by 1996. Staff's analysis of the feasibility of the standards are discussed in further detail in section IV, "Technological Feasibility."

Table 3

Proposed Mandatory Urban Bus Engine Emission Standards (g/bhp-hr)

	THC	NMHC	CO	NOx	PM
1994 and 1995 Model Years	1.3	1.2	15.5	5.0	0.07*
1996+ Model Years	1.3	1.2	15.5	4.0	0.05*

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

2. Proposed Optional Emission Standards

a. Range of NOx Standards

Under the optional emission standards, beginning with the 1994 model year, staff is proposing to establish a range of NOx standards from 0.5 g/bhp-hr to 3.5 g/bhp-hr, at 0.5 g/bhp-hr increments. This range of standards would be used to certify engines that emit substantially less NOx than the current mandatory 5.0 g/bhp-hr NOx standard. However, in 1996, the optional 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, because the mandatory NOx standard would be lowered to 4.0 g/bhp-hr NOx.

Table 4

Proposed Optional Urban Bus Engine Emission Standards (g/bhp-hr)

Pollutant		1994 and 1995 MYs	1996+ MYs
THC		1.3	1.3
NMHC		1.2	1.2
CO		15.5	15.5
NOx	(by 0.5 gram increments)	0.5 to 3.5	0.5 to 2.5
PM		0.07*	0.05*

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

The adoption of the proposed optional emission standards would allow low-emitting urban bus engines to be certified to more stringent standards and purchased to create NOx emission credits that could be used in a mobile source emission credit program. For example, if an urban bus engine emits 2.0 g/bhp-hr NOx and meets the proposed 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 1994 and 1995 model years. The standard selected would depend on the manufacturer's confidence as to which standard could be maintained in-use for the engine's useful life. If a manufacturer chose to certify to a 2.5 g/bhp-hr NOx standard, and a transit agency were to purchase a bus utilizing this lower emitting engine, a maximum reduction of 2.5 g/bhp-hr NOx could be obtained. This is the difference between the mandatory 5.0 NOx and optional 2.5 NOx standards.

In 1996, however, a manufacturer would be limited to certifying an urban bus engine that emits 2.0 g/bhp-hr NOx to only a 2.0 or 2.5 g/bhp-hr NOx standard. A maximum reduction of 2.0 NOx could be obtained, which is the difference between the proposed mandatory 4.0 NOx and optional 2.0 NOx standards. It is necessary to set the optional emission standards significantly more stringent than the mandatory emission standards in order to assure that "low-emission" control technology is, indeed, utilized on any buses that would receive credits. Zero-emission or electric bus fleets would also be considered candidates for receiving credits under an air pollution control district's emission reduction credits program. With zero-emission buses, maximum NOx reductions of 3.5 g/bhp-hr for the 1994 and 1995 model years and 2.5 g/bhp-hr for the 1996 and later model years would be obtained to generate credits.

The reason for allowing a range of optional NOx standards limited to 0.5 g/bhp-hr increments is 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 engine from that engine family may actually be emitting in-use at 2.0 NOx, another engine at 1.9 NOx and another at 2.1 NOx. All three engines under that engine family have been certified to a 2.0 NOx standard and credits would be granted accordingly. However, if other optional NOx standards were allowed too close in range to the optional 2.0 NOx standard, (i.e., less than 0.5 g/bhp-hr increments), then another engine family that could be certified to an optional 1.9 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 NOx standard. This would make it virtually impossible to determine if the additional credits granted for the 1.9 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. 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 the optional standards is actually meeting the emission standards in-use for which credits were granted.

b. 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 SAE specifications (J1877, J1892) for letter sizing and spacing.

c. Tamper-Resistance Requirement

Staff is also proposing that additional measures be taken to discourage tampering of urban bus engines that are intended to be certified under the proposed optional emission standards. Staff proposes that all 1995 and later model year urban bus 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 credits that are generated under a mobile source emission reduction credit program.

d. Mobile Source Credit Programs

The ARB recently published specific guidance for the generation and use of mobile source emission reduction credits to help those air pollution control districts that are interested in developing their own emission credits programs. This guidance advises that certain criteria must be met before emission reductions may qualify as credits. Among these criteria are the principles that the reductions must be in excess of what is required by law, must be real, and must be quantified to an acceptable degree of certainty. Also, the mechanism used to obtain mobile source emission reduction credits must be enforceable and legally binding, and have an established life span. These criteria would necessitate a strong enforcement program, and in-use testing of urban buses 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 and PM emissions from urban buses while encouraging the use of cleaner operating buses.

IV. TECHNOLOGICAL FEASIBILITY

In recent years, there has been significant advancement in controlling NOx and PM emissions from heavy-duty diesel engines. Staff has determined 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.

A. DIESEL TECHNOLOGY

Currently, there are heavy heavy-duty diesel engines that have been certified to NOx levels near 4.0 g/bhp-hr, but with high PM levels (no aftertreatment). However, 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. If needed, exhaust gas recirculation (EGR) on diesel-trap engines would provide another means to comply with the proposed mandatory emission 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 emission standards.

Diesel engines operate by compression ignition which causes the air/fuel mixture to ignite under high pressures. This condition also results in high flame temperatures. NOx formation is directly dependent on the flame temperature; as combustion temperatures increase, NOx emissions also increase. Therefore, NOx control technologies generally focus on reducing the combustion temperatures and the amount of time at which these high temperatures exist in the cylinder.

1. Fuel Injection

Retarding injection timing is the simplest and lowest-cost method of controlling NOx emissions by starting combustion later in the engine cycle and reducing the peak combustion temperatures. However, as the injection timing is retarded, PM emissions and brake specific fuel consumption increase. To reduce fuel economy and PM emission penalties, manufacturers are developing higher pressure injection systems.

Higher injection pressures result in better atomization and, therefore, better air utilization, more complete combustion, and subsequently a reduction in PM emissions. From one study, with fuel injection pressures increased from 15,000 psi to 20,000 psi, PM is reduced from 0.25 g/bhp-hr to 0.15 g/bhp-hr at a NOx level of 5.0 g/bhp-hr. One diesel engine manufacturer is currently developing 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. Preliminary emission results of 4.79 g/bhp-hr NOx and 0.088 g/bhp-hr PM were obtained without a particulate trap. A direct injection diesel engine with high pressure injection could be operated with retarded combustion timing, providing low NOx emissions down to 4.0 NOx or lower for turbocharged/aftercooled engines, possibly in combination with a particulate trap to meet a 0.05 PM standard.

2. Advanced 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 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 can reduce NOx emissions. Further improvements in turbocharging and charge air cooling, in conjunction with other engine modifications, will be important in achieving better fuel economy and lower emissions.

3. Exhaust Gas Recirculation

EGR is one of the most effective methods for reducing emissions to low NOx levels. Recirculating spent combustion gases back into the intake system serves 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 and the 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. Hot EGR is utilized at low loads to improve the ignition delay and to reduce the air/fuel ratio, thereby reducing PM and HC emissions as well as NOx. Above low loads, cold EGR is used (cooled through the aftercooler) to reduce NOx emissions.

Navistar's experimental 7.3 liter DIT 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). Although this is not an urban bus engine, it demonstrates the significant NOx reduction potential of EGR on diesel engines. In addition, with the very low PM levels in current diesel engines and low-sulfur diesel fuel, EGR systems would be expected to not be subject to plugging. Therefore, EGR is more durable and feasible for heavy-duty diesel engines than in the past. Staff believes that EGR could be used to reduce NOx emissions to 4.0 g/bhp-hr and lower. 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 0.05 g/bhp-hr.

4. Exhaust Aftertreatment

Particulate traps are currently being 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. Traps are used to capture the exhaust particulate matter. Periodically, the trapped particles must be burned off to "regenerate" the trap. 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 has been certified with the DDC 6V92-TA and the Cummins L-10 urban bus engines for California that meet PM levels as low as 0.05 g/bhp-hr. The EPA certified the DDC diesel-trap urban bus engine at a PM level of 0.02 g/bhp-hr using low-sulfur diesel fuel.

Durability, however, must still be established and improved. During the life of a vehicle, the particulate trap ceramic core will experience a wide range of thermal stress as well as normal operating and vibrational stresses. The possibility exists where the honeycomb cell structure of the ceramic monolith could be plugged due to faulty heating equipment. At this time, it is estimated that the initial cost of a particulate trap would be $15,000, and it is expected that the trap core would need to be replaced every 150,000 miles at a cost of $5,000 each.

Another particulate trap that is gaining much attention is the Engelhard catalytic trap. This trap is coated with a precious metal catalyst which causes regeneration to be initiated at much lower temperatures (700 to 800°F) than normal (1500°F), therefore eliminating the need for an outside heat source. Also, the heat stress is reduced by approximately 50 percent, thereby extending the life of the ceramic honeycomb filter. The Orange County Transportation Authority (OCTA) is currently operating two buses equipped with catalytic traps and plans on obtaining eight more. The OCTA has observed that their buses are performing well and are operating 20 to 30 percent of the time at the minimum regeneration temperatures needed for the catalytic trap to work. Currently, this catalytic trap will only work on 4-stroke engines, such as the Cummins L-10 and DDC Series 50 and 60 engines, because of the higher exhaust temperatures required. There is work underway, however, for adapting catalytic traps for use on 2-stroke engines such as the DDC 6V-92TA urban bus engine.

Catalytic traps are still being developed and improved, but it is expected that the emission reduction potential for PM would be comparable to that of a non-catalyzed trap and yet provide an additional benefit in HC and CO emissions. Catalytic traps currently cost about $8,000 each, but it is expected that the cost could go down to $5,000 each with larger volumes. Catalytic traps would offer a cost advantage over non-catalyzed traps, in that no external regeneration hardware would be needed. Catalytic traps should also be more durable because of lower regeneration temperatures (less thermal stress) and the lack of heating equipment problems.

Oxidation catalysts are another exhaust aftertreatment method of reducing exhaust particulates, especially volatile particulates, as well as HC and CO emissions. Diesel oxidation catalysts must operate at lower temperatures and oxidize heavier hydrocarbons than gasoline catalysts. Also, catalysts are sensitive to the sulfur content in fuels. Therefore, it is desirable to use the low-sulfur diesel fuel (0.05 percent sulfur) that is currently mandated in southern California and will be required throughout California and nationwide by the end of 1993. Oxidation catalysts may typically provide a 30 to 50 percent reduction in the total PM emissions, and at a lower cost than that for particulate traps. Some engine manufacturers are endeavoring to meet a 0.05 g/bhp-hr PM standard using a catalytic converter instead of particulate traps on some engine models because of the potential cost savings. It is estimated that oxidation catalysts will cost approximately $1,000 to $2,000 initially, with similar replacement intervals as a particulate trap, but at a lower estimated cost of $1,000 per replacement.

Overall, manufacturers have several options to consider in meeting the proposed mandatory emission standards. Turbocharger and aftercooling improvements, increased timing retard, higher injection pressures or EGR combined with either an oxidation catalyst or trap could allow diesel urban bus engines to meet the proposed standards.

B. ALTERNATIVE FUEL TECHNOLOGY

Alternative fuels have provided manufacturers with new options to meet increasingly stringent 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 PM emission levels. Because of this NOx reduction potential, alternative fuels have made the proposed optional emission standards feasible. The following is a brief discussion of current promising alternative fuel technologies that are being applied to urban buses.

1. Methanol

Methanol (M100) has been demonstrated to be a clean-burning alternative fuel in urban buses. Currently, the DDC 6V92-TA engine is the only methanol urban bus engine certified for California. There are two different horsepower ratings, 253 hp and 277 hp, that a purchaser may choose from. 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 meet the proposed optional emissions standards for the 1994 and 1995 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 was willing to demonstrate compliance with for the full useful life. For the 1996 model year, the manufacturer could certify both engines only to the proposed optional 2.5 NOx standard or less.

Methanol engines sometimes 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 also provides a lower flame temperature, 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 charge will not burn completely, resulting in high HC and CO emissions. Therefore, methanol engines use oxidation catalysts to control the 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.

2. Compressed Natural Gas (CNG)

Natural gas is another alternative fuel that provides significant emission reductions. There is currently one CNG urban bus engine, the Cummins L-10, that has been certified in California, and meets levels of 2.0 g/bhp-hr NOx and 0.02 g/bhp-hr PM. This engine could comply with the proposed optional standards while also meeting the proposed mandatory 0.05 g/bhp-hr PM standard. 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.

Most of the natural gas engine research has centered on CNG where the fuel is stored on-board in high pressure vessels between 3,000 to 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.

3. Liquefied Natural Gas (LNG)

Because of the weight issue associated with CNG, transit agencies have expressed great interest in LNG. LNG must be stored at very low temperatures (-260°F), but provides increased vehicle range, while avoiding substantial increases in total vehicle weight. This is because LNG is volumetrically closer to diesel fuel than CNG. 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.

Houston Metropolitan Transit Authority is conducting a demonstration program of several urban buses retrofitted to use LNG fuel. Also, the Southern California Rapid Transit District (SCRTD) will be launching its own LNG urban bus demonstration project with the aid of the Southern California Gas Company in the near future. Staff anticipates that once the infrastructure has been established, any LNG urban bus engines that manufacturers may certify in the future would meet the proposed optional emission standards with emission levels comparable to CNG urban bus engines.

4. Other Fuels

Besides methanol and natural gas, there are other fuels which industry and transit agencies have expressed an 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 buses. 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 methanol and other alternative fuels, so it is questionable whether it would be widely used for urban buses. Nevertheless, DDC has plans to certify an ethanol urban bus engine for the 1993 model year.

Liquefied petroleum gas (LPG) is another alternative fuel that has been used mainly in retrofit applications, but is gaining interest with some transit agencies as a potential new bus engine technology. As LPG is a petroleum-based fuel, the emissions from an LPG engine are not likely to be as low as that from methanol or natural gas engines. However, it is likely that an LPG urban bus engine may provide emission reductions over a diesel urban bus engine. Currently, there are no certified LPG urban bus engines, but LPG provides manufacturers with another technology option to explore.

C. 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 other technologies are either available or are being developed for transit buses.

Electric and fuel cell technology for transit buses offer attractive opportunities from an air quality standpoint. Electric trolley buses provide passengers with very quiet rides, with no fumes, and with essentially zero emissions, unlike the characteristics of a conventional bus with an internal combustion engine. Battery-powered electric buses would offer similar advantages, as well as buses powered by fuel cells. Unfortunately, the availability of battery-powered buses has been slowed by the high cost as well as limitations in current battery technology. Fuel cell-powered buses are still in the early stages of development. However, emission reduction credits obtained through an air pollution control district's mobile source emission reduction credit program could potentially help fund the additional costs of electric and fuel cell buses. The guidelines for mobile source emission reduction credits programs, which the Board recently adopted, addresses the credit-generating potential of zero-emitting technologies.

1. Electric Trolley Buses

Electric vehicles offer the greatest emissions benefit potential of any alternative-fuel transportation vehicle. A number of cities, like San Francisco, California, have operated electric trolley buses successfully for many years. For bus routes with high passenger use in downtown areas, trolley buses are the most practical of the electric transportation options available. A Booz-Allen and Hamilton study for the SCRTD concluded that a trolley bus overhead catenary wire and associated power distribution system would cost approximately $1.5 million per two-way track mile. A 40-foot trolley bus could cost approximately $400,000 to $450,000 and a 60-foot articulated trolley bus could cost as much as $600,000 to $650,000.

On the other hand, overall operating costs for a trolley bus system are expected to be lower than that for an alternative-fuel bus fleet. Even though trolley buses would incur a high initial capital cost, the amortized annual cost would be competitive with alternative-fuel buses. This is mainly due to the fact that electric trolley buses have typical lifetimes of about 20 years, whereas diesel and alternative-fuel buses last about 12 years. Furthermore, electric motors are inherently more durable and reliable than internal combustion engines and would, thus, require far less maintenance which would lower operating costs. Also, low fuel (electricity) costs for electric trolley buses amount to an estimated $0.24 to $0.33 per mile, comparable to methanol ($0.31 to $0.37) and diesel ($0.26) per mile fuel costs. Therefore, electric trolley buses are an option, that is available now, for substantial emissions reductions for all pollutants.

2. Battery-Powered Buses

Battery-powered buses also offer an additional low-emission option for transit agencies. Currently, there is an electric shuttle vehicle that is being used in Santa Barbara and in other transit agency and utility fleets. This vehicle is being marketed by Clean Air Transit and was designed in partnership with Southern California Edison and the Santa Barbara Transit District. The Clean Air Transit vehicle is 22 feet in length and has a 29-passenger capacity. It is powered by lead/acid batteries with the total battery weight estimated at over 4,000 pounds and a vehicle range of 75 miles per battery charge.

The Electric Vehicle Marketing Corporation (EVMC) is also offering electric buses in 22 feet and 26 feet lengths with a maximum passenger capacity of 33 persons. These buses also operate on lead/acid batteries, with a vehicle range of 75 to 100 miles. Both the Clean Air Transit and the EVMC electric buses utilize regenerative braking to add battery range. Overall, battery-powered buses provide significant emissions reductions. However, battery technology will need to be improved to reduce increased weight concerns and vehicle range before becoming widely available.

3. Fuel Cells

Fuel cells are devices that electrochemically convert hydrogen and oxygen into electric power and water. Most fuel cell systems obtain oxygen from the air and hydrogen can be generated on-board the vehicle by using a hydrogen-rich fuel, such as methanol or natural gas.

Hydrogen could also be carried in compressed or liquid form. Similar to battery-powered buses, the emissions are expected to be zero or near-zero, but fuel cell technology would provide increased vehicle range and faster refueling time. Also, fuel cells can typically weigh approximately 3,000 pounds less than a battery system of an electric bus. The South Coast Air Quality Management District currently has a program to design, build, and demonstrate fuel cell buses. The co-sponsors include the U.S. Department of Energy, U.S. Department of Transportation, and Georgetown University. It is anticipated that three small test-bed buses of 25 to 30 feet in length will be built by late 1993 or early 1994. A design concept for a standard 40 foot urban transit bus will also be developed. However, it is expected that this technology will need additional development and demonstration, and may not be commercially available until the year 2000.

V. ISSUES OF CONTROVERSY

A. EMISSION STANDARDS AND ASSOCIATED COSTS

1. Background

The proposed regulations give transit agencies the option of purchasing buses meeting either a 4.0 g/bhp-hr mandatory NOx standard beginning in 1996, or more stringent optional NOx standards of a range between 0.5 to 2.5 g/bhp-hr NOx, at 0.5 gram increments. Also, to help facilitate earlier implementation of a mobile source emission reduction credits program, the proposed regulations provide for optional NOx standards of a range between 0.5 to 3.5 g/bhp-hr, at 0.5 gram increments, for the 1994 and 1995 model years.

The staff held two general workshops to discuss the staff's proposals; the first workshop was held in April, 1992. The staff's original proposal required all 1996 and later model year transit buses greater than 14,000 pounds GVWR to meet a 2.5 g/bhp-hr NOx standard and a 0.05 g/bhp-hr PM standard. After modifying the proposal, based on information provided by the affected parties, staff held a second workshop in September, 1992. At this workshop, staff proposed that all 1996 and later model year urban buses (generally greater than 33,000 pounds GVWR) meet a mandatory 4.0 g/bhp-hr NOx standard and a 0.05 g/bhp-hr PM standard. Staff also proposed an optional 2.5 g/bhp-hr NOx standard effective in 1994, for transit agencies choosing to purchase cleaner operating buses.

Prior to the first workshop, staff had determined that a mandatory 2.5 g/bhp-hr NOx standard would be cost effective (in spite of being alternative-fuel-forcing) during the first few years of implementation. Transit agencies responded to this proposal by indicating that, although it was cost effective, the purchase, operation, and maintenance of alternative-fuel buses, as well as the installation of a new refueling infrastructure, would require a prohibitively large investment.

2. Cost Impact on Transit Agencies

To evaluate the impact on transit agencies of converting to an alternative-fueled fleet, staff estimated the cost associated with purchasing and operating alternative-fueled buses rather than diesel-fueled buses. During this analysis, it became apparent to staff that the final outcome was very sensitive to, and largely dependent on, the price of fuel.

Since there are large fluctuations in the price of the baseline diesel fuel, the incremental costs of operating alternative-fuel buses would also have wide fluctuations. As shown in Table 5, the statewide average quarterly diesel prices, from the California Energy Commission's Quarterly Oil Report, fluctuated by as much as $0.10 per gallon in one quarter of 1992. Recognizing this, the staff's intent is to use the fleet cost estimates only as indicators of feasibility, not as precise predictors of future costs.

Table 5

California Quarterly Wholesale Diesel Prices (Cents per Gallon)

Year	1991				1992	
Quarter	1	2	3	4	1	2
Price	79.8	66.4	72.0	69.3	58.7	69.3

Staff has provided a range of estimated costs of alternative-fuel buses compared to diesel-trap buses for a 200-bus fleet in Table 6. These numbers were also used in the "Mobile Source Emission Reduction Credits" guidelines document that was presented to the Board in February, 1993. A diesel-trap-equipped bus, meeting the 5.0 g/bhp-hr NOx and 0.1 g/bhp-hr PM standards, was considered the baseline vehicle; and all incremental costs were calculated from this baseline vehicle costing $225,000. As shown, methanol-powered buses would cost approximately $240,000 to $250,000. CNG-powered buses would cost approximately $250,000 to $260,000.

Installation of new fueling facilities for methanol and CNG would have a low cost of $700,000 and $1.5 million and a high cost of $1.5 and $3.5 million, respectively. There is an expected additional cost of $0.04 to $0.08 per therm for operating a CNG facility that would come from electricity costs for running the compressor. Compressor maintenance cost estimates are also included. The actual costs would vary considerably for the different transit agencies depending on site-specific factors.

The per-mile fuel costs are based on current prices and a range of costs for methanol and CNG fuel are provided, taking into account a certain degree of variability. The diesel fuel price is $0.69 per gallon plus $0.06 per gallon for the low-sulfur, low-aromatic reformulation required in California in 1993 (plus $0.03/mile for periodic trap-core replacement); the methanol price was assumed to fall within a range of $0.44 to $0.52 per gallon; and the CNG price was assumed to fall within a range of $0.30 to $0.35 per therm.

Table 6

Estimated Costs of Alternative-Fuel Buses
200-Bus Fleet

		New Bus	Facility	Fuel	
Diesel-Trap		$225,000	--	$0.75/gal	$0.26/mi*
Methanol	(low)	$240,000	$700,000	$0.44/gal	$0.31/mi
	(high)	$250,000	$1.5 M	$0.52/gal	$0.37/mi
CNG	(low)	$250,000	$1.5 M	$0.30/therm	$0.16/mi
	(high)	$260,000	$3.5 M	$0.35/therm	$0.18/mi

* includes $0.03/mi for periodic trap-core replacement

Using the values given in Table 6, staff estimated the lifetime and incremental cost of operating and maintaining a 200-bus alternative-fuel fleet as shown in Table 7. Bus and facility capital expenditures are assumed to be made upfront. Fuel and facility operating costs are assumed to be spread over the lifetime and inflated at 3% per year, then discounted to the present value at 10% per year. For example, a 200-bus methanol fleet would have an estimated lifetime cost between approximately $69 to $76 million, i.e., $7.4 to $14 million more than the $62 million diesel fleet lifetime costs. The estimated incremental cost of operating a CNG fleet ranges from approximately $1.6 million to $8.7 million. As stated earlier, this range of costs is largely dependent on the future price of fuel and each transit agency is encouraged to do their own case-specific cost evaluation. For example, the incremental costs would be much different for a fleet much smaller than the one analyzed here.

Table 7

Lifetime Cost of a 200-Bus Fleet
(500,000 miles, Million $)

		Cost	Incremental	% in Excess of Diesel
Diesel-Trap		$62	-	-
Methanol	(low)	$69	$7.4	12%
	(high)	$76	$14.0	23%
CNG	(low)	$63	$1.6	3%
	(high)	$70	$8.7	14%

For a typical 200-bus fleet transit agency, the maximum incremental costs of requiring alternative fuels were estimated to represent a cost increase of as much as 3 to 23 percent over a diesel bus fleet. This shows that there could be a significant overall cost impact to a transit agency's budget for mandating an alternative fuel-forcing 2.5 g/bhp-hr NOx standard.

Also, based on the Annual Transit Development Act Report, California transit agencies have had an operating deficit each year since 1985. Transit agencies receive the majority of their operating revenue through local sales taxes, but sales tax revenues have decreased during the current recession and consequently transit agency funding has decreased. Transit agencies also receive funds from state and federal government, mostly for capital expenditures. However, these funds are limited, and in order to qualify for federal funds transit agencies must first obtain a minimum 20 percent match from local funding sources. These local funding sources are often the same funding sources as those for operating expenses; this competition between providing capital funds or operating funds makes local match for federal funds more difficult to obtain. Because of the decreased revenue and funding, transit agencies have had difficulty in sustaining current passenger service. In some cases, transit agencies have had to curtail transit services and delay new bus purchases. By mandating emission standards that would require alternative fuel use, transit agencies maintain that the significant cost increases would require further cuts in transit services without additional funding.

3. Potential Sources of Funding

Since the increased up-front costs associated with operating alternative-fuel fleets was a valid concern, staff investigated existing and potential transit agency funding sources. One possible source of additional funds would be to increase transit passenger fares. The disadvantage to this approach is that a 3 percent decrease in ridership occurs for every 10 percent increase in passenger fares, as estimated by transit agencies that use the Simpson-Curtin formula. This is contrary to local air district's efforts to encourage mass transit ridership and may be detrimental to overall transit service. A new source of funds would be Assembly Bill (AB) 2766 (Stats. 1990, ch. 1705) funds. Under AB 2766 and past laws, air pollution control districts which are in non-attainment areas may levy a fee of up to $4 on motor vehicles registered within the district. The actual distribution and use of the funds will vary from district to district. Unfortunately, these funds are, if not already committed, in great demand by many competing programs and are not likely to be available.

The most viable form of additional funding would likely be mobile source emission reduction credits. The ARB has recently published guidance to local districts for mobile source emission reduction credits programs regarding buses. The actual credits programs would be developed by the local air pollution control districts, and the implementation of such a program would provide transit agencies with an additional source of funds to help them purchase cleaner-operating buses.

4. Other Concerns

Another concern raised by the transit agencies at the first workshop was the additional weight of alternative-fuel buses. Methanol and CNG buses are heavier than diesel by approximately 500 pounds and 2,500 pounds, respectively. Not only does this reduce fuel economy, but more importantly, it may cause the buses to exceed the legal axle weight limit. Some transit agencies are willing to buy CNG buses despite the possible axle weight exceedance and may compensate by carrying less than full passenger loads. However, ongoing research into lighter-weight materials for CNG fuel tanks will be important to reduce the additional weight to compensate for any increased loss in passenger-carrying capability for future CNG bus purchases.

Some transit agencies are concerned that if they were to purchase alternative fuel buses and invest in new fueling facilities, that alternative-fuel buses may become obsolete, after a time, if diesel buses were later able to obtain low NOx emissions. We acknowledge that low-NOx diesel buses are a distinct possibility. In fact, there are early studies to suggest that even NOx emissions in the range of 2.0 g/bhp-hr may be achievable near the year 2000. Preliminary data already shows encouraging results near 3.0 g/bhp-hr NOx for an experimental diesel engine utilizing EGR. The ARB plans on taking advantage of these diesel technological advances by adopting more stringent low-emission standards for all heavy-duty vehicles in a future regulatory action.

5. Conclusions

From these analyses, given the burden of continuing transit agency deficits and the potentially higher costs associated with operating alternative-fueled buses, staff concluded that setting transit bus emission standards that could only be met by alternative-fuel fleets would adversely impact transit operations.

Therefore, staff proposed at the second workshop, held in September, 1992, the combination of mandatory and optional standards to give the transit agencies the flexibility to make financial decisions appropriate to their specific situation. By revising the proposal to include a mandatory 4.0 g/bhp-hr NOx standard instead of a mandatory 2.5 g/bhp-hr NOx standard, transit agencies would be able to continue purchasing and operating diesel-powered buses, thus avoiding a mandated cost of converting to alternative fuels. Also, adoption of the proposed optional NOx emission standards would facilitate emission reduction credits programs and may encourage transit agencies to purchase cleaner operating urban buses.

The Engine Manufacturers Association (EMA) and others commented that they would like the option of certifying urban buses to any optional NOx standard (below the mandatory NOx standard) that they felt confident about meeting over the useful life of the engine. The ARB had originally proposed only one optional NOx standard at 2.5 g/bhp-hr based on the emission reduction capabilities of alternative fuels. However, the optional standards proposal has been revised to include a range of NOx standards below 3.5 g/bhp-hr for the 1994 and 1995 model years and below 2.5 g/bhp-hr for the 1996 and later model years, at 0.5 g/bhp-hr increments, that would provide increased flexibility and still provide confidence that low-emission technology would be used. This change partly addresses the EMA's concerns while assuring that low-emission technology will be used to certify these urban buses that may receive credits.

B. IMPLEMENTATION SCHEDULE

The EMA has requested that the proposed urban bus regulations be delayed until 1998 when the EPA is required to implement a 4.0 g/bhp-hr NOx standard for all heavy-duty vehicles. The manufacturers have commented that alignment with EPA emission standards in 1998 would provide greater product availability at a lower cost. Alternatively, if the proposed urban bus regulations are implemented in 1996, manufacturers say that they would not have enough leadtime to cost-effectively produce 4.0 g/bhp-hr NOx engines and that there is a risk of pre-buying or delayed purchases by fleets. To meet the statutory mandate, the EMA proposed that the ARB simply adopt the 0.05 PM standard for the 1996 and 1997 model years.

As mentioned earlier in this report, SB 135 clearly mandates that the regulations are to become effective beginning in 1996. Also, there is alternative fuel technology which is currently available to provide significant emissions reductions. However, because of the above cost analyses and other transit agency concerns cited, the staff's proposal of a mandatory 4.0 g/bhp-hr NOx standard and the more stringent optional NOx standards provides a more balanced and reasonable approach. The proposal would allow voluntary transit agency participation in operating alternative-fuel buses, thereby giving them the flexibility to deal with the economics particular to their situation. Furthermore, since engine manufacturers did not feel that there was adequate lead time to develop alternative-fuel engines for the lighter buses (<33,000 pounds GVWR), staff proposed that only larger buses generally greater than 33,000 pounds GVWR be included in the proposed regulations. This also alleviated some of the smaller transit agency concerns since they operate a proportionately larger mix of small and medium size buses. Finally, staff believes that the EMA's suggestion that only the 0.05 PM standard should be adopted for 1996-1997 would not meet the statutory mandate to use the best available technology, since technology capable of meeting 4.0 g/bhp-hr NOx is available for 1996.

C. CALIFORNIA DIESEL FUEL QUALITY

In 1988, the Board adopted new statewide diesel fuel quality specifications to limit the sulfur content to 0.05 percent and the aromatic hydrocarbon content to 10 percent for implementation by October 1993. This cleaner diesel fuel will generate emission reductions for NOx and PM from all diesel vehicles on the road in California. In the staff's report for the adoption of the diesel fuel quality regulations, it was estimated that NOx would be reduced by approximately 13 percent by lowering the aromatics from 31 to 10 percent and PM would be reduced by approximately 31 percent by lowering the sulfur from 0.28 to 0.05 percent.

Engine manufacturers have requested that they be allowed to use California diesel fuel that meet these specifications for low sulfur and aromatics for certifying urban bus engines to meet the proposed emission standards. Engine manufacturers have commented that this would be consistent with what was allowed for light- and medium-duty vehicles in the low-emission vehicle (LEV) and clean fuels regulations.

Recently, the Board adopted changes (13 CCR Section 1956.8(b)) to the heavy-duty diesel test procedures to allow manufacturers to use low-sulfur diesel fuel (0.05 percent) to do exhaust emission testing and service accumulation for certification of 1993 and later model year heavy-duty diesel engines. This will provide manufacturers with more flexibility in meeting current and proposed future emission standards. Also, it would allow certain emission control technologies, such as diesel catalysts, to be used more readily since they are sensitive to the sulfur content of the fuel.

Staff believes that allowing low-sulfur and low-aromatics diesel fuel for certification in the light- and medium-duty LEV regulations is justified because of the very stringent low-emission standards. However, staff believes that a 4.0 g/bhp-hr NOx standard is not stringent enough to justify the need to allow the use of a low-aromatics diesel fuel for certification in addition to the low-sulfur diesel fuel that is already allowed. In addition, the federal Clean Air Act requires the U.S. EPA to implement a 4.0 g/bhp-hr NOx standard for all heavy-duty vehicles beginning with the 1998 model year. The EPA has not indicated that low-aromatics fuel will be available then nationwide. Consequently, staff believes the engine manufacturers will be forced to meet the EPA NOx standard with more sophisticated engine emissions control technology than would be required if they were allowed to certify engines with low-aromatics fuel. California-certified engines would need to have similar engine technology. Therefore, staff recommends that only low-sulfur (0.05 percent) diesel fuel be allowed for certifying urban bus engines.

D. OTHER ISSUES

Staff had also originally proposed that positive crankcase ventilation (PCV) valves or closed breather systems be required on all 1996 and later transit bus engines to address crankcase emissions from petroleum fueled diesel-cycle transit bus engines. The EMA requested a delay of this requirement until more information could be obtained on crankcase emissions from diesels. The EMA has contracted with the SwRI to further quantify diesel crankcase emissions. After further consideration, the staff has decided to delay this requirement until the EMA/SwRI study has been completed and the ARB staff have had the chance to review and evaluate this study. It is likely that a PCV system requirement will be addressed in a later board item for all heavy-duty engines.

Finally, staff has endeavored to provide an emissions standards proposal that could be reasonably complied with by diesel technology while providing significant emissions reductions and the opportunity for participation in a mobile source emission reduction credits program.

VI. REGULATORY ALTERNATIVES

Staff had originally proposed a mandatory 2.5 g/bhp-hr NOx standard for all 1996 and later transit buses at the April, 1992, workshop. After receiving numerous comments and conducting further investigation into the impacts of the original proposal on transit agencies, staff revised the proposal to include a mandatory 1996 4.0 g/bhp-hr NOx standard and optional emission standards to begin with the 1994 model year. Staff considers this revised proposal to be the most feasible, cost-effective, and flexible alternative that still reasonably complies with the statutory mandate. More stringent urban bus emission standards will be proposed as part of the heavy-duty low emission vehicle program that is planned to be presented to the Board in a regulatory hearing within the next couple of years. However, these future standards would not go into effect until after the 1996 timeframe of this proposal.

No alternative considered by the Executive Officer 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.

VII. AIR QUALITY AND COST EFFECTIVENESS ANALYSIS

A. AIR QUALITY IMPACT

The staff has estimated the emissions benefit of the proposed regulations for the year 2010; the time when the maximum emissions benefits would be achieved. The proposed regulations will result in a reduction of NOx and PM emissions. Potential NOx emission credits could also be generated through the use of lower-emitting urban buses that are certified to the proposed optional emission standards.

The staff has estimated the statewide emissions benefit of the proposed mandatory emission standards for urban buses as 4.4 tons per day of NOx and 1.5 tons per day of PM. These reductions would account for 20 percent of the NOx and half of the PM emissions from urban buses statewide.

The optional emission standards could provide increased flexibility to stationary sources in meeting regulations by allowing participation in an air pollution control district's mobile source emission reduction credit program. Given this premise, there would be no air quality benefits with the proposed optional standards, in that, the vehicle emission reductions would be offset by the allowed increase in stationary source emissions. However, an air pollution control district has the right to require that a percentage of the emission reductions be earmarked to improve air quality. Based on an optional 2.5 g/bhp-hr NOx standard as compared to the current 5.0 g/bhp-hr NOx standard, a total of 5.9 tons of NOx for methanol and 6.2 tons of NOx for CNG would be reduced over the lifetime (12-year, 500,000 miles) of a bus. The overall lifetime NOx reduction for a fleet of buses will vary according to the optional NOx standards the buses are certified to and the number of buses in the fleet.

B. COST EFFECTIVENESS

As discussed earlier, there are several technical options available for manufacturers to develop diesel bus engines that would comply with the proposed mandatory 4.0 NOx standard. It is likely that manufacturers will combine various technologies (such as high pressure fuel injection and EGR) to maximize NOx and PM control as well as engine performance and fuel efficiency. Given the uncertainty of which emission control technologies would be selected by the manufacturers, staff has assumed that a number of technologies would be employed, including EGR. Staff has therefore assigned a "worst case" cost estimate for these technologies as being a $5,000 incremental cost over a baseline trap-equipped urban bus engine. Also, there would be a slight fuel penalty when using EGR that equates to approximately a 1 cent per mile fuel cost difference between a diesel-trap bus ($0.26/mile) and a diesel-trap bus with

EGR ($0.27/mile). Therefore, the fuel cost for the lifetime of a diesel-trap bus (500,000 miles) is $130,000 and the lifetime fuel cost of a diesel-trap bus with EGR and related engine modifications is $135,000. The total incremental lifetime cost difference is $10,000.

A typical diesel-trap bus will emit approximately 1 ton of NOx per year at a 5.0 g/bhp-hr NOx standard. At a 4.0 g/bhp-hr NOx standard, the bus is expected to emit 0.80 tons of NOx per year. The emission reduction over the lifetime of the vehicle is expected to be 2.4 tons of NOx. Therefore, the overall cost effectiveness of the mandatory proposal is approximately $2.10 per pound of NOx reduced.

The proposal's NOx cost effectiveness compares favorably with other emission control strategies adopted by the Board, and is well within the range of the average rate of $1 to $5 per pound of NOx reduced. For the proposal's PM cost effectiveness, there is not expected to be any significant cost increase over the current diesel-trap bus for meeting the proposed 0.05 g/bhp-hr PM standard. California diesel-trap buses currently meet PM emission levels as low as 0.05 g/bhp-hr. Furthermore, the use of clean, low-sulfur diesel fuel, that will be available statewide at the end of 1993, will provide even more flexibility for meeting the standards.

The cost effectiveness of the proposed optional emission standards is not important for this regulatory action given that these standards are not mandated. However, for informational purposes, the final cost effectiveness of the optional emission standards using a 2.5 g/bhp-hr NOx standard for a 200 bus fleet is estimated to be between $3.10 and $5.90 per pound of NOx reduced for using methanol urban buses and between $0.70 to $3.50 per pound of NOx reduced for using CNG urban buses. These numbers were obtained from the "Mobile Source Emission Reduction Credits" guidance document which provides a more detailed cost analysis. This document was prepared through a joint effort of the Stationary Source and Mobile Source Divisions of the ARB and the numbers were used to determine the feasibility of implementing a mobile source emission reduction credits program.

VIII. FISCAL AND BUSINESS IMPACT ISSUES

A. LOCAL GOVERNMENT IMPACT

SB 135 requires that the ARB adopt emission standards and test procedures for transit buses. Public transit agencies that own or operate transit buses shall purchase transit buses that conform to the standards and test procedures adopted by the Board.

There are approximately 150 public transit agencies that are supported by local government in California. The incremental cost for a 4.0 g/bhp-hr NOx bus over a baseline diesel-trap bus, has been estimated to be $5,000 with approximately 300 to 400 urban bus engines being sold each year in California. Also, it is estimated that there would be an additional $417/bus/year in fuel cost that comes from a slight fuel penalty from the use of EGR on a diesel-trap bus. Staff estimates that the maximum statewide incremental cost to purchase new urban buses (600-800 engines) to meet the mandatory emission standards for 2 years is approximately $3.3 to $4.3 million (bus capital costs + fuel cost). This cost is based on the assumption that the same number of engines will be sold after the 1996 implementation of the urban bus standards and takes into account EPA's adoption of a 4.0 g/bhp-hr NOx standard for 1998 and later heavy-duty engines (including buses). However, the actual costs will be unique to each transit agency, dependent on the number of new buses that are purchased.

It is expected that there will be a small cost impact difference between small transit agencies and larger transit agencies. Staff has estimated the cost of a 4.0 g/bhp-hr NOx diesel-trap bus to be $230,000. However, small transit agencies may incur an extra 5 to 10 percent cost increase in the bid price per bus due to smaller quantity bus orders. Thus, a small transit agency could pay as much as $241,500 to $253,000 per bus whereas a larger transit agency could be paying $230,000 per bus. It is expected that prices will differ for each transit agency depending on the bid price agreement made with the bus supplier. This is a historical trend and is based on the cost of doing business. Therefore, any additional cost to smaller transit agencies is not expected to be a result of the proposed urban bus regulations. Furthermore, staff has endeavored to minimize the cost impact to small transit agencies as well as larger transit agencies while still resulting in increased emission benefits. As proposed, the applicability of the regulations would be limited to urban buses, which may exempt many of the small transit agencies which use smaller transit buses (<33,000 pounds GVWR). Also, staff has proposed a mandatory 4.0 g/bhp-hr NOx standard which is feasible for diesel urban buses, and optional NOx standards which would allow transit agencies the option of purchasing cleaner operating buses.

These local costs are not reimburseable state mandated local costs pursuant to Section 6 of Article XIII B of the California Constitution because the only costs which may be incurred by a local agency will be incurred because this act creates a new crime or infraction, changes the definition of a crime or infraction, changes the penalty for a crime or infraction, or eliminates a crime or infraction, as stated in SB 135.

B. BUSINESS IMPACT

The transit bus regulations would apply to all manufacturers of urban bus engines that intend to certify urban bus engines for sale in the State of California. Manufacturers subject to the regulations would be required to comply with the emission standards, test procedures, and other requirements of the regulations.

Staff has determined that the maximum incremental cost to manufacturers for complying with the regulations is estimated to be $5,000 per bus or $1.5 to $2 million for an average California sales projection of 300 to 400 urban buses per year.

The transit bus regulations may also impose compliance costs on manufacturers directly affected, if manufacturers choose to use the optional supplemental labeling requirement provided by the regulations.

IX. ENVIRONMENTAL IMPACTS

Implementation of the proposed emission standards and test procedures for urban buses, as described in this staff report, would have a substantial positive impact on the environment by reducing emissions of NOx and PM, 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 urban bus 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.

X. REFERENCES

1. California Summary of 1991 Air Quality Data (Vol. XXIII), California Air Resources Board.

2. EMFAC7E, Predicted California Vehicle Emissions, California Air Resources Board.

3. Senate Bill 135 (Stats. 1991, ch. 496), adopted on October 5, 1991.

4. Mobile Source Emission Reduction Credits-Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits, California Air Resources Board, issued January 1993.

5. 1992 Transit Passenger Vehicle Fleet Inventory, American Public Transit Association.

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

7. Electric Trolley Bus Study, Booz-Allen and Hamilton Inc., December 1991.

8. Notices of Public Workshops to Consider Adoption of New Emission Standards for Transit Buses, Mailout #92-17 and Mailout #92-35.

9. Quarterly Oil Report, California Energy Commission, July 1992.

10. Annual Report for Financial Transactions Concerning Transit Operators and Non-Transit Claimants Under the Transportation Development Act, Office of State Controller.

11. Assembly Bill 2766 (Stats. 1990, ch. 1705), adopted September 30, 1990.

12. Engine Manufacturers Association Comments on the Proposed Transit Bus Regulations, dated September 21, 1992, and October 12, 1992.

APPENDIX I

PROPOSED AMENDMENTS TO SECTIONS OF TITLE 13,
CALIFORNIA CODE OF REGULATIONS

PROPOSED REGULATION ORDER
(Transit Bus Elements of the Rulemaking)

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.

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	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
1996 and[F] subsequent	1.3	1.2	15.5	4.0	0.05 [H]
1996 and[G] subsequent	1.3	1.2	15.5	2.5 to 0.5	0.05 [H]

[A] The total or optional non-methane hydrocarbon standards apply to petroleum-fueled, natural-gas-fueled and liqu~~i~~efied-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 liqu~~i~~efied 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.

(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 ~~July 12, 1991~~[insert date of amendment], which is incorporated herein by reference.

(c) through (h) [No Change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43103, ~~and~~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, ~~and~~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 ~~July 12, 1991~~[insert date of amendment], 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.

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.

(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 paragraph (11); 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.

(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.

APPENDIX 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:	[ ]
Amended:	____________

NOTE: This document is printed in a style to indicate amendments to the existing 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 federal provisions incorporated in this document with modifications, the new federal provisions are underlined and the modifications to those provisions are displayed in double underline and ~~strikeout~~ to indicate additions to and deletions from the federal language. 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.

On December 10, 1992, the Board approved amendments to various provisions in the test procedures entitled "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles." These amendments have not yet been formally approved by the Office of Administrative Law. Therefore, the amended dates listed on the cover page to the test procedures include a bracketed entry to reserve space for this approval date. The specific provision affected by the current proposed regulatory action was not amended in the December 1992 action.

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.

# # # # #

86.093-2 Definitions. March 24, 1993.

The definitions of 86.092-2 remain effective. The definitions listed in this section apply beginning with the 1993 model year.

* * * * *

Urban bus means a passenger-carrying vehicle powered by a heavy heavy-duty diesel engine, or of a type normally powered by a heavy heavy-duty diesel engine, with a load capacity of fifteen or more passengers and intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area. Urban bus operation is characterized by short rides and frequent stops. To facilitate this type of operation, more than one set of quick-operating entrance and exit doors would normally be installed. Since fares are usually paid in cash or tokens, rather than purchased in advance in the form of tickets, urban buses would normally have equipment installed for collection of fares. Urban buses are also typically characterized by the absence of equipment and facilities for long distance travel, e.g., rest rooms, large luggage compartments, and facilities for stowing carry-on luggage. The useful life for urban buses is the same as the useful life for other heavy heavy-duty diesel engines.

* * * * *

86.094-2 Definitions. March 24, 1993.

* * * * *

Useful life means:

* * * * *

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

(1) For light heavy-duty diesel engines, a period of use of 8 years or 110,000 miles, whichever first occurs.

(2) For medium heavy-duty diesel engines, a period of use of 8 years or 185,000 miles, whichever first occurs.

(3) For heavy heavy-duty diesel engines, a period of use of 8 years or 290,000 miles, whichever first occurs, except as provided in paragraph (4).

(4) For heavy heavy-duty diesel engines used in urban buses, for the particulate standard, a period of use of 10 years or 290,000 miles, whichever first occurs.

*   *   *   *   *

#   #   #   #   #

86.094-11 Emission standards for 1994 and later model year diesel heavy-duty engines and vehicles. ~~April 11, 1989~~March 24, 1993.

*   *   *   *   *

(a)(1)(iv) Particulate. (A) For diesel engines to be used in urban buses, 0.07 gram per brake horsepower-hour (0.026 gram per megajoule), as measured under transient operating conditions.

(B) For all other diesel engines only, 0.10 gram per brake horsepower-hour (0.037 gram per megajoule), as measured under transient operating conditions.

(a)(1)(iv)~~(B)~~(C) A manufacturer may elect to include all or some of its diesel heavy-duty engine families in the appropriate heavy-duty particulate averaging program (petroleum or methanol or gaseous fuel), provided that engines produced for sale in California or in 49-state areas may be averaged only within each of those areas. Dual-fuel and multi-fuel engines may not be included in the diesel particulate averaging program. With the exceptions regarding methanol-fueled or gaseous-fuel diesel urban bus engines as noted below, averaging is not permitted between fuel types. Non-methanol-fueled and non-gaseous-fuel engines for use in urban buses may not be included in either heavy-duty particulate averaging program. Emissions from methanol-fueled and dedicated gaseous-fuel urban bus engines certified to 0.10 grams per brake horsepower-hour particulates for 1991-1993 model years, and certified to 0.07 grams per brake horsepower-hour particulates for 1994-1995 model years, may be included in the averaging program for petroleum fueled engines other than urban bus engines. Averaging is limited to engines within a given primary service class as defined in 86.085-2. Averaging across primary service classes is not permitted. If the manufacturer elects to participate in either averaging program, individual family particulate limits may not exceed 0.60 gram per brake horsepower-hour (0.22 grams per megajoule). Heavy-duty diesel engines converted to methanol fuel or gaseous fuel may be used to comply with the urban bus particulate standard and may be used in the diesel particulate averaging program. Such engines must comply with all applicable heavy-duty diesel engine emission standards and test procedures in this Part.

* * * * *

(a)(2) A manufacturer may elect to certify 1994 and 1995 model year heavy heavy-duty diesel engines to be used in urban buses to an optional oxides of nitrogen emission standard between 0.5 grams per brake horsepower-hour and 3.5 grams per brake horsepower-hour at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(b)(1) The opacity of smoke emission from new 1994 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

* * * * *

86.096-11 Emission standards for 1996 and later model year diesel heavy-duty engines and vehicles. March 24, 1993.

(a) Exhaust emission from new 1996 and later model year diesel heavy-duty engines shall not exceed the following:

(1)(i) Hydrocarbons (for petroleum-fueled diesel engines). 1.3 grams per brake horsepower-hour (0.48 gram per megajoule), as measured under transient operating conditions.

(ii) Organic Material Hydrocarbon Equivalent (for methanol-fueled diesel engines). 1.3 grams per brake horsepower-hour (0.48 gram per megajoule), as measured under transient operating conditions.

(iii) Non-methane hydrocarbons (an option for diesel, natural gas, or liquefied petroleum gas engines). 1.2 grams per brake horsepower-hour, as measured under transient operating conditions.

(2) Carbon monoxide. (i) 15.5 grams per brake horsepower-hour (5.77 grams per megajoule), as measured under transient operating conditions.

(ii) 0.50 percent of exhaust gas flow at curb idle (methanol-fueled diesel only).

(3) Oxides of Nitrogen. (i) For diesel engines to be used in urban buses, 4.0 grams per brake horsepower-hour, as measured under transient operating conditions.

~~(i)~~ (ii) For all other diesel engines only, 5.0 grams per brake horsepower-hour (1.9 grams per megajoule), as measured under transient operating conditions.

~~(ii)~~ (iii) DELETE

(4) Particulate. (i) For diesel engines to be used in urban buses, 0.05 gram per brake horsepower-hour (0.019 gram per megajoule) for certification testing and selective enforcement audit testing, and 0.07 gram per brake horsepower-hour (0.026 gram per megajoule) for in-use testing, as measured under transient operating conditions.

(ii) For all other diesel engines only, 0.10 gram per brake horsepower-hour (0.037 gram per megajoule), as measured under transient operating conditions.

(iii) DELETE

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

(b)(1) The opacity of smoke emission from new 1996 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

* * * * *

# # # # #

86.085-35 Labeling. Labels shall comply with the requirements set forth in the "California Motor Vehicle Emission Control Label Specifications", as last amended July 12, 1991[insert date of amendment].

# # # # #

Additional Requirements

# # # # #

7. Non-methane hydrocarbon emissions shall be measured in accordance with the "California Non-methane Hydrocarbon Test Procedures" as last amended May 15, 1990July 12, 1991, which is incorporated herein by reference.

# # # # #

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.

# # # # #

86.093-2 Definitions. March 24, 1993.

The definitions of 86.092-2 remain effective. The definitions listed in this section apply beginning with the 1993 model year.

* * * * *

Urban bus means a passenger-carrying vehicle powered by a heavy heavy-duty diesel engine, or of a type normally powered by a heavy heavy-duty diesel engine, with a load capacity of fifteen or more passengers and intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area. Urban bus operation is characterized by short rides and frequent stops. To facilitate this type of operation, more than one set of quick-operating entrance and exit doors would normally be installed. Since fares are usually paid in cash or tokens, rather than purchased in advance in the form of tickets, urban buses would normally have equipment installed for collection of fares. Urban buses are also typically characterized by the absence of equipment and facilities for long distance travel, e.g., rest rooms, large luggage compartments, and facilities for stowing carry-on luggage. The useful life for urban buses is the same as the useful life for other heavy heavy-duty diesel engines.

* * * * *

86.094-2 Definitions. March 24, 1993.

* * * * *

Useful life means:

* * * * *

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

(1) For light heavy-duty diesel engines, a period of use of 8 years or 110,000 miles, whichever first occurs.

(2) For medium heavy-duty diesel engines, a period of use of 8 years or 185,000 miles, whichever first occurs.

(3) For heavy heavy-duty diesel engines, a period of use of 8 years or 290,000 miles, whichever first occurs, except as provided in paragraph (4).

(4) For heavy heavy-duty diesel engines used in urban buses, for the particulate standard, a period of use of 10 years or 290,000 miles, whichever first occurs.

*   *   *   *   *

#   #   #   #   #

86.094-11 Emission standards for 1994 and later model year diesel heavy-duty engines and vehicles. ~~April 11, 1989~~March 24, 1993.

*   *   *   *   *

(a)(1)(iv) Particulate. (A) For diesel engines to be used in urban buses, 0.07 gram per brake horsepower-hour (0.026 gram per megajoule), as measured under transient operating conditions.

(B) For all other diesel engines only, 0.10 gram per brake horsepower-hour (0.037 gram per megajoule), as measured under transient operating conditions.

(a)(1)(iv)~~(B)~~(C) A manufacturer may elect to include all or some of its diesel heavy-duty engine families in the appropriate heavy-duty particulate averaging program (petroleum or methanol or gaseous fuel), provided that engines produced for sale in California or in 49-state areas may be averaged only within each of those areas. Dual-fuel and multi-fuel engines may not be included in the diesel particulate averaging program. With the exceptions regarding methanol-fueled or gaseous-fuel diesel urban bus engines as noted below, averaging is not permitted between fuel types. Non-methanol-fueled and non-gaseous-fuel engines for use in urban buses may not be included in either heavy-duty particulate averaging program. Emissions from methanol-fueled and dedicated gaseous-fuel urban bus engines certified to 0.10 grams per brake horsepower-hour particulates for 1991-1993 model years, and certified to 0.07 grams per brake horsepower-hour particulates for 1994-1995 model years, may be included in the averaging program for petroleum fueled engines other than urban bus engines. Averaging is limited to engines within a given primary service class as defined in 86.085-2. Averaging across primary service classes is not permitted. If the manufacturer elects to participate in either averaging program, individual family particulate limits may not exceed 0.60 gram per brake horsepower-hour (0.22 grams per megajoule). Heavy-duty diesel engines converted to methanol fuel or gaseous fuel may be used to comply with the urban bus particulate standard and may be used in the diesel particulate averaging program. Such engines must comply with all applicable heavy-duty diesel engine emission standards and test procedures in this Part.

* * * * *

(a)(2) A manufacturer may elect to certify 1994 and 1995 model year heavy heavy-duty diesel engines to be used in urban buses to an optional oxides of nitrogen emission standard between 0.5 grams per brake horsepower-hour and 3.5 grams per brake horsepower-hour at 0.5 grams per brake horsepower-hour increments, as measured under transient operating conditions.

(b)(1) The opacity of smoke emission from new 1994 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

* * * * *

86.096-11 Emission standards for 1996 and later model year diesel heavy-duty engines and vehicles. March 24, 1993.

(a) Exhaust emission from new 1996 and later model year diesel heavy-duty engines shall not exceed the following:

(1)(i) Hydrocarbons (for petroleum-fueled diesel engines). 1.3 grams per brake horsepower-hour (0.48 gram per megajoule), as measured under transient operating conditions.

(ii) Organic Material Hydrocarbon Equivalent (for methanol-fueled diesel engines). 1.3 grams per brake horsepower-hour (0.48 gram per megajoule), as measured under transient operating conditions.

(iii) Non-methane hydrocarbons (an option for diesel, natural gas, or liquefied petroleum gas engines). 1.2 grams per brake horsepower-hour, as measured under transient operating conditions.

(2) Carbon monoxide. (i) 15.5 grams per brake horsepower-hour (5.77 grams per megajoule), as measured under transient operating conditions.

(ii) 0.50 percent of exhaust gas flow at curb idle (methanol-fueled diesel only).

(3) Oxides of Nitrogen. (i) For diesel engines to be used in urban buses, 4.0 grams per brake horsepower-hour, as measured under transient operating conditions.

~~(i)~~ (ii) For all other diesel engines only, 5.0 grams per brake horsepower-hour (1.9 grams per megajoule), as measured under transient operating conditions.

~~(ii)~~ (iii) DELETE

(4) Particulate. (i) For diesel engines to be used in urban buses, 0.05 gram per brake horsepower-hour (0.019 gram per megajoule) for certification testing and selective enforcement audit testing, and 0.07 gram per brake horsepower-hour (0.026 gram per megajoule) for in-use testing, as measured under transient operating conditions.

(ii) For all other diesel engines only, 0.10 gram per brake horsepower-hour (0.037 gram per megajoule), as measured under transient operating conditions.

(iii) DELETE

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

(b)(1) The opacity of smoke emission from new 1996 and later model year petroleum-fueled diesel heavy-duty engines shall not exceed:

* * * * *

\# \# \# \# \#

86.085-35 Labeling. Labels shall comply with the requirements set forth in the "California Motor Vehicle Emission Control Label Specifications", as last amended July 12, 1991[insert date of amendment].

\# \# \# \# \#

Additional Requirements

\# \# \# \# \#

7. Non-methane hydrocarbon emissions shall be measured in accordance with the "California Non-methane Hydrocarbon Test Procedures" as last amended May 15, 1990July 12, 1991, which is incorporated herein by reference.

\# \# \# \# \#

APPENDIX III

PROPOSED AMENDMENTS TO THE CALIFORNIA MOTOR VEHICLE EMISSION CONTROL LABEL SPECIFICATIONS

<u>PROPOSED</u>

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: ______________

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

State of California

AIR RESOURCES BOARD

California Motor Vehicle Emission Control

Label Specifications

1. through 3. [No Change]

3. 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)."

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."

(b) through (d) [No Change]

4. through 10. [No Change]