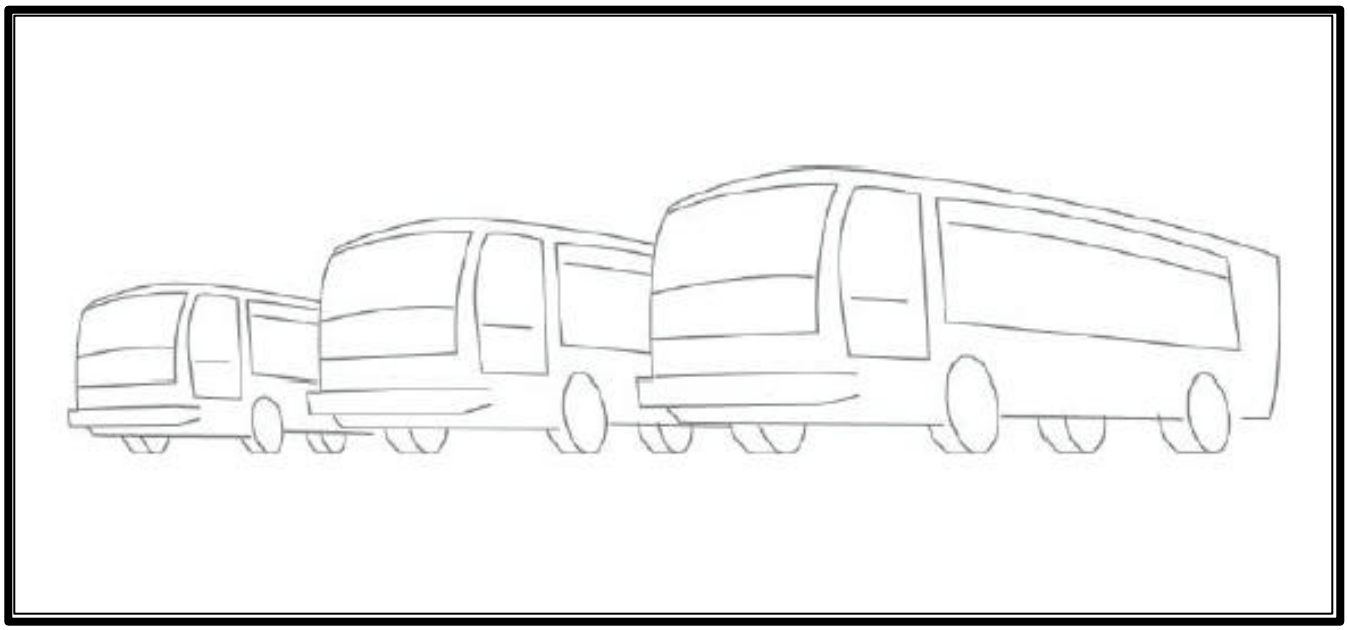
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS

PROPOSED MODIFICATIONS TO THE PUBLIC TRANSIT BUS FLEET RULE AND INTERIM CERTIFICATION PROCEDURES FOR HYBRID-ELECTRIC URBAN TRANSIT BUSES



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URBAN BUSES

EXECUTIVE SUMMARY

A major goal of the Air Resources Board (ARB or "the Board") is to provide clean, healthful air to all the citizens of California. California's commitment to providing clean public transportation is an important part of achieving this goal. Public transportation provides important societal benefits. It provides access to work and education, reduces congestion, and meets the mobility needs of the public, including the elderly and physically challenged. However, urban transit buses, one of California's modes of public transportation, are also a source of oxides of nitrogen (NOx) and diesel particulate matter (PM). NOx contributes to the atmospheric formation of ozone and fine particles. Diesel PM has been identified as a toxic air contaminant – a cancer-causing pollutant. These emissions often occur within California's most populated urban areas. It is vital to all Californians that the ARB continue its efforts to reduce NOx and PM emissions from all sources, specifically transit vehicles which transport California citizens every day.

In February 2000 the Board confirmed its continued commitment toward improving emissions from public transportation by approving the "Public Transit Bus Fleet Rule and Emission Standards for New Urban Buses." The multi-faceted transit bus regulations set fleet requirements applicable to transit agencies, and set more stringent mid- and long-term emission standards for new urban bus engines, applicable to manufacturers. Transit agencies were required to choose between diesel or alternative fuel compliance paths. The fuel path selected would determine the compliance schedule and reporting requirements. The fleet rule was designed to provide transit agencies with flexibility in meeting the NOx standard while achieving near-term PM reductions and promoting advancement of PM control technology. The PM standard required transit agencies to retrofit progressively newer model-year buses in their fleets with devices capable of reducing PM emissions by 85 percent.

Recognizing the progressive nature of the fleet rule and emission standards, the Board required staff to report back on the progress made by transit agencies toward implementing the regulatory requirements. Since adoption of the rule, staff has worked closely with transit agencies, urban transit bus and engine manufacturers, and control technology manufacturers. Staff conducted three workshops and several stakeholder's meetings, attended industry meetings, and issued written memoranda and advisories to the transit agencies. Staff gave progress reports to the Board on September 20, 2001, and March 21, 2002. Working together we have ensured that the vast majority of transit agencies will be in compliance with the NOx fleet average requirements. Staff reported,

however, that PM retrofit technology capable of reducing PM emissions by the mandated 85 percent or more would not be available for the 1993 model-year and older engines in time to meet the first implementation deadlines.

Understanding the importance of maintaining the PM emission reductions anticipated in the February 2000 public transit bus rulemaking and recognizing the lack of PM retrofit technology for older buses, the Board directed staff through Resolution 02-16, to consider another approach for requiring PM retrofits. The Board's objective was to provide transit agencies with additional flexibility while obtaining as close to the same reductions in diesel PM as would have been achieved had the existing regulations been fully implemented. This report describes staff's proposed amendments to the February 2000 public transit bus rule to implement the Board's directive, along with the environmental and cost impacts associated with the proposed modifications.

Staff also reported that a testing and certification protocol needed to be developed and adopted to accurately assess the emissions from hybrid-electric urban transit buses (HEBs). HEBs are a relatively new but promising technology for urban transit buses that would provide transit agencies with another option for reducing both NOx and PM emissions. Current heavy-duty certification and test procedures are based on engine testing and do not accurately reflect, without modifications, the vehicle emissions of a hybrid-electric drive system. This report presents staff's proposed interim certification procedures for HEBs.

Summary of the Amendments

PM Emission Reduction Proposal

As directed by the Board in March 2002, staff reviewed the technology available to achieve the current PM retrofit requirements. Staff concluded that PM retrofit technology capable of reducing PM emissions by 85 percent or more is not currently available for 1993 model-year and older engines. The 85 percent requirement was to go into effect during 2002 with 100 percent of pre-1991 urban bus engines retrofitted by January 1, 2003. In order to provide transit agencies with maximum flexibility in reducing PM emissions, yet still aggressively reduce in-use PM emissions, staff proposes to amend the current rule which requires transit agencies to retrofit a percent of its overall fleet for each model year. The proposed amendments would require transit agencies to reduce PM by a specified percentage based on total diesel PM emissions. The proposed schedule to achieve a required percent of PM emission reductions is based on the implementation dates of the original regulation's implementation schedule and on the fuel path selected.

The proposed amendments would require that a transit agency on the diesel path reduce its overall diesel fleet PM emissions by 40 percent of its January 1, 2002 total diesel PM emissions baseline by January 1, 2004, with increasing

reductions through 2007. Transit agencies that selected the alternative fuel path would also be required to reduce PM emissions from diesel-fueled buses remaining in their fleets. Those agencies would be required to reduce PM emissions by 20 percent by 2004, with increasing reductions through 2009. This new proposal provides transit agencies with the flexibility to choose the control methodology for achieving the required percentage reduction, rather than the use of retrofit control technology. A transit agency may choose to reduce in-use PM emissions by replacing buses with new buses, repowering buses with new engines, purchasing alternative-fueled engines that are not required under current requirements, or installing ARB-verified PM emission reduction technology.

Fuel Path Change

The proposed amendments include a one-time allowance for a transit agency to change its fuel path selection from diesel to alternative fuel, in response to the Board's request that staff consider allowing this change. After surveying transit agencies and examining potential impacts of the proposed modification, staff determined that minimal impact would result from allowing transit agencies on the diesel path located in the South Coast Air Quality Management District (SCAQMD) to make the change to the alternative fuel path. Some of these transit agencies chose the diesel path, although SCAQMD Rule 1192 requires them to purchase alternative fuel buses. Because these transit agencies are already required to purchase alternative-fueled buses, allowing any of them to change fuel path would not have an impact on the emission reductions anticipated from the current regulation. Staff's proposal is to limit the scope of the fuel path change only to transit agencies in the SCAQMD. Based on the transit agencies' response to staff's solicitation to declare a fuel path change from diesel to alternative fuel, only transit agencies in the SCAQMD replied and expressed interest in the change. A transit agency that wishes to change fuel path must make a declaration of its intention by January 31, 2004, at the same time as it makes its regular annual report.

Alternative Fuel Bus Purchase Provision for Diesel Path Transit Agencies

The certified emission level of an engine that a transit agency wishes to purchase during 2004 through 2006 is dependent on the agency's selected fuel path. The current regulations require engines sold to transit agencies on the diesel path to meet a 0.5 g/bhp-hr NOx standard. This standard applies whether the engine is a diesel-fueled, dual-fueled, bi-fueled, or alternative-fueled engine. Staff does not expect any full-sized alternative-fueled or diesel-fueled urban bus engines certified to 0.5 g/bhp-hr NOx emissions to be available through 2006. Transit agencies on the alternative fuel path are currently allowed to purchase alternative-fueled engines meeting a 2.5 g/bhp-hr NMHC + NOx standard through 2006.

To encourage and facilitate transit agencies on the diesel path to purchase alternative-fueled engines, and to ensure that transit buses are available to be purchased in the 2004 through 2006 time period, some flexibility is needed for transit agencies on the diesel path. Staff proposes to have consistent emission standards for all alternative-fueled buses in the 2004 through 2006 model years, regardless of the fuel path chosen by the transit agency. Thus, all transit agencies may purchase any certified alternative-fueled engines from 2004 through 2006.

Transit Agency Request for Delay

On occasion, transit agencies have requested delays to allow them to deviate from the schedule because of financial hardship. Small transit agencies may face unique situations and lack the ability to utilize some of the flexibility within the regulations. In order to provide a mechanism whereby the Executive Officer can hear exceptional requests and decide on the merits whether an implementation delay is warranted, staff proposes adding a general provision that would allow a transit agency with fewer than 20 buses to request an implementation delay based on demonstrated financial hardship.

Modifications to Definitions

To clarify and update the transit bus regulation in response to stakeholder inquiries, staff proposes to modify the definitions of “active fleet” and “alternative fuel”, and to add definitions for “emergency contingency vehicle” and “spare bus”. The most significant modification pertains to alternative-fueled engines. Previously the definition precluded any use of diesel fuel. The proposed revision will allow the use of a small quantity of diesel as a pilot ignition source only.

Repeal Certification Procedures for PM Retrofit Devices

The proposed amendments require that any device installed on urban buses to meet the diesel PM reduction requirement be verified under the procedures adopted therein. Currently, there are two procedures available to manufacturers of diesel emission control strategies to certify technology. To ensure that all manufacturers follow the same procedures and have the same warranty and in-use compliance requirements, it is necessary to repeal “California Certification Procedures for PM Retrofit Devices for On-Road Heavy-Duty Diesel Vehicles”, adopted November 22, 2000 and incorporated by reference in CCR title 13, section 1956.2 (f) (7). These procedures would be replaced with those adopted by the Board in May 2002: "Diesel Emission Control Strategy Verification Procedure, Warranty and In-Use Compliance Requirements for On-Road, Off-Road, and Stationary Diesel-Fueled Vehicles and Equipment.” This modification would have no impact on transit agencies or businesses because no manufacturer has followed the certification procedures that were adopted November 22, 2000.

Hybrid-Electric Bus (HEB) Certification Procedure

Hybrid-electric drive systems are emerging in the marketplace, offering lower energy use and lower emissions. Part of the challenge in developing a certification procedure for buses that use hybrid electric drive systems is designing a method that quantifies the emission benefits of the drive system in various HEB platforms.

Currently, manufacturers have one option for certifying an HEB – apply for certification to ARB on a case-by-case basis. Current procedures are engine-based and an HEB would be certified at a level that does not represent actual emission benefits of the HEB. Current engine-based certification test procedures do not have a method of quantifying the amount of power provided by the electric drive system incorporated into the HEB. Although recent ARB tests of HEBs being demonstrated in California indicate substantial emission reductions, these conclusions have been based on a few results and are not representative of all of the types of HEB platforms that are available for commercialization. Hence, staff believes it is appropriate to propose an interim certification procedure that better represents HEB emissions, to be effective for three years. This would allow ARB to work closely with manufacturers to determine whether modifications or more appropriate requirements are warranted in future years.

The proposed interim certification procedure for determining compliance with the urban transit bus emission standards, applicable to 2004 and subsequent model-year hybrid-electric buses, is based on a modified version of the Society of Automotive Engineers (SAE) Recommended Practice SAE J2711. This protocol was developed to test the emissions of heavy-duty hybrid-electric vehicles using a chassis dynamometer. The HEB's certification value is determined through calculations using chassis dynamometer test results and engine certification values for both the HEB and a conventional drivetrain urban transit bus. ARB's procedures include a provision for chassis dynamometer testing of conventional drivetrain urban transit buses to determine baseline emissions.

Environmental Impacts and Cost-Effectiveness

The proposed amendments achieve close to the same emissions reductions, beginning in 2005, as the original regulations. Prior to 2005, the benefits will be less than the original regulations. Two factors account for the rule relaxation in the early years: the lack of technology to retrofit older engines now and the need to provide transit agencies additional time to obtain funding to replace older engines.

If approved, the proposed amendments will reduce PM emissions statewide in 2010 by approximately 180 lbs/day (33.4 tons per year). Estimated costs to transportation planning agencies, commissions, and transit agencies would

remain similar (about $2.5 million) to the estimate in the February 2000 rulemaking. The cost-effectiveness during 2003 to 2009 would range from $10.91 to $44.51 per pound of PM, with an average expected cost effectiveness of $25.23 per pound reduced. The original regulation cost-effectiveness was reported as $17.90 per pound of PM reduced, which is within the range calculated for the proposed amendments.

The proposed amendments seek to balance the need to reduce diesel PM emissions to the extent technologically feasible with the need of the regulated entities for flexibility in achieving those reductions. The calculated benefits do not include the value of health benefits associated with a reduction in exposure the diesel PM, a toxic air contaminant.

Recommendations

The ARB staff recommends that the Board adopt the proposed amendments and incorporated test procedures. The new amended provisions will continue to require that PM emissions from urban transit buses be reduced, while providing transit agencies with additional flexibility. This proposal continues California's commitment to provide reductions of NOx and PM emissions from urban transit buses.

I. INTRODUCTION

California's air quality has improved significantly over the last thirty years, yet there is a need to continue establishing and implementing regulatory and incentive programs that are designed to achieve future air quality goals and provide healthful air to all Californians. Over 90 percent of Californians still breathe air that violates one or more health-based air quality standards.

Mobile source control and incentive programs have been innovative and progressive and are vital to the attainment of air quality standards. Mobile sources account for about 60 percent of ozone precursors and about 40 percent of combustion particulate matter (PM) emissions, statewide. Mobile source diesel engines account for 30 percent of the particulate emissions. ARB identified diesel PM as a toxic air contaminant in 1998. Hence, the control of PM for diesel-fueled engines is critical.

With this in mind, in February 2000 ARB adopted new regulations establishing a public transit bus fleet rule and emission standards for new urban buses. These regulations promote advanced technology for urban buses that will result in significant reductions in NOx and PM emissions. The requirements were designed to reduce NOx, an ozone precursor, and PM by encouraging transit agencies to voluntarily purchase cleaner alternative fuel buses and to incorporate ARB-certified PM retrofit traps on urban bus engines.

Recognizing the progressive nature of these regulations, the Board required staff to report back regularly on the progress for implementing the regulatory requirements and to consider developing a test procedure to certify hybrid-electric urban transit buses (HEBs) – an evolving propulsion system for urban transit buses. As such, staff worked closely with transit agencies to encourage compliance with the requirements and reported back to the Board at its September 20, 2001 and March 21, 2002 meetings. Based on staff's reports, the vast majority of the transit agencies will meet the NOx fleet average requirements. However, PM retrofit technology for early model-year urban transit buses would not be available for transit agencies to comply with the PM requirements.

Understanding the importance of reducing PM, the Board directed staff through Resolution 02-16 to consider another approach for reducing diesel PM while still obtaining similar PM benefits as achieved in the current adopted urban transit bus regulations. The Board also directed staff to consider an approach for allowing transit agencies that selected the diesel fuel path to change to the alternative fuel path, thus encouraging more PM reductions. The Board directed staff to present the proposed modifications to the urban transit bus fleet rule

requirements in the fall of 2002, while also presenting proposed recommendations for certifying HEBs.

This proposal contains ARB's proposed amendments to the Public Transit Bus Fleet Rule and Emission Standards for Urban Buses. The proposed amendments are designed to provide transit agencies with greater flexibility to comply with the required emission standards while recapturing the PM emission reductions lost because of the lack of verified technology to meet the mandated 85 percent reduction. The most significant modifications include proposed amendments that require transit agencies to reduce overall diesel PM emissions through use of a variety of mechanisms, rather than through the use of one method, a retrofit with a diesel particulate filter. Other proposed amendments include: a method for allowing transit agencies in the South Coast Air Basin to change from the "diesel" path to the "alternative fuel" path; a mechanism for a transit agency to request a delay with compliance due to financial hardship; and modifications to definitions for clarification of current regulations. This proposal also includes proposed procedures for interim certification of HEBs.

II. BACKGROUND

This chapter provides a brief overview of California's current regulations designed to reduce emissions from urban transit bus engines. The chapter also presents a brief overview of implementation and the need to modify current regulations to ensure PM reductions, as anticipated from adoption of the February 2000 Public Transit Bus Fleet Rule, are achieved.

A. Urban Buses and Emission Standards

In general, urban buses are owned or leased by public transit agencies that receive federal, state, and local funds to subsidize new bus purchases and to operate and maintain their bus fleets and facilities. Urban buses usually operate in heavily populated areas, with a typical route consisting of stops and starts as passengers are routinely picked up and delivered to their destinations. Commuter bus operation within metropolitan areas (such as the Yolo-Sacramento metropolitan area) that consists of more than a few pick-up and drop-off stops is considered to fall within the definition of urban bus operation.

Urban buses are generally 35 to 40 feet long, are normally powered by a heavy heavy-duty diesel engine; and fall within the heavy heavy-duty vehicle classification of greater than 33,000 pounds gross vehicle weight (GVW). The ARB staff estimates that there are about 9,100 full-size transit buses operating in California in 2002. Of these, approximately 80 percent are operated by the 18 largest transit fleets with more than 100 buses in their fleet. The remaining buses are spread among 50 other transit agencies that operate urban buses throughout California.

Urban buses have relatively high emissions (on a per vehicle basis) of NOx and PM. Based on ARB's most current emission inventory model, urban buses will emit 8 tons per day of NOx and a half ton per day of PM in 2005. NOx is critical because it is one of the major components of ozone formation. Diesel particulate matter has been identified as a toxic air contaminant because it increases the risk of lung cancer, increases the onset and severity of respiratory and cardiac diseases, and increases mortality. Diesel engines emit relatively low levels of other pollutants, such as hydrocarbons (HC), and carbon monoxide (CO). Tables 1 and 2 below list both California and federal NOx and PM emission standards for urban bus engines.

Table 1

California and Federal NOx Emission Standards for Urban Bus Engines (g/bhp-hr)		
Model Year	**California**	**Federal**
1988	6.0	10.7
1990	6.0	6.0
1991	5.0	5.0
1996	4.0	5.0
1998	4.0	4.0
October 2002	2.0(1)(2)	2.0(1)(2)
2004	0.5(3)	--
2007	0.2	0.2

1. Nominal NOx level based on U.S. EPA and ARB emission standards of 2.4 g/bhp-hr NOx plus non-methane hydrocarbons (NMHC) or 2.5 g/bhp-hr NOx plus NMHC with 0.5 g/bhp-hr NMHC cap to take effect in October 2002.

2. For those engines subject to the Settlement Agreements between the heavy-duty engine manufacturers, the U.S. Environmental Protection Agency, and ARB. As part of the Settlement Agreements, the federal and state heavy-duty engine emission standards adopted for 2004 are to take effect in October 2002.

3. Standard applies to urban buses for fleets that have selected the diesel path, whether equipped with diesel-fuel, dual fuel, bi-fuel, or alternative fuel engines.

Table 2

California and Federal PM Emission Standards for Urban Bus Engines (g/bhp-hr)		
Model Year	**California**	**Federal**
1988	0.6	0.6
1991	0.1	0.25
1993	0.1	0.1
1994	0.07	0.07
1996	0.05(1)	0.05(1)
October 2002	0.01	0.05
2007	0.01	0.01

(1) In-use standard of 0.07 g/bhp-hr.

In addition to the mandatory emission standards listed above, the ARB also has optional, reduced-emission standards, which were integrated into the February 2000 urban transit bus fleet rule. The optional reduced-emission standards for NOx are listed in Table 3, below.

Table 3

Existing California Required and Optional, Reduced-Emission Standards for Urban Buses (g/bhp-hr)

Model Year	Primary Standard	Optional Standards	Increment
2000 - 10/2002	4.0 (NOx)	2.5 – 0.5	0.5
10/2002 – 2003	2.4 NOx+NMHC or 2.5 NOx+NMHC with 0.5 NMHC cap	1.8-0.3	0.3
2004 – 2006[a]	2.4 NOx+NMHC or 2.5 NOx+NMHC with 0.5 NMHC cap	1.8-0.3	0.3

Notes: a. Emission standards apply to alternative fueled engines on the alternative fuel path.

B. February 2000 Urban Transit Bus Regulations

Urban Transit Bus regulations were approved by the Board in February 2000. This regulation contains two elements to reduce emissions from urban buses: 1) a multi-component transit bus fleet rule applicable to transit agencies that ultimately requires zero-emission bus (ZEB) purchases beginning in 2008; and 2) more stringent emission standards for engines used in urban buses, applicable to engine manufacturers.

The fleet rule was designed to provide transit agencies with flexibility in meeting the NOx standard while also achieving very near-term PM benefits and progressively promoting advanced PM control technology for California's urban transit buses. The engine standards were designed to achieve long-term emission benefits resulting from new bus engines. In order to provide agencies with flexibility in complying with the standards, transit agencies were required to choose between two fleet rule compliance paths -- the "diesel" path or the "alternative fuel" path.

1. Requirements for PM

Based on the need for PM emission reductions, California set technology-forcing PM emission standards for new engines. Beginning with engines produced after October 1, 2002, new engines used in urban transit buses must meet a 0.01 g/bhp-hr PM standard. In order to comply with these standards by the end of 2002, however, staff was aware that advanced fuel and control technology, such as ultra low sulfur (<15 ppm) fuel, and diesel particulate filters (DPFs) would be necessary.

Staff's approach was to include requirements that reduce in-use PM emissions from older diesel engines used in urban transit buses. In order to enable the use of PM-reducing technology and also obtain some reductions in diesel PM immediately, transit agencies on both paths were required to use ultra low-sulfur fuel as of July 1, 2002. Use of ultra low-sulfur fuel would facilitate use of DPFs, a technology likely needed to meet future PM standards. In addition, by January 1, 2003, and through 2009, transit agencies must retrofit their in-use diesel fuel, dual fuel, bi-fuel and diesel HEB engines produced through October 1, 2002, with ARB-verfied devices that reduce PM by 85 percent or more. The only current technology that can achieve this level of control is the DPF. The compliance path selected would determine the model years affected, percent of the fleet retrofitted, and the date for compliance. Table 4 lists the compliance schedule for PM retrofits that is in the original rule.

Table 4

PM Retrofit Requirements By Fuel Path

Diesel Path	Alternative Fuel Path
Tier 1 (pre 1991) 100% by January 1, 2003	Tier 1 (pre 1991) 100% by January 1, 2003
Tier 2 (1991 - 1995) 50% by 1/1/03 100% by 1/1/04	Tier 2 (1991-1995) 20% by 1/1/03 75% by 1/1/04 100% by 1/1/05
Tier 3 (1996 - pre-Oct. 2002) 20% by 1/1/05 75% by 1/1/06 100% by 1/107	Tier 3 (1996 – pre-Oct. 2002) 20% by 1/1/07 75% by 1/1/08 100% by 1/1/09

2. Anticipated Emission Reductions

Staff estimated that the new low-emission standard and ZEB requirements would result in about 5.4 tons per day (tpd) NOx and 0.04 tpd (50 lbs/day) PM emissions reductions in 2010. The PM retrofit component of the February 2000 fleet rule would provide California with a PM emissions benefit of about 300 lbs/day in 2005, and 100 lbs/day in 2010. Requiring PM retrofits for older model-year engines is important in order to achieve significant and much needed PM emission reductions early.

C. Implementation of the Urban Transit Bus Regulations

Staff has reported back to the Board on a regular basis on implementation progress by transit agencies. The Board asked staff to report: (1) on the transit agency program; (2) on implementation of NOx emission reduction strategies as an alternative to compliance with the 2004 standards along with an analysis of the first exemption application and a recommendation; (3) on the status of the advanced aftertreatment systems; and (4) on progress and development of a test procedure for HEBs. ARB staff has presented the Board with its first and second updates on September 20, 2001, and March 21, 2002. Staff has also worked with industry to develop the appropriate test procedure for certification of a hybrid-electric urban transit bus. This section provides a brief overview of the status on implementation and compliance with the February 2000 rulemaking for urban transit buses.

1. PM Retrofit Requirements

The approach for reducing PM relied heavily on the availability of DPFs for the older model-year urban transit bus engines beginning in 2003. At the time the public transit bus fleet rule was adopted, experience with DPFs was limited but promising. Demonstration programs using DPFs on a variety of engines showed promise for incorporation of this technology on all vehicles -- including older vehicles. Hence the 2000 Urban Transit Bus Fleet Rule required that 100 percent of pre-1991 diesel engines used in urban transit buses be retrofitted with ARB certified PM retrofits by January 1, 2003. Furthermore, the PM retrofit must reduce PM emissions by a minimum of 85 percent. Staff focused the original regulations on retrofitting the oldest engines first, even though they were more technologically challenging, because these were the engines with the highest PM emissions.

After the rules were adopted, staff worked closely with transit agencies and manufacturers to determine compliance with the approved PM retrofit requirements. Staff analyzed the status of PM retrofit technology and, by

March 2002, concluded that it was unlikely that retrofit technology for the oldest engines would be made available by manufacturers within the next year, or even in the near future. The only technology that will reduce PM emissions by 85 percent or more, as required, is the DPF. ARB staff had verified two DPF systems for use in 1994 and newer engines, but the DPF manufacturers had indicated that they would not be verifying technology in the near future for pre-1994 and any two-stroke engines.

The major issues preventing the use of this technology include very high in-use PM emissions from the older transit bus engines, which clogs diesel particulate filters rapidly, and low exhaust emission temperatures from two-stroke engines, which inhibit regeneration of DPFs. Another major issue that may prevent development of a new technology for these older engines is the small and declining number of older, two-stroke engines remaining in the transit bus fleet, which makes it less likely that manufacturers will invest in research and development to bring feasible technology to market. Indeed, the major manufacturers have shown little interest in developing technology for the oldest engines.

Based on these findings, staff reported to the Board on March 21, 2002, that currently there are no ARB-verified PM retrofits available for pre-1994 engines that would reduce PM by 85 percent. Hence, transit agencies would not be able to comply with current requirements by January 2003. The Board responded by directing staff, in Resolution 02-16 (March 21, 2002), to make the necessary changes to the diesel PM retrofit implementation schedule to recapture the diesel PM emission reductions lost because of the unavailability of technology. The ultimate goal for a new proposal would be to achieve as close to the same reductions in diesel PM as feasible, when compared to the PM reductions that would have been achieved had the existing regulation been fully implemented.

2. Selecting a Fuel Path

Under the current Public Transit Bus Fleet Rule, transit agencies were also required to declare an irrevocable fuel path – alternative fuel or diesel fuel – by January 31, 2001. The fuel path selected would determine the fraction of new bus purchases required to be alternative-fueled, and the compliance dates for incorporating PM retrofits and purchasing ZEBs. For example, for a transit agency on the alternative fuel path 85 percent of all new purchases must be alternative fuel buses. However, under this path transit agencies are provided with two years additional time to meet the PM retrofit, and ZEB purchase requirements.

During the March 2002 update to the Board, witnesses testified in favor of allowing transit agencies to change their fuel path selection from diesel to alternative fuel. Recognizing the benefits of alternative fuel technology, the

Board directed staff to evaluate the impact of allowing a transit agency to change its fuel path selection and make a recommendation.

3. HEB Test Procedures

Staff has also been working with industry to develop an interim certification procedure for hybrid-electric buses. Without a certification procedure in place, transit agencies planning to purchase HEBs as part of their fleet would not have a method for determining full emission benefits from the hybrid-electric technology. To allow transit agencies to receive emission reduction credit from the use of hybrid-electric buses, prior to the adoption of a certification procedure, ARB's Executive Officer established that HEBs would receive emission certification values 25 percent below the urban bus engine certification standard. A brief description of the proposed interim certification procedures for hybrid-electric urban buses is presented in Chapter III. The detailed interim certification procedure is provided in Appendix B of this document.

D. The Role of HEBs in California

Hybrid-electric propulsion systems combine two motive power sources: an energy storage system such as a battery pack, and an internal combustion engine, turbine or fuel cell functioning as an auxiliary power unit (APU). An electric motor provides partial or complete power to the wheels. In addition, energy otherwise lost as heat during braking is captured through regenerative braking to charge the energy storage system. Since the engine/turbine/fuel cell is not the sole power source in hybrid-electric drivetrains, a smaller engine can be used and is operated at high efficiency and low emissions. Transit buses and delivery trucks with frequent stop-and-go drive cycles are ideal for hybrid-electric applications. The energy storage system is used during periods of initial acceleration which are usually high emission episodes, and regenerative braking during frequent stops will charge the energy storage system.

Current requirements under the Public Transit Bus Fleet Rule and future urban bus emission standards in California have been designed to encourage advanced technology in buses. Hybrid-electric drive systems provide another viable option to reduce NOx and PM emissions from urban transit buses and heavy-duty vehicles operating in California. Emissions testing results from HEBs (presented in section 3) indicate that these buses can potentially meet the future more stringent urban bus standards. If certified to full emission benefits, HEBs may be purchased to meet upcoming regulatory requirements, and potentially future more stringent requirements.

1. HEB Available Technology

Hybrid-electric drive systems for urban transit buses have been available commercially for five years. Within this time, a number of engine and turbine configurations have been developed. HEBs are available with internal combustion engines fueled with diesel, CNG, propane, or gasoline. Turbines fueled with diesel, CNG or liquefied petroleum gas (LPG) are also used in urban buses equipped with hybrid-electric drive systems. Fuel cell HEBs will be available in the near future.

Current hybrid-electric drive systems for urban transit buses use battery packs for energy storage. Energy storage systems using ultracapacitors or flywheels are under development. It is anticipated that hybrid-electric drive system technology will continue to advance at a rapid rate.

2. HEB Demonstration Programs

New York City Transit was the first North American transit agency to demonstrate full-size HEBs in revenue service. The program started in 1998 with four diesel HEBs; an additional six diesel HEBs were added in 2000. The favorable results from this initial study resulted in plans for delivery of an additional 375 diesel HEBs over the next four years.

A number of transit agencies are conducting small HEB demonstration projects in California. HEBs are in operation in Fresno, Los Angeles, Orange County, San Bernadino, San Francisco, and Torrance. Additional transit agencies in California have indicated an interest in purchasing HEBs for their fleets in the future.

3. Development of Heavy-Duty Hybrid-Electric Vehicle Test Procedures

Heavy-duty vehicles are currently certified using an engine test procedure, which cannot reflect the emission benefits provided by a hybrid-electric drive system. A new testing method for exhaust emissions from heavy-duty hybrid-electric vehicles needed to be developed. ARB staff participated with members from industry, academia, and government in the Northeast Advanced Vehicle Consortium (NAVC) Heavy-Duty Hybrid Certification Work Group to establish draft heavy-duty hybrid-electric vehicle test procedures. SAE, collaborating with the Heavy-Duty Hybrid Certification Work Group, developed a heavy-duty hybrid-electric chassis testing protocol, SAE J2711, based on the light-duty hybrid-electric chassis testing protocol J1711. This proposed recommended practice has received final approval by SAE through a balloting process in April 2002.

4. Emissions Testing of HEBs

The proposed (now approved by SAE as a recommended practice) chassis test procedure has been used for emission testing of a limited number of HEBs and conventional drivetrain buses. The test results illustrated in Figures 1 and 2, on the following page, were compiled from studies conducted in four testing facilities over the past three years. The model year of each bus is listed with manufacturer and fuel for each HEB, model years are indicated for the conventional drivetrain buses. All buses are 40-foot platforms except for the E-bus turbine LPG hybrid. Currently, the only data available for buses that utilize turbines pertains to a 22-foot platform and is included in these figures. Examples of older and newer diesel hybrid technology are provided for two manufacturers, Allison Electric Drives and BAE SYSTEMS. The diesel HEBs all utilize diesel particulate filters; the gasoline HEB has a catalytic converter.

Figure 1: NOx Emission Results from HEBs

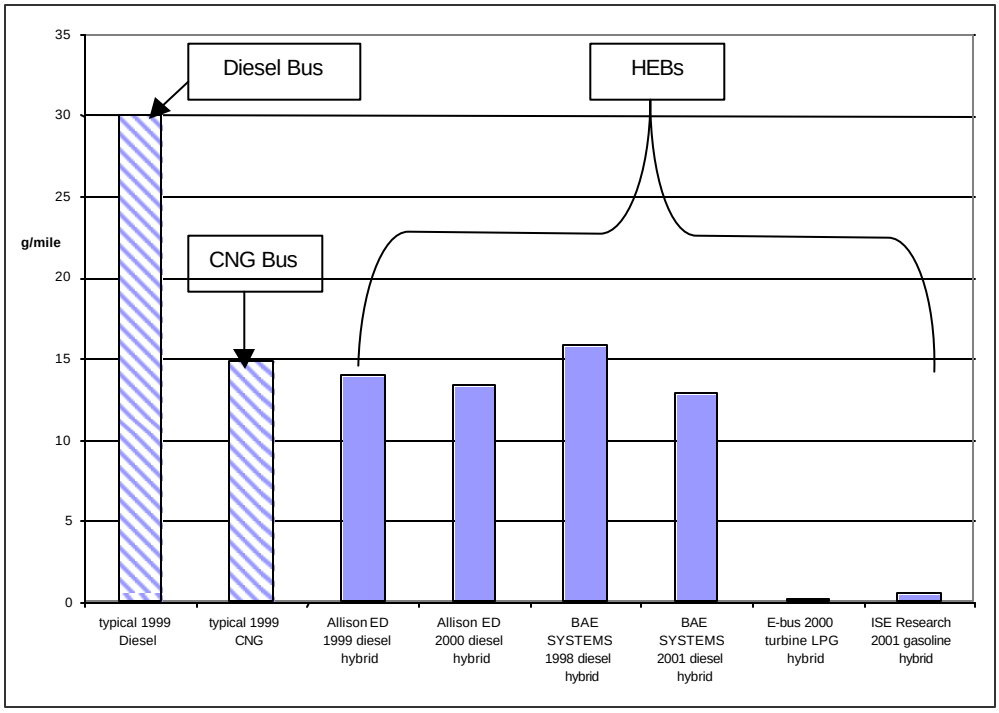
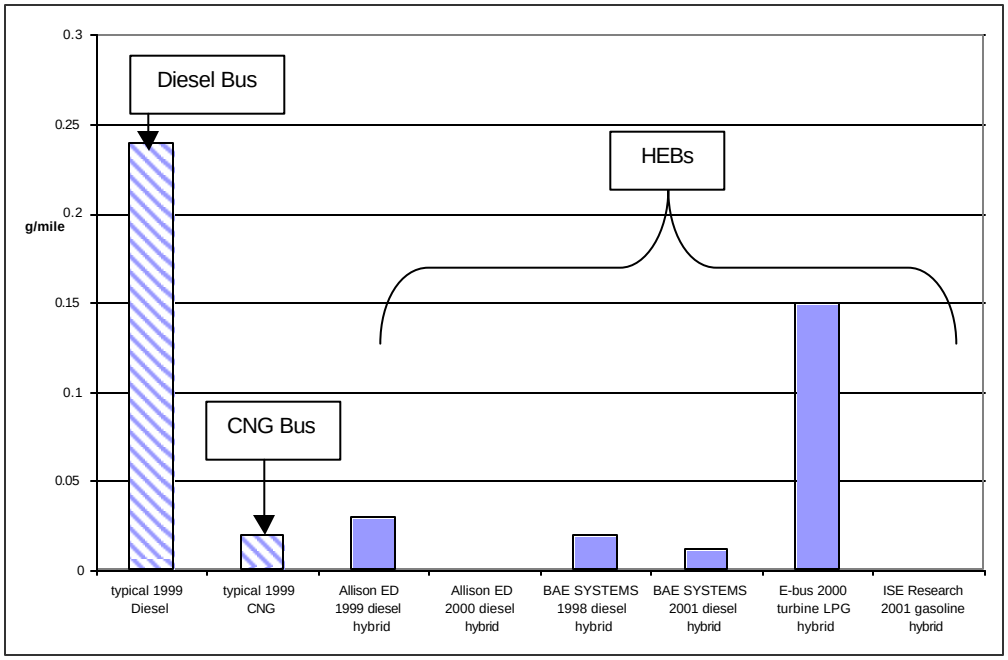


Figure 2: PM Emission Results from HEBs



It is important to understand that chassis testing provides results in units of grams per mile instead of g/bhp-hr used for engine certification. However, NOx emissions results for the diesel HEBs indicate about a 50 percent reduction over emissions from the conventional diesel bus. Furthermore, the turbine LPG hybrid and gasoline hybrid indicate a potential for much lower NOx emissions over the diesel hybrids.

While limited test data is available to make statistical significant evaluations, HEBs are considered a viable technology for reducing emissions from urban transit buses. However, HEBs are rapidly changing, there are many configurations and designs, and the available test data does not represent every type of HEB available. For these reasons, staff is proposing an interim certification procedure. The interim certification procedure would follow a modified SAE J2711 in conjunction with a supplemental formula that would calculate an emission factor ratio to determine a certification value in units of g/bhp-hr. An interim test procedure would provide a method for testing HEBs through which ARB staff would perform complete and comparable evaluations.

E. Need for Modifications

1. PM Retrofit

During the March 2002 status update on the public transit bus rule making, staff informed the Board that there were no DPFs verified for 1993 and older model-year urban transit bus engines that would reduce PM emissions by 85 percent or more. This is a problem because the rule requires transit agencies to retrofit 100 percent of their pre-1991 model-year engines by January 1, 2003, and differing percentages of their 1991-1995 model-year engines, based on fuel path, also by January 1, 2003, using devices that reduce diesel PM by 85 percent or more.

The regulation allows ARB's Executive Officer to grant one-year delays for retrofitting because of unavailability of a retrofit device. After evaluating the status of technology development, however, staff determined that technology to reduce diesel PM by 85 percent or more from pre-1994 and two-stroke engines is unlikely to be available even after one year, by January 1, 2004. Transit agencies, therefore would be unable to comply with the PM retrofit requirements. The Board directed staff to revise the current PM retrofit requirements and consider another approach that would achieve as close to the same reductions in diesel PM as feasible, when compared to PM reductions anticipated from full implementation of the 2000 urban transit bus rule making.

2. Fuel Path Change from Diesel Path to Alternative Fuel Path

At its March 21, 2002 meeting, the Board heard testimony regarding the fuel path selection by transit agencies. Under the regulation, transit agencies elected a fuel path as of January 31, 2001, which may not be changed for the life of the rule. Some transit agencies located in the SCAQMD have asked staff in the past if they could change their fuel path, but the rule does not allow any change. Witnesses at the March 21, 2002, meeting asked the Board to allow transit agencies on the diesel path the option of changing to the alternative fuel path, and the Board directed staff to analyze the impact of and need for such a change.

3. Alternative Fuel Bus Purchase Provision for Diesel Path Transit Agencies

The certified emission level of an engine that a transit agency wishes to purchase, during 2004 through 2006, is dependent on the agency's selected fuel path. The current regulations require engines sold to transit agencies on the diesel path to meet a 0.5 g/bhp-hr NOx standard, unless the transit agency has an approved alternative NOx strategy exemption. This standard applies whether the engine is a diesel-fueled, dual-fueled, bi-fueled, or alternative-fueled engine.

Staff does not expect, however, any full-sized alternative-fueled or diesel-fueled urban bus engines certified to 0.5 g/bhp-hr NOx emissions to be available through 2006. Transit agencies on the alternative fuel path are currently allowed to purchase alternative-fueled engines meeting a 2.5 g/bhp-hr NOx+NMHC standard through 2006.

To encourage and facilitate transit agencies on the diesel path to purchase alternative-fueled engines, and to ensure transit buses are available to be purchased in the 2004 through 2006 time period, some flexibility is needed. Staff proposes to have consistent emission standards for all alternative fuel buses in the 2004 through 2006 model years, regardless of transit agency fuel path.

4. Transit Agency Request for Delay

Staff has been asked periodically by transit agencies to allow them to deviate from the schedule and delay implementation because of financial hardship. Specifically, a small number of transit agencies, two or three, have requested a compliance delay in meeting the July 1, 2002 ultra low sulfur (<15 ppm) fuel requirement. One transit agency, for example, has two transit buses operating on diesel fuel, which it plans to replace with natural gas buses in two years. This transit agency does not have ultra low sulfur fuel available locally and would have to build infrastructure (storage tanks), which it would use for only two years while it is converting all of its fleet to alternative fuels. They have requested, therefore, a two-year delay in complying with the ultra low sulfur diesel fuel mandate, after which they will no longer have any buses operating on diesel fuel.

In some cases, staff has viewed the request for a delay favorably, yet is unable to consider these requests because of the lack of any provision in the regulation for dealing with variations from implementation. Staff has therefore proposed adding a general provision that would allow a transit agency to request an implementation delay because of financial hardship, and a mechanism by which the Executive Officer could grant or deny the request.

5. Amended Definitions

Staff has determined that two modifications and two additions are needed to the list of definitions. Staff proposes to modify the definition of “active fleet” and define terms that are used in that definition. The modification is necessary to improve clarity and to assure that terms agree more closely to the Federal Transit Administration (FTA 2001) definitions. The two terms that must be defined are “emergency contingency vehicles” and “spare buses.” Defining these two terms is important because the term “active fleet” is used several times in the rule to determine how many buses must be included when calculating, for example, the NOx fleet average and which buses must be retrofitted to reduce PM emissions.

In addition, staff has determined that the definition of “alternative fuel” needs to be modified to clarify the classification of a new-technology engine which uses a very small amount of diesel fuel for pilot ignition, but otherwise uses alternative fuel for operation.

6. Repeal California Certification Procedures for PM Retrofit Devices

In the February 2000 rulemaking, the Board adopted "California Certification Procedures for PM Retrofit Devices for On-Road Heavy-Duty Diesel Vehicles.” These procedures were adopted to enable this technology to enter into California’s market and transit agencies would have technology available to comply with the PM retrofit requirements. In May 2002 the Board adopted the "Diesel Emission Control Strategy Verification Procedure, Warranty and In-Use Compliance Requirements for On-Road, Off-Road, and Stationary Diesel-Fueled Vehicles and Equipment.” The proposed amendments require that any device installed on urban buses to meet the diesel PM reduction requirement be verified under the procedures adopted therein. Currently, there are two procedures available to manufacturers of diesel emission control strategies to certify technology. To ensure that all manufacturers follow the same procedures and have the same warranty and in-use compliance requirements, it is necessary to repeal “California Certification Procedures for PM Retrofit Devices for On-Road Heavy-Duty Diesel Vehicles”, adopted November 22, 2000 and incorporated by reference in CCR title 13, section 1956.2 (f) (7). This modification would have no impact on transit agencies or businesses because no manufacturer has followed the certification procedures that were adopted November 22, 2000.

7. Hybrid-Electric Bus Test Procedures

For heavy-duty engines, the U.S. EPA and ARB ensure maximum emission reductions by adopting engine test procedures that measure emissions occurring during typical in-use driving conditions. In order to sell an engine in California, manufacturers must follow the federal/ARB regulatory test procedure and certify engines to the appropriate regulatory standard or optional standard. Typically, owners of heavy-duty vehicles powered by engines certified to the optional standards are also eligible to receive either incentive funds or emission reduction credits for operating vehicles that are cleaner than required.

Standards implemented beginning this month require NOx emissions from heavy-duty vehicles and urban transit buses to be nearly 50 percent lower than previous standards. Hybrid-electric drive systems have the potential to allow urban transit buses to meet the already adopted urban transit bus standards and future more stringent standards. This technology can also be used in other heavy-duty vehicles to meet the future 2007 standards. However, test procedures are needed to certify these systems in heavy-duty vehicles for sale in California. At this time, there is not an approved certification procedure available to certify full emission benefits of hybrid-electric drive systems. Current heavy-

duty vehicle certification is conducted using engine-based test procedures. As hybrid-electric vehicles utilize both an electric motor and an internal combustion engine, engine testing alone will not reflect the contribution of the electric motor, or the emission benefits associated with it. Hence, there is need to develop a methodology for determining the actual emission benefits provided by heavy-duty hybrid-electric drive systems, specifically urban transit buses.

III. SUMMARY OF PROPOSED REGULATIONS

Staff recommends that the Board adopt proposed amendments to sections 1956.1, 1956.2, 1956.4, 1956.8, and 2112, title 13, California Code of Regulations, and the incorporated "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, in the Urban Bus and Heavy-duty Vehicle Classes", as set forth in Appendix A. All the provisions in the proposed amendments and new test procedures apply to engines and vehicles produced for sale in California. There are two components to this proposal 1) to the urban transit fleet rule and 2) incorporation of the exhaust emission test procedures for HEBs. The proposed amendments to the urban transit fleet rule would provide transit agencies with additional flexibility in meeting the PM retrofit requirement. The proposed amendments also include a one-time allowance for a transit agency in the SCAQMD to change its fuel path selection from diesel to alternative fuel and a method for ARB's Executive Officer to grant transit agencies a delay in compliance with the Public Transit Bus Fleet Rule. Finally, staff is proposing modifications to clarify the definitions of an "active fleet" and "alternative fuel bus"; and adding two new definitions -- "emergency contingency vehicle", and "spare bus."

With this proposal, staff is proposing to incorporate exhaust emission test procedures to certify HEBs for an interim period of three years. Since the technology for HEBs is fairly new and rapidly evolving, staff will use the interim period to determine the appropriateness of the proposed test procedures. Staff proposes to present modifications to the Board after two years, if necessary.

A. Applicability

The current urban bus definition, as specified in Section 86.094-2 of Subpart N, Part 86, title 40, CFR, is a passenger-carrying vehicle (+33,000 pound GVW) powered by a heavy heavy-duty diesel-powered engine with a load capacity of fifteen or more passengers and intended primarily for intra-city operation, or operation within a metropolitan area. Equipment on urban buses usually includes quick-opening exit and entrance doors and fare collection equipment. Urban buses are of various lengths, and include articulated buses, but are usually at least 25 feet long.

The proposed amendments to the fleet rule apply to those public transit fleets operated by government agencies or operated by private entities under contract to government agencies. The proposed amendments to the fleet rule only apply to urban transit buses. The proposed amendments would not apply to buses used in shuttle services, airport shuttle services, paratransit services, and school

transportation services. Buses used to provide long-distance charter service, that are generally equipped with luggage compartments, rest rooms, and overhead storage, are not included.

The proposed interim certification procedures for heavy-duty hybrid-electric vehicles apply to urban transit buses as incorporated during a 3-year interim period. All other heavy-duty hybrid-electric vehicles would follow incorporated procedures on a case-by-case basis as approved by ARB's Executive Officer.

B. Amendments to the Fleet Rule, 1956.2

1. PM Emission Reduction Proposal

Staff analyzed several alternatives to the current PM retrofit implementation schedule that could achieve as close to the same reductions in diesel PM as feasible. This section describes staff's proposal for PM emission reductions. The alternatives to this proposal are presented in Chapter IV.

In order to provide transit agencies with maximum flexibility in reducing PM emissions, yet still aggressively reduce in-use PM emissions, staff proposes to amend the rule and replace the PM retrofit program with a program that requires that transit agencies reduce their total diesel PM emissions through 2009. The proposed schedule is based on the implementation dates set in the original regulation's implementation schedule based on the fuel path selected by the transit agency. The proposed new schedule is provided in Table 5, below.

As listed in the table, beginning in 2004 each transit agency would be required to achieve a percent reduction of their January 1, 2002, total diesel PM emissions baseline. For example, in 2004 transit agencies that selected the diesel fuel path would be required to reduce their January 1, 2002, total diesel PM emissions baseline by 40 percent. Transit agencies that selected the alternative fuel path, however, would be required to reduce their January 1, 2002, total diesel PM emissions baseline by 20 percent. By 2007, transit agencies on the diesel path would be required to achieve an 85 percent emission reduction of their PM emissions baseline. This is two years earlier than transit agencies that have selected the alternative fuel path.

Table 5

Proposed Compliance Schedule for Total Diesel PM Emission		
Compliance Year (as of January 1st)	**Diesel Fuel Path Percent Reduction**	**Alternative Fuel Path Percent Reduction**
2004	40	20
2005	60	40
2007	85	60
2009	85	85

The diesel PM emission reduction proposal applies only to diesel-fueled, dual-fueled, bi-fueled, and diesel HEBs, in other words, any engine that uses diesel fuel and has diesel PM emissions. A transit agency with only alternative-fueled buses does not have to reduce its total diesel PM emissions, because alternative-fueled buses emit zero diesel PM emissions. However, a transit agency with mostly alternative-fueled buses and some diesel-fueled buses would be required to reduce PM emissions from its diesel buses only. In this case a PM emissions baseline would only be calculated for the transit agency's diesel buses. This proposal is designed to ensure that every diesel fleet will have its in-use PM emissions significantly reduced by 2007 or 2009, depending on fuel path.

Staff is proposing additional modifications to the rule to allow transit agencies to apply for delays under special circumstances. In the first case, a transit agency that cannot comply with the percentage reductions because technology is not available may apply for an implementation delay of up to one year for each of the compliance deadlines. The transit agency must justify its request by providing the Executive Officer with information on why technology is unavailable, for example, either the technology is not being sold yet or it is being sold but all units have already been purchased by others. Additional required information includes why the transit agency cannot comply by retiring older buses, a plan for compliance, and when the transit agency can comply. In the case where technology is on the market but sold out, the transit agency should supply correspondence with the manufacturer that states when the units would be available.

In the second case, a transit agency that operates fewer than 20 buses and is located in a federal one hour ozone attainment area may delay complying with

the intermediate deadlines of January 1, 2004, 2005, and 2007[1] so long as the transit agency complies with the 85 percent reduction requirement by either January 1, 2007 (diesel path) or January 1, 2009 (alternative fuel path). In this case, the transit agency does not need to make an application for delay, but should include information regarding its intent in its annual reports.

Two other new sections describe how transit agencies are to reduce diesel PM emissions through the use of aftertreatment or other add-on devices. In the first section, staff proposes that transit agencies be required to use only diesel emission control strategies that are verified by the ARB under section 2700 et seq., title 13, CCR, or an urban bus retrofit kit certified and exempted from Vehicle Code section 27156 as an engine rebuild kit. The engine rebuild kits that are currently certified for use in California may be applied to engines of model 6V92 TA DDEC for various specified model years and reduce diesel PM emissions to 0.1 g/bhp-hr.

Additionally, staff provides guidance to transit agencies as to the allowable percentage reductions when using a diesel emission control strategy. The verification procedure categorizes a strategy into Level 1, which is a minimum of 25 percent reduction, Level 2, which is a minimum of 50 percent reduction, or Level 3, which is a minimum of 85 percent reduction. It is these values that staff proposes be used by transit agencies when calculating their diesel PM emission reductions.

Finally, section 1956.2 (f)(6) (formerly 1956.2 (f)(5)), which requires that transit agencies use only diesel fuel with a sulfur content of less than 15 parts per million by weight as of July 1, 2002, in their diesel buses, has been modified to allow the use of a fuel that is verified by the Executive Officer as a diesel emission control strategy (i.e. emulsified fuels). This is necessary because a verified fuel may be something other than a ultra low sulfur diesel fuel, and yet be verified to reduce diesel PM emissions.

2. Fuel Path Change

Staff has analyzed the impact of allowing a transit agency to change its fuel path three years into the implementation of what is a fifteen year rule. In establishing the fleet rule, the implementation dates for transit agencies on each fuel path were determined in order to ensure that emission reductions were essentially equivalent over the life of the rule. A transit agency on the alternative fuel path has been required to make 85 percent of its annual purchases or leases of alternative fuel buses since the January 31, 2001, fuel path selection date. Transit agencies that selected the diesel path have been purchasing only diesel-fueled buses, which are less expensive than alternative-fueled buses. Thus, a transit agency that changes now from the diesel path to the alternative fuel path

[1] The 2007 delay only applies to a transit agency on the alternative fuel path. A transit agency on the diesel path would be required to comply in 2007 as this is the full compliance deadline.

would have a higher proportion of diesel buses and lower proportion of alternative fuel buses over the life of the rule (through 2015).

As stated in the Staff Report for the regulation, the alternative fuel path was designed to achieve equivalent NOx and greater PM reductions than the diesel path. The rule also includes incentives for transit agencies on the alternative fuel path in terms of timing of the PM retrofit schedule, ZEB demonstration program, and timing of ZEB purchases (ARB 1999). An argument for not allowing transit agencies to switch paths, some three years into the regulation, is that such a change could affect the overall emission reductions achieved and the ZEB program.

The transit agencies located in the SCAQMD, however, are subject to Rule 1192, Clean On-Road Transit Buses, which was adopted June 16, 2000. The rule specifies that all purchases or leases of heavy-duty vehicles must be alternative-fueled, as of the date of adoption for transit agencies with 100 or more urban buses and as of July 1, 2001, for transit agencies with 15 or more urban buses. Seven transit agencies in the SCAQMD elected the diesel fuel path under the ARB's rule (Table 6). All but one of these transit agencies[2] must follow the SCAQMD rule where it is more stringent, i.e., they must purchase alternative fuel buses.

Table 6

Transit Agencies in the SCAQMD on the Diesel Fuel Path	
Transit Agency	**Size of Fleet**
Commerce Municipal Bus Line[3]	12
Gardena Municipal Bus Line	35
Long Beach Transit	190
Montebello Bus Line	78
Norwalk Transit	24
Santa Clarita Transit	60
Torrance Transit	33

None of the transit agencies in the SCAQMD are mandated to participate in the ZEB demonstration project, which only applies to transit agencies on the diesel path with more than 200 urban buses in their fleet as of January 31, 2001. The schedule for ZEB purchases is dependent both on fleet size and fuel path, but is

[2] Commerce is not subject to Rule 1192 because it has fewer than 15 buses.
[3] With only 12 urban buses in its fleet, Commerce is not subject to Rule 1192 and may purchase diesel buses.

determined based on fleet size as of either January 1, 2007, for diesel path agencies or January 1, 2009, for alternative fuel path agencies.

In order to determine which, if any, transit agencies would consider making a fuel path change, staff notified transit agencies and asked for comment on the proposal at workshops in Sacramento on May 3 and El Monte on May 9. Staff then sent electronic mail (e-mail) to the California Transit Association, again requesting comments from members, and finally sent e-mails to the transit agencies on the diesel path in the SCAQMD. In response, staff received one positive response (would change), one negative response (would not change), and one response that the transit agency would consider making the switch if the regulation was changed. The only transit agencies that responded to the request for comment were in the SCAQMD.

Staff concludes, therefore, that there is little interest in transit agencies making a fuel path change, and that the only transit agencies that would likely change are located in the SCAQMD. Allowing any transit agencies in the SCAQMD to change fuel path would have little or no impact on the benefits expected from the current regulation. Transit agencies in the SCAQMD have already been purchasing alternative fuel buses, because of the requirements set forth in South Coast's Rule 1196 pertaining to large heavy-duty fleets operating in the SCAQMD. Staff therefore proposes to limit the scope of the fuel path change only to transit agencies in the SCAQMD, and to require that any transit agency that wishes to change fuel path make a declaration of its intention by January 31, 2004. This date would allow transit agencies sufficient time to bring the question before their management or Board, and would allow them to combine reporting with the annual report due each January 31st.

3. Alternative Fuel Bus Purchase Provision for Diesel Path Transit Agencies

Staff proposes to delete the language "alternative-fueled" from section 1956.2 (d)(4) to remove the restriction on transit agencies on the diesel path from purchasing model year 2004 to 2006 alternative-fueled urban bus engines with NOx exhaust emission standards in excess of 0.5 bhp-hr. The intended effect of this change is to encourage transit agencies on the both paths to purchase alternative-fueled bus engines during this time period when staff expects there to be no complying diesel-fueled engines available.

4. Transit Agency Request for Delay

Staff is proposing that a new section be added to the existing regulation allowing transit agencies with fewer than 20 buses to request an implementation delay based on financial hardship. Current regulations have significant flexibility incorporated for the larger transit agencies ($\geq$ 20 buses) to comply with the

requirements. For very small transit agencies, financial hardship is a valid reason to consider in granting a delay for compliance.

The new provision is designed to provide a mechanism whereby ARB's Executive Officer can hear and decide on the merits of exceptional requests for an implementation delay. The transit agency would be required to provide evidence of financial hardship. Evidence must include an analysis of the cost of compliance, the source of funds available for complying with the regulation, the shortfall between funds available and the cost of compliance, and the data by which the transit agency would achieve compliance. The Executive Officer would then consider the transit agency's request along with the emission reductions forgone by delayed compliance before issuing a decision.

The new section allows a transit agency to apply for the delay within 30 days of the implementation deadline. Until a decision is made, a transit agency would be responsible for compliance. As the Executive Officer may take up to 90 days to render a decision, however, the transit agency should apply earlier to avoid the assessment of noncompliance penalties.

5. Amended Definitions

Staff proposes to modify the definition of "active fleet" to the following: "Active fleet means the total number of urban buses operated by a transit agency or under contract to a transit agency, including spare buses, but not emergency contingency vehicles or non-revenue producing vehicles."

Staff proposes to add two definitions, for "emergency contingency vehicle" and "spare bus," which are used in the definition of "active fleet." The proposed definitions are modeled on those published by the Federal Transit Administration National Transit Database (http://www.ntdprogram.com, 2001).

"Emergency contingency vehicle" would be defined as an urban bus placed in an inactive contingency fleet for energy or other local emergencies, after the urban bus has reached the end of its normal minimum useful life.

"Spare bus" would be defined as an urban bus that is used to accommodate routine maintenance and repair operations, and to replace a bus in scheduled service that breaks down or is involved in an accident.

There should be no impact from these changes, as staff has referred transit agencies to these already-existing definitions for "emergency contingency vehicle" and "spare bus" when a transit agency is determining the composition of its active fleet.

Staff proposes to modify the definition of “alternative fuel” as follows:

“Alternative fuel” means natural gas, propane, ethanol, methanol, electricity, fuel cells, or advanced technologies that do not rely on diesel fuel except as a pilot ignition source at an average ratio of less than 1 part diesel fuel to 10 parts total fuel on an energy equivalent basis. Alternative fuel also means any of these fuels used in combination with each other or in combination with other non-diesel fuels. Urban bus engines operating on alternative fuel may not have the capability to idle or operate solely on diesel fuel at any time.

The definition of alternative fuel is changed to include an engine that uses diesel fuel only as a pilot ignition source at less than 10 percent of the total fuel usage. The energy equivalent basis is in terms of Btus per gallon. In this case, natural gas is the primary fuel and the use of diesel fuel is limited to the small pilot quantity required to initiate combustion, precluding engine operation or idling solely on diesel fuel. Because natural gas is the primary fuel, allowing this small usage of diesel fuel in a system otherwise alternative-fueled is appropriate. Prohibiting such an engine from operating or idling solely on diesel fuel ensures that an engine with multiple operating modes, which may include operation on diesel fuel, does not come under this definition.

6. Repeal California Certification Procedures for PM Retrofit Devices

Staff proposes to repeal the "California Certification Procedures for PM Retrofit Devices for On-Road Heavy-Duty Diesel Vehicles,” adopted November 22, 2000, that are incorporated by reference in 1956.2 (f)(7). In its place, the Board adopted in May 2002, the "Diesel Emission Control Strategy Verification Procedure, Warranty and In-Use Compliance Requirements for On-Road, Off-Road, and Stationary Diesel-Fueled Vehicles and Equipment," new sections 2700-2710, chapter 14, title 13, CCR. The proposed amendments require that any device installed on urban buses to meet the diesel PM reduction requirement be verified under the procedures adopted therein.

This change is necessary so manufacturers of all diesel emission control strategies follow the same procedures and have the same warranty and in-use compliance requirements for verification. As no manufacturer has followed the certification procedures that staff proposes to repeal, this change has no impact on transit agencies or businesses. This change will have a beneficial impact on transit agencies because the newly adopted verification procedures provide greater assurance of efficacy and reliability of the device.

C. HEB Interim Certification

Based on preliminary results from HEBs tested following a chassis-based procedure, staff considers HEBs to be a viable technology for reducing emissions from urban transit buses. Full market penetration of the hybrid-electric drive

systems in urban buses, and eventually heavy-duty vehicles, will continue to be a challenge until a niche market is realized. The technology is rapidly changing with improvements in diesel HEBs to an expanded market for gasoline, natural gas, and fuel cell HEBs. In order for these systems to enter into the market smoothly and provide California with substantial emission reductions, recognition of full emission benefits is necessary. Staff proposes manufacturers to certify buses following a chassis-based test procedure and a calculation of emission reductions from the hybrid-electric drive system. Exhaust emissions would be verified following the HEB test procedures briefly described in section 9, below, (full detailed description in Appendix B). In lieu of testing, manufacturers would also have the choice to claim a 25 percent reduction from the engine's NOx certification value. Manufacturers may also continue to follow existing engine test procedures. Other types of heavy-duty hybrid-electric vehicles would also be eligible for certification on a case-by-case basis through the approval of ARB's Executive Officer.

Initially, flexibility is needed so manufacturers could sustain a market in the urban bus arena allowing the technology ample time to flourish from the urban bus into the heavy-duty vehicle market. To facilitate the introduction of this promising new technology in California, and to provide staff with a period of further evaluation of the technology, staff proposes interim certification procedures for a period of three years. To allow for additional flexibility staff proposes an approach that allows engine manufacturers to remain responsible for emissions from the engine during the interim period, while the hybrid-electric drive system manufacturer would be responsible for the emission reductions it provides for the HEB ("dual party" or "single party certification"). This approach would provide hybrid-electric drive system and engine manufacturers a period to develop a working relationship, collaborate efforts, and determine who would remain responsible for emissions beyond the interim period. Recognizing the merits and the age of the technology staff is also proposing relaxed useful life requirements during the interim period. In addition, proposed durability and emission testing requirements during the interim period would be based on the quantity of HEBs sold for a particular HEB family.

1. Definitions

Staff is defining various terms related to HEBs that are equivalent to those defined in the approved SAE J2711. These definitions are provided in Appendix B. The interim certification procedure includes using an emissions ratio factor to calculate a certification standard for the HEB. The ratio is determined by comparing emissions from a baseline certified heavy-duty engine and a baseline urban transit bus with emissions resulting from a chassis tested HEB.

ARB's Executive Officer would select the "baseline engine" that best represents the engine used in a family of HEBs as part of the hybrid-electric drive system.

Certified emissions for the selected engine would be used in calculating an emission factor for a particular hybrid-electric drive system. The "baseline urban transit bus" would also be selected by the Executive Officer to represent a conventional drivetrain (non-hybrid-electric) urban transit bus. Exhaust emissions for the "baseline urban transit bus", as determined by the chassis dynamometer test procedure, would be used with the certified emissions for the engine incorporated into that urban transit bus to calculate a non-HEB emission factor. The ratio of the hybrid emission factor to the non-HEB emission factor will then be used to calculate the appropriate emission reduction for a hybrid-electric drive system.

2. Test Procedures

The procedures for determining compliance with the urban transit bus emission standards applicable for 2004 and subsequent hybrid-electric urban buses are based on a chassis dynamometer test procedure and calculation of emissions attributed to the hybrid-electric drive system. The chassis dynamometer test procedure is a modified version of a SAE Recommended Practice, SAE J2711, developed for heavy-duty hybrid-electric vehicles. An emissions factor is calculated from the chassis dynamometer test results and the engine certification value for both an HEB and baseline urban transit bus. The ratio of the two emissions factors is then applied to the engine certification value of the engine used in the HEB, resulting in a hybrid-electric drive system certification value. Staff proposes that the Board adopt the modified chassis dynamometer test procedure with the emission factor ratio calculation and application as the method for determining exhaust emissions from hybrid-electric drive systems during the interim period.

SAE J2711, "Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles", was formally approved in April 2002, and is considered a starting point for standardizing heavy-duty hybrid-electric vehicle testing. Staff has modified this comprehensive document for use as a chassis dynamometer test procedure for HEBs. SAE J2711 recommends the use of three driving cycles for exhaust emissions testing. Staff's proposed test procedure requires two heavy-duty vehicle driving cycles, the Orange County Bus Cycle and the Urban Dynamometer Driving Schedule (d) cycle, as well as the option of substituting a different driving cycle upon approval of ARB's Executive Officer. The SAE procedure includes a method for correcting the state of charge (SOC) for a series of test runs, resulting in emissions or fuel economy determination at zero net energy change (NEC). The test procedure proposed by staff does not use a SOC correction but instead requires each test run have a NEC variance of less than two percent. In addition, staff's proposed test procedure includes a provision for chassis dynamometer testing of conventional drivetrain urban transit buses, which is necessary for calculating the emission factor ratio.

Chassis level certification standards do not exist for heavy-duty vehicles and current engine certification methods do not reflect any emission reductions attributable to a hybrid-electric drive system. Staff proposes using an emission factor ratio for calculating a hybrid-electric drive system certification value from an engine certification value. An emissions factor is calculated by dividing the chassis test procedure result by the engine certification value. Emissions factors are calculated for both a hybrid-electric drive system and a baseline (conventional) urban transit bus. An emission factor ratio is then determined by dividing the emissions factor for the hybrid-electric drive system by the emissions factor for the baseline urban transit bus. The emission factor ratio is a number less than one and is indicative of the emission reduction benefit of the hybrid-electric drive system. The engine certification value is multiplied by the emission factor ratio to determine a certification value for the hybrid-electric drive system. Emission factors can be calculated for any mass emission or particulate emission species. Staff proposes to use the emission factor method for calculating NOx certification values for hybrid-electric drive systems. An example of applying an emission factor ratio for hybrid-electric drive system certification is provided in Figure 3.

Figure 3: Example of Emission Factor Ratio Calculations

Hybrid-electric Bus NOx = 8 g/mi
Engine (Hybrid-electric Bus) NOx = 2.5 g/bhp-hr

$$EF_{hybrid} = \frac{8\ g/mi}{2.5\ g/bhp\text{-}hr} = 3.2\ bhp\text{-}hr/mi$$

Baseline Bus NOx = 15 g/mi
Engine (Baseline Bus) NOx = 2.5 g/bhp-hr

$$EF_{baseline} = \frac{15\ g/mi}{2.5\ g/bhp\text{-}hr} = 6.0\ bhp\text{-}hr/mi$$

$$EFR = \frac{3.2\ bhp\text{-}hr/mi}{6.0\ bhp\text{-}hr/mi} = 0.53$$

Hybrid-electric Bus_{cert} NOx = 2.5 g/bhp-hr x 0.53 = 1.3 g/bhp-hr

Where,

g/mi	= grams per mile
g/bhp-hr	= grams per brake horsepower-hour
EF	= emissions factor
EFR	= emission factor ratio
Hybrid-electric Bus_{cert}	= certification value for hybrid-electric drive system

In the example provided above, NOx emission values for a hybrid-electric drive system and a baseline urban transit bus were obtained by chassis dynamometer testing. The NOx emission value for the engine used in either the hybrid-electric drive system or baseline urban transit bus was provided by engine certification. In this example, an emission factor ratio of 0.53 is calculated. The certification value of 1.3 g/bhp-hr for the hybrid-electric drive system reflects a 47 percent emission reduction attributed to the hybrid electric drive system.

If a single party assumed sole responsibility of emissions for the HEB in the above example, the certification value on the Executive Order would be as low as 1.3 g/bhp-hr, where as the certification standard would be the optional standard of 1.5 g/bhp-hr. If two parties (i.e. the engine manufacturer and the HEB system manufacturer) assumed responsibility for emissions, two Executive Orders would be granted. The engine manufacturer would be responsible for the emissions from the engine that is incorporated into the hybrid-electric drive system, 2.5 g/bhp-hr. The Hybrid-electric Bus manufacturer would be responsible for the hybrid-electric system that reduces emissions to the optional emission standard of 1.5 g/bhp-hr.

3. Certification

Staff is proposing an approach for interim certification that provides manufacturers with flexibility in introducing this viable technology into California's market, while still providing staff with ample time to evaluate technology for proper enforcement. With new technology, the conventional approach would be to allow the technology to be demonstrated through experimental permit. Under that approach, however, once the permit expires the technology would be removed from operation until certified. Under staff's proposal, during the interim period dual party or a single party certification would be granted through the 2006 model year. This approach provides manufacturers with an extended window of opportunity to develop technology to meet the more stringent enforcement requirements of a fully certified engine.

Under dual party certification two Executive Orders would be granted. One Executive Order would be for the baseline engine/turbine/fuel cell that is used as a source of motive energy (auxiliary power unit). The Executive Order for the baseline engine/turbine/fuel cell must contain certification levels that meet California's most current emission standards for heavy-duty on-road or urban transit bus engines. For PM, the engines must be certified to meet the PM emission standards for urban bus engines. Exhaust emission standards would be tested following "California Exhaust Emissions Standards and Test Procedures for 1985 and subsequent Heavy-Duty Diesel Engines and Vehicles," or "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Year heavy Duty Otto-Cycle Engines." Optional test procedures for the turbine or fuel cell would be used at the approval of ARB's Executive Officer.

The second Executive Order would be for the electric drive components listing overall emission standard for the hybrid-electric drive system. Overall emissions would be determined by multiplying the engine certification by an emission factor ratio determined for the hybrid electric drive components. The end result would be a certification value in units of g/bhp-hr. The HEB must meet California's most current emission standards for Urban Transit Buses following "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, In the Urban Bus and Heavy-Duty Vehicle Classes."

Beginning with the 2007 model year, one party would be granted an Executive Order. The Executive Order must contain certification levels that meet California's most current emission or optional emission standards for urban transit bus engines. Exhaust emission standards would be tested following "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, In the Urban Bus and Heavy-Duty Vehicle Classes."

On a case-by-case basis, a heavy-duty hybrid-electric vehicle may be certified with the approval of ARB's Executive Officer.

4. 25 Percent Reduction Claim

During the interim period, hybrid-electric drive system manufacturers have the option of claiming a 25 percent reduction from the certification standard of any on-road certified heavy-duty engine incorporated as part of the hybrid-electric drive system. During this period, ARB's Executive Officer also has the authority to chassis test any HEB that incorporates a hybrid-electric drive system selecting this option. If the resulting emission reduction is smaller, the entire HEB family incorporating the system in its platform would be required to claim the smaller percent emission reduction.

After the interim period, this option is not available. Hybrid-electric drive system manufacturers must follow the proposed "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, In the Urban Bus and Heavy-Duty Vehicle Classes," for testing and emission standards certification.

5. Useful Life, Warranties, Testing, and Emissions Related Maintenance

In order to provide flexibility and allow HEBs to enter into the market place more quickly, staff is proposing that for the interim period (model years 2004 through 2006) the useful life of the hybrid electric drive system would be 5 years or 150,000 miles, which ever occurs first. After the interim period the useful life requirement would remain consistent with already adopted urban transit bus regulations, 10 years, 435,000 miles or 22,000 hours, which ever occurs first. The emissions defect and performance warranties would be five years,

100,000 miles, or 3,000 hours of operation, whichever occurs first. An alternative useful life would be acceptable as approved by ARB's Executive Officer.

For 2004 and subsequent model years the HEB and its engine (diesel or otto-cycle), turbine, or fuel cell, and the electric drive components, by model year, would meet the requirements as listed in title 13, CCR sections 2035 and 2036: "Defects Warranty Requirements for 1979 through 1989 Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles; 1979 and Subsequent Model Motorcycles and Heavy-Duty Vehicles; and Motor Vehicle Engines Used in Such Vehicles."

During the interim period, staff proposes durability and emission testing requirements for an HEB family similar to what is already approved for urban transit buses. While durability and emissions testing would remain the same, during the interim period testing would be conducted only when a certain quantity of HEBs are sold per HEB family. Staff proposes that HEB families with less than 50 HEBs sold for the 2004 through 2006 model years be exempt from durability-data vehicle and emission-data vehicle testing. An HEB family in California with 50 or more HEBs sold, and any HEB families (regardless of the quantity of HEBs sold) 2007 and later would meet the durability-data vehicle and emission-data vehicle testing as required in title 13, CCR, sections 2111, 2112, and Appendix A as adopted and last amended.

Staff proposes that emission related maintenance intervals for the HEBs emission related components would be the same as already approved for heavy-duty urban bus engines.

6. Labeling Requirements

The applicant shall label each hybrid-electric drive system with a permanent, non-destructible label or stamp identifying the manufacturer, the model number, the month and year of manufacture, and the Executive Order number issued by the ARB. Labeling must conform with title 13, CCR, section 1965. Specific details on labeling are listed in Appendix B, "California Test Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, in the Urban Bus and Heavy-duty Vehicle Classes." The label or stamp shall be easily visible after installation of the system according to the applicant's written instructions for proper maintenance and use. Each applicant shall submit a sample of its label or stamp to the ARB for review and approval, prior to selling the hybrid-electric drive system. Staff will propose modifications to the current labeling requirements for all heavy-duty vehicles in a regulatory item next month. Those modifications may also apply to HEBs.

7. Engine Service Manuals

Staff proposes that the Board adopt the same manufacturer requirements for service manuals as already approved for urban transit buses. The manufacturers of HEBs would provide owners with manuals specifying maintenance needed to ensure proper hybrid-electric drive system operation. The manual would also identify maintenance that may be needed for emissions-related components after the end of the regulatory useful life of any components, including mileage/hour intervals, and procedures for determining whether maintenance or repair is needed. Manufacturers are not required to incorporate additional on-board systems beyond what they already have. However, the maintenance manual must include instructions for access and responding to any emissions-related diagnostic codes that may be stored in any existing on-board monitoring systems.

The recommended maintenance practices may be based on engineering analysis or other sound technical rationale. In the event that an emission-related component is designed not to need maintenance during the full life of the engine or electric drive system, the manual would need to contain, at a minimum, a description of the component, noting its purpose, and a statement that the component is expected to last the life of the engine and electric drive system without maintenance or repair. In addition, the manual would include the rebuild provisions described in item 9 below, to ensure that owners and rebuilders are aware of the requirements.

8. Equipment Maintenance Signals

According to Health and Safety Code section 43009 manufacturers must ensure that critical emissions-related scheduled maintenance has a reasonable likelihood of being performed in-use. Manufacturers may chose a form of on-board driver notification that would be triggered based either on mileage intervals or component failure. Staff proposes that regulatory requirements already approved for equipment maintenance signals used in heavy-duty vehicles also be set for HEBs. Specifically, manufacturers of 2004 and subsequent model-year hybrid-electric drive systems must use equipment maintenance signals designed to function at or beyond the end of the regulatory useful life of the HEB. Recall liability is limited to failures during the regulatory useful life.

9. Rebuild Provisions and Record Keeping Requirements

Section 27156 of the California Vehicle code prohibits tampering, when rebuilding engines or at any other times. Currently, for 2004 and subsequent model-year heavy-duty diesel and Otto-cycle engines no one may remove or render inoperative any device or element of design installed on or in a heavy-duty vehicle or engine in compliance with current regulations. Furthermore, a

remanufactured engine must be rebuilt equivalently from an emissions standpoint, to the original certified engines. Staff proposes the Board adopt rebuild requirements for HEBs and hybrid-electric drive systems incorporated into HEBs. The proposed rebuild requirements would be the same as those already approved for heavy-duty vehicles and engines and would apply to the hybrid-electric drive system at the time of rebuild.

Staff also proposes that the Board adopt record keeping requirements for HEB rebuilds that are consistent with those already adopted for heavy-duty vehicles and engines. These requirements include the following

- Mileage and/or hours at the time of hybrid-electric drive system rebuild;
- A list of the work performed on the hybrid-electric drive system (engine/turbine/fuel cell and electric drive components);
- Any repair of emission control systems, including a list of replacement parts used, hybrid-electric drive system parameter adjustments, and design element changers;
- Emissions-related codes and equipment monitoring signals that are responded to and reset; and
- Responses to such signals and codes, and work performed.

Staff proposes records be kept for two years after the hybrid-electric drive system is rebuilt. For single party responsibility, maintaining records for HEB families rather than specific engines is allowed. However, under dual party responsibility, records would be maintained for the engine/turbine/fuel cell family separate from those for the electric drive components.

10. Information Requirements

When applying for certification, the application except as noted below, must follow Part I (40 CFR §86.1843-01(c)):

- Identification and description of the vehicle(s) covered by the application.

- Identification of the heavy-duty vehicle weight category to which the vehicle is certifying: light heavy-duty, medium heavy-duty, heavy-heavy duty, urban transit bus, and the curb weight and gross vehicle weight rating of the vehicle.

- Identification and description of the propulsion system for the vehicle.

- Identification and description of the climate control system used on the vehicle.

- Projected number of vehicles produced and delivered for sale in California, and projected California sales.

- All information necessary for proper and safe operation of the vehicle, including information on the safe handling of the battery system, emergency procedures to follow in the event of battery leakage or other malfunctions that may affect the safety of the vehicle operator or laboratory personnel.

- Method for determining battery state-of-charge, and any other relevant information as determined by the Executive Officer.

IV. TECHNOLOGICAL FEASIBILITY

There have been major advances in heavy-duty diesel engine technology over the last several years to meet current and future PM and NOx standards for heavy-duty and urban bus engines. Retrofit manufacturers continue to improve PM retrofit technology that could be used in urban transit buses to meet future PM standards. Part of the challenge in meeting current PM requirements for urban buses will be having retrofit technology available for older buses.

Hybrid-electric drive system manufacturers have developed innovative technology to provide urban transit agencies with another method for meeting the current and future standards. Although considered a viable solution, entering into the production stage in California is a challenge for HEB manufacturers.

Staff's proposal for PM retrofits and hybrid-electric buses was designed considering the progress of PM retrofits and the fairly young and rapid development of hybrid-electric drive technology. This chapter discusses the feasibility of staff's proposal for PM retrofits and HEB certification.

A. PM Emission Reduction Technology

Transit agencies may use a variety of methods to reduce their diesel PM emissions to comply with the proposed diesel PM emission reduction requirement, including bus retirement, engine repower, purchase of new low-emission buses, and installation of a verified diesel emission control strategy. Transit agencies may retire older buses or repower engines certified to higher emissions levels and replace them with newer diesel, dual-fuel, bi-fuel, or diesel hybrid-electric buses certified to 0.01 g/bhp-hr, or with alternative fuel buses. Replacement of a diesel bus with an alternative fuel bus also reduces the total diesel PM emissions.

A transit agency may comply with this proposal by installing a diesel emission control strategy that has been verified by ARB's Executive Officer to reduce diesel PM. There are several different options verified at Level 3, which is a verified 85 percent or greater reduction, and one option verified at Level 1, which is a verified 25 percent or greater reduction. Staff expects that additional technologies at all Levels will be verified for urban bus engines as a result of this proposal. Removal of the requirement to use only 85 percent reduction technologies will open the market to more innovative technologies for urban buses. Thus, a transit agency can use a variety of technologies and strategies to comply with this proposal.

Staff has reviewed retrofit technology for diesel PM reduction in the September 2001 and March 2002 status reports for the transit bus fleet rule (ARB 2001, ARB 2002). Staff's review of these technologies is provided in Appendix D. Other possible strategies that have been discussed with staff include alternative diesel fuels, such as a fuel-water emulsion; fuel additives, used with or without a diesel particulate filter; a fuel delivery optimization mechanism; a diesel oxidation catalyst used alone or in combination with a diesel fuel-water emulsion; cam modifications; and catalytic coatings inside the cylinder.

Some of these strategies are newly developed, while others have been in use for years, especially in Europe or in other industries such as mining. Verification by ARB proves to the consumer and to the State that the diesel emission control strategy is effective and durable, and provides a standard warranty that provides the user with some protection. Thus, any technology that has been verified is both feasible and effective.

B. Availability of Ultra Low Sulfur Diesel Fuel

Beginning July 1, 2002, public transit agencies were required to operate their diesel buses on diesel fuel with a sulfur content of 15 parts per million by weight. To ensure availability of ultra low sulfur diesel fuel, staff surveyed each transit agency to determine availability in and around their area for heavy-duty buses in their fleets. Eight of the transit agencies operate fleets of only alternative fuel urban buses and, therefore, were excluded from the survey.

The regulation allows a transit agency that has fewer than 20 buses and operates in a one-hour ozone attainment area to delay implementation of the ultra low sulfur fuel requirement to July 1, 2006. Nine transit agencies are located in a one-hour ozone attainment area and have fewer than 20 buses (Table 7), and can therefore delay implementation of the requirement. Of these nine, two transit agencies – Monterey-Salinas Transit and Santa Cruz Metropolitan Transit – began using the fuel by July 1, 2002:

Table 7

Transit Agencies Eligible for Fuel Delay		
Transit Agency	**Implement by 07/01/02**	**Delay to 07/01/06**
Arcata & Mad River Transit		**X**
Eureka Transit Service		**X**
Humboldt Transit Authority		**X**
Mendocino Transit Authority		**X**
Monterey - Salinas Transit	**X**	
Redding Area Bus Authority		**X**
San Luis Obispo		**X**
San Luis Obispo Regional Transit Authority		**X**
Santa Cruz Metropolitan Transit District	**X**	
Siskiyou County STAGE		**X**
South County Area Transit		**X**

The majority of the remaining 50 transit agencies have the fuel readily available to them with a cost differential ranging from $0.05 to $0.12 per gallon relative to regular diesel fuel. Approximately 62 percent of these transit agencies contract to purchase the ultra low sulfur diesel fuel and the remaining 38 percent purchase fuel weekly on the open commercial market.

Four transit agencies with fewer than 20 buses, but that operate in one-hour ozone non-attainment areas have requested relief from the rule because of cost impacts: Stanislaus Regional Transit in San Joaquin Valley Unified (4 buses), Santa Maria Area Transit in Santa Barbara County (7 buses), El Dorado County Transit Authority in the El Dorado County (12 buses), and Chico Transit in Butte County (10 buses). All of these very small transit agencies have discussed with staff their claims of financial hardship because they would have to install infrastructure (storage tanks) that would be used for only four years, or in the case of Stanislaus, only two years. Two of the transit agencies are in air districts that either have not been formally designated attainment (Butte) or have been redesignated (Santa Barbara). In each case, the transit agency is claiming that the local commercial facilities are unwilling to carry the ultra low sulfur diesel fuel because there is not enough demand in advance of the national standard deadline of July 1, 2006. In the absence of any delay in the rule, staff is unable to evaluate the claims of financial hardship by transit agencies.

Thus, although ultra low sulfur diesel fuel is available in most areas of the state, the high cost of installing infrastructure to bring in a fuel prior to its mandated availability throughout the nation may render this requirement financially infeasible for a small number of transit agencies. Section 1956.2 (g) is proposed for addition to the regulation to allow the Executive Officer to consider applications for delay based on financial hardship, which would allow staff to evaluate the claims by these transit agencies. Allowing these transit agencies to delay adopting ultra low sulfur fuel should have little or no effect on their ability to reduce diesel PM emissions as these transit agencies could meet the requirements by retiring buses or installing diesel emission reduction technology that does not require ultra low sulfur fuel. In addition, staff expects the availability of ultra low sulfur fuel to grow throughout the state. Already, ARCO stations that carry diesel fuel now carry ultra low sulfur diesel.

C. HEBs and Interim Certification

Bus manufacturers and transit agencies have expressed interest in diesel hybrid-electric technology because of their familiarity with diesel technology and its compatibility with current fueling infrastructure. Diesel hybrid-electric technology utilizes electric traction drive motors, batteries, and a diesel engine/generator set combination, rather than the conventional engine/transmission combination. The batteries, typically lead acid (PbA) or nickel metal hydride (NiMH), can be charged by the engine/generator set and through regenerative braking. On site "plug-in" charging may also be used to recharge batteries in some cases.

HEBs have been developed within the last decade and have been commercialized in the last 5 years. Over this period, hybrid-electric drive systems for urban transit buses most commonly included series or parallel platforms. Hybrid-electric drive systems are designed in many different configurations, incorporating compressed natural gas, liquid natural gas, gasoline, or propane engines, as well as turbines and fuel cells into the overall HEB platform. HEB platforms are designed so that the system achieves maximum fuel economy and emission benefits. This is done by typically incorporating smaller, medium-heavy duty engines (Cummins ISB 5.9 liter, Detroit Diesel Series 30, etc.) into the hybrid-electric drive system assisted by the power generated from the batteries. In general a HEB can achieve top speed, range, and acceleration equal to or better than a conventional diesel bus.

Several demonstration projects with hybrid-electric buses are underway with promising results. Preliminary reports indicate that the higher efficiencies associated with hybrid-electric technology, compared to conventional diesel technology, can reduce fuel consumption by 25 percent, and reduce emissions of NOx by about 50 percent. In addition, an engine operating in a hybrid-electric vehicle generally operates in a limited operating range. Therefore, without the severe transient parameters that typically accompany urban bus operation,

exhaust aftertreatment could be designed far more efficiently. Significant emphasis is being placed on cost reductions for future hybrid-electric buses.

Hybrid-electric drive systems are rapidly changing to improve energy management -- storage, regeneration and fuel economy, which will translate to greater emission reductions. Part of the challenge in developing a certification procedure is designing a method that quantifies full emission benefits of the technology that are comparable with the various HEB platforms and are fully enforceable, while considering rapid modifications and improvements in the technology. Currently, manufacturers have one option for certifying an HEB – apply for certification to ARB on a case-by-case basis. Current procedures are engine-based and an HEB would be certified at a level that does not represent actual emission benefits of the HEB. Although recent ARB tests of HEBs being demonstrated in California indicate substantial emission reductions, these conclusions have been based on a few results and do not include all types of HEB platforms available for commercialization. Hence, staff believes it is appropriate to propose an interim certification procedure for three years. This would allow ARB to work closely with manufacturers to determine whether modifications or more appropriate requirements are warranted.

V. ISSUES

Staff held three public workshops to discuss proposals for amending the Public Transit Bus Fleet Rule and one workshop with two stakeholders meetings to discuss the proposed interim certification procedures for HEBs. This chapter describes the issues that remain after consideration of public comments.

A. Buses that Should be Included in the Total Diesel PM Emissions Calculation

The original regulation included a provision that exempted transit agencies from retrofitting buses within one year (alternative fuel path) or two years (diesel path) of retirement. This provision has been removed from the proposed amendments, because the total diesel PM emission reduction approach allows maximum flexibility in choosing how to comply. Some transit agencies have argued that buses within one year of retirement should not be included in the calculations of diesel PM. In addition, some transit agencies have argued that new buses, on order but not yet in operation, should be figured in the diesel PM calculation, instead of the old buses those will replace. Finally, others have argued that PM emissions from alternative fuel buses should be included in the calculations.

Staff has considered these requests and does not feel that they are necessary or wise. Allowing a transit agency to remove certain buses from its calculations of total diesel PM emissions, based on an anticipated bus retirement date, would be contrary to the goal of reducing diesel PM emissions from each transit agency's fleet, as the transit agency would be able to continue to operate certain buses, without counting them in its total diesel PM emissions, for up to one year. In addition, allowing a transit agency to include a bus that has not yet been received, but not count a bus that is being operated in anticipation that it will be replaced, would not make sense. Bus delivery schedules change, and thus a bus anticipated to be delivered by one date may not arrive for several months, and may not be fully operational for several more months.

Finally, alternative fuel buses do not emit diesel PM, thus it is not appropriate to include their PM emissions in the calculation of diesel PM emissions. Staff has considered including alternative fuel buses in the calculation of total diesel PM emissions with "zero" diesel PM emissions, to provide an additional incentive to transit agencies to purchase alternative fuel buses. This approach, however, could encourage transit agencies with alternative fuel buses to keep the oldest, highest emitting diesel buses in their fleets because those emissions would be offset by the "zero" emissions from alternative fuel buses. A regulation that allows transit agencies to offset high-emitting diesel buses with alternative fuel

buses would have the negative effect of allowing people who ride on those diesel buses to continue to be exposed to the health impacts of breathing higher levels of diesel PM. Staff is already providing a different implementation schedule for transit agencies on the alternative fuel path, thus retaining the incentive to those agencies provided in the original rule.

B. Baseline Emission Year that Should be Used

Staff proposed that the baseline year, against which reductions are measured, be January 1, 2002. Staff chose this year because it was prior to the mandated retrofit date of January 1, 2003, for all Tier 1 and some Tier 2 buses. Staff requested comments from transit agencies if another year, such as January 1, 2001, would be better for calculating a baseline. Staff specifically requested that transit agencies "do the calculations" and tell us if one date would be more advantageous than another for their agency.

Staff received two comments that an earlier year, before January 1, 2002, might be a better date for determining a total PM emissions baseline for transit agencies. However, no analysis was provided to ARB to back up this assertion. Furthermore, no specific examples of any transit agency for which a different baseline year might be better were provided. Out of the eight comment letters received, no transit agency provided evidence that a more appropriate date was better for its agency or any other transit agency.

Staff, however, did analyze the impact of a baseline date of January 1, 2001, on the emissions benefits. Based on the analysis conducted, staff determined that there would be a small negative impact on the ultimate diesel PM reductions if we use this date as a baseline instead of January 1, 2002. Staff, therefore, concluded that the January 1, 2002, baseline date for total PM emissions is the most appropriate date, was acceptable to transit agencies, and provides a small additional benefit over the January 1, 2001 baseline.

C. Request for Allowing Credit for Buses Rebuilt/Retrofitted Using a Certified Kit Under the U.S. EPA Mandated Program

In a related comment, some transit agencies requested that ARB allow credit for bus engines that have had their PM reduced through installation of a rebuild/retrofit kit, perhaps by removing these buses from the total diesel PM calculation. These kits were mandated by the U. S. EPA urban bus retrofit/rebuild program, which in California applies to 1990[4] and earlier model-

[4] The U.S. EPA requires retrofit kits for 1994 and earlier model year urban bus engines whose engines are rebuilt or replaced after January 1, 1995.

year urban bus engines. In California urban bus engines are required to meet a 0.10 g/hb-hr standard in 1991, two years earlier than the federally-adopted 0.10 g/bhp-hr standard went into effect. Many transit agencies have already complied with this program by installing retrofit/rebuild kits on their bus engines. The original regulation included a provision that such a bus, which had its PM emissions reduced to 0.10 g/bhp-hr from 0.60 g/bhp-hr, did not need to be further retrofitted.

Staff does not believe it is wise to allow what would be retroactive credit for these buses for several reasons. First, the U. S. EPA rule applies in California to 1993 and earlier model-year bus engines. Over the life of this program, from 2004 through 2009, these buses will reach the end of their useful lifetimes and should be removed from transit bus fleets or the engines should be repowered. The second reason pertains to which baseline year and buses should be included in the calculations. Since the goal is to reduce diesel PM from transit bus fleets, staff believes that these buses should remain in the calculation of diesel PM emissions. Furthermore, if necessary to achieve the overall program goals, transit agencies may have to retire the buses or repower the engines to reduce the overall total diesel PM emissions from their fleets.

D. Allow All Transit Agencies the Option of Switching to the Alternative Fuel Path

Several comments requested that all transit agencies be given the option of changing fuel paths. The option should remain the same as currently required. Staff has examined all available options (including the option in the proposed amendments), and concluded that providing only the SCAQMD with the option of changing from the diesel fuel path to the alternative fuel path would have the least negative impact on the anticipated benefits of the current regulation.

The current regulation has a schedule that requires the purchase and demonstration of ZEBs in transit fleets depending on the fuel path selected. Allowing all transit agencies the option of changing to the alternative fuel path could have the negative effect of slowing the ZEB demonstration by reducing the number of transit agencies required to participate and delaying purchase requirements. Providing the six transit agencies in the SCQMD the option to switch to the alternative fuel path would have no effect on the ZEB demonstration and purchase provisions, with little effect on the reduction of diesel PM emissions.

Furthermore, transit agencies in the SCAQMD requested that they be allowed to change their fuel path because of the timing of adoption of SCAQMD Rule 1192 and ARB's Public Transit Bus Fleet Rule. Rule 1192 was adopted June 16, 2000, six months before transit agencies had to choose their fuel path under ARB's Public Transit Bus Fleet Rule. Thus, some of those transit agencies

believe there was insufficient time to consider the dual impacts of Rule 1192 and ARB's rule. In addition, the six SCAQMD transit agencies that chose the diesel path and are subject to Rule 1192 have been required to purchase alternative fuel buses – Long Beach Transit since June 16, 2000, and the other five transit agencies since July 1, 2001. Thus, these transit agencies are already making current and future purchase decisions in line with the alternative fuel path requirements.

E. Proposed Useful Life, Durability, and Emissions Warranty Are Too Stringent to Allow the HEB Technology Into the Market Place

The conventional approach for certification would be to require manufacturers to certify with full useful life, durability and emission warranty requirements. Staff worked closely with manufacturers and determined that a different approach was necessary in order to introduce this viable technology into California's market.

Staff understands that reliability is critical to transit agencies and that market flexibility is critical to manufacturers. As such, staff's proposal is designed to provide manufacturers with flexibility, while providing urban transit agencies with reliability. In the first 3 years (the interim period), staff's proposal allows manufacturers to meet a shorter useful life (when compared to conventional useful life requirements for an urban bus): 150,000 miles or 5 years. Recognizing that HEBs are new, limited in quantity, and have not been in operation long enough to determine durability, staff's proposal allows manufacturers with less than 50 HEBs sold in California during the interim period to be exempt from durability requirements. After the interim period, manufacturers are expected to meet the full certification requirements already adopted for urban bus engines.

F. HEBs Should Be Verified Following Retrofit Procedures

One manufacturer requested that ARB allow HEBs to be certified following the Regulation for the Verification Procedure for In-Use Strategies to Control Emissions from Diesel Engines approved by the Board May 16, 2002. The, verification procedures were designed with the intent to certify both PM and NOx retrofit devices. While the hybrid-electric drive system may be both a PM and a NOx reduction device, issues associated with hybrid systems can be significantly different than those related with aftermarket retrofits, such as DPFs. The current verification procedures may not be the appropriate avenue for verifying emissions from HEBs. Staff, is willing to work with manufacturers to determine a more appropriate method, outside of this proposal and within the context of another protocol.

G. Chassis Testing May Be too Costly for Measuring Exhaust Emission Standards from HEBs

Since typically, heavy-duty and urban bus engines are certified following an engine dynamometer test procedure resulting in engine-based standards (measured in g/bhp-hr), and have not been correlated to chassis dynamometer tests, some manufacturers believe that it may be too costly to follow chassis-based test procedures. Although chassis test results have not been correlated to engine-based test standards, HEBs incorporate a technology by which actual emission benefits could not be measured following engine-based procedures.

Several options are available to manufacturers, however. Currently, manufacturers have the option of certifying HEBs following already adopted engine-based procedure, as long as the engine is certified to meet the urban transit bus regulations. Furthermore, a technology that may not fall in the category of an engine, i.e. a fuel cell or a turbine, may also certify to the urban bus standards on a case-by-case basis, as approved by ARB's Executive Officer. While less costly, testing the engine used in an HEB solely following an engine-based test procedure would result in values that may not account for full emission benefits provided by the hybrid-electric drive system. An engine certification may not account for the power provided by the electric drive components, which offsets some of the load on the engine, thus reducing emissions. Recognizing the emission reduction potential of hybrid-electric drive system technology, ARB has provided manufacturers with the option of claiming a 25 percent emission reduction from the engine certification standard for a certified engine used in the HEB. To provide manufacturers with additional flexibility, staff has proposed to extend the 25 percent reduction claim through the interim period (3 years). This would relieve some of the costs associated with conducting a chassis-based test during the interim.

It has been a challenge to design a chassis-based test procedure that could be correlated to engine-based certification standards, considering the costs. Staff worked closely with manufacturers to develop a protocol that would balance economics, yet best represent actual benefits of the technology. One manufacturer recommended the use of an emission factor ratio in conjunction with the engine certification and chassis test results as a method for determining actual emissions. Recognizing the lack of data available to correlate chassis-based emission results with engine-based emission standards for HEBs, and the rapid change in technology, staff's proposal incorporates the manufacturer's recommendation with the goal of achieving enough data to develop a correlation. These data are necessary for staff to make a determination on the appropriateness of the certification procedure and the need for future modifications. It is important to recognize that this proposal is considered voluntary, since manufacturers currently have other options available to certify the technology on a case-by-case basis.

VI. REGULATORY ALTERNATIVES

A. Change PM Retrofit Schedule

Staff initially considered modifying the existing PM retrofit schedule to match its best predictions on when technology would be available for the older, pre-1994, engines. At this time, no PM retrofit device that reduces diesel PM by 85 percent or more is available and verified for engines older than 1994 or for any two-stroke engines. In addition, no technology is verified at any level, although that may change, for engines older than 1994. Staff rejected this alternative because it does not address the problem of reducing emissions from the oldest, dirtiest engines, and it relies completely on retrofit technology. This alternative would not be as effective, therefore, as the proposal.

B. Declining PM Fleet Average

Staff also considered and rejected a declining PM fleet average based on setting a PM fleet average that every transit agency must meet or a percentage reduction from baseline. This alternative was rejected because neither approach obtained as much reductions in diesel PM as the preferred alternative.

For example, setting the first maximum fleet average of 0.2 g/bhp-hr to be met in 2004 would require only 10 transit agencies to reduce their PM fleet average, some of which currently have a PM fleet average of 0.6 g/bhp-hr or more. Since those fleets with a fleet average of 0.6 g/bhp-hr or more are made up of the oldest engines, the only option available to the transit agency would be purchase of new engines or complete buses. Thus, the ten dirtiest transit agencies would have to reduce their diesel PM but no other transit agency would have to take any action, and the cost of reducing emissions, using the methods open to those transit agencies, would be very high.

Setting a maximum fleet average of 0.1 g/bhp-hr to be met, for example in 2006 (with a declining PM fleet average over time), would require an additional 13 transit agencies to take action. Again, the options open to these transit agencies would be limited to replacement of the oldest engines with new engines, a very costly proposal.

Thus, the effect of this type of a declining PM fleet average is that a transit agency that already has relatively low average PM emissions would not have to take any action for several years. Following the same schedule, the next cut-point would be set at 0.05 g/bhp-hr, which would require 24 transit agencies to reduce emissions. Within this group, large numbers of engines can be retrofitted

with verified diesel particulate filters, allowing these transit agencies to utilize verified diesel emission control technologies.

Another approach, the declining PM fleet average based on percentage reductions, was rejected because some transit agencies would be unable to comply with the intermediate compliance deadlines. These transit agencies made the decision to purchase alternative fuel buses some years ago but maintain a small number (relative to the size of the fleet) of older diesel buses. Because most or all of these buses are in the same age class, the diesel PM fleet average does not change until all of the buses are gone from the fleet. Therefore, to meet even the first requirement would mean the transit agency would have to retire and replace every one of these buses. This approach is therefore infeasible.

In conclusion, staff did not select this approach because it would be very costly for many transit agencies. It would also allow most transit agencies to delay action for many years, placing the burden of reducing emissions mainly on the smaller transit agencies with the oldest engines. Finally, communities and individuals would be impacted unequally.

C. Interim Certification for HEBs Following Chassis Test Procedure Without Emission Factor Ratio

Staff considered allowing interim certification for HEBs following a chassis-based test procedure, without using the proposed emission factor ratio. Following this approach would yield test results in grams/mile. Currently emission standards for urban transit buses are engine-based standards and measured in units of g/bhp-hr. With emission standards changing and technology evolving rapidly, insufficient data is available that accurately correlates engine-based standards with chassis-based test results.

To provide leniency, staff has provided manufacturers with an option of claiming a 25 percent reduction in lieu of testing during a 3-year interim period. In order to allow manufacturers to claim a larger emission reduction, however, ARB must validate emissions to ensure emission benefits are real and enforceable. Hence, staff selected an approach that incorporates an emission factor ratio. The emission factor ratio is designed to use both an engine dynamometer test and a chassis dynamometer test. The engine factor ratio correlates the overall chassis dynamometer results to certification levels in units of g/bhp-hr (engine certification result). Staff believes that the proposed interim certification procedure would provide data to correlate both types of emissions tests. Furthermore, in the interim the procedure would allow staff to gather more data to determine whether the correlation is appropriate or modification is necessary.

D. Continue Allowing 25 Percent Emission Reduction Claim Without Interim Certification

Staff also considered allowing manufacturers to claim the 25 percent reduction, as granted by the Executive Officer, instead of interim certification. While this approach would cost less, and seems simple compared with staff's proposal, it would not account for the true benefit of the HEB. Preliminary test data indicates that many HEBs could reduce NOx emissions from diesel engines by about 50 percent.

Secondly, HEBs typically incorporate medium-duty diesel engines as part of the hybrid-electric drive system. These engines are not certified to the urban transit bus standard. Allowing a 25 percent emission reduction would not be enough for HEBs to meet future more stringent standards. Although a 25 percent emission reduction claim in the interim may be sufficient to encourage sale of HEBs, in the long term enforceability would be a challenge. Solely allowing a percent emission reduction claim does not include durability, useful life, in-use testing, and warranty requirements as those typically written into an interim certification procedure.

VII. ECONOMIC IMPACTS

The proposed amendments to the Public Transit Fleet Rule and Emission Standards For New Urban Buses regulation will provide transit agencies with greater flexibility to comply with the required emission standards. Staff believes that the proposed amendments would cause no noticeable adverse impacts in California employment, business status, competitiveness or increase costs above those estimated for the Public Transit Bus Fleet Rule and Emission Standards for Urban Buses regulations adopted February 2000.

A. Legal Requirement

Sections 11346.3 and 11346.54 of the Government Code requires state agencies proposing to adopt or amend any administrative regulation to assess the potential for adverse economic impact on California business enterprises and individuals. The assessment shall include consideration of the impact of the proposed regulatory amendments on California jobs; business expansion, elimination, or creation; and, the ability of California businesses to compete in other states.

State agencies are also required to estimate the cost or savings to any state or local agency and school district in accordance with instructions adopted by the Department of Finance. This estimate is to include nondiscretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

B. Affected Businesses

Businesses that may be affected as a results of the proposed regulatory amendments include manufacturers of heavy-duty diesel or alternative fuel bus engines, urban buses, hybrid-electric buses, micro turbines, fuel cells, electric drives, engine retrofit kits, and exhaust aftertreatment devices. Most manufacturers of urban bus engines, hybrid-electric urban transit buses, and aftertreatment devices are located outside of California. There are only three hybrid-electric bus manufacturers and one urban bus manufacturer located in California.

C. Potential Impact on Businesses

The proposed amendments include a modification to allow some transit agencies to change from the “diesel” path to the “alternative fuel” path, establish a new PM

emission reduction requirement, and include an interim certification procedure for hybrid-electric urban transit buses. Since the proposed amendments provide transit agencies with greater flexibility to comply with the required emission standards they are not expected to impose costs above those already estimated for the Public Transit Bus Fleet Rule and Emission Standards for Urban Buses regulations approved February 2000. The proposed amendments could provide cost savings in some cases. (The February 2000 estimated cost per bus ranged from $3,000 to $10,000.) Most impacts to business, both positive and negative, will likely occur in other states.

Testing of hybrid-electric buses could increase the cost of purchasing a hybrid-electric bus. Manufacturer costs for testing a family of hybrid-electric buses, according to the proposed interim procedure, would range from $70,000 to $120,000 per certification. However, the proposed interim certification procedure would provide manufacturers with a method for demonstrating the full emission benefits achieved by using a hybrid-electric drive system. Manufacturers could opt to certify their hybrid system using current engine-based certification procedures, depending on approval on a case-by-case basis by ARB's Executive Officer.

Since it is not certain how many hybrid-electric buses will be purchased the proportional increased cost of a hybrid bus cannot be determined. A transit agency does not typically cover the total cost of purchasing a new bus. Federal funds are available to cover 80 percent of the total cost of a new diesel urban bus and 83 percent of a new low emission alternative fuel bus. The remaining cost would have to be covered by other funding sources such as state or local incentive programs, transportation planning agencies, transit agencies, and air quality and energy funds. Since transit agencies can make the choice among emission control options, based on their individual transportation planning and operational needs, the increased cost of purchasing a hybrid bus is not considered a significant cost impact.

D. Potential Impact on Business Competitiveness

The proposed amendments are not expected to impact the ability of California businesses to compete with businesses in other states. As indicated above, most businesses that produce products needed to meet the proposed amendments are located in other states. By providing additional options to transit agencies, this proposal may actually provide new opportunities for California business engaged in manufacturing HEBs, hybrid-electric drive systems and respective components, and exhaust aftertreatment devices.

E. Potential Impact on Employment

Manufacturers of HEBs, hybrid-electric drive systems and respective components, and exhaust after treatment devices located in California may increase their production and thus result in the creation of new jobs.

F. Potential Impact on Business Creation, Elimination, or Expansion

The proposed amendments could impact any companies involved in the manufacture and production of heavy-duty alternative fuel urban bus engines, urban buses, HEBs, fuel cells, micro turbines, hybrid-electric drive systems and respective components, and exhaust aftertreatment devices that sell in California. Most manufacturers that could benefit from the potential increase in business created by requiring cleaner engines and buses are located outside of California. There are only three HEB manufacturers and one urban bus manufacturer located in California. To the extent that those business choose to locate in California, or in state business increase production, the amendments could lead to the creation or expansion of businesses in California.

G. Potential Cost to Local and State Agencies

The proposed amendments are not expected to impose additional fiscal impacts on transportation planning agencies, commissions, transit agencies, or the ARB, above those estimated for the implementation or enforcement of the February 2000, Public Transit Bus Fleet Rule and Emission Standards for Urban Buses regulations.

VIII. ENVIRONMENTAL IMPACTS, ENVIRONMENTAL JUSTICE, AND COST-EFFECTIVENESS

This chapter presents the air quality benefits and cost-effectiveness resulting from the implementation of the proposed amendments to the Public Transit Bus Fleet Rule and the interim-certification procedures – "California Exhaust Emission Standards and Test Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, in the Urban Bus and Heavy-duty Vehicle Classes." Adoption of the proposed amendments would continue to provide PM emission reductions close to those anticipated in the original rule, while providing additional flexibility in meeting the requirements. There are no direct air quality benefits resulting from approval of the proposed interim-certification procedure for HEBs. Instead there is a benefit to transit agencies that another control option would be available to comply or potentially go beyond the already approved urban transit bus standards.

A. Air Quality Benefits

1. PM Emission Reduction Proposal

The proposed modifications provide close to the same air quality benefits as anticipated in the original regulation adopted in February 2000. The amendments will reduce the public's exposure to toxic diesel particulate emissions and benefit California's environment. Since February 2000, staff has gained more information about California's transit bus fleet, and ARB's mobile source inventory and modeling capabilities have been further refined. The air quality benefits presented here have been modeled based on the January 31, 2001 and 2002 reports from transit agencies regarding composition of their fleets and the updated mobile source inventory, EMFAC 2001, which has been adopted by the Board.

The original transit bus rule was written to achieve maximum PM and NOx emissions benefits with available technology, while minimizing the economic impact on affected businesses and transit agencies. The proposed amendments were written to maintain that same goal. Each transit agency has the flexibility under the proposed amendments to reduce their total diesel PM emissions by retrofitting, retiring, or replacing the bus engines. Staff assumes that transit agencies will retrofit newer engines, retire older buses, and repower older buses with new engines under this proposal.

In the original rule, retrofit devices that reduce diesel PM by 85 percent or more were to be installed on engines beginning in 2002. By January 1, 2003, all pre-

1991 MY engines (Tier 1) were to be retrofitted. Tier 2 engines, comprising 1991 to 1995 MYs, were to be retrofitted in phases (Chapter II, Table 4), with the first phase implemented as of January 1, 2003. The rule allowed for a one year delay in retrofitting if no technology was available within six months of the applicable compliance dates.

When no technology achieving an 85 percent PM reduction was verified by ARB staff by January 1, 2002 for any pre-1994 MY or two-stroke engine, staff concluded that the benefits of the rule would be less than expected. Staff evaluated the status of the technology and, at the March 21, 2002 meeting of the Board, staff reported that it did not expect to see any 85 percent diesel PM reduction technology verified for these older engines in 2002, and possibly not in the near future. The Board directed staff to revise the rule to recapture the diesel PM reductions that were not going to be achieved because of the lack of verified PM reduction technology for older bus engines.

The proposed amendments achieve slightly more emissions reductions after 2005, compared to the original regulations. Prior to 2005, the benefits will be less than the original regulation. Two factors account for the smaller emission reductions prior to 2005: the lack of technology to retrofit older engines now, and the need to provide transit agencies additional time to obtain funding to replace older engines.

The proposed amendments seek to balance the need to reduce diesel PM emissions as much as technologically feasible with the need for flexibility in achieving those reductions. A mandatory progressive reduction in total diesel PM emissions will require transit agencies to use a variety of approaches to strike a balance between retiring the oldest buses, repowering buses that have remaining useful life, and retrofitting the newer buses (1994 MY and newer engines) for which there are verified diesel emission reduction devices. Although the minimum useful life for a transit bus is twelve years, transit agencies report that many of the oldest buses are kept much longer. Providing for a flexible implementation schedule will allow transit agencies the time necessary to replace these older buses, or repower them.

The ARB staff estimates that the proposed amendments will reduce PM emissions statewide in 2010 by approximately 180 lbs/day (33.4 tons per year). Staff recalculated the baseline emissions from transit buses using an improved model and better data. New information received from transit agencies in 2001 and 2002 showed that the transit bus population was significantly lower than assumed for the original staff report. In addition, emission factors and annual mileage have changed, based on research into emissions and reports from transit agencies. Finally, EMFAC 2001 has been approved thus staff took this opportunity to recalculate an improved baseline inventory on which to base the analysis for these proposed amendments (see Appendix E).

With no PM retrofit and only emission reductions from new transit bus engine standards, the total statewide PM emissions would be 300 lbs/day in 2005 and 239 lbs/day in 2010 (Baseline, Figure 4, Table 8). With full implementation of the original rule, the statewide PM emissions would drop to 125 lbs/day in 2005 and 68 lb/day in 2010 (Current, Figure 4). With the proposed amendments, PM emissions are 15 lbs/day higher in 2005 than was expected with the current rule, and 12 lbs/day lower by 2010 (Proposed, Figure 4). In devising the scenario for this comparison, staff assumed a ten percent allowance for delays and exemptions from rule implementation.

Figure 4: Comparison of PM Emissions Scenarios

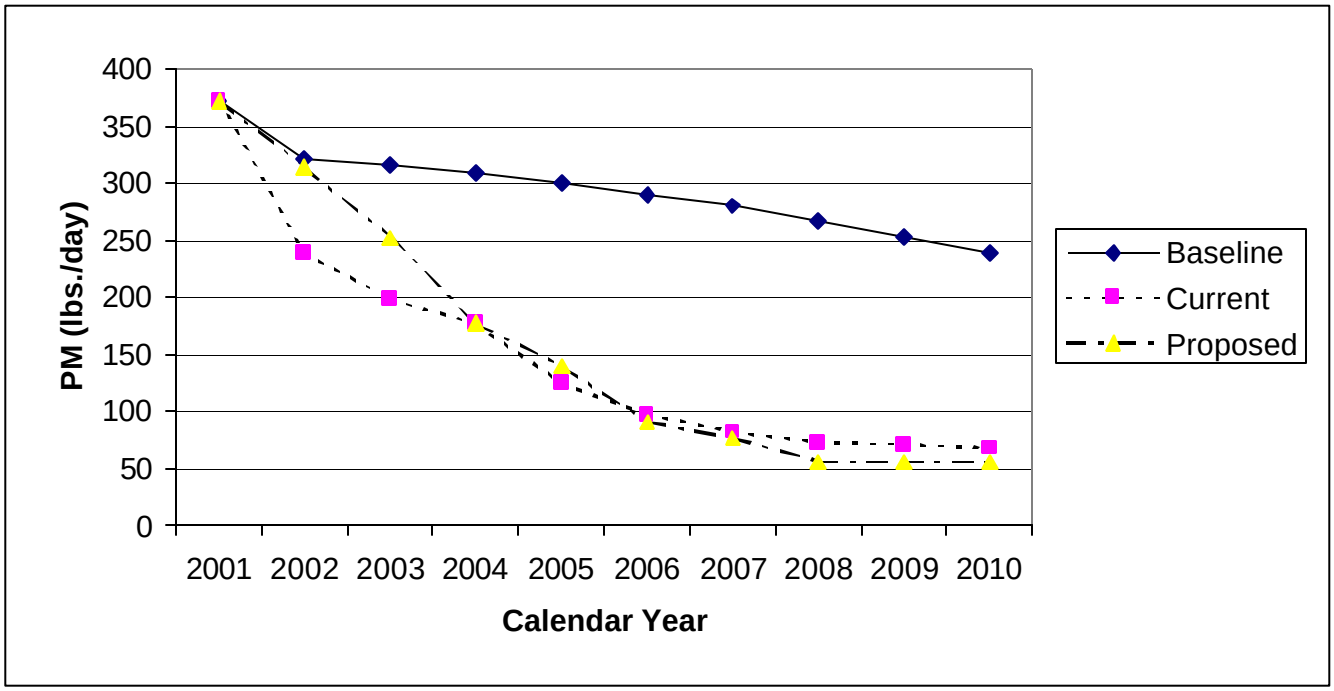


Table 8

Statewide Transit Bus PM Inventory Scenarios (pounds per day)			
Calendar Year	**Baseline Inventory, No Retrofit**	**Current Regulation, Fully Implemented**	**Proposed Amendment**
2005	300	125	140
2010	239	68	56

The original rule included further emission reductions through the demonstration and implementation of zero-emission bus programs beginning in 2003. Combining the zero-emission bus requirement with more stringent NOx and PM emission standards over the next several years, the original transit bus fleet rule was expected to ensure a long-term solution to continued reduction in toxic air contaminants. The proposed modifications will not change the long-term requirements of the original rule or the benefits from the zero-emission bus program. The zero-emission bus requirements will remain the same as adopted in 2000.

2. HEB Interim Certification Procedure

HEBs are one technology that is available for transit agencies to purchase to comply with the Public Transit Bus Fleet Rule. The procedure that certifies HEBs does not itself produce emission benefits. Instead, certification is the method for determining compliance with emission standards. Hence, no air quality benefits have been calculated or considered to be associated with approval of staff's proposed interim certification procedure for HEBs.

B. Environmental Justice

The proposed amendments provide urban transit agencies with greater flexibility to meet current regulations and were designed to achieve PM emission reductions similar to those anticipated in the February 2000 rulemaking. The proposed amendments regulate all transit agencies throughout the state to ensure that emission benefits are achieved for all Californians. In addition, urban transit buses transport people every day to destinations in various communities throughout California; hence, environmental impacts resulting from the proposed amendments would affect all communities where urban transit buses travel.

C. Cost-Effectiveness

1. PM Emission Reduction Proposal

The goal of the proposed amendments is to achieve benefits that are as close as possible to those anticipated in the February 2000 rulemaking. The estimated costs to transportation planning agencies, commissions, and transit agencies would be about $2.5 million per year to comply with the requirements in the February 2000 rulemaking. Total estimated costs per bus ranges from about $3,000 to $10,000 dollars. Furthermore, the cost-effectiveness for the PM retrofit requirements average about $17.90 per pound of PM reduced annually from 2003 to 2009.

Staff has determined that while costs per bus would remain within the same range for implementation of the proposed amendments, the cost per pound of PM reduced (cost-effectiveness) may increase. The cost-effectiveness each year from 2003 to 2009, based on the median cost option (Appendix F), would range from $13.67 to 32.77 per pound of PM reduced, with an average cost-effectiveness of $25.23 per pound (Table 9). Staff also calculated a low cost scenario, which resulted in an average cost-effectiveness of $10.91 per pound, and a high cost scenario, which resulted in an average cost-effectiveness of $44.51 per pound of PM reduced.

Table 9

Average Cost-Effectiveness 2003 - 2009			
	Low Cost	**Median Cost**	**High Cost**
Cost per Pound	$10.91	$25.23	$44.51

The original cost-effectiveness of $17.90 per pound is within the range of the recalculated cost-effectiveness range for these amendments. The slightly higher estimated cost-effectiveness for these amendments is caused by a combination of revised assumptions regarding emission benefits and costs (for example the lifetime of the DPF, the number of buses that would be retrofitted each year, and the cost of maintenance of the DPF). In determining the revised cost-effectiveness, staff used the updated EMFAC 2001 model and the updated transit bus inventory, which are based on reports from transit agencies.

Staff assumed that the current cost of a DPF is $5,500 and the future cost could be as low as $1,100. A median cost of $3,000 was used as an average of current and future costs to calculate the median average cost-effectiveness over the life of the rule. Staff also assumed that only model year 1994 through 2002 engines would be retrofitted, as these are the only engines from which verified technology is available. Staff has determined that it is unlikely that a DPF would be available for older buses. While older buses could be retrofitted with oxidation catalysts, most older transit buses have already been retrofitted under the U.S. EPA Urban Bus Retrofit/Rebuild Program. Those that have not yet been retrofitted with an oxidation catalyst represent a small portion of the urban buses. Newer buses would also not be retrofitted. Bus engines produced after October 1, 2002, are required to meet an engine standard for PM of 0.01 g/bhp-hr which requires use of a particulate filter.

Transit agencies may also retire their oldest buses, and replace engines in buses with remaining useful life with newer engines (repower). An engine repower may also extend the useful life of a bus if additional improvements are made at the

same time as the engine repower. Staff did not count the cost of bus retirement in this cost-effectiveness calculation as staff anticipates that those buses retired will have already exceeded their useful Federal minimum lifetime. Transit agencies have access to Federal funds for 80 to 83 percent of the cost of new buses, with State and local funding making up the balance of the cost. Likewise, a repower can qualify for Federal, State, and local funds, with 50 to 100 percent of the cost being covered (Appendix F, Table 1). In either bus retirement or engine repower the transit agency realizes significant savings in fuel economy and maintenance. Over the life of the engine, these savings often pay for the portion of the cost that is not covered by Federal funding. Consequently, staff did not include the cost of bus retirement or engine repower in calculating cost-effectiveness.

As with the original regulation, the cost-effectiveness of the proposed modifications does not include the value of health benefits associated with a reduction in exposure to a toxic air contaminant. While assessing the health benefits of PM control continues to be an important part of the ARB's risk management process, the benefits of the proposed transit rule modifications are not part of this cost-effectiveness determination.

2. HEB Interim Certification Procedure

When staff proposes rules that set new technology enforcing standards, costs associated with compliance of the standards are typically calculated. In February 2000, when staff proposed the rules setting future more stringent standards for urban transit buses and the fleet rule for public transit agencies, HEBs were considered a future control technology available for transit agencies to achieve the standards. However, no certification procedures were available to certify HEBs at the time the rule was approved.

The proposed interim certification for HEBs is voluntary. Staff's proposal provides manufacturers with an approach for certifying full emission benefits of HEBs. Furthermore, certified HEBs provide transit agencies with another control option for complying with the already approved Public Transit Bus Fleet Rule. Because the interim certification procedure is not setting new emission standards and thus no direct emissions benefits are associated with the proposal, no traditional cost-effectiveness can be calculated. Since staff's proposal for certifying HEBs is considered voluntary, there will be no economic impacts associated with reasonable compliance with interim certification of HEBs.

IX. SUMMARY AND STAFF RECOMMENDATION

A. Summary of Staff's Proposal

As presented in the previous chapters, ARB staff's proposed modifications to the Public Transit Fleet Rule are designed to reduce PM emissions to a level as close as possible as those anticipated from the already approved February 2000 Public Transit Fleet Rule. Furthermore, they are designed to provide transit agencies with additional flexibility in meeting PM retrofit requirements by allowing transit districts to achieve a PM emission reduction from its January 1, 2002, total PM emission baseline. The proposed amendments allow transit agencies in the South Coast the opportunity to switch from the diesel path to the alternative fuel path. Lastly, the proposed modifications introduce new definitions for clarification of already adopted fleet rule, and an interim certification procedure for HEBs.

B. Staff Recommendation

The ARB staff recommends that the Board adopt modifications to 1956.1, 1956.2, 1956.4, 1956.8, and 2112, title 13, California Code of Regulations, and the new incorporated "California Interim Certification Procedures for 2004 and Subsequent Model Hybrid-Electric Vehicles, in the Urban and Heavy-duty Vehicle Classes." The modifications to the regulations are set forth in the proposed regulation Order in Appendix A. The proposed incorporated test procedures for HEBs are set forth in Appendix B.

X. REFERENCES

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