

California Air Resources Board

School Bus Emission Reduction Programs

Report to the California Legislature

January 2008



This report has been reviewed by the staff of the California Air Resources Board (ARB) and approved for publication. To obtain this report in an alternative format, please contact the ARB ADA Coordinator at (916) 322-8168.

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Report to the California Legislature on
California Air Resources Board
School Bus Emission Reduction Programs

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I. Executive Summary

Over the past seven years, the California Legislature has funded efforts to reduce air pollution caused by California's public school bus fleet. The California Air Resources Board (ARB or Board), the local air pollution control districts, the California Energy Commission (CEC), California's school districts, and other State and local government entities have established various programs to carry out the Legislature's mandates in this area. The pollutant of most concern is diesel particulate matter or diesel PM. In a Supplemental Report to the 2007 Budget Act, the Legislature requested the following information relating to ARB's efforts:

By January 10, 2008, the Air Resources Board shall report to the Legislature on its program to enforce the proper maintenance and emission reporting of school buses. The report shall include an accounting of the total amount of school buses surveyed, the amount of buses that were found in violation, a description of each violation and the penalty assessed, and, if applicable, a description of the action(s) that were taken to prevent the future occurrence of said violation(s). The report shall also include any recommendations to the Legislature as to how the Board's monitoring and enforcement program could be strengthened or improved to ensure that all school buses are properly maintained for the public health and safety of riders.

ARB enforces several regulations to control school bus emissions. These include emission standards that apply to heavy-duty diesel school bus engines, regulations that restrict school bus idling, and regulations that establish the Heavy-Duty Vehicle Inspection Program (HDVIP), which is the roadside truck exhaust smoke opacity tests conducted by ARB, and Periodic Smoke Inspection Program (PSIP), which is the testing conducted by every fleet owner and audited by ARB. ARB has surveyed approximately 27,000 school buses pursuant to these regulations, and has found relatively few violations, including no violations of tampering of the engine emission equipment. Eighteen violations of the school bus idling regulations were discovered, however. Two violations of the heavy-duty vehicle inspection regulations and 589 violations of the periodic smoke inspection regulations involving school buses were also found. In each of these cases penalties were assessed and the violations were corrected.

The regulations ARB enforces in this area are necessary, and appear to have their intended effect of deterring most violations while punishing and correcting those that do occur. Accordingly, ARB has no recommendations for how the Legislature might strengthen or improve these enforcement programs. Based on its experience administering the Lower-Emission School Bus Program, however, ARB notes that strategies to accelerate the retirement of older, high-emitting buses so they may be replaced with new buses certified to ARB's current, low emission standards have merit, as do strategies to retrofit older buses with diesel emission control devices. Both show promise to further protect school children as well as the general public from exposures to school bus diesel PM.

II. Background

Diesel engines emit a complex mixture of air pollutants composed of gaseous and solid materials. The solid fraction of diesel exhaust is called diesel particulate matter or diesel PM. In 1998, ARB identified diesel PM as a toxic air contaminant regulation (Title 17, California Code of Regulations, section 93000) because of its potential to cause cancer and a host of other health problems. Subsequent research indicates that exposure to diesel PM also has serious acute health consequences, including cardiopulmonary effects and the exacerbation of asthma. Children are especially vulnerable to the ill effects of diesel PM because they suffer exposures while their lungs are developing. Children have higher inhalation rates, narrower airways, and less mature immune systems than adults do, which also make them especially susceptible to diesel PM. Oxides of nitrogen (NO_x) emitted by diesel engines frustrate California's efforts to attain air quality standards for photochemical ozone. High levels of ozone also have disproportionate impacts on children.

Heavy-duty school buses are mainly powered by diesel engines that are subject to the same emission standards that apply to heavy-duty truck engines. As discussed in more detail in the next section of this report, older, diesel-fueled school buses—those manufactured before the 1987 model year—emit high levels of both diesel particulate matter and oxides of nitrogen. In 2003 concerns about the health effects of diesel bus particulate pollution on school children led the ARB, the South Coast Air Quality Management District, and the United States Environmental Protection Agency to sponsor a study at the University of California (UC). The 2003 UC study concluded that diesel PM pollution inside California's school buses was likely to be worse than levels found in ambient roadway air. The study found that in-bus pollution came from several sources: driving through polluted areas, following behind high-emitting vehicles, and diesel PM emissions from the school buses' own engines that enter the buses' passenger cabins, especially in older, higher-emitting buses. The study recommended that: school bus-related exposures be reduced by assigning the newest and cleanest buses to the longest routes, that conventional, uncontrolled diesel school buses be replaced with buses powered by natural gas or retrofitted with particulate traps, and diesel school buses should be properly maintained to reduce visible exhaust, as required in the HDVIP and PSIP programs.

III. ARB's School Bus Programs

A. Introduction

ARB operates programs to lower emissions of diesel PM from the school bus fleet. These include ARB's emission standards and the Lower-Emission School Bus Program that seeks to maximize their effect. ARB also enforces restrictions on diesel vehicle idling near schools and operates the HDVIP and PSIP programs to ensure that the on-road diesel fleet is properly maintained and operating as cleanly as possible from an air quality perspective.

B. Emission Standards, the Retirement or Retrofit of Older, Higher-Emitting Buses and the Lower-Emission School Bus Program

1. Emission Standards, Vehicle Retirement and Retrofit

Before 1987, emissions of PM and NO_x from heavy-duty diesel engines were uncontrolled, but as Table 1 shows, that is no longer the case. ARB's heavy-duty diesel emission standards were optional in the 1987 model year, became mandatory in the 1988 model year, and ARB has tightened them considerably over time. Although ARB has discovered violations of the NO_x standards for diesel engines in its in-use compliance program and prosecuted them, it has not found violations of the PM standards to date.

Table 1 shows historical and current emission standards for NO_x and PM for diesel engines used in school buses and other heavy duty vehicles. A new school bus certified to current ARB standards emits 98 percent less toxic diesel PM, and nearly 80 percent less smog-forming NO_x, than one manufactured in the late 1980s. Speeding the removal of old school buses from the road and replacing them with new buses that meet current, stringent emission standards are crucial to reducing emissions of diesel PM and NO_x and the health threats these emissions pose to all Californians, especially school children.

Table 1: California Heavy-Duty Diesel Engine Emission Standards
(Engines used in vehicles with Gross Vehicle Weight Ratings
greater than 14,000 pounds, excluding urban bus engines.)

Model Year	PM (g/bhp-hr)	NO _x (g/bhp-hr)	NO _x + NMHC (g/bhp-hr)
1988 ^(a) - 1990	0.60	6.0	---
1991 - 1993	0.25	5.0	---
1994 - 1997	0.10	5.0	---
1998 - 2003	0.10	4.0	---
2004 - 2006	0.10	---	2.5 ^(b)
2007 - 2009	0.01	1.2 ^(c)	---
2010	0.01	0.2	---

(a) Manufacturers had the option of certifying 1987 model year engines to the 1988 standards one year early.

(b) This is the standard for the arithmetic sum of the oxides of nitrogen exhaust component certification value and the non-methane hydrocarbon exhaust component certification value, with the non-methane hydrocarbon individual component value not to exceed 0.5 g/bhp-hr.

(c) This is an emissions level. Between 2007 and 2009, ARB requires 50 percent of Heavy-Duty Diesel Engines (HDDE) family certifications to meet the 0.2 g/bhp-hr NO_x standard for 2010 model year engines. The other 50 percent may continue to meet the 2.5 g/bhp-hr NO_x+NMHC standard for 2006 model year engines. Averaging is allowed, and in practice, most 2007 model year diesel truck engines are certifying at a NO_x level around 1.2 g/bhp-hr. Model year 2007 school bus engines have been certifying at levels slightly higher than average, with a range of 1.1 to 2.2 g/bhp-hr.

Eventually, ARB's emission standards will produce a much cleaner on-road, heavy-duty diesel fleet. However, school buses accumulate mileage much more slowly than other heavy-duty diesel vehicles do because their duty cycles are shorter. These lower mileage accumulations, combined with the high purchase prices of new buses (which range in from \$125,000 to \$145,000 each), and the fiscal challenges facing California's schools, make it common for old high-emitting buses to remain in service for periods in excess of 25 years, delaying the impact of ARB's emission standards, which rely on vehicle turnover to have full effect. And, as the 2003 UC study shows, these aging buses pose the most significant health risks to the children who ride in them. Finding ways to speed the retirement of older, high-emitting school buses is crucial to achieving the emission reductions made possible by ARB's emission standards and lowering health risks attributable to school bus emissions. ARB is doing this in its Lower-Emission School Bus Program described in the following section of this report.

Another way to reduce emissions from the on-road school bus fleet is by installing diesel emission control devices. ARB has adopted regulations (Title 13, California Code of Regulations, Section 2700-2710) that establish a process by which manufacturers of such devices may demonstrate their emission reduction efficiency and obtain ARB's verification. Under these regulations, ARB may verify a range of PM reduction efficiencies, the upper range being greater than 85 percent. NO_x reductions may also be verified. Once a device is verified, its installation may be eligible for funding via various incentive programs, including in ARB's Lower-Emission School Bus Program,

or it may be used to satisfy compliance obligations imposed by other ARB regulations. Averaging approximately \$20,000 per vehicle, retrofits are less expensive than replacing an older bus with a new one.

2. ARB's Lower-Emission School Bus Program

In the FY 2000/01 budget, the California Legislature allocated \$50 million to ARB to establish a Lower-Emission School Bus Program. The Board adopted the Lower-Emission School Bus Program in December 2000. ARB administers this incentive program which was designed to reduce school children's exposure to both diesel PM and smog-forming NOx emissions through two program components:

- a) A school bus purchase and infrastructure component to replace the oldest, highest-polluting buses with new, lower-emitting buses meeting the latest federal motor vehicle safety standards.
- b) A retrofit component to significantly reduce diesel PM emissions from the in-use diesel school bus fleet.

Since its inception in 2000 through June 1, 2007, the Lower-Emissions School Bus Program has replaced approximately 600 older buses with new low-emitting models (including low-sulfur diesel engine equipped buses as well as compressed natural gas models), and has retrofitted close to 4,000 in-use diesel buses. Through State and local funding¹ nearly all of the pre-1977 school buses, that are not only high-polluters but also do not meet minimum federal motor vehicle safety standards, have been retired from public school fleets.

In the FY 2001/02 budget, the Legislature allocated an additional \$16 million. ARB staff, in coordination with CEC and local air pollution control districts, developed guidelines for the program that provide criteria for the purchase of new school buses and retrofits of existing school buses to reduce diesel PM emissions.

In 2002 through 2004, the program received \$10 million of further funding from Proposition 40 (the California Clean Water, Clean Air, Coastal Protection and Safe Neighborhood Parks Bond Act of 2002) for use on new bus purchases.

The State Legislature appropriated, and Governor Schwarzenegger approved, \$25 million in the FY 2005/06 budget for the Lower-Emission School Bus Program. Of these funds, \$12.5 million was for new bus purchases and \$12.5 million to retrofit in-use diesel buses with Level 3 particulate filters. All new bus purchases acquired with these funds were required to replace pre-1977 in-use buses.

Proposition 1B, approved by the voters on November 7, 2006, enacts the Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006. This bond act authorizes \$200 million, appropriated in the FY 2007/08 budget, for

¹ Some purchases have been made using air district vehicle registration fee revenues authorized pursuant to AB 2766, Sher (Chapter 1705, Statutes of 1990) and AB 923, Firebaugh (Chapter 707, Statutes of 2004).

replacing and retrofitting school buses. These funds will replace the remaining pre-1977 school buses from California's fleet.

Throughout the life of this program, ARB has worked with CEC, air districts, and school districts to develop program guidelines and enforce them to ensure effective and cost-effective use of these funds.

For more information on the Lower-Emissions School Bus Program visit <http://www.arb.ca.gov/msprog/schoolbus/schoolbus.htm>

C. ARB's Enforcement Programs

In addition to tightening its emission standards, verifying diesel emission control devices to support various fleet modernization and retrofit programs, and operating the Lower-Emission School Bus Program, ARB has established enforcement programs to specifically target emissions from school buses. These undertakings include the Airborne Toxic Control Measure to Limit School Bus Idling and Idling at Schools, the Heavy-Duty Vehicle Inspection Program, and the Periodic Smoke Inspection Program, which are discussed below, along with the enforcement-related information requested within the Supplemental Budget Report of 2007. Table 2 summarizes this information.

1. Airborne Toxic Control Measure to Limit School Bus Idling and Idling at Schools (Title 13, CCR, Section 2480)

In 2002, ARB approved an airborne toxic control measure (ATCM) that limits school bus idling and other diesel engine idling on or near school grounds. With an effective date July 16, 2003, the ATCM aims to reduce school children's exposure to diesel PM and other air pollutants present in heavy-duty motor vehicle exhaust.

The regulation applies to school buses, transit buses, school pupil activity buses, and other commercial motor vehicles. It requires a driver to manually turn off the bus or vehicle engine upon arriving at a school and to restart it no more than 30 seconds before departing. A driver is subject to the same requirement when operating within 100 feet of a school, and is prohibited from idling for more than five minutes at each stop beyond schools, such as parking or maintenance facilities, school bus stops, or school activity destinations. A driver of a transit bus, or other commercial motor vehicle, is prohibited from idling more than five minutes at each stop within 100 feet of a school. Idling necessary for health, safety, or operational concerns is exempt from these restrictions.

In addition, the ATCM requires a motor carrier of an affected bus or vehicle to ensure that drivers are informed of the idling requirements, to track complaints and enforcement actions, and to keep records of these driver education and tracking activities. Violations of this regulation carry a minimum penalty of \$100 per violation. To facilitate violation reporting, ARB maintains a public complaint website (<http://www.arb.ca.gov/enf/complaints/complaints.htm>) and

toll-free hotline (1-800-END-SMOG). ARB takes enforcement actions based on these complaints.

Statewide enforcement of the school bus idling regulation commenced on July 1, 2004. Since that time ARB has performed more than 4,750 inspections for compliance with idling and/or recordkeeping requirements. Thanks to ARB's early and concerted compliance assistance and enforcement efforts, the compliance rate has been outstanding and stands at over 99 percent today. Only eighteen notices of violation and \$1,800 in penalty assessments have been issued under this program to date.

For more information on the ATCM to Limit School Bus Idling and Idling at Schools visit: <http://www.arb.ca.gov/toxics/sbidling/sbidling.htm>

2. Heavy-Duty Vehicle Inspection Program (*Title 13, CCR, Section 2180*)

The Heavy-Duty Vehicle Inspection Program (HDVIP) requires that heavy-duty trucks and buses be inspected for excessive smoke and engine tampering, engine certification label compliance, and in certain cases, installation of low-NO_x software.² Any heavy-duty vehicles traveling in California, including vehicles registered in other states and foreign countries is subject to testing. Tests are performed by ARB inspection teams at border crossings, California Highway Patrol (CHP) weigh stations, fleet facilities, and randomly selected roadside locations. The smoke opacity test and emissions test equipment specifications for this program are specified in the Society of Automotive Engineers (SAE) J1667 test procedure. ARB is required to use this SAE procedure under the program's governing regulations. If the measured smoke opacity is above the regulated limits, or if engine tampering or other violations are detected, the vehicle owner is cited and fined \$800 (\$500 of which is waived if the cited owner demonstrates that the engine has been repaired and has passed a retest within 45 days of the citation). Subsequent violations within a one-year period are assessed penalties of \$1,800.

Revisions to the regulations governing the HDVIP were adopted in December 1997 and enforcement of the revised program commenced in June 1998. Since that time, more than 170,000 vehicles have been tested—which is approximately 18,000 per year. Due to the high number of tests performed each year, staff does not maintain information relating to vehicle or engine type

² Controlling visible diesel PM through such programs as the HDVIP and PSIP does not directly address all of the health threats posed by diesel PM. One fraction of diesel exhaust is ultrafine diesel PM, which poses a significant health risk due to its chemical composition and its potential to lodge deep in the lungs. The HDVIP and the PSIP programs focus on controlling emissions of visible diesel PM by the use of visual inspections and smoke opacity meters, but unfortunately, ultrafine diesel PM is neither visible to the naked eye nor detectable by smoke opacity equipment. Nevertheless, the HDVIP and the PSIP programs ensure that the on-road fleet is properly maintained and achieves the emission reductions envisioned by ARB's emission standards, which serves to reduce ultrafine diesel PM as well.

for those vehicles that do not violate the smoke opacity standards or other program requirements. So the exact number of school buses tested cannot be determined. However, staff estimates that less than one percent of all heavy-duty vehicles inspected under this program are school buses.

Of the vehicles tested, nearly 8,000 citations have been issued. Only two of these have been issued to school bus owners (one in 2003 and one in 2007), each for excess smoke opacity. As required by AB 1107, Moore, (Chapter 940, Statutes of 1989), the regulation provides an exemption for school bus owners from monetary penalties for the first instance of a violation. In both of these cases, the cited owners demonstrated completion of the necessary repairs and passed the required retest within the allotted 45 days.

For more information on HDVIP visit:

<http://www.arb.ca.gov/msprog/hdvp/hdvp.htm>.

3. Periodic Smoke Inspection Program (*Title 13, CCR, Section 2190*)

The Periodic Smoke Inspection Program (PSIP) regulation requires that owners of California-based fleets of two or more heavy-duty, diesel-powered vehicles with engines four years old and older, including fleets of school buses, perform annual inspections for excessive smoke opacity. Vehicles failing the smoke opacity test must be repaired and retested. Fleet owners are required to maintain specific records regarding their periodic inspections and follow-up repairs. Current penalties are \$500 per violation.

Enforcement of this regulation commenced in 1999 for the general fleet population; however, focused enforcement specific to school bus fleets began in 2003. Inspection audits originally consisted of site visits to school bus fleet terminals, where inspectors checked for paperwork demonstrating that annual opacity testing had been completed and that when a vehicle had failed the test, it had been repaired and retested. Because there are more than 800 school districts within California, on-site audits have not been conducted at each terminal. To improve efficiency, ARB staff has developed, and continues to refine, a reporting process wherein school bus fleets would annually submit compliance information that includes fleet inventory data and actual opacity test results. Inspection staff would then perform follow-up site audits at a sample of the fleets.

Between July 1, 1999, and June 30, 2004, ARB audited 73 school bus fleets (2,262 buses). From July 1, 2004, through December 31, 2007, ARB audited 295 school bus fleets (6,344 buses), for a total of 8, 606 buses.

In most cases where non-compliance has occurred, staff has worked with fleet terminal staff to correct them. When failure to comply has been extreme, ARB enforcement and legal staff have pursued enforcement action. To date, ARB has resolved one formal action against a school bus company for failure to produce records demonstrating compliance testing of their fleet. The fleet contained 491 diesel-powered school buses, and 589 separate violations were

noted (committed over multiple years). The fleet was assessed \$80,000 in direct penalties. The fleet also agreed to complete a Supplemental Environmental Project within three years, to provide no less than \$25,000 in free public transportation services.

Additional conditions of compliance included requirements for all maintenance staff to attend CCDET³ training, to commit no future violations, and for the fleet manager to continue to provide annual testing records.

For more information on the PSIP visit:

<http://www.arb.ca.gov/msprog/hdvip/hdvip.htm>.

D. Table 2: Summary of School Bus Enforcement Information

Table 2 summarizes the inspection, violation, and penalty information (i.e., an accounting of the total number of school buses surveyed and found in violation, and a description of each violation, the penalty assessed, and compliance activities). As discussed above, the Airborne Toxic Control Measure (ATCM) to Limit School Bus Idling and Idling at Schools was adopted in December 2002 and enforcement of this regulation was initiated in July 2004. Because enforcement of the Heavy-Duty Vehicle Inspection Program (HDVIP) and the Periodic Smoke Inspection Program (PSIP) commenced in 1998, the enforcement information provided in Table 1 below relating to the HDVIP and PSIP has been separated into two groups: 1) pre-July 2004 and 2) July 2004 - December 31, 2007, in order to present a standardized set of statistics with respect to enforcement of the ATCM to Limit School Bus Idling and Idling at Schools.

³ CCDET: California Council on Diesel Education and Technology offers, through selected California community colleges, a one-day, low-cost course that provides hands-on training on administration of the SAE J1667 "Snap Acceleration Smoke Test Procedures used in HDVIP and PSIP, as well as basic smoke emissions trouble shooting and repairs, and record keeping requirements.

Table 2: Summary School Bus Enforcement Information

Program	Number of Buses Surveyed	Nature of Violation(s)	Number of Violations	Penalties Assessed	Compliance Activities
<p>School Bus Idling Regulation</p> <p>Title 13, California Code of Regulations (CCR), Section 2480</p>	<p>4,750 inspections (2004 to present)</p>	<p>Excessive idling at or near a school</p>	<p>18</p>	<p>\$1,800</p>	<p>Required payment of penalties starting at \$100 per violation. Cease excessive idling.</p>
<p>Heavy-Duty Vehicle Inspection Program (HDVIP)</p> <p>Title 13, CCR, Section 2180</p>	<p>More than 170,000 heavy-duty vehicle smoke opacity and tampering inspections have been performed since enforcement of the program began in 1998 (approximately 18,000 per year). Staff does not maintain information relating to vehicle or engine type for those vehicles that do not violate these inspections. However, staff estimates that less than one percent of all heavy-duty vehicles inspected under this program are school buses.</p> <p>Of these inspections, 101,391 were performed prior to July 1, 2004, with the remaining 70,445 performed between July 1, 2004 and December 31, 2007.</p>	<p>Excessive smoke opacity</p>	<p>2 involving school buses—one in 2003 and one in 2007.</p>	<p>N/A</p> <p>Per AB 1107, Moore, (Chapter 940, Statutes of 1989), school buses are exempt from monetary penalties for the first violation. Neither of the buses was cited for more than one violation.</p>	<p>Repair engine and retest smoke opacity. Payment of monetary penalties is required for second or subsequent violation by same bus within one year.</p>

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Program	Number of Buses Surveyed	Nature of Violation(s)	Number of Violations	Penalties Assessed	Compliance Activities
Periodic Smoke Inspection Program (PSIP) Title 13, CCR, Section 2190	Formal enforcement commenced in July 1999; between that date and June 30, 2004, ARB audited 73 school bus fleets (2,262 buses). From July 1, 2004, through December 31, 2007, ARB audited 295 school bus fleets (6,344 buses).	Failure to demonstrate compliance at time of audit (i.e., no testing records maintained).	589 This total constitutes multiple violations within the fleet of 491 school buses, since a specific bus may have been involved in more than one violation.	\$80,000 direct penalty assessment \$25,000 for a Supplemental Environmental Project—SEP (see also “Compliance Activities” column)	All maintenance staff required to attend CCDET* training. Commit no future violations. Provide annual testing records to ARB. SEP—Within three years the violating fleet required to provide no less than \$25,000 in free public transportation services.

*CCDET: California Council on Diesel Education and Technology offers, through selected California community colleges, a one-day, low-cost course that provides hands-on training on administration of the SAE J1667 “Snap Acceleration Smoke Test Procedures” used in the HDVIP and PSIP, as well as basic smoke emissions trouble shooting and repairs, and record keeping requirements.

IV. Recommendations

The regulations ARB enforces in this area are necessary, and appear to have their intended effect of deterring most violations while punishing and correcting those that do occur. Accordingly, ARB has no recommendations for how the Legislature might strengthen or improve these programs. Based on its experience administering the Lower-Emission School Bus Program, however, ARB notes that strategies to accelerate the retirement of older, high-emitting buses so they may be replaced with new buses certified to ARB’s current, low emission standards have merit, as do strategies to retrofit older buses with diesel emission control devices. Both show promise to further protect school children as well as the general public from exposures to school bus diesel PM.