

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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## **Executive Summary**

For the past seven years, the California Legislature has appropriated significant levels of funding to reduce air pollutants emitted by the California public school bus fleet and lower the risk such emissions pose to public health. The California Air Resources Board (ARB or Board), the local air pollution control districts, the California Energy Commission (CEC), school districts, and other State and local government entities have established a number of programs to address the Legislature's concerns. In a Supplemental Report to the 2007 Budget Act, the California Legislative Analyst's Office (LAO) 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 in-use school bus emissions and operations. These include the emission standards that apply to engines that power school buses, regulations that restrict school bus idling, and regulations that establish the heavy-duty vehicle inspection and periodic smoke inspection programs. Over time, ARB has surveyed approximately 27,000 school buses pursuant to these regulations, and has found relatively few violations, including no violations of the emission standards for diesel particulate matter, the pollutant of most concern. 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 violations were corrected. The regulations ARB enforces in this area are necessary, appear to have their intended effect of deterring and punishing violations, and ARB has no recommendations as to how these programs could be strengthened or improved by the Legislature. However, strategies to accelerate the retirement of older, high-emitting buses and replacing them with new buses certified to ARB's stringent low emission standards show great promise in protecting children who ride in school buses from exposures to diesel PM.

## **Background**

Diesel engines emit a complex mixture of air pollutants composed of gaseous and solid materials. The solid fraction of diesel exhaust is called particulate matter or diesel PM. In 1998, ARB identified diesel PM as a toxic air contaminant based on its potential to cause cancer, premature death, and a host of other health problems. Research reported since that time indicates that exposure to diesel PM also has serious acute health consequences, including cardiopulmonary effects and the exacerbation of asthma. Children are among those most vulnerable to the ill effects of diesel PM because they suffer exposures while their lungs are still developing. Children are also more vulnerable because they have higher inhalation rates, narrower airways, and less mature immune systems than adults do. Oxides of nitrogen (NOx) emitted by diesel engines frustrate California's efforts to attain air quality standards for photochemical ozone, which also has disproportionate impacts on children who are exposed to it in the ambient air they breath.

Heavy-duty school buses are generally powered by diesel engines that are subject to the same emission standards as heavy-duty truck engines. Older, diesel-fueled school buses—those in the pre-1987 population—emit particularly high levels of both diesel particulate matter and oxides of nitrogen. In 2003 concerns about the health effects that diesel particulate emissions have on 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 worse than the 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 PM emissions from the school buses' own engines that leak into 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 equipped with particulate traps, and diesel school buses should be properly maintained to reduce visible exhaust. It should be noted here, however, that controlling visible diesel PM alone does not fully address the health threat posed by diesel PM because ultrafine diesel PM (which is not visible to the naked eye) poses a significant health risk due to its chemical composition and its potential to lodge deep in the lungs. This limits, to some extent, the efficacy programs such as the HDVIP and the PSIP that focus on controlling emissions of visible diesel PM. Nevertheless, these programs are essential to ensuring that the onroad fleet is properly maintained and achieves the emission reductions envisioned by ARB's emission standards, which does reduce ultrafine PM as well.

## **ARB's School Bus Programs**

### **A. Introduction: Emission Standards and Retirement or Retrofit of Older, Higher- Emitting Buses**

Emissions of PM and NOx from heavy-duty diesel engines were uncontrolled prior to 1987, but as Table 1 shows, that is no longer the case. Emission standards were imposed in the 1988 model year and have been tightened considerably over time. Although ARB has discovered and prosecuted violations of the NOx standards for diesel engines, it has not found violations of the PM standards to date. Eventually, ARB's emission standards will result in a much cleaner on-road fleet of heavy-duty diesel vehicles, including school buses. However, school buses typically accumulate mileage much slower than other heavy-duty diesel vehicles do. This allows school buses to remain in service for a very long period of time and blunts the impact of ARB's emission standards, which rely on vehicle turnover to have full effect. Given the high cost of new buses (ranging from \$125,000 to \$145,000), and the fiscal challenges facing California's schools, it is not uncommon for old high-emitting buses to remain in service for periods in excess of 25 years. These aging vehicles pose a significant and ongoing health risk, especially to the children who ride in them as was shown in the 2003 UC study.

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

**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.)

<b>Model Year</b>	<b>PM (g/bhp-hr)</b>	<b>NOx (g/bhp-hr)</b>	<b>NOx + NMHC (g/bhp-hr)</b>
<b>1988<sup>(a)</sup> - 1990</b>	0.60	6.0	---
<b>1991 - 1993</b>	0.25	5.0	---
<b>1994 - 1997</b>	0.10	5.0	---
<b>1998 - 2003</b>	0.10	4.0	---
<b>2004 - 2006</b>	0.10	---	2.5 <sup>(b)</sup>
<b>2007 - 2009</b>	0.01	1.2 <sup>(c)</sup>	---
<b>2010</b>	0.01	0.2	---

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

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(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<sub>x</sub> standard for 2010 model year engines. The other 50 percent may continue to meet the 2.5 g/bhp-hr NO<sub>x</sub>+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<sub>x</sub> 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.

Another way to reduce emissions from the on-road school bus fleet is by installing diesel emission control devices. The 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. Under these regulations, the ARB may verify a range of PM reduction efficiencies, the upper range being greater than 85%. NO<sub>x</sub> reductions may also be verified. Once a device is verified, its installation may be eligible for funding via various incentive programs, or it may be used to satisfy compliance obligations imposed by other regulations. Averaging approximately \$20,000 per vehicle, retrofits are less expensive than replacing an older bus with a new one.

The California Legislature dedicated funding during the past seven years to help modernize the school bus fleet—either through new school bus purchases or through the application of retrofit devices. In addition, ARB and local air districts, CEC, school districts, and other State and local government entities have enacted regulations, policies, and other measures to address the problems associated with the outdated portion of the fleet.

In addition to tightening its emission standards and verifying diesel emission control devices, ARB has adopted other programs, policies, and regulations, and refocused enforcement efforts on existing ones to specifically target emissions from school buses. These include the Lower Emission School Bus Program, 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.

## **A. Program Overview**

### **1. 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. This incentive program was designed to reduce school children's exposure to both diesel PM and smog-forming NO<sub>x</sub> 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.

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). However, these funds were restricted for use on new bus purchases and did not support the diesel PM retrofit program component.

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 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 to ensure effective and cost-effective use of these funds.

Since its inception in 2000 through June 1, 2007, the Lower Emissions School Bus Program has replaced in the neighborhood of 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 funding<sup>1</sup> 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.

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

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<sup>1</sup> 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).

2. 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 is intended to reduce school children's exposure to diesel PM and other air pollutants 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 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).

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>

3. 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-NOx software. 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. The 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.

For more information on the HDVIP visit:

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

#### 4. Periodic Smoke Inspection Program (Title 13, CCR, Section 2190)

This 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.

For more information on the PSIP visit:

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

### **B. Program Enforcement**

The following section provides enforcement-related information requested within the Supplemental Budget Report of 2007. Table 2 also summarizes of this information.

#### 1. School Bus Idling Regulation

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 concentrated 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.

#### 2. Heavy-Duty Vehicle Inspection Program (HDVIP)

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 large number of tests performed each year, staff does not maintain information relating to vehicle or engine type for those vehicles that do not violate the smoke opacity standards or other program requirements. 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.

### 3. Periodic Smoke Inspection Program (PSIP)

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, performing on-site audits at each terminal has been problematic. 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).

In most cases where examples of non-compliance have surfaced, staff has worked with fleet terminal staff to bring them into compliance. When failure to comply has been extreme, ARB enforcement and legal staff have pursued an 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. They also agreed to complete a Supplemental Environmental Project within three years, wherein they were to provide no less than \$25,000 in free public transportation services.

Additional conditions of compliance included requirements for all maintenance staff to attend CCDET<sup>2</sup> training, to commit no future violations, and for the fleet manager to continue to provide annual testing records.

As stated, 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

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<sup>2</sup> 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.

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.

Table 1, 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).

**Table 2: Summary School Bus Enforcement Information**

<b>Program</b>	<b>Number of Buses Surveyed</b>	<b>Nature of Violation(s)</b>	<b>Number of Violations</b>	<b>Penalties Assessed</b>	<b>Positions for Enforcement</b>	<b>Compliance Activities</b>
<b>School bus idling regulation</b>  Title 13, California Code of Regulations (CCR), Section 2480	<b>4,750</b> inspections  (2004 to present)	Excessive idling at or near a school	<b>18</b>	<b>\$1,800</b>	<b>1</b>	Required payment of penalties starting at \$100 per violation.
<b>Heavy-Duty Vehicle Inspection Program (HDVIP)</b>  Title 13, CCR, Section 2180	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	Excessive smoke opacity	<b>2</b> involving school buses – one in 2003 and one in 2007.	<b>N/A</b>  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.	<b>20</b>	Repair engine and retest smoke opacity. Payment of monetary penalties is required for second or subsequent violation by same bus within one year.

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<b>Program</b>	<b>Number of Buses Surveyed</b>	<b>Nature of Violation(s)</b>	<b>Number of Violations</b>	<b>Penalties Assessed</b>	<b>Positions for Enforcement</b>	<b>Compliance Activities</b>
	<p>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><b>Periodic Smoke Inspection Program (PSIP)</b></p> <p>Title 13, CCR, Section 2190</p>	<p>Formal enforcement commenced in July 1999; between that date and June 30, 2004, ARB audited 73 school bus fleets (2,262 buses).</p> <p>From July 1, 2004, through December 31, 2007, ARB audited 295 school bus fleets (6,344 buses).</p>	<p>Failure to demonstrate compliance at time of audit (i.e., no testing records maintained).</p>	<p><b>589</b></p> <p>This total constitutes multiple years of violations within the fleet of 491 school buses.</p>	<p><b>\$80,000</b> direct penalty assessment</p> <p><b>\$25,000</b> for a Supplemental Environmental Project – SEP (see also “Compliance Activities” column)</p>	<p><b>4</b></p>	<p>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.</p>

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\*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.

## **Recommendations**

In the "Supplemental Report to the 2007 Budget Act," the California Legislative Analyst's Office requested recommendations on how to improve or strengthen the Board's monitoring and enforcement programs to ensure that all school buses are properly maintained for the public health and safety of riders. ARB believes that its efforts to improve management of these programs over time have been quite effective and has no recommendations to make to the Legislature at this time. Nevertheless, strategies to accelerate the retirement of older, high-emitting buses so they may be replaced with new buses certified to ARB's stringent emissions standards show great promise, as do strategies to retrofit older buses with diesel emission control devices.