Maine Clean School Bus Program
Final Report

Prepared by:
Maine Department of Environmental Protection
And
Asthma Regional Council of New England

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U.S. EPA *Clean School Bus USA* 2003 Grant

The U. S. Congress in 2003 authorized $5 million in funding under EPA's *Clean School Bus USA* grant competition. Maine was one of 17 demonstration projects selected from 117 applications nationwide to implement the first statewide clean school bus retrofit project in the country. Maine's Clean School Bus Program has become a national model and earned the distinction of receiving the National Clean Bus Leader Award in 2004 from the Environmental and Energy Study Institute. The Union of Concerned Scientists in 2005 gave Maine high marks as one of the top five states in the country with a successful school bus cleanup program.

1. Project Description

In October 2003, the Maine Departments of Environmental Protection and Education in partnership with the New England Asthma Regional Council (ARC) were awarded $567,376 from EPA's *Clean School Bus USA* program. The objective of the grant was to retrofit 266 Maine school buses with diesel oxidation catalyst mufflers to reduce harmful diesel particulate matter by at least 25 percent from each bus. The state established a sub-grant program to distribute EPA grant funds directly to more than thirty school districts across the state. For our contribution, the State of Maine purchased 180 new school buses. ARC evaluated the effectiveness of this project and shared results with the ARC Diesel Committee members from all six New England States.

2. Project Partners and Goals

A goal was to educate the transportation directors and school bus drivers of the adverse health effects from exposure to diesel exhaust, which even at low levels is a serious health hazard and can cause respiratory problems such as asthma and bronchitis, lung damage and increases the risk of lung cancer. As part of this grant the Maine Department of Environmental Protection (DEP) collaborated with the Maine Department of Education and the Maine Association for Pupil Transportation (MAPT) to reduce school bus idling statewide by developing comprehensive outreach materials for school officials, transportation directors, bus drivers, and others. These informational materials included a model no-idling policy as well as other emission reduction

strategies including parking configurations, alternative fuels, and retrofit technologies using the *Clean School Bus USA* grant funding.

3. Publicity and Events

On October 22, 2003 a press event was held at the Maine Statehouse announcing the Clean School Bus USA award for $567, 376 to Maine Department of Environmental Protection (DEP). EPA New England Regional Administrator Robert Varney as well as staff of Maine's Congressional Delegation addressed the superintendents and transportation directors of the participating school districts which attended the event. The event was carried by one television station, public radio and the Kennebec Journal, the local newspaper.

In July, 2004 training for the installation of the emission control equipment on school buses was held at the annual Maine Association of Pupil Transportation Conference (MAPT). Maine DEP video taped the mechanic's training as well as the workshop at the MAPT conference reinforcing no-idling, and demonstrating other emission reduction strategies. Our partner, Asthma Regional Council gave a presentation on the health effects of diesel exhaust which was also video taped and posted on the Maine DEP website. A CD ROM was developed of ARC's presentation and included the presentation of implementing a no-idling policy at school given by Lennie Goff, Transportation Director at MSAD 47. A VHS tape was produced of the mechanic's training workshop and distributed to the school districts.

On September 9, 2004 a press event was held in Fort Kent to celebrate the first district in Maine to install the retrofit technology as a way to ensure cleaner, healthier air around schools and in the community. The event received great television and newspaper coverage. The *Clean School Bus USA* (CSB) magnets, pencils and bookmarks were a great hit with the kids and the media. Maine DEP also presented the Transportation Director with a CSB award.

On September 21, 2004 EPA Administrator Leavitt, and the EPA New England Regional Administrator, Robert Varney attended a press event in Portland to recognize Maine's leadership in the CSB program. Six Southern Maine Transportation Directors received awards signed by Administrator Leavitt. It was a great event but received little press coverage.

In February 2004, Office of Air Quality and Program Standards filmed a segment of the Air Toxics video on the Maine Clean School Bus program. They filmed at the Messalonskee school district, a grant recipient. The webcast aired on March 23rd.

On May 26, 2005 a press event was held in Presque Isle to commend them for retrofitting 22 diesel school buses with emission control devices. The event received great media coverage.

In July of 2005 Maine DEP had a display at the MAPT conference using an EPA poster showing the health effects from air pollution. Many school district transportation directors asked for copies. Maine DEP printed 600 brochures with the 11" x 17" EPA

health poster on the backside of the brochure for statewide distribution. Maine DEP continues to maintain a presence at the annual MAPT conference to reinforce changing attitudes and behaviors for reducing diesel emissions.

4. Emission Control Technology

The project team investigated several emission control options to meet the specified reduction in particulate matter (PM). The Donaldson Diesel Oxidation Catalyst muffler (DOC) and Spiracle closed crankcase ventilation system (CCV) offered the greatest reduction of diesel particulate matter (PM) at the lowest cost of $37.00 per % PM reduction. Donaldson Company was selected as the primary contractor.

We were also impressed with the Platinum Plus Purifier system offered by Clean Diesel Technologies, Inc. (CDTI) which using the fuel-borne catalyst (FBC) removes 15-25% of the PM emitted from the engine, predominantly the elemental carbon portion, a contributor to climate change. The DOC muffler reduces the soluble organic fraction of the particulate. This combined reduction of emissions is why the system claims twice the pollution reduction of regular DOC muffler systems. CDTI also claims a 7% fuel economy savings using the FBC. However, only one third of Maine's districts has a central fueling depot and could use CDTI's fuel borne catalyst. Therefore, we selected CDTI to do a demonstration project at four selected school districts that have central fueling depots and could splash blend the fuel additive.

CDTI offered in their proposal to train the districts on how to splash blend the fuel borne catalyst to the fuel storage tank. For quality assurance, CDTI randomly collected fuel samples from the participating school bus fleets to send to an independent lab for analysis of the FBC dose levels to ensure fuel quality and peak system performance.

To purchase the emission control technology (ECT) at the lowest cost, we selected the option for purchasing the DOC muffler, closed crankcase ventilation system or FBC, instruction manual with training. Training for the installation of the ECT on a school bus was held at the annual Maine Association of Pupil Transportation Conference (MAPT) on July 28, 2004.

In January 2005 EPA met with the transportation directors that were using the fuel-borne catalyst provided by Clean Diesel Technologies, Inc. (CDTI). EPA OTAQ has some concerns about emissions from diesel engines using CDTI's Platinum Plus fuel-borne catalyst and the potential health effects from exposure to this exhaust. Additional testing was recommended to address the concerns that allergenic platinum salts can be formed from combustion of Platinum Plus. The transportation directors chose to discontinue using the FBC until additional testing was completed and EPA had verified the safety of using this product. Maine is still waiting for EPA to disclose results from the subsequent testing of the catalysts. EPA has not to date recommended reusing the fuel-borne catalyst.

5. Program Implementation

Because of the competitive contract price Maine received from Donaldson Company for their product and services, funding was available to retrofit 163 more school buses than identified in the original proposal. Thirty-three school districts statewide have benefitted from retrofitting 429 school buses with emission control technology. The state relied upon a sub-grant program to distribute the EPA grant funds directly to the thirty-three school districts across the state. The below totals exceed the objectives stated in the grant application of 266 buses retrofitted in 20 districts. See Appendix A.

Of this total,

- 273 school buses have been retrofitted with both a DOC and closed crankcase ventilation system.
- Forty of those buses that retrofitted with the CDTI DOCs later installed the Spiracle closed crankcase ventilation system.
- Seventy-five buses did not install a closed crankcase ventilation system partly because of engine design; therefore 75 buses were retrofitted with DOCs only.
- Eighty-one buses already had an existing OEM DOC and therefore, were retrofitted with only the Spiracle closed crankcase ventilation system.

In addition, the Department of Education included in their school bus bid specifications and school bus purchases contracts a requirement that new school buses be retrofitted with diesel oxidation catalysts and CCVs when applicable. The Department of Education paid the cost of the equipment and installation for 69 MBE 906 Thomas Freightliner school buses to be retrofitted with the diesel oxidation catalyst supplied by Donaldson Company on new buses to be delivered in FY07 (after July 01 2006). The balance of buses ordered were CAT engines with DOCs equipped from the factory, therefore the retrofits are only for MBE 960 Thomas Freightliner school buses. Also nineteen 2006 model year International engines were retrofitted with CCVs. The total state and local cost of the DOC retrofits is $82,200. This program was not funded by the CSB grant.

6. Project Evaluation

ARC evaluated the effectiveness of this project and shared results with the ARC Diesel Committee members from all six New England States. In summary, the team met or exceeded all benchmarks identified in the grant agreement.

On behalf of the Maine DEP, the Asthma Regional Council of New England (ARC) contacted school transportation directors and school bus fleet managers to assess the success of the retrofit portion of the grant. ARC contracted with Ellen Tohn of Tohn Environmental Strategies, to direct this effort. Interviews occurred prior to the installation of the retrofit equipment; 6 months post installation; and one year post installation. The post installation results were compiled based on interviews with 20 of the 31 districts. ARC provided the results of these assessments in three reports (June 2004; April 2006; and April 2007) and shared regionally. Complete copies of all evaluation reports were submitted previously to EPA. Key results are summarized below.

Baseline Results

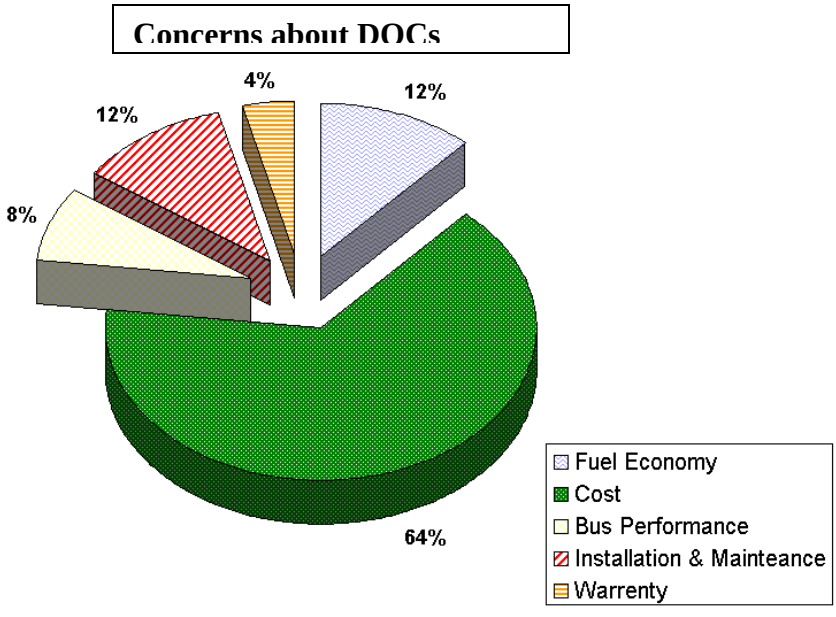
The goal of this effort was to document baseline knowledge and design future survey questions to track issues of concern identified by the districts.

- Transportation directors and school superintendents from Maine (in participating and non-participating school districts) and from outside the state are well informed about the health effects caused by exposure to diesel exhaust and actions they can take to reduce emissions.

- All school districts believed that no idling policies were a good "first-step" in reducing harmful emissions, but felt that enforcing these policies could be extremely difficult. As a result, more than half had adopted additional practices to reduce diesel emissions and were open to additional solutions.

- Over 80% of districts were well informed about pollution control equipment, but had little "hands on" experience with pollution control devices such as diesel oxidation catalysts (DOCs).

- School districts were universally willing to consider using DOCs as pollution control devices on school buses. Their primary concerns in adopting this new technology were upfront and ongoing maintenance costs, difficulty with installation, negation of warranties, and potential adverse affects on bus performance. See below figure.

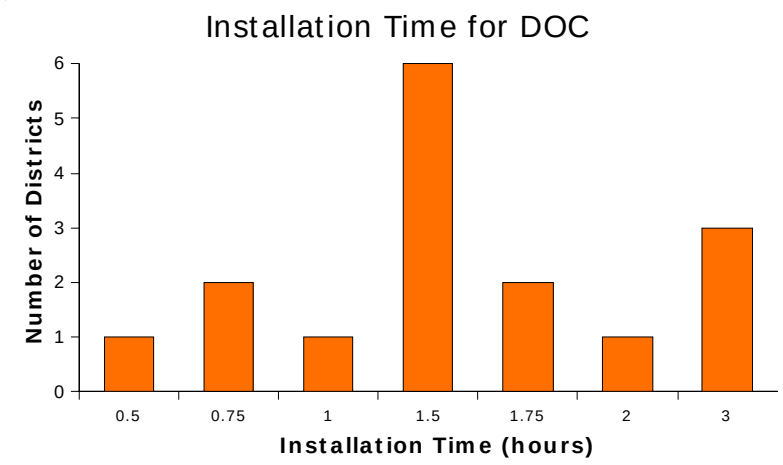


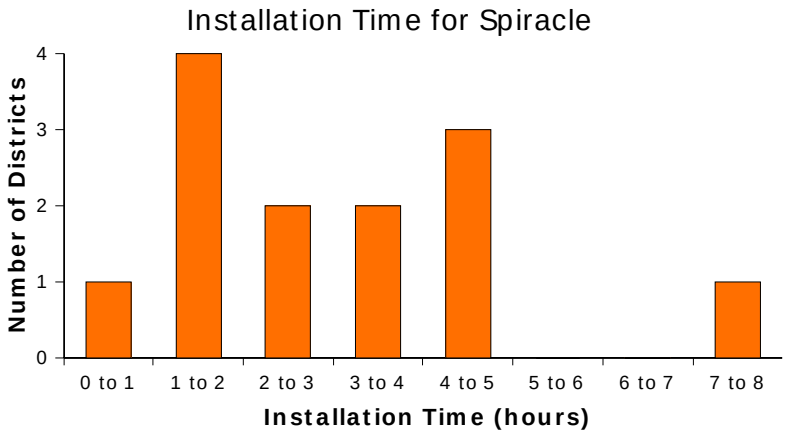
Post Installation Results

- All districts rated the Diesel Oxidation Catalysts (DOCs) installation process as good or excellent. Ninety percent (18/20) of the districts installing DOCs rated the product as excellent or good. Several districts reported that the DOC was a very high quality stainless steel muffler that they felt would last much longer than the typical muffler helping to reduce maintenance costs.

- On average districts allocated 1-2 hours for DOC installation. However, a few districts reported significantly longer installation requirements. Mechanics reported that they had to cut the exhaust pipe to make it fit properly. Districts also reported the need to rework the brackets provided in the kits to fit properly, appropriate sized brackets had to be machined. Variation among bus configurations required some unique adjustments. Transit buses required significantly more time for installation than Type C conventional school buses.

- On average districts allocated 3-4 hours to install the Spiracle closed crankcase ventilation system. CCV installation posed greater challenges than installation of the DOCs. Nonetheless, more than half the districts reported that it took under two hours for closed crankcase installation. Key issues with the installation involved the lack of hoses with the initial kits, tubing too stiff, and confusion about where to mount the device. Mechanics ascribed the extra time requirement to manufacturing new brackets rather than employing the ones provided in the kits or difficulties working with the tubing.





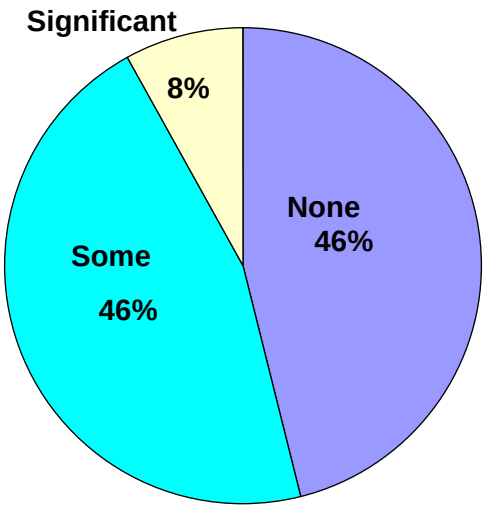
- Installation instructions were on average rated as somewhat helpful but too generic. The primary concern with the installation process was variation from bus to bus and the trial-and-error necessary for each installation.

▪ Despite significant concerns prior to the project about potential adverse affects on bus performance, 16 of 20 districts installing equipment did not report any operational issues in the six months following installation. Three reported minor issues that may be associated with the retrofit equipment (e.g., possible noise). One district indicated that they wanted to monitor possible concerns with a water temperature gauge running warm, although it was still in the safe zone. A concern was raised that the CCV may be increasing engine temperatures on a rear CAT engine transit bus.

Post Twelve Months Results

Twenty-five districts reported experiencing minimal problems with the DOCs but experienced more concerns with the CCVs. Only one district reported a significant issue with the DOC (odor). Approximately half the districts experienced some issues with the CCVs that included: oil leakage (11 districts), back pressure (5 districts), and reliability (4 districts). One mechanic reported the oil that re-circulates is not being appropriately contained and escaping out of the fitting.

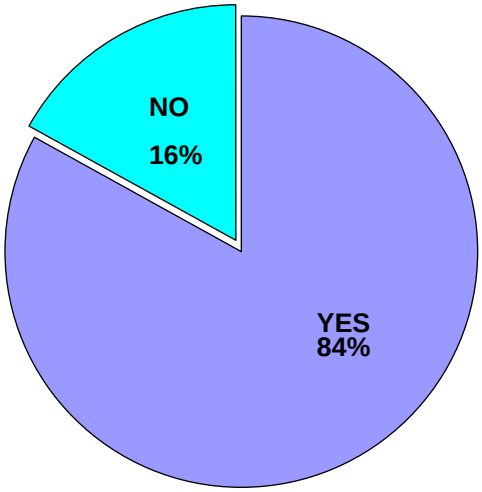
Problems w/ CCVs



After twelve months, three districts that received new buses with CCVs reported some problems with buses "freezing up." All three of these districts had their buses modified by International Corporation Bus Company and have since had no problems.

Equal number of districts reported some problems with operation as did districts that reported no problems.

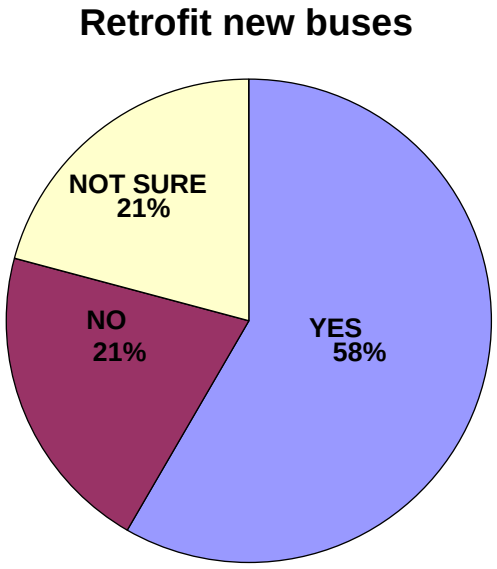
Recommend others to retrofit



After twelve months, districts felt the program was successful. Twenty one districts (84%) reported that they would recommend other districts retrofit their buses with the new equipment; however four of those districts suggested only installing the DOC, while seventeen said they would recommend installing both types of equipment. Of the four districts that would not recommend others retrofit their school buses; none experienced significant problems with either the DOCs or the Closed Crankcase Ventilation System. Many districts also reported positive comments about the

program such as being “glad to be active in global health”, and feeling that the program is “great.” The majority of districts also reported they would like to retrofit their new buses.

Would you like to retrofit your newest buses (2005 and 2006) with a closed crankcase ventilation system?



Almost sixty percent of the districts said that they would like to retrofit their new buses with the equipment, while a little more than twenty percent said they would not, and another twenty percent said they were not sure. Most districts that did not want to install retrofit equipment on their new buses were districts that had experienced various problems with the equipment.

7. Successes

Statewide Purchase of OEM DOCs and CCVs

The Department of Education included in their new school bus bid specifications and school bus purchases contracts a requirement that new school buses be retrofitted with diesel oxidation catalysts and CCVs, when applicable. The Department of Education paid the additional cost of the equipment and installation. This integration with existing specifications worked well and is a model for any future improvements in emission control equipment. This program expanded the reduced emissions benefits of CSB grant.

Idling Reduction

Many drivers are now minimizing idling time in the school yard to reduce diesel emission exposure. Local school transportation directors have become involved by posting “no-idling” signs in driveways and by using route planning software to minimize student time on the bus. Other actions include rewiring safety lights to run off the battery and installing auxiliary fuel-fired heaters to keep the bus warm as students board in cold weather.

Acceptance by Transportation Directors

After twelve months, most districts felt good about the program and were happy to participate. An overwhelming majority of districts reported that they would recommend others to retrofit their school buses. The initial concerns of the potential for DOCs to adversely affect bus power/performance were unfounded. Many districts also reported positive comments about the program such as being “glad to be active in global health”, and feeling that the program is “great.” The majority of districts also reported they would like to retrofit their new buses.

8. Challenges

An important challenge was to identify which buses were already equipped with diesel oxidation catalysts. Caterpillar engines on school buses were equipped with OEM DOCs from model years 1994 through 1997 when federal emission standards became more stringent. In 1998 Caterpillar manufactured an electronic engine and discontinued using DOCs to meet federal emission standards. School buses with Caterpillar 2001 and subsequent model year engines are factory equipped with DOCs in order to meet PM emission standards. Since the lowest bidder for the bus contract include CAT engines, Maine could not meet the goal of equipping all new buses with DOCs to reduce PM emissions beyond the standard.

The initial retrofit kits did not include the clamps and tubing necessary to complete installation of the CCV. In addition the brackets for both the CCV and DOCs provided in the kits were inadequate and had to be manufactured by the mechanics, significantly increasing installation time. Some districts complained that condensation in the Spiracle closed crankcase filter froze and caused increased crankcase pressures, damaging the engine and placing the school bus out of commission. It was not determined whether the increased crankcase pressure was caused by an internal engine problem or the Spiracle crankcase ventilation system retrofit

Improper installation of CCVs on nineteen International school buses with 2006 model year engines resulted in operational issues following a cold snap (e.g., backpressure and oil leaks resulted from a frozen CCV). After investigation it appears that the problem was caused by improper CCV installation by DATTCO who did not receive prior training. DATTCO was responsible for refitting the CCVs and correcting any damage as a result of the improper installation. Therefore, installation by a trained mechanic is essential.

Another challenge was the wide geographic dispersion of the participating districts. Maine is a large state and vendors stated it was too costly to distribute product and services to such a large area.

9. Lessons Learned

Over the course of this project, the Maine DEP and its partners experimented with new technologies and systems to further reduce school bus diesel emissions. As with all such efforts, it is useful to take a step back and ask "What have we learned?" Several key observations are presented below which may be of interest to future EPA, state and local efforts.

Working with Emission Control Contractor

It was challenging to work with a contractor who did not have experience working directly with schools or in Maine. Require future contractors to have an established local presence and consider giving preferences to those who have worked with school districts. Donaldson's experience prior to this grant was at the wholesale level. Their lack of experience with schools and Maine in general necessitated considerable Maine DEP staff time to orient them to the state and explain the needs and abilities of the

school district staff. These issues were minimized once Donaldson Company developed a relationship with a Maine vendor -- New England Detroit Allison. However, when Donaldson Company lost their contractor the remaining school bus retrofit installations were delayed two years.

It was beneficial to have specific contract language to ensure the contractor provided added support and services when retrofit devices did not function well. EPA should provide model language to any future grantees. The State of Maine contract specified that the vendor provide all supplies necessary to complete installation and conduct a post installation inspection. Thus when issues arose over the lack of sufficient tubing for the CCV, Maine DEP was able to secure the parts from Donaldson Company and change the manufacturing process. The contract also required an on site inspection which proved invaluable in verifying that the mechanic had the ability to complete the installation successfully and it also provided an opportunity for the mechanic to ask questions. During the inspection the vendor was also able to learn from the mechanics about the need to modify key pieces of equipment (universal brackets for the CCV) to fit specific buses and that generic installation instructions were not sufficient to address the unique configurations of various buses. As a result, Donaldson Company tailored the instructions to meet the mechanics needs.

<u>Dissemination</u>

The Maine Association for Pupil Transportation (MAPT) is a useful partner to distribute information to transportation directors and mechanics. The Maine DEP worked successfully with MAPT to include presentations at their annual conference and used MAPT resources to share key information. This was extremely beneficial for this large statewide project.

<u>Sub-granting to School Districts</u>

School districts were not typically staffed to contract directly for emission control equipment requiring substantial DEP staff oversight to ensure the proper equipment arrived was installed and payment was submitted to the vendor. Recommend developing a more streamlined contracting process that does not rely on school district personnel. The school districts did not send copies of their invoices for processing payment with EPA. Sub granting funds add multiple layers to the process and is very inefficient.

The EPA grant award specified that school districts purchase the retrofit equipment. This necessitated a sub-grant agreement between the state and each district. This contractual arrangement required schools to pay the vendor directly for equipment provided. Maine DEP observed inconsistent payment performance that required continual Maine DEP oversight, an unanticipated use of Maine DEP resources.

Vendor invoices were sent before the devices were inspected creating an expectation for payment before the districts could verify that the equipment was working. Structure invoices to be sent post delivery and inspection. Donaldson shipped the emission control kits with invoices. Schools, however, would not pay for the devices until they were installed and inspected. Donaldson's accounting department contacted districts for payment before it was procedurally appropriate. Issues related to the billing

created a poor customer service relationship and feelings of distrust among districts for working with Donaldson Company. Donaldson did adjust their invoicing policy to require payment when the installations and inspections were completed creating appropriate incentives for the mechanics to install the devices and the contractor to inspect the devices in order to receive payment.

Installation Issues

Future projects should rely upon a contractor to complete the equipment installations. The experience in Maine revealed that mechanics have varying levels of expertise. In contrast, contractors have the proper training, expertise, time and resources to ensure consistent installation. This is particularly important for CCV installation which was substantially more complicated than DOC installations which were generally straightforward. On the other hand, installing district mechanics were more reliant to properly maintain the equipment.

Further assessment is needed to better understand the ideal location for the CCV and to provide more effective installation instructions. Districts struggled with installation and have experienced operational problems that may be linked to the location of the CCV. For example, some districts have experienced condensation when the CCV is installed in a cold spot. The recommended location was to mount the CCV near the fender exposed to the elements. Instead a mechanic mounted the CCV above the engine by the firewall. The brackets provided by the vendor caused a lot of frustration from the mechanics who found it necessary to machine new brackets.

Technology and Operational Issues

DOCs functioned well in nearly all buses. This technology can be installed on a widespread basis.

Further evaluation and follow up is needed to assess the operational issues with the CCV as roughly half the districts experienced some concerns (e.g., oil leakage -11 districts; back pressure - 5 districts, and reliability - 4 districts).

The lack of a clear EPA opinion on the Fuel Borne Catalyst has been frustrating and a more definitive conclusion is needed. EPA OTAQ continues to endorse CDTI's Platinum Plus fuel-borne catalyst on the verified technology website yet has raised some concerns that allergenic platinum salts can be formed from combustion of Platinum Plus which could negatively affect emissions. This has been very frustrating to the transportation directors who chose to discontinue using the FBC until EPA verified the safety of using this product. Approximately 1/3 of buses were targeted to use this product. EPA has not communicated with Maine DEP about the results of its further assessment of this product. Several local districts would like to continue to use it because it improved fuel economy and helped the engine run cleaner.

The Maine public school districts that are participating in the Clean School Bus USA program are:

Auburn School Department
Brunswick School Department
Bridgewater School Department
Caribou School District
Ellsworth School Department
MSAD #1, Presque Isle,
MSAD #6, Standish
MSAD #9, Farmington
MSAD #17, Oxford Hills
MSAD #20, Fort Fairfield
MSAD #27, Fort Kent
MSAD #29, Houlton
MSAD #39 Buckfield
MSAD #41, Milo School District
MSAD #43, Mexico
MSAD #47, Oakland
MSAD #49, Fairfield
MSAD #51 Cumberland
River Valley School District, MSAD #52, Turner
MSAD #77, East Machias
Union #7, Saco
Union #42, Readfield
Falmouth School Department
Freeport School Department
Gorham School Department
Limestone School Department
Medway School Department
Portland Public Schools
Scarborough School Department
South Portland Public Schools
Waterville Schools
Westbrook School Department
Wiscasset School Department

Appendix A
School District Retrofit Equipment Installed

School District	Donaldson DOC and Crankcase Kits	Donaldson DOC Only	CDTI DOC	FBC	Crankcase Kits Only
MSAD 27/Fort Kent			16	20 gallons/12 Qts	12
MSAD 6			20	55 gallons	48
MSAD 47/Messalonskee			28	55 gallons	4
MSAD17/Oxford Hills			33	70 gallons	
MSAD 41/Milo	8				
MSAD9/Farmington	11				8
Westbrook	14	1			4
MSAD 1, Presque Isle	22				
Falmouth			4	27 gallons	18
SAD 77, East Machias	6				
South Portland	5				1
Caribou	6				2
Portland	20				1
Brunswick	12				2
MSAD 52, Turner	16	4			4
Freeport	7				
Gorham	18				
MSAD 43, Mexico	6	5			
Maranacook	6	3			8
Auburn	3				
Union 113, Medway	5				1
Wiscasset	3				
Ellsworth	6				4
Fort Fairfield	5				
Fairfield	16				

Buckfield	9				
Saco	14	1			3
Asthma Regional Council					
Scarborough	7				1
Houlton	4				
Cumberland	4				
Total	**233**	**14**	**101**	**227 gallons**	**121**